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GROWTH IN THE REINDEER

By

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TIMISJÄRVI, J., M. NIEMINEN, K. ROINE, M. KOSKINEN and H. LAAKSONEN: *Growth in the reindeer*. Acta vet. scand. 1982, *23*, 603—618. — The growth of the reindeer from birth to adulthood is cumulative consisting of a rapid weight accretion during summers followed by a weight loss or stasis during winters. The birth weight of the newborn calves is about 5.3 kg. The peri- and neonatal growth rate is rather high, with a greatest individual daily weight gain as high as 400 g. The polynomial growth curve and its first order time derivative of calves show a deceleration of weight gain towards the autumn. The weight of calves at an age of 10 months was 36 to 40 kg. Adult body weight is reached by females at an age of 3 to 4 years and by males on average a year later. Serum alkaline phosphatase activity showed a negative linear correlation with age and weight in calves and it was highest both in calves and adults in summer. The creatine phosphokinase activity in both calves and adults was higher in summer than in other seasons. Serum inorganic phosphorus was highest in the growing calves. On the other hand serum thyroxine (T4), blood glucose and calcium did not show significant age-dependent or seasonal variations.

alkaline phosphatase; blood glucose; body weight; calcium; creatine phosphokinase; seasons; serum inorganic phosphorus; serum thyroxine.

The growth of the reindeer and caribou from birth to adulthood is cumulative and shows a phasic pattern consisting of a rapid weight accretion during summers followed by a weight loss or stasis during the long winters. The growth rate of the reindree is, thus, a complex of events. Mathematical analyses on the dynamics of the growth based on logarithmic or exponential solutions have been carried out on the reindeer by *Krebs & Cowan*

(1962) and on the caribou by *McEwan* (1968). When considering a construction of special growth curves such as those published by *Tanner* (1978) a follow-up on a single large animal population should be carried out which in the case of the reindeer is not possible because of the several factors discussed by *Moen* (1980a). Hence, in the present paper the growth rate of the reindeer is handled mathematically with the aid of polynomial functions fitted to the average values obtained from several populations, since the race of the reindeer in Finland is relatively uniform (*Nieminen & Helle* 1980). In addition to the weight measurements blood analyses on serum alkaline phosphatase and creatine phosphokinase activities, serum thyroxine, blood glucose, calcium and inorganic phosphorus were carried out.

MATERIAL AND METHODS

Altogether 642 reindeer (Rangifer tarandus tarandus) were studied. The number, sex, age, weight, time of estimate, living conditions and main food sources of the animals are described in Tables 1 and 2. The calves ranging in age from 1 day to 20 days were weighed with a steelyard to the nearest 0.1 kg. The older calves and adults were weighed using a spring balance to the nearest 0.5 kg.

Blood samples were taken from the jugular vein with new plastic syringes containing EDTA (disodium-ethylenediamine-tera-acetate) as an anticoagulant and into centrifuge tubes within 5 min after the capturing of the animal. Aliquots of blood were immediately diluted with perchloric acid for the determination of blood glucose (Glu) according to the Boehringer GOD-perid® enzymatic method (Boehringer GmbH, Mannheim). Serum alkaline phosphatase activity (SAP) was determined by the method of *Bodansky & Schwartz* (1961), serum creatine phosphokinase activity (CPK) by using the Calbiochem Stat-Pack method (*Calbiochem* 1971), serum inorganic phosphorus (Pi) by a quantitative colorimetric method (Pierce Chemical Company), serum calcium (Ca) by titration with EGTA [ethylenglycol-bis(β-amino-ethylether)N,N^+-tetra-acetic acid] using calcein as an indicator or by an atomic absorption spectrophotometer (Perkin-Elmer 290 B) using routine procedures (*Perkin-Elmer Corporation* 1972) and serum thyroxine (T4) levels by radioimmunological assay (RIA).

Table 1. Reindeer calves used in the study and the sampling conditions. (Numbering of the groups according to the age and season, F = female, M = male.)

Group	n	Sex	Age	Sampling time	Sampling locality	Living conditions before sampling
1	14	F,M	1 day	10.5.—10.6.1977	Inari, Kaamanen (69°10'N)	In captivity out of doors. Main food milk from the hinds.
2	14	F,M	3 days	„	„	„
3	16	F,M	6 „	„	„	„
4	15	F,M	10 „	„	„	„
5	15	F,M	3 weeks	„	„	„
6	15	F,M	5 „	20.6.1978	Rovaniemi (66°70'N)	Freely grazing on good summer pastures. Main food milk and Betula and Salix leaves and green grasses.
7	10	F,M	6 „	24—25.6.1975	Kittilä (67°70'N)	„
8	10	F,M	6 „	27.6.1977	Kuusamo (66°30'N)	„
9	33	F,M	7 „	27.6.—2.7.1973	„	„
10	7	F,M	7 „	30.6.1974	„	„
11	5	F,M	7 „	5.7.1975	„	„
12	7	F,M	10 „	22.7.1975	„	„
13	15	F,M	20 „	2—5.10.1973	„	Freely grazing in the forests. Good supply of mushrooms (Boletus spp.) and green grasses and most were also still suckling.
14	2	F	20 „	2—4.10.1974	„	„
15	8	F,M	20 „	4.10.1977	„	„
16	5	F,M	21 „	6.10.1977	„	„
17	8	F,M	21 „	6.10.1978	„	„
18	9	F,M	21 „	10.10.1978	Rovaniemi	Freely grazing in the forests. Good supply of Deschampsia flexuosa grass and Cladonia lichens and most were also still suckling.
19	3	F	21 „	11.10.1974	Kittilä	„
20	16	F,M	25 „	3.11.1975	Pudasjärvi (65°40'N)	„
21	13	F,M	38 „	8.2.1978	Savukoski (67°90'N)	Freely grazing in the forests or mountain areas. Snow conditions difficult for digging for Cladonia lichens.
22	5	F,M	38 „	6—9.2.1974	Kuusamo	Freely grazing in the forests at timber-cutting sites. Good supply of Alectoria and Bryoria lichens from felled trees. Snow condition also favorable for digging for Cladonia lichens or Deschampsia flexuosa grass.
23	11	F,M	40 „	18.2.1978	„	Freely grazing in the forests. Snow conditions difficult for digging for Cladonia lichens, but good supply of arboreal lichens (Alectoria, Bryoria).
24	10	F,M	40 „	22.2.1979	Savukoski	Freely grazing in the forests or mountain areas. Living conditions as group 21.
25	7	F,M	40 „	22.2.1975	Kittilä	In captivity out of doors. Fed on dry hay, Betula leaves and lichens (Cladonia) during one month before sampling.
26	6	F,M	40 „	23.3.1978	Kuusamo	„
27	10	F,M	45 „	23.3.1979	„	„
28	17	F,M	49 „	21.4.1976	Posio (66°10'N)	„
29	4	F	72 „	2.10.1974	Kuusamo	Freely grazing in the forests. Good supply of Deschampsia flexuosa grass and Cladonia lichens.
30	6	F,M	76 „	3.11.1975	Pudasjärvi	„
31	3	F	90 „	6—9.2.1974	Kuusamo	Living conditions as group 22.
32	9	F,M	95 „	9—14.3.1973	„	Living conditions as group 23.

Table 2. Reindeer hinds and stags used in the study and the sampling conditions. (Numbering of the groups according to the age and season, F = female, M = male.)

Group	n	Sex	Age	Sampling time	Sampling locality	Living conditions before sampling (at least one month)
1	4	M	3 years	2.6.1980	Rovaniemi	In captivity out of doors. Fed on silage, dry hay and molasses during winter.
2	15	F	3—5 years	10.5.—10.6.1977	Inari, Kaamanen	Pregnant hinds in captivity out of doors. Snow conditions difficult for digging for Cladonia lichens. Fed on dry horsetails (Equisetum spp.) and molasses.
3	13	F	3—5 „	„	„	Lactating hinds in captivity. Living conditions as group 2.
4	11	F	3—5 „	20.6.1978	Rovaniemi	Freely grazing on good summer pasture. Good supply of Betula and Salix leaves and green grasses.
5	9	F	3—5 „	25.6.1975	Kittilä	„
6	6	F	3—5 „	27.6.1977	Kuusamo	„
7	32	F	3—5 „	27.6.—2.7.1973	„	„
8	30	F	3—5 „	27.6.—2.7.1974	„	„
9	4	M	3 „	9.9.1980	Rovaniemi	In captivity out of doors..Betula and Salix leaves and green grasses.
10	2	M	5—10 „	9.9.1980	„	„
11	40	F	3—5 „	2—5.10.1973	Kuusamo	Freely grazing in forests. Good supply of green grasses and mushrooms (Boletus spp.)
12	8	F	3—5 „	2—4.10.1974	„	„
13	9	F	3—5 „	6.10.1977	„	„
14	8	F	3—5 „	4.10.1978	„	„
15	10	F	3—5 „	10.10.1975	Kittilä	Freely grazing in the forests. Good supply of Deschampsia flexuosa hay and Cladonia lichens.
16	4	F	3—5 „	11.10.1974	„	„
17	9	F	3—5 „	10.10.1978	Rovaniemi	„
18	2	M	3—5 „	10.10.1975	Kittilä	„
19	12	F	8—10 „	10.10.1975	„	„
20	4	F	3—5 „	8.2.1978	Savukoski	Freely grazing hinds in the forests and mountain areas. Snow conditions difficult for digging for Cladonia lichens.
21	18	F	3—5 „	6—9.2.1974	Kuusamo	Freely grazing in the forests at timber-cutting sites. Good supply of Alectoria and Bryoria lichens. Snow conditions also favorable for digging for Cladonia lichens or Deschampsia flexuosa hay.
22	11	F	3—5 „	16.2.1978	„	Freely grazing in the forests. Snow conditions difficult for digging for Cladonia lichens, but good supply of arboreal lichens (Alectoria, Bryoria).
23	5	F	3—5 „	16.2.1978	Joensuu	In captivity out of doors. Fed on dry hay, leaves of Betula and Salix and molasses.
24	6	F	3—5 „	22.2.1975	Kittilä	„
25	6	F	3—5 „	22.2.1979	Savukoski	Freely grazing hinds in the forests and mountain areas. Living conditions as group 20.
26	7	F	3—5 „	9—14.3.1973	Kuusamo	In captivity out of doors. Fed on dry hay, leaves of Betula and lichens (Cladonia). Most hinds pregnant.
27	11	F	3—5 „	9—14.3.1973	„	Freely grazing in the forest. Living conditions as group 21.
28	7	F	3—5 „	23.3.1979	„	In captivity out of doors. Living conditions as group 25.
29	6	F	3—5 „	29.3.1979	Yli-Kiiminki (65°10'N)	In captivity out of doors. Fed on silage and molasses during 3—4 months before sampling. Hinds pregnant.
30	12	F	3—5 „	13—16.4.1973	Enontekiö (68°30'N)	Freely grazing. No arboreal lichens. Hard crust on the snow, and digging conditions for Cladonia lichens very difficult. Soon after sampling a large number of reindeer in this area died of malnutrition. Pregnant or aborted.
31	8	F	3—5 „	30.4.1979	Sodankylä (68°10'N)	„

The function fittings used were obtained from least square solutions on the basis of the means of the actual measurements calculated by a computer (PDP 11). Correlation coefficients used were obtained from analyses of linear regression. The significance between the group mean values was calculated by one-way analysis of variance and continued with the standard t-test. Before the analysis of variance the equality of the individual group variances was checked with Bartlett's test. When checking the effects of the seasons the groups of the adult animals were pooled to form 3 larger groups representing summer, autumn and winter, respectively.

RESULTS

The mean birth weight of the reindeer calves was 5.3 kg (Table 3). The birth weight doubled within 4 weeks, and then again within 6 weeks. At the age of 5 to 5.5 months the weight showed a range of from 33 to 45 kg, but during the late autumn and early winter the differences became smaller and the calves weighed on average from 36 to 40 kg at the age of 9 to 10 months. No significant sexrelated weight differences were observed during the calfhood summer. Winter stopped the growth and in some cases reduced the body weight.

Fig. 1 represents an average growth curve for the calves during the first summer. The calculated curve reached its highest point at the time of the 27th week after birth. The range of the average daily weight gain was from 190 to 270 g/day when calculated and smoothed for the whole growth period of the calfhood summer. When estimated mathematically as the first order time derivative of the growth curve the daily weight gain showed a tendency to increase up to the 9th week of life whereafter it decreased (Fig. 1). The second order time derivative of the growth curve shows the rate of change of the weight gain.

The growth proceeded during the next spring and summer and the total weight gain was on average 15 kg (Table 3). The hinds reached the adult body weight at the age of 3 to 4 years (Table 4) and the stags at the age of 5 to 6 years (Table 4). Fig. 2 represents the mathematical estimates of the growth and weight gain in the hinds and Fig. 3 in the stags, respectively.

In the adult animals the weight increased during summer, remained rather stable during autumn and early winter but de-

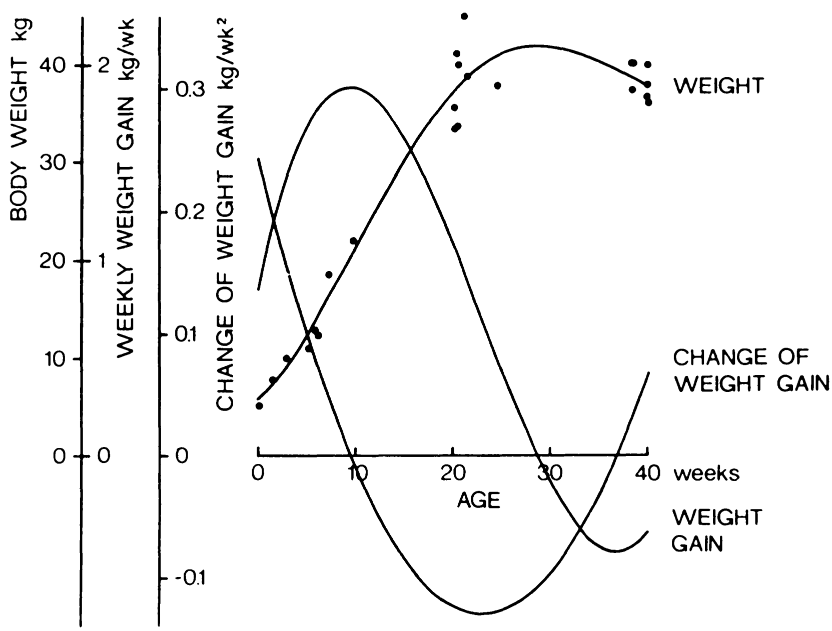

Figure 1. The body weight of the reindeer calves as plotted against the age of the calves. The age is estimated in weeks with May 15th as a zero point. The weight curve is a least square solution based on actual mean values of the given groups. The weight gain curve is the first order time derivative of the weight curve roughly estimating the weekly weight gain (actually it depicts the slope of the tangent of the weight curve) and the curve of the change of weight gain is the second order time derivative of the weight curve. The equations are: weight $= 0.0001x^4 - 0.0054x^3 + 0.1215x^2 + 0.8473x + 5.74$, $R = 0.986$, $R^2 = 0.973$, $F = 217$; weight gain $= 0.0004x^3 - 0.0162x^2 - 0.243x + 0.8473$; change of weight gain $= 0.0012x^2 - 0.0324x + 0.243$.

creased during late winter and spring. Parturition caused an average weight reduction of 7.4 kg (Table 4, groups 2 and 3).

The alkaline phosphatase activity was about 2000 U/l at birth and decreased significantly ($P < 0.001$) during the first 3 weeks (Table 3). At the age of 6 weeks the alkaline phosphatase activity was about 1300 U/l. It slightly decreased during summer and dropped significantly during autumn ($P < 0.001$). The alkaline phosphatase activity correlated with weight and age ($r = -0.81$; $n = 306$; $P < 0.001$). In the adult animals the alkaline phosphatase activity was greater during summer (on an average 265 U/l, $s = 227$) than during autumn (185 U/l, $s = 278$) or than during winter (150 U/l, $s = 64$), but according to

Table 3. The body weights and serum chemical values ($\bar{x} \pm$ s.e.) in the groups of reindeer calves studied (see Table 1). (The statistical significances are given in the text.)

Group	n	Age	Weight (kg)	SAP (U/l)	CPK (U/l)	Thyroxine (T_4) (nmol/l)	Glucose (mmol/l)	Calcium (mmol/l)	Inorganic Phosphorus (mmol/l)
1	14	1 day	5.3±0.2	2076±77	107±8.3	459±21	4.4±1.6	2.4±0.1	1.6±0.1
2	14	3 days	6.1±0.2	2172±69	78±7.6	346±68	4.8±1.4	2.5±0.1	2.2±0.2
3	16	6 „	6.9±0.3	2226±65	109±12.1	354±40	3.8±1.6	2.5±0.1	2.4±0.2
4	15	10 „	7.8±0.3	1556±31	171±15.7	378±57	4.3±1.2	2.6±0.1	2.5±0.2
5	15	3 weeks	10.1±0.5	1032±29	176±6.3	399±50	4.4±1.0	2.9±0.2	3.0±0.2
6	15	5 „	11.1±0.7	1727±143	650±24.1	488±46	5.1±0.1	2.9±0.1	2.2±0.0
7	10	6 „	13.0±0.7	1206±38			4.8±1.3	2.7±0.1	2.1±0.1
8	10	6 „	12.4±0.8	1512±90	577±18.3	456±21	4.7±1.6	2.8±0.0	2.4±0.1
9	33	7 „	14.8±0.5	1244±76	270±21.7		4.9±0.1	2.6±0.1	
10	7	7 „	14.9±1.2	1268±40				2.7±0.1	2.1±0.1
11	5	7 „	18.5±1.4	1108±63				2.6±0.1	2.1±0.1
12	7	10 „	22.1±1.0	1076±51				2.7±0.1	2.2±0.1
13	15	20 „	35.7±0.8	947±32				2.8±0.2	2.3±0.2
14	2	20 „	33.5±3.5	980±60				2.3±0.0	1.6±0.1
15	8	20 „	41.4±1.2	778±40	476±32.4	455±43	2.9±1.4	2.7±0.0	2.1±0.1
16	5	21 „	33.8±3.5	764±44					
17	8	21 „	40.1±1.4	678±22	452±18.7	449±23	4.9±0.9	2.7±0.1	2.3±0.1
18	9	21 „	45.1±3.2	885±31	431±35.5	430±40	4.2±1.1	2.8±0.1	2.1±0.0
19	3	21 „	39.0±1.2	659±57				2.4±0.1	1.8±0.1
20	16	25 „	38.4±1.2	521±32					
21	13	38 „	40.0±1.6	156±15	290±23.4	427±25	4.6±1.1	2.1±0.1	1.4±0.1
22	5	38 „	40.3±1.8	164±15				2.3±0.0	1.6±0.1
23	11	40 „	37.5±1.3	185±13	197±13.2	432±27	3.1±1.1	2.5±0.1	1.8±0.1
24	10	40 „	36.2±0.9	169±15	321±16.7	413±28	4.0±0.7	2.2±0.2	1.7±0.1
25	7	40 „	40.1±2.1	162±31				2.2±0.2	1.7±0.1
26	6	45 „	35.4±1.8	160±16					
27	10	45 „	38.1±0.6	151±10	255±8	438±29	2.5±1.1	2.5±0.0	2.0±0.1
28	17	49 „	40.6±1.4	147±23					
29	4	72 „	44.7±3.5	156±10					
30	6	76 „	50.1±2.0	143±30					
31	3	90 „	62.0±2.0	138±16					
32	9	95 „	49.0±1.1	140±27					

Bartlett's test the group variances were unequal and the differences observed are statistically not significant.

The creatine phosphokinase activity increased from about 100 to ca 170 during the first 3 weeks of life (Table 3) and it was higher during summer and autumn than at birth ($P < 0.01$) and greater in the calves than in the adult animals ($P < 0.01$). In the adult animals the creatine phosphokinase activity was

Table 4. The body weights and serum chemical values ($\bar{x} \pm s.e$) in the groups of adult reindeer studied (see Table 2). (The statistical significances are given in the text.)

Group	n	Age	Weight (kg)	SAP (U/l)	CPK (U/l)	Thyroxine (T_4) (nmol/l)	Glucose (mmol/l)	Calcium (mmol/l)	Inorganic Phosphorus (mmol/l)
1	4	3 years	54.0±1.6	245±24					
2	15	3—5 „	67.6±1.4	156±69	185±8.1	306±33	3.3±0.7	2.1±0.0	1.5±0.1
3	13	3—5 „	60.2±1.4	138±69	234±10.6	459±21	4.4±1.6	2.9±0.1	2.4±0.2
4	11	3—5 „	57.7±2.0	546±81	292±38.4	436±52	4.6±0.1	2.2±0.0	1.4±0.0
5	9	3—5 „	57.0±2.6	326±42				2.3±0.1	1.7±0.0
6	6	3—5 „	55.3±1.7	483±68	304±20.6	413±22	4.4±1.5	2.4±0.1	1.7±0.1
7	32	3—5 „	56.2±1.1	231±43			4.7±0.2	2.5±0.1	
8	30	3—5 „	56.9±1.1	246±35			4.5±1.0	2.4±0.2	
9	4	3 „	86.0±2.1	212±22					
10	2	5—10 „	96.2±3.1	173±14					
11	40	3—5 „	65.4±1.5	215±62			3.8±0.3	2.5±0.1	
12	8	3—5 „	65.3±1.7	166±15			4.1±0.9	2.4±0.1	1.6±0.1
13	9	3—5 „	66.3±1.5	196±28	260±30.7	387±32	4.9±0.6	2.5±0.1	2.0±0.1
14	8	3—5 „	66.3±1.3	146±35	280±21.6	372±31	4.9±0.8	2.6±0.0	2.2±0.0
15	10	3—5 „	65.0±1.3	138±27					
16	4	3—5 „	67.8±1.9	159±32				2.5±0.1	1.8±0.1
17	9	3—5 „	65.8±1.5	152±26	290±24.0	367±47	4.4±0.1	2.8±0.1	2.3±0.1
18	2	3—5 „	78.2±2.4	168±34					
19	12	8—10 „	65.8±0.8	145±15					
20	4	3—5 „	65.6±3.2	131±17	265±30.6	416±16	4.2±0.5	2.4±0.1	1.6±0.1
21	18	3—5 „	70.3±1.9	136±20				2.5±0.1	
22	11	3—5 „	67.5±1.5	113±25	179±8.6	423±19	4.0±1.2	2.5±0.1	1.8±0.1
23	5	3—5 „	66.2±3.2	133±11		410±22	3.4±0.4	2.4±0.3	1.7±0.2
24	6	3—5 „	68.7±2.4	136±23				2.0±0.2	1.6±0.2
25	6	3—5 „	64.7±1.4	144±20	297±24.3	408±19	4.1±1.0	2.2±0.0	1.6±0.1
26	7	3—5 „	63.2±2.5	132±19				2.3±0.1	
27	11	3—5 „	61.1±1.4	157±22			3.6±0.8	2.1±0.1	
28	7	3—5 „	62.3±1.2	132±14	247±13.1	433±25	4.0±1.2	2.4±0.1	2.1±0.1
29	6	3—5 „	67.8±2.1	141±15	109±10.2	425±30	4.2±1.1	2.6±0.1	2.2±0.1
30	12	3—5 „	55.2±1.3	158±16				1.7±0.0	
31	8	3—5 „	50—55*	279±20	1044±240	376±19	2.1±0.9	1.9±0.1	1.3±0.1

* Approximated body weight

smaller during winter and spring than during summer and autumn (mean values 211 U/l, s = 40; 241 U/l, s = 71; and 276 U/l, s = 77, respectively; $P < 0.001$).

The serum thyroxine level was about 460 nmol/l in the new-born calf and decreased during the first 3 weeks and then increased during the subsequent 4 months ($P > 0.05$; Table 3). The thyroxine level of the calves was slightly, but insignificantly,

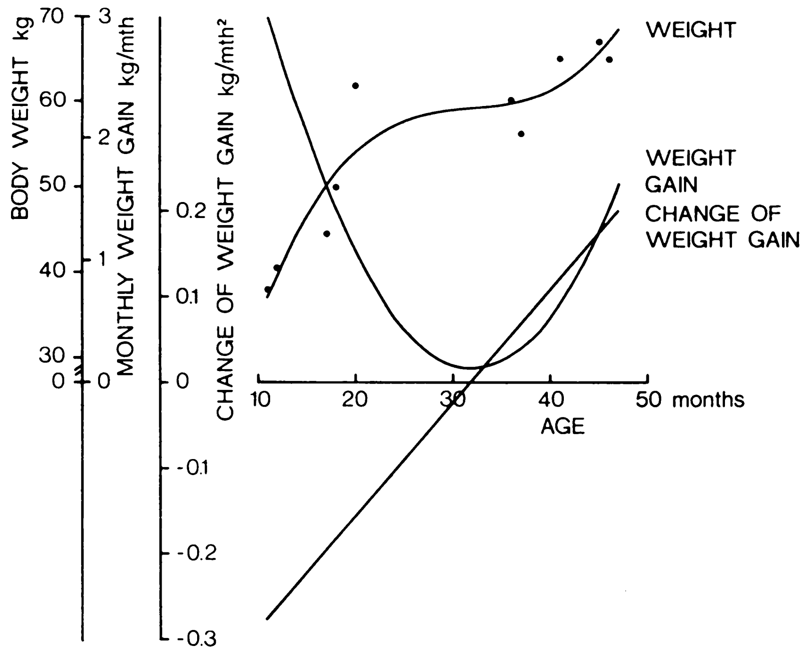

Figure 2. The body weight of the older female reindeer as plotted against the age of the animals. The age is estimated in months with May 15th as a zero point. The curves are constructed as in Fig. 1. The equations are: weight $= 0.0022x^3 - 0.2124x^2 + 6.8751x - 15.77$, $R = 0.938$, $R^2 = 0.879$, $F = 14.5$; weight gain $= 0.0066x^2 - 0.4248x + 6.8751$; change of weight gain $= 0.0132x - 0.4248$.

higher than that of the hinds during autumn and winter. The changes of the thyroxine level were small and insignificant in the different seasons and the average values of the adult animals were 396 nmol/, s = 122 in summer, 375 nmol/l, s = 112 in autumn and 413 nmol/l, s = 58 in winter and spring.

The blood glucose concentration did not show age-dependent variations. It was slightly greater in summer than in autumn or winter and spring (average values 4.4 mmol/l, s = 3.8; 4.2 mmol/l, s = 1.9; and 3.7 mmol/l, s = 2.9, respectively) but the differences were statistically not significant.

The serum calcium concentration showed slight changes at different ages but these changes were statistically not significant (Table 3). In the adult animals the serum calcium concentrations remained practically unchanged during the whole year (average values 2.4 mmol/l, s = 0.7 in summer, 2.5 mmol/l, s = 0.5 in

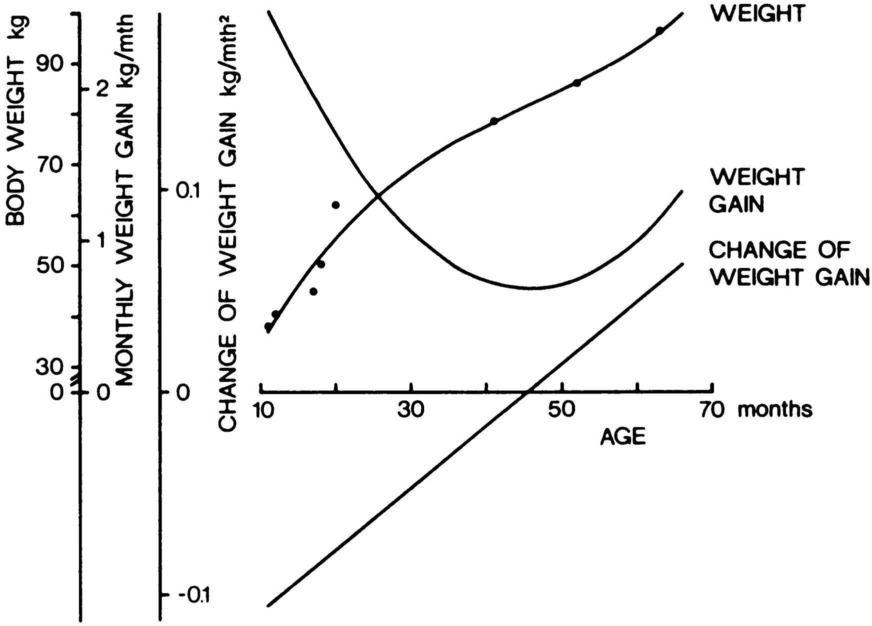

Figure 3. The body weight of the older male reindeer as plotted against age of the animals. The age is estimated as in Fig. 2. The curves are constructed as in Fig. 1. The equations are: weight $= 0.0005x^3 - 0.0699x^2 + 3.8613x + 2.4112$, $R = 0.989$, $R^2 = 0.978$, $F = 59$; weight gain $= 0.0015x^2 - 0.1398x + 3.8613$; change of weight gain $= 0.003x - 0.1398$.

autumn and 2.2 mmol/l, s = 0.4 in winter and spring).

The serum inorganic phosphorus increased in the newborn calf during the first 3 weeks of life from 1.6 mmol/l to 3 mmol/l ($P < 0.05$) and it was slightly higher in the calves than in the hinds in summer and autumn. The serum inorganic phosphorus in the adult animals was at a higher level in autumn (2.01 mmol/l, s = 0.25) than in summer (1.75 mmol/l, s = 0.42) or in winter and spring (1.74 mmol/l, s = 0.33) ($P < 0.001$).

DISCUSSION

The birth weight of the reindeer calves depends among others on the hind's age, on the prevailing grazing conditions, and also on the geographic area. In Finland the mean birth weight is, according to *Varo & Varo* (1971), 5.9 kg in the male and 5.3 kg in the female calves (range 4 to 7.4 kg, *Alaruikka* 1964). These values are slightly smaller than those observed in the Soviet

Union (*Druri & Mituschev* 1965), in Alaska (*Nowosad* 1975), or in Sweden (*Espmark* 1971), but greater than observed in the present study or by *Ringberg et al.* (1981) in Alaska. In autumn at the age of about 5 to 6 months the live body weight of the reindeer calves is 42 to 52 kg in Finland (*Alaruikka* 1964) which is in accordance with the corresponding values in Norway (*Skjenneberg & Slagsvold* 1968), but greater than in the present material. According to *Alaruikka* (1964) the maximal living body weight can rise up to 90 kg in the hinds and up to 120 kg in the stags with such high weights being, however, rarities and usually the normal body weight remains at a considerably lower level.

The daily weight gain as judged from the weighing showed immediately after birth values of up to 400 g/day which are in agreement with the maximal weight gain of 400 to 500 g/day reported by *Krebs & Cowan* (1962) and by *Nieminen et al.* (1980). The weight gain reduced during the subsequent days. The mathematical estimation gave only 110 g/day as a weight gain for the perinatal period which may be a result of averaging of longer periods. The foetal growth rate increases during the last weeks of pregnancy and the mathematical estimation gives about 160 g/day as a daily weight gain at the termination of the gestation (*Roine et al.* 1982). Although the mathematical derivations carried out by *Roine et al.* and in the present paper concern different materials they, nevertheless, give an impression that the growth rate will decrease during the perinatal period whereafter it increases again. In the present material the greatest daily weight gain of 270 g/day occurred at the 9th weeks of life, whereafter it gradually decreased towards zero. These average values obtained from mathematical derivations agree with those reported by *Skjenneberg & Slagsvold* (1968). In the yearlings the corresponding growth rates are smaller and it seems that the highest rate occurs in early summer.

The neonate ruminants are absolutely dependent on milk until the rumen function develops, usually between the 4th and 6th weeks of life (*Leat* 1970). The milk of the reindeer contains abundant fat and proteins but the range of the daily milk output of the hind extends from 100 ml up to 2 l (for details see *Arman* 1979, *Nieminen* 1980b). The milk yield of the reindeer declines after 4 weeks but the fat and protein concentrations increase while lactose decreases (*Luick et al.* 1974). The calves compensate for the decreased milk intake by increased forage intake and in the case of the white-tailed deer this transition occurs without discernible changes in the growth rate (*Robbins & Moen* 1975), while the growth of the elk calves transiently decelerates at the corresponding time (*Robbins et al.* 1981).

In winter the growth in the reindeer is stopped. The energy input is reduced (see *Moen* 1980b), and the body weight is either maintained or it may be reduced as also observed in the white-tailed deer by *Severinghaus* (1981). A large amount of the body fat storage is replaced by water but the circulating plasma volume remains relatively constant (*Cameron & Luick* 1972) and, hence, it is reasonable to carry out an analysis on some blood constituents as discussed by *Nieminen* (1980 a and b).

The serum alkaline phosphatase activity correlated with weight and age in the calves and is in winter at same level as in older animals which is indicative for cessation of growth. The slight increase in the alkaline phosphatase activity in summer in the older animals is suggested to be attributable to the activity of osteoblasts (*Wasserman* 1970, for details see *Irving* 1978) in bone regeneration and antler growth. *Hyvärinen et al.* (1976) have suggested that also the increase in creatine phosphokinase activity as observed in calves and in summer also in the older animals contributes to the growth or recovery from the rigours of winter although on other occasions the creatine phosphokinase activity is regarded as being indicative of protein catabolism (see e.g. *Harper* 1969). In the present material the serum inorganic phosphorus showed greater concentrations during the active growth periods than at other times.

Thyroxine levels are reported to be lower in winter than in summer (*Ringberg et al.* 1978, *Ryg & Jacobsen* 1982) as observed also for the white-tailed deer (*Seal et al.* 1972). In the present study such differences were not discernible. *Yousef & Luick* (1971) have suggested that there occur no seasonal differences in thyroxine levels although the secretion rate is smaller in winter than in summer. Our material did not show age-dependent changes in thyroxine levels.

The growth hormone concentrations seem to be smaller in winter than in summer (*Ringberg et al.* 1978, *Ryg & Jacobsen* 1982) as observed also in the white-tailed deer (*Bubenik et al.* 1975). In bovine species *Ohlson et al.* (1981) have observed higher levels of growth hormone in fast growing breeds than in more slowly growing breeds.

Studies on cortisol in white-tailed deer (*Bubenik et al.* 1975) show no seasonal rhythms. Testosterone is observed to have a circannual rhythm with a peak concentration in August to mid-September (*Whitehead & McEwan* 1973) which is true also of oestradiol levels in the white-tailed deer (*Bubenik et al.* 1979).

In conclusion, the growth in the reindeer is phasic and complex with the greatest growth rate in the neonatal period. The growth is stopped by winter and proceeds the next spring but now at a lower rate. The growth is reflected by the activities of serum alkaline phosphatase and creatine phosphokinase and serum inorganic phosphorus concentrations. The mathematical estimates used give average values for growth and growth rate.

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SAMMANFATTNING

Tillväxten hos ren.

Renens tillväxt från födseln till en vuxen ren är en kumulativ process och omfattar en snabb viktökning under sommaren. Därefter följer en period då vikten sjunker eller slutar öka under vintern. De nyfödda kalvarna väger ca 5,3 kg. Peri- och neonataltillväxtsiffran är relativt hög med en individuell viktökning upp till 400 g/dag. Den polynomiska tillväxtkurvan och dess första derivat, visar hos kalvarna en avtagande trend mot hösten. En fullvuxen rens kroppsvikt nås av vajor i 4—5 årsålder och av tjurar i genomsnitt ett år senare. Alkalinfosfatasaktiviteten av serum visade en negativ lineär korrelation till ålder och vikt hos kalvarna och var störst på sommaren både hos kalvar och vuxna renar. Kreatinfosfokinasaktiviteten var högre på sommaren både hos kalvar och vuxna än under övriga årstider. Å andra sidan visade serumets tyroxin (T4)-, blodsocker- och kalciumhalt inte vara signifikant beroende av årstidernas variering.

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