GRØNLANDS FISKERI- OG MILJØUNDERSØGELSER

Moskusokse-undersøgelser på Jameson Land 1984 - 85 samt bestandens økologi 1982-85

Henning Thing August 1985

INDHOLDSFORTEGNELSE

FORORD

Hermed foreligger så en samlet fremstilling af moskusokse-projektets resultater i 1984 og 1985. Der er blevet udført feltarbejde i perioderne 15. marts - 15. april 1984, 15. juli - 20. august 1984 samt 12. april - 11. maj 1985. Flytællinger blev udført i tidsrummet 27. januar - 1. februar 1984 samt 25. februar - 5. marts 1985.

Med afslutningen af feltarbejdet i maj 1985 er den egentlige baggrunds-undersøgelse af moskusokse-bestanden på Jameson Land tilendebragt. Den startede med flytællingeer i april og maj 1981 og for feltarbejdets vedkommende i april 1982.

Fremover vil indsatsen fortrinsvis komme til at bestå i overvågning af forskellige indikator-parametre som f. eks. kalveproduktion, forstyrrelsesniveau, vinterdødelighed samt regional og lokal udbredelse.

Den viden, de sidste fire års undersøgelser har tilvejebragt, er løbende blevet bearbejdet og vurderet, således at man nu er i stand til at præsentere et forholdsvis nuanceret billede af moskusoksernes samspil med omgivelserne, deres overlevelsesstrategi og reproduktionsforhold. En sådan økologisk fremstilling af moskusokse-bestanden på Jameson Land vil være at finde i denne publikation efter den egentlige årsrapport. Den må betragtes som en foreløbig kulmination af vore fælles anstrengelser for at forstå, hvorledes disse dyr trives og fungerer i det arktiske miljø.

Til slut vil jeg gerne takke Peter Aastrup, Sune Holt og Carsten Riis Olesen for ufortrøden indsats, godt kammeratskab og festligt samvær under alle forhold. Endvidere værdsættes Grønlands Hjemmestyres velvillige indstilling til vores arbejde, og Landbrugsministeriets Vildtforvaltning, Vildtbiologisk Station takkes for samarbejdet i perioden indtil april 1985.

Henning Thing

AKTIVITETSBUDGET

Siden august 1983 er der systematisk blevet indsamlet oplysninger om moskusokseflokkenes aktivitet. Der er tale om "aktivitetsbudget" samt "aktivitetsmønster". Udtrykket `budget` hentyder til, hvor meget tid, dyrene anvender til deres forskellige aktiviteter (ligger, fouragerer, står, går, dier og andet) gennem et døgn udregnet for hver sæson. `Mønster` angiver, hvorledes dyrenes liggeperioder (drøvtygning/hvile) samt aktive perioder fordeles gennem døgnet.

Der er observeret på uforstyrrede dyr, og flokkene er valgt således, at de så vidt muligt indeholder individer fra alle køns- og aldersklasser (kalv, årsdyr, ungdyr, køer og tyre). De voksne køer er valgt som "standard"-moskusokser, og værdierne for denne gruppe anvendes som et udgangspunkt for sammenligning med de øvrige fire grupper hver sæson (Tabel 1 a-f).

Vi har valgt at lægge mest vægt på aktivitetsdata fra sommersæsonen 1984 og senvinteren 1985 (27/7-19/8 og 12-31/4), idet disse to årstider repræsenterer yderpunkter i levevilkårene i omgivelserne samt i dyrenes indre fysiologiske miljø. Data fra brunsttiden (31/8-13/9), i den tidlige vinter (16/9-3/10) og kælvningen (1-11/5) kommer ind som supplerende materiale, da dyrene i disse sæsoner befinder sig i en overgangstilstand med hensyn til fødevalg og fourageringsbetingelser (f.eks. når sneen begynder at dække planterne henholdsvis smelter væk). Desuden er der i brunsttiden en selvgenereret uro i flokkene på grund af brunstspecifik adfærd hos især tyrene, og dette har tendens til at sløre de forhold, der ville herske i "uforstyrrede" flokke.

Sommerens aktivitetsbudget karakteriseres af korte liggetider (Tabel 1). Tyre og ungdyr har om sommeren liggeværdier meget tæt på køernes, medens kalvenes ligge% er godt 20% højere end køernes (52.5 vs 43.3). Årsdyrenes ligge% er midt imellem (49.4).

Om vinteren (marts-april) forøges køernes ligge% med 48% i forhold til om sommeren (64.2 vs 43.3). Tyrene ligger 50% mere i senvinteren end i

A — AUGUST 31 - SEPTEMBER 13 1983

	CALF	YEARLING	SUBADULT	COW (3yr+)	BULL(5yr+)
LYING	43.8% (291)	45.9% (45)	36.4% (92)	40.6% (323)	41.6% (141)
FEEDING	49.7% (330)	46.9% (46)	55.7% (141)	50.1% (398)	41.9% (142)
STANDING	1.4% (9)	0	0.8% (2)	2.9% (23)	6.2% (21)
WALKING	4.8% (32)	7.1% (7)	6.3% (16)	6.0% (48)	7.4% (25)
NURSING	0	0	0	0	0
OTHER	0.3% (2)	0	0.8% (2)	0.4% (3)	3.0% (10)
	N = 664	N = 98	N = 253	N = 795	N = 339

No. of observation periods = 312

B — SEPTEMBER 16 - OCTOBER 3 1983

	CALF	YEARLING	SUBADULT	COW(3yr+)	BULL(5yr+)
LYING	46.9% (328)	50.6% (89)	44.2% (239)	49.6% (719)	48.8% (148)
FEEDING	45.9% (321)	47.2% (83)	51.0% (276)	46.0% (667)	42.9% (130)
STANDING	2.4% (17)	0.6% (1)	1.1% (6)	1.6% (23)	3.6% (11)
WALKING	4.9% (34)	1.7% (3)	3.7% (20)	2.8% (40)	4.6% (14)
NURSING	0	0	0	0	0
OTHER	0	0	0	0	0
	N = 700	N = 176	N = 541	N = 1449	N = 303

No. of observation periods = 397

C — MARCH 23 - APRIL 7 1984

	CALF	YEARLING	SUBADULT	COW(3yr+)	BULL(5yr+)
LYING	63.0% (203)	57.1% (104)	51.3% (157)	57.8% (537)	66.6% (233)
FEEDING	25.2% (81)	31.3% (57)	33.7% (103)	33.5% (311)	18.6% (65)
STANDING	6.2% (20)	8.2% (15)	10.5% (32)	5.5% (51)	8.6% (30)
WALKING	3.7% (12)	0.6% (1)	3.9% (12)	3.0% (28)	2.6% (9)
NURSING	0	0	0	0	0
OTHER	1.9% (6)	2.8% (5)	0.7% (2)	0.2% (2)	3.7% (13)
	N = 322	N = 182	N = 306	N = 929	N = 350

No. of observation periods =

Tabel 1 Aktivitetsbudget for kalve, årsdyr, ungdyr, køer og tyre i brunsttiden, tidlig vinter samt i senvinteren 1983 og 1984.

D JULY 27 - AUGUST 19 1984

	CALF	YEARLING	SUBADULT	COW(3yr+)	BULL(5yr+)
LYING	52.5% (383)	49.4% (286)	45.6% (267)	43.3% (567)	42.9% (228)
FEEDING	37.5% (274)	39.0% (264)	45.1% (264)	46.2% (605)	37.2% (198)
STANDING	3.8% (28)	4.2% (24)	2.9% (17)	5.4% (71)	5.8% (31)
WALKING	4.3% (31)	5.2% (30)	5.1% (30)	4.0% (52)	6.0% (32)
NURSING	0.4% (3)	0	0	0.2% (3)	0
OTHER	2.2% (16)	1.7% (10)	0.7% (4)	0.8% (11)	8.1% (43)
	N = 730	N = 579	N = 586	N = 1309	N = 532

No. of observation periods =

E APRIL 12 - APRIL 31 1985

	CALF	YEARLING	SUBADULT	COW(3yr+)	BULL(5yr+)
LYING	60.3% (433)	61.8% (303)	62.2% (625)	64.2% (1142)	64.3% (354)
FEEDING	29.4% (211)	29.2% (143)	31.0% (311)	27.1% (482)	19.1% (105)
STANDING	6.7% (48)	4.9% (24)	3.7% (37)	4.7% (83)	6.4% (35)
WALKING	3.6% (26)	4.1% (20)	3.2% (32)	3.8% (67)	10.0% (55)
NURSING	0	0	0	0	0
OTHER	0	0	0	0.2% (4)	0.4% (2)
	N = 718	N = 490	N = 1005	N = 1778	N = 551

No. of observation periods =

F MAY 1 - MAY 11 1985

	CALF	YEARLING	SUBADULT	COW(3yr+)	BULL(5yr+)
LYING	54.9% (284)	49.5% (359)	52.0% (119)	50.9% (747)	62.9% (66)
FEEDING	30.0% (155)	40.6% (294)	41.5% (95)	38.4% (563)	35.2% (37)
STANDING	5.0% (26)	4.6% (33)	4.4% (10)	4.4% (65)	0
WALKING	8.7% (45)	5.4% (39)	2.2% (5)	5.8% (85)	1.9% (2)
NURSING	1.4% (7)	0	0	0.5% (7)	0
OTHER	0	0	0.	0	0
	N = 517	N = 725	N = 229	N = 1467	N = 105

No. of observation periods =

Tabel 1 fortsat Aktivitetsbudget for kalve, årsdyr, ungdyr, køer og tyre i sommer-, senvinter- og kælvningssæsonen i 1984 og 1985.

juli-august (64.3 vs 42.9). For ungdyr, årsdyr og kalve øges liggetiden med henholdsvis 36%, 25% og 15% i forhold til sommerværdierne.

Den tid, der anvendes til fouragering om sommeren, er på samme niveau for køer og ungdyr (45-46%), medens tyre, årsdyr og kalve bruger ca. 10% mindre tid til at søge føde (37.2%, 39% og 37.5%, henholdsvis).

Dyrene reducerer alle deres fourageringstid meget om vinteren (marts-april) sammenlignet med værdierne for sommersæsonen. Køerne går 41% ned i fourageringstid, tyrene halverer fourageringstiden, ungdyr reducerer parameteren med 31%, årsdyr fouragerer 25% mindre tid, og kalvenes fouragerings% er 22% lavere end i juli-august.

De øvrige parametre i budgettet (står, går, dier, andet; Tabel 1) vil ikke blive gennemgået nærmere i denne præsentation. Generelt kan det siges, at der er tale om meget lave værdier i forhold til de to vigtigste parametre (ligger og fouragerer). Rubrikken "andet" kan indeholde agonistisk adfærd, leg, komfortadfærd, brunstadfærd. I senvinteren 1984 har tyrene en relativ høj værdi for "andet" (3.7%), hvilket afspejler en vis brunstlignende aktivitet hos tyrene (falsk brunst) i tiden lige efter forårsjævndøgn, hvor dag- og natlængden svarer nøje til de lysforhold, som er til stede i den egentlige brunstperiode i slutningen af august - begyndelsen af september.

Ligge% og fouragerings% sammenlignet mellem sommer, brunst og tidlig vinter viser generelt for samtlige katagorier, at dyrene ligger mindre og fouragerer mere i sensommeren (31/8-13/9) end om sommeren. For køer, tyre, ungdyr og årsdyr er der tale om gennemsnitlig 9%`s reduktion i liggetid og 15%`s øgning i fouragering. Kalvene viser større udsving (liggetid går 17% ned, og fourageringstid øges med 33%), idet denne gruppe samtidigt gennemgår en betydelig ontogenetisk udvikling med hensyn til fysisk styrke, fordøjelseskapacitet og diening, således at den nærmer sig de øvrige gruppers niveau.

Øgningen i fourageringstiden i sensommeren-brunsttiden er også dokumenteret hos moskusokser og rensdyr i andre områder og må tilskrives nedgangen i fødeplanternes kvalitet i forbindelse med afslutningen af vækstsæsonen og generel henvisning. Dyrene må derfor søge føde i længere tid for at tilfredsstille kravene til nødvendige næringsstoffer.

Det omvendte forhold mellem liggetid og fourageringstid ses i den efterfølgende sæson, tidlig vinter (16/9-3/10). Snelaget blev permanent i midten af september, og i løbet af to dage skiftede dyrenes adfærd helt tydeligt, og aktivitetsbudgettet vil i løbet af den tidlige vintersæson (som antages at vare indtil begyndelsen af november) indstille sig på det niveau, vi har konstateret i marts-april.

For voksne køer og tyre er ligge% nu større end om sommeren, medens ungdyr og årsdyr er på samme niveau som i juli-august. Kalvene derimod ligger stadigvæk mindre end i sommertiden. Fouragerings% er i sidste halvdel af september reduceret 8% i forhold til primo september, men er dog 56% over senvinter-niveauet. Tyrene bruger samme mængde tid på fødesøgning som i brunsttiden, men stadigvæk 124% over senvinter-værdien (42.9 vs 19.1). Samme tendens gælder for ungdyr, årsdyr og kalve med en gennemsnitlig forskel på 61% over niveauet i marts-april.

AKTIVITETSMØNSTER

For moskusoksen, som er en planteædende drøvtygger, er det af afgørende betydning, at der med regelmæssige mellemrum bliver mulighed for uforstyrret at lægge sig ned og drøvtygge den indtagne føde. Liggetiden, d.v.s. den fysiske hvile samt drøvtygningen er nødvendig for normalt fungerende fordøjelsesprocesser, og det sæsonmæssige tidskrav til drøvtygning (og dermed liggeperioden) kan der kun kortvarigt afviges fra uden væsentlige negative metaboliske konsekvenser for dyrene.

Der er konstateret en tydelig årstidsbestemt forskel i dyrenes aktivitetsmønster mellem sommer og vinter (Fig. 1 a-g). Figuren angiver det gennemsnitlige mønster for et stort antal observerede flokke, således at periodiske skift mellem fouragering og hvile/drøvtygning kun afsløres, såfremt der er stor tidsmæssig synchronisering af dyrenes aktivitetsskift. Værdier afsat som 100% eller 0% på Fig. 1 skal tolkes med varsomhed, idet der oftest vil være tale om et spinkelt observationsmateriale på disse tidspunkter af døgnet.

Sommeren 1984 (27/7-19/8) og senvinteren (12-31/4) er igen interessante som repræsentanter for to yderpunkter af aktivitetsmønsteret. I sommertiden er der ingen perioder af døgnet, hvor dyrene generelt foretrækker at være aktive eller ligge. Det kontinuerlige dagslys (midnatsol) har en udjævnende virkning på synchroniseringen blandt flokkene, således at vore data intet generelt mønster viser. Dyrene er sandsynligvis temmelig fleksible i de periodiske skift mellem aktivitet og hvile/drøvtygning.

Den periodiske varighed af en aktiv og en liggeperiode i denne sæson er 201 min. ialt (Tabel 2), hvilket svarer til, at dyrene gennemfører 7.2 aktivitetscyklus i døgnet.

Modstykket hertil findes i senvinteren, hvor der finder en væsentlig større synchronisering sted (midnatsolen mangler; lysintensiteten er en del lavere i nattetimerne end om dagen). Flokkene har fortrinsvis liggeperioder fra midnat til kl. 07 (lokal soltid) og igen fra middag og eftermiddagen ud.

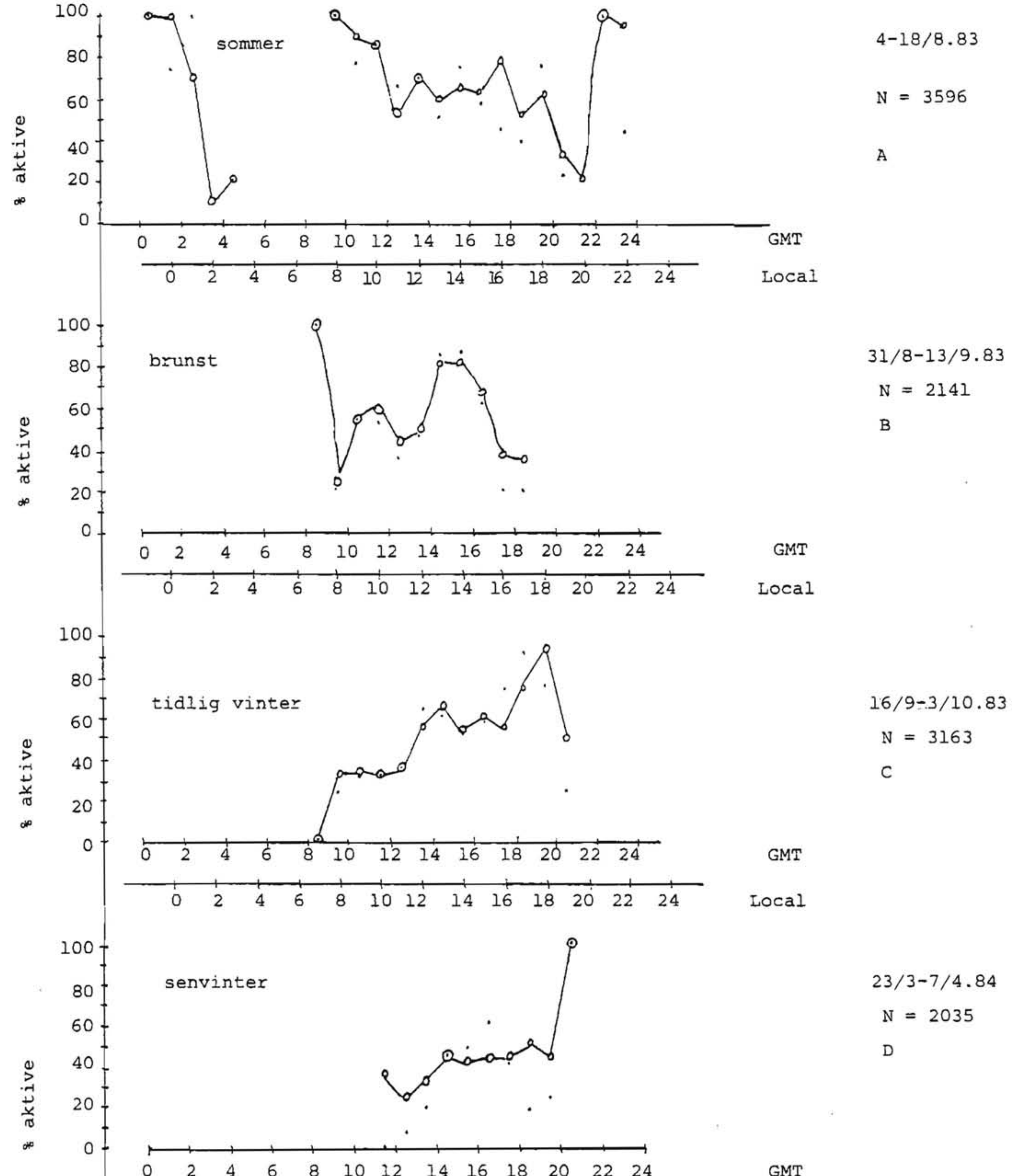

Fig. 1 A-G. Aktivitetsmønster for kalve (prikker) samt for øvrige aldersklasser (åbne cirkler) i syv forskellige sæsoner. Lokal tid svarer til soltid, som her (24°W) er 1 time 36 min. efter GMT.

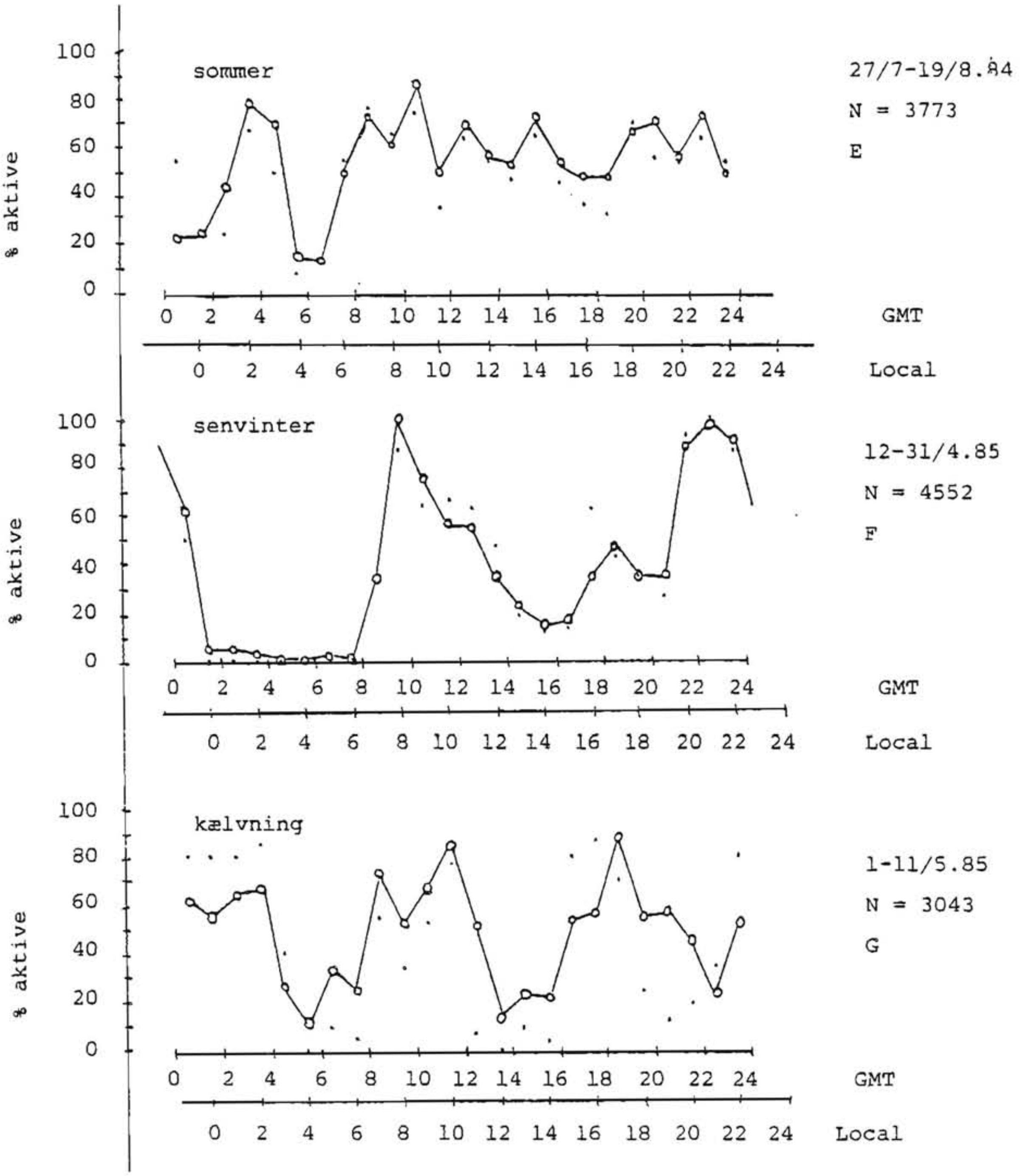

Fig. 1 A-G fortsat. Aktivitetsmønster for kalve (prikker) samt for øvrige aldersklasser (åbne cirkler) i syv forskellige sæsoner. Lokal tid svarer til soltid, som her (24°W) er 1 time 36 min. efter GMT.

	1983			1984		1985	
	Aug 4 - Aug 18 sommer	Aug 31 - Sep 13 brunst	Sep 16 - Oct 3 tidl.vinter	Mar 23 - Apr 7 senvinter	Jul 27 - Aug 19 sommer	Apr 12 - Apr 31 senvinter	May 1 - May 11 kælvning
AKTIV PERIODE (min.)	126$\pm$57 (19)	165$\pm$70 (13)	178$\pm$94 (16)	240(210-270)	107$\pm$43 (25)	203$\pm$62 (6)	216$\pm$85 (5)
LIGGEPERIODE (min.)	77$\pm$23 (19)	130$\pm$25 (12)	154$\pm$69 (18)	273$\pm$68 (5)	94$\pm$40 (27)	348$\pm$98 (11)	288$\pm$69 (5)
$\bar{x}$ ANTAL AKTIVITETSCYKLUS/DØGN	7.1	4.9	4.3	2.8	7.2	2.6	2.9

Tabel 2 Varighed af moskusokseflokkenes aktive og liggeperioder i syv sæsoner på Jameson Land (August 1983 - Maj 1985). Værdierne angivet som genemsnit $\pm$ S.D. Antal observationer i ().

I overensstemmelse hermed viser Tabel 2, at cyklus varer ialt 551 min. (godt 9 timer), og dyrene har derfor kun 2.6 aktivitetscyklus pr. døgn.

Dette er et tydeligt udtryk for, at moskusokserne i vintertiden helt er indstillet på en "spar - energi - livsform" og samtidig også en konsekvens af, at føden i denne del af året er af ringe kvalitet (lavt protein/fiber forhold), således at omsætningstiden i vommen er øget betydeligt i forhold til om sommeren (der kræves mere drøvtygning).

Aktivitetsmønsteret og hele adfærden i forbindelse med aktive og hvileperioder kan kun tolkes som, at dyrene har en ringe fleksibilitet i livsstil på denne årstid og dermed også en lav tolerance over for forstyrrelser. Dette formodes at være endnu mere udpræget i midvinter-perioden.

Som det fremgår af Fig. 1, er der i kælvnings- og sommertiden ofte betydelig forskel i niveauet af aktivitet hos kalve sammenholdt med de øvrige kategorier af moskusokser; trods denne forskel er det generelle mønster sammenligneligt. Væsentlige afvigelser mellem kalves og øvriges aktivitetsmønster på andre årstider beror hovedsagelig på et lille observationsmateriale for kalvenes vedkommende.

Når moskusokserne er aktive, er det relevant at studere to parametre: fourageringseffektivitet (Tabel 3) og længde af daglige vandringer (Tabel 4).

Medens dyrene søger føde på de snefrie årstider, går de kun lidt omkring (ca. 7% af tiden) for at finde føden. Hvor sneen dækker foderet, bruges ca. 15% af tiden til at lokalisere eller afdække fødeplanterne. Moskusokserne har altså meget lidt "spildtid" i forbindelse med fourageringen, og med baggrund i de presænterede data kan det beregnes, at dyrene gennemsnitligt anvender 13.8 x 0.41 x 0.93 = 5.3 time/døgn til netto-fødeindtagelse om sommeren og 9.6 x 0.27 x 0.85 = 2.2 time til netto-fødeindtagelse pr. døgn i senvinteren.

Effektiviteten under fourageringen kan næppe blive større, og det er derfor vanskeligt at forestille sig, at moskusoksen ville kunne kompen-

<table>
<tr><th></th><th>1982</th><th colspan="3">1983</th><th colspan="2">1984</th><th>1985</th></tr>
<tr><th></th><th>Jul 2 -
Jul 12
sommer</th><th>Aug 9 -
Aug 14
sommer</th><th>Sep 6 -
Sep 13
brunst</th><th>Sep 18 -
Oct 3
tidl.vinter</th><th>Mar 23 -
Apr 7
senvinter</th><th>Aug 1 -
Aug 16
sommer</th><th>Apr 18 -
Apr 25
senvinter</th></tr>
<tr><td>KØER (3 yr+)</td><td>90.0±3.9
(10)</td><td>95.9±2.3
(13)</td><td>92.7±6.3
(25)</td><td>89.8±7.3
(32)</td><td rowspan="2">83.8±5.6
(34)</td><td rowspan="2">95.5±3.3
(37)</td><td rowspan="2">83.9±2.8
(15)</td></tr>
<tr><td>TYRE (5 yr+)</td><td>93.1±3.7 (12)
(12)</td><td>89.1±3.9
(3)</td><td>95.8±1.7
(6)</td><td>83.9±11.8
(3)</td></tr>
</table>

Tabel 3 Fourageringseffektivitet udtrykt som %-del tid anvendt til fødeindtagelse i relation til total fourageringstid. Værdierne er gennemsnit ± S.D. Antal observationer angivet i ().

	1983		1984		1985	
	Aug 4 - Aug 18 sommer	Aug 31 - Oct 3 brunst	Mar 24 - Apr 7 senvinter	Jul 24 - Aug 19 sommer	Apr 12 Apr 31 senvinter	May 1 - May 11 kælvning
UFORSTYRRET	4.740 (36)	2.637 (41)	0.891 (6)	1.850 (41)	0.792 (10)	1.160 (9)
FORSTYRRET	14.645 (6)	-	-	-	-	-
AKTIVE TIMER/DØGN	15.2	12.1	10.1	13.8	9.1	11.0

Tabel 4 Strækning (km) som moskusokseflokkene tilbagelægger pr. døgn i seks forskellige sæsoner. Værdierne er gennemsnit. Antal observationer, d.v.s. flokke, er angivet i ().

sere for evt. forstyrrelser under fødesøgningen uden at forlænge fourageringstiden på bekostning af andre dele af aktivitetsbudgettet.

I de aktive perioder tilbagelægger flokken en given strækning enten i forbindelse med fourageringen eller som egentlig vandring. Som det fremgår af Tabel 4, flytter uforstyrrede flokke sig i gennemsnit 3 km/døgn i de snefrie sæsoner (sommer-brunst), medens de i gennemsnit i senvinteren bevæger sig 0.840 km på et døgn. Moskusokseflokkene kan således periodevis betragtes som `sedentære` på denne årstid, hvilket helt er i overensstemmelse med den energibesparelsesstrategi, som er hovedhjørnestenen i moskusoksernes livsstil i den lange vinter. senvinteren

ADFÆRD I LIGGEPERIODEN

Da tidskravet til drøvtygning og hvile er en kritisk størrelse for moskusoksernes trivsel, er der blevet foretaget detaljerede studier af adfærden i løbet af uforstyrrede dyrs liggeperioder for at påvise vigtige sæsonmæssige ændringer samt adfærdsparametre, der vil kunne egne sig som indikatorer på forstyrrelsesniveau. Disse data er præsenteret i Tabel 5.

De fleste parametre viser tydelige forskelle mellem sommer og vinter (dagobservationer). Disse kan sammenfattes således: Lange liggeperioder om vinteren, korte om sommeren; få men lange drøvtygningsperioder om vinteren, hyppige og korte om sommeren (parameter 1 og 9); få aktivitetsskift i løbet af liggetiden om vinteren, mange om sommeren (parameter 6); lange sove- og hvileperioder om vinteren, korte om sommeren (parameter 17 og 18).

De få natobservationer i senvinter - kælvningstiden (mærket med $^{+}$) blev udført i meget koldt og blæsende vejr ($-25^{o}C$, 15-18 m/s), og resultaterne indicerer, at dyrenes adfærd er endnu mere ekstrem end i ultimo marts - primo april. Det giver sandsynligvis et fingerpeg om, hvorledes forholdene vil være i midvinterperioden.

Tabellen præsenterer data fra uforstyrrede flokke, og det forventes, at forstyrrelser vil medføre væsentlige ændringer i mange af parametrene, naturligvis afhængig af forstyrrelsernes hyppighed og intensitet. I forbindelse med de fremtidige studier af forstyrrelsers effekt på dyrene vil der blive fokuseret på følgende parametre; 8, $\bar{x}$ længde af 1. drøvtygningsperioder; 12, $\bar{x}$ længde af soveperioder; 15, $\bar{x}$ % drøvtygning/liggetid; 16, $\bar{x}$ hvile-sovetid/liggetid (%). Disse parametre formodes ved intensive observationer at kunne danne basis for en kvantificering af forstyrrelsernes indvirkning på moskusokserne.

		23/3-7/4^{o}	26/4-10/5^{o}	26/4-10/5*	28/7-18/8^{o}	3/9-3/10^{o}
	$\bar{x}$ længde af liggetid (min)	229.9±91.3(16)	148.1±86.4(33)	328.8±188.6(4)	81.2±15.5(33)	146.4±44.1(43)
	total observeret liggetid (hr)	31.6	103	21.9	59	136
1	antal drøvtygperioder/ time liggetid	1.2(71)	1.3(130)	0.9(20)	2.2(129)	1.4(192)
2	antal hvile-soveperioder/ time liggetid	1.1(69)	0.9(96)	0.9(19)	1.6(96)	1.2(158)
3	antal hvileperioder/ time liggetid	0.8(26)	1.4(140)	1.1(24)	2.4(144)	-
4	antal soveperioder/ time liggetid	0.9(27)	1.2(127)	0.1(3)	2.8(164)	-
5	antal op-ned/time liggetid	0.3(17)	0.2(23)	0.2(5)	0.6(37)	-
6	antal aktivitetsskift/ time liggetid	2.8(89)	4.1(419)	2.4(52)	8.3(490)	-
7	$\bar{x}$ længde af drøvtygperioder(min)	23.0±12.0(71)	25.4±15.8(132)	35.8±15.9(20)	15.9±12.4(118)	24.9±11.5(145)
8	$\bar{x}$ længde af 1.drøvtygperiode(min)	30.9±9.8(14)	39.9±12.7(43)	57.5±14.8(4)	34.4±8.7(33)	34.8±9.8(47)
9	$\bar{x}$ længde af drøvtygperioder excl. 1.perioderne (min)	20.6±12.3(55)	17.1±11.8(77)	31.0±10.9(16)	8.9±6.0(85)	21.1±10.4(135)

fortsættes

^{o} angiver data fra dagtimerne 08-20

* angiver data fra nattimerne 20-08

Tabel 5 Parametre i forbindelse med dyrenes liggetid. Årstidsvariationer gennem senvinter, kælvning, sommer brunst og tidlig vinter. Der er angivet gennemsnitsværdier ± S.D. . Antal observationer er angivet i ().

		23/3-7/4°	26/4-10/5°	26/4-10/5*	28/7-18/8°	3/9-3/10°
10	$\bar{x}$ længde af hvile-soveperioder	29.2±22.7(69)	31.6±20.5(85)	30.3±10.7(19)	15.6±15.4(103)	20.2±12.9(160)
11	$\bar{x}$ længde af hvileperioder (min)	17.2±11.9(26)	12.3±16.8(141)	22.8±12.4(24)	5.8±5.3(145)	-
12	$\bar{x}$ længde af soveperioder (min)	20.0±17.0(27)	9.1±7.9(127)	5.3±5.1 (3)	4.0±3.4(147)	-
13	antal defækeringer/time liggetid	0.3 (16)	0.2 (14)	-	0.5 (28)	-
14	antal urineringer/time liggetid	0.2 (11)	0.1 (6)	-	0.5 (27)	-
15	$\bar{x}$ drøvtygning/liggetid (%)	44.4±9.7(16)	58.3±16.4(45)	57.9±9.6(4)	60.9±11.1(26)	58.8±10.4(40)
16	$\bar{x}$ hvile-sovetid/liggetid (%)	55.6±9.7(16)	40.2±16.1(45)	39.0±11.0 (4)	39.6±10.8(26)	41.2±10.4(40)
17	$\bar{x}$ hviletid / liggetid (%)	30.6±16.6(8)	21.7±13.9(45)	37.0±13.2(4)	25.9±10.8(26)	-
18	$\bar{x}$ sovetid / liggetid (%)	31.9±12.7(10)	18.6±12.8(45)	2.0±3.4 (4)	13.7±8.7(26)	-

° angiver data fra dagtimerne 08-20

* angiver data fra nattimerne 20-08

Tabel 5 FORTSAT.

ANDRE DATA

Udover de allerede omtalte data er der indsamlet en række parametre, som præsenteres i Tabel 6, 7, 8, 9 og 10. Disse har at gøre med dyrenes drøvtygning, fordøjelsessystem, metabolisme og energiforbrug; de vil blive suppleret i de kommende to feltsæsoner og derefter behandlet i en større sammenhæng.

I 1984 og 1985 er de dyr, som er blevet skudt i forbindelse med projektets arbejde, indgået i et detaljeret studium af fordøjelsessystemet med henblik på en morfologisk karakteristik af systemets enkelte afdelinger (Tabel 11). Tabellen giver blot en summarisk oversigt over en del af parametrene. Materialet er under bearbejdning i samarbejde med fysiologisk ekspertise ved Zoologisk Institut, Norges Landbohøjskole, og vil være klar til publicering i løbet af 1986.

	Sample date	N	$\bar{x}$ antal tyg/s	$\bar{x}$ drøvbolletid (s)
1983	August 31- Sept. 2	41	1.51±0.11	68.0±5.8
1983	Sept. 6 - Sept. 8	49	1.38±0.04	67.8±6.6
1983	Sept. 10- Sept. 12	89	1.37±0.08	69.3±7.1
1983	Sept. 13- Sept. 16	58	1.30±0.10	73.6±8.9
1983	Sept. 18- Sept. 23	44	1.22±0.08	79.0±17.1
1983	Sept. 25- Sept. 30	74	1.26±0.17	68.9±13.1
1984	March 23- March 24	28	0.85±0-19	100.6±33.1
1984	March 27- April 7	40	0.91±0.12	84.8±10.8
1984	July 22 - July 28	20	1.30±0.09	67.1±6.3
1984	August 2- August 6	36	1.36±0.11	58.5±6.1
1984	August 9- August 18	35	1.37±0.27	67.2±12.7
1985	April 21- May 9	26	0.93±0.11	78.7±29.4

Tabel 6 Sæsonmæssige variationer i to drøvtygningsparametre, som direkte afspejler føden relative kvalitet.

	Sample date	Water contents of wet weight (%)
Carex saxatilis	March 26	71.6
Dryas octopetala	March 31	32.0
Salix arctica	April 6	49.0
Silene acaulis	April 6	25.0
Vaccinium uliginosum	March 26	30.8
fæces	March 31	57.0
rumen-indhold	March 31	74.8
rumen-indhold	August 16	83.0
omasum-indhold	August 16	67.0
abomasum-indhold	August 16	94.0

Tabel 7 Vandindhold i forskellige fødeplanter i senvinteren samt i gødning og maveindhold i senvinteren og sommersæsonen. Tørvægt af prøverne opnået gennem ovntørring.

	26/8-1/10	24/3	27/7-18/8
ligger,drøvtygger			
insektplage 0	60.0±6.1(6)	-	82.3±7.4(8)
insektplage 2	-	-	77.5±0.7(2)
ligger,sover			
insektplage 0	19.6±8.7(9)	9.0±1.4(2)	38.5±12.0(2)
insektplage 2	-	-	85.0±21.2(2)
ligger			
insektplage 0	-	-	67.0±9.5(6)
insektplage 2	-	-	89.8±16.7(4)
står, let stresset	-	-	92.5±3.5(2)

Tabel 8 Respirationfrekvenser (respirationer/min) hos voksne moskusokser under forskellige miljømæssige påvirkninger.

Insektplage 0 = ingen generende stikkende insekter.

Insektplage 2 = mange gerende stikkende insekter på og omkring dyret. Ligeledes er det altid relativt varmt og som regel vindstille ved insektplage 2.

	WINTER[2]	SUMMER[3]
$\bar{x}$ number of pellets/ dung pile	187.3±67.4 (32)	226.9±17.2(4)
$\bar{x}$ dry weight of dung pile (g)	108.7±30.4(48)	151.2±39.3(35)
$\bar{x}$ dry weight of 1 pellet (g)	0.59±0.1 (89)	0.54±0.1 (6)
$\bar{x}$ H_2O - contents (% of w.w.)	64.8±4.2 (5)	69.1±7.7 (6)
wet weight of rectum contents (kg)	1.011±0.433 (3)	-

[2] samples from March 20 - May 2

[3] samples from July 15 - August 10

numbers in () are sample size

Tabel 9 Parametre i forbindelse med observationer af fæces - produktion, energi- og vandbalance i sommer- og vintertiden. Data gælder kun voksne dyr.

omtrentlig dødstidspunkt	køn/alder	generel fysisk kondition *		% fedt i knoglemarv
medio april	hun/11 mdr	0	(sultedød)	1.3
ultimo april	hun/5år+	0	"	4.8
26.april	hun/12mdr	0	"	5.0
medio april	hun/11mdr	0	"	5.0
primo april	han/6år+	0	"	7.0
primo april	hun/5år+	0	"	7.4
primo april	hun/5år+	0	"	10.0
ultimo april	hun/12mdr	0	"	12.5
medio april	hun/11mdr	0	"	13.0
23.april	hun/5år+	+	(alderdom)	36.0
15. april	han/5år+	+	(skudt)	48.0
medio april	hun/5år+	+++	(akut sygdom)	84.0
medio april	hun/5år+	+++	"	87.0
2. maj	han/6år+	+++	(skudt)	89.2
26.april	han/6år+	+++	"	92.4

* konditionen subjektivt bedømt ved feltobduktionen.0 = intet kropsfedt, + = små mængder kropsfedt,+++ = store mængder kropsfedt.

I () er angivet den(formodede) dødsårsag.

Tabel 10 Tilbageværende fedtreserver hos selvdøde og skudte moskusokser, senvinteren 1985.

MUSKOX; JAMESON LAND

CHARACTERISTICS OF THE DIGESTIVE TRACT (ADULT ANIMALS ONLY)

	WINTER°	SUMMER*
Total Body Weight (TBW)	175.1±33.7 (10)	296.8±29.3 (18)
$TBW^{.75}$	48.0±6.8 (10)	71.4±5.3 (18)
length of S_1-R_3/TBW	0.2±0.03 (7)	0.2±0.01 (4)
length of S_1-R_3/$TBW^{.75}$	0.8±0.1 (7)	0.7±0.03 (4)
length of S_1-S_3/$TBW^{.75}$	0.5±0.1 (7)	0.5±0.02 (4)
length of C_1/$TBW^{.75}$	0.01±0.001 (7)	0.01±0.002 (4)
length of S_1-S_3/total intestinal length x100	67.5±3.5 (7)	68.7±2.3 (4)
length of C_2-R_3/total intestinal length x100	31.1±3.4 (7)	29.9±2.2 (4)
weight of rumen-R_3/$TBW^{.75}$	0.9±0.1 (10)	1.1±0.1 (17)
weight of omasum-R_3/$TBW^{.75}$	0.3±0.1 (10)	0.5±0.1 (17)
weight of rumen-abomasum tissues/$TBW^{.75}$ x100	9.1±1.0 (7)	13.8±2.7 (4)
weight of rumen-reticulum tissues/$TBW^{.75}$ x100	6.1±0.8 (4)	8.4±1.0 (4)
weight of rumen-reticulum w.contents/$TBW^{.75}$ x100	52.2±10.0 (10)	63.3±8.1 (17)
weight of rumen-reticulum w.contents/TBW x100	14.6±2.0 (10)	15.4±4.4 (17)
weight of rumen-abomasum: weight of S_1-R_3	5.2 : 1 (7)	3.4 : 1 (4)
volume of rumen/TBW x100	18.9±4.3 (3)	21.3±3.9 (3)
volume of rumen/$TBW^{.75}$ x100	69.2±11.8 (3)	81.1±7.6 (3)
volume of C_1/$TBW^{.75}$ x100	5.0±0.5 (3)	-
volume of C_1/volume of rumen-reticulum x100	5.7±0.3 (3)	-
volumen of rumen:reticulum: omasum:abomasum	12.0 : 0.8 : 1.1 : 1.0 (5)	

° winter period = samples from March 25 to May 2

* summer period = samples from June 27 to August 28

Tabel 11. Characteristics of the digestive tract of adult muskoxen.

DØDELIGHED

Tabel 12 og 13 viser livstabeller for voksne moskusokser og tyre, henholdsvis. Materialet baserer sig på indsamlede underkæber af selvdøde okser (omkommet i perioden 1977-1984). Også disse data er under bearbejdning, og livstabeller for skudte okser samt relationer mellem femurlængde, underkæbelængde, hornudvikling og ontogenetisk alder vil fremkomme i løbet af foråret 1986.

Det kan dog bemærkes, at den gennemsnitlige årlige dødelighed for voksne tyre er dobbelt så stor som de voksne køers (16.2% vs 8.6%), hvilket er i overensstemmelse med den forventede gennemsnitlige livslængde for tyrene på 8.6 år og for køerne på 15.7 år.

Disse dødelighedsdata afspejler forholdene på Jameson Land uden katastrofevintre med svær overisning og massedød på grund af sult og er således et udtryk for forholdene i en bestand under "gunstige" livsbetingelser. For så vidt angår dødeligheden for kalve, årsdyr og 2års dyr i perioden 1981-1984 henvises til gennemgangen i artiklen om moskusoksebestandens økologi.

age(yr)	N	fx	lx	dx	qx	px
5-6	9	172	1.000	0.052	0.055	0.945
6-7	10	163	0.948	0.058	0.065	0.935
7-8	6	153	0.890	0.035	0.041	0.959
8-9	5	147	0.855	0.029	0.036	0.964
9-10	4	142	0.826	0.023	0.029	0.971
10-11	4	138	0.802	0.023	0.029	0.971
11-12	4	134	0.779	0.023	0.030	0.970
12-13	7	130	0.756	0.041	0.031	0.969
13-14	8	123	0.715	0.047	0.057	0.943
14-15	7	115	0.669	0.041	0.070	0.930
15-16	6	108	0.628	0.035	0.065	0.935
16-17	12	102	0.593	0.070	0.059	0.941
17-18	9	90	0.523	0.052	0.133	0.867
18-19	23	81	0.471	0.134	0.111	0.889
19-20	13	58	0.337	0.076	0.397	0.603
20-21	7	45	0.262	0.041	0.289	0.711
21-22	14	38	0.221	0.081	0.184	0.816
22-23	6	24	0.140	0.035	0.583	0.417
23-24	9	18	0.105	0.052	0.333	0.667
24-25	2	9	0.052	0.012	0.222	0.778
26-27	2	7	0.041	0.012	0.286	0.714
27-28	2	5	0.029	0.012	0.400	0.600
29-30	1	3	0.017	0.006	0.667	0.333
30-31	1	2	0.012	0.006	0.500	0.500
33-34	1	1	0.006	0.006	1.000	0

$\bar{x}$ annual mortality = $\sum d_x \cdot 100/\sum l_x$ = 8.58 %

Tabel 12 Livstabel for voksne moskusokse-køer (5år+). Baseret på 172 selvdøde køer i perioden 1977-1984

age(yr)	N	fx	lx	dx	qx	px
5-6	4	192	1.000	0.021	0.021	0.979
6-7	14	188	0.979	0.073	0.075	0.925
7-8	17	174	0.906	0.089	0.098	0.902
8-9	31	157	0.817	0.161	0.198	0.802
9-10	29	126	0.656	0.151	0.230	0.770
10-11	24	97	0.505	0.125	0.247	0.753
11-12	21	73	0.380	0.109	0.288	0.712
12-13	15	52	0.271	0.078	0.289	0.711
13-14	10	37	0.183	0.052	0.270	0.730
14-15	7	27	0.141	0.037	0.259	0.741
15-16	9	20	0.104	0.047	0.450	0.550
16-17	3	11	0.057	0.016	0.273	0.727
17-18	2	8	0.041	0.010	0.250	0.750
18-19	2	6	0.031	0.010	0.333	0.667
19-20	1	4	0.026	0.005	0.250	0.750
20-21	1	3	0.021	0.005	0.333	0.667
21-22	1	2	0.016	0.005	0.500	0.500
22-23	1	1	0.011	0.005	1.000	0

$\bar{x}$ annual mortality = $\Sigma d_x \cdot 100 / \Sigma l_x = 16.23$ %

Tabel 13 Livstabel for voksne moskusokse-tyre (5år+). Baseret på 192 selvdøde tyre i perioden 1977-1984.

FLYTÆLLING

Som en naturlig videreførsel af de tidligere udførte optællinger af bestanden fra fly gennemførtes i perioderne 28-31 januar 1984 og 26 februar - 5 marts 1985 to registreringer af bestandens fordeling på Jameson Land og størrelse. Flyruter, antal observerede moskusokser samt disses områdemæssige placering fremgår af Fig. 2, 3, 4 og 5.

Ved tællingen i 1984 blev der anvendt en Cessna Skymaster og traditionel visuel navigation under flyvningerne; resultatet blev 2952 observerede moskusokser, i fin overensstemmelse med det gennemsnitlige totale antal observerede okser i de tre foregående flytællinger om vinteren ($\bar{x}$ = 2967).

Imidlertid har der til stadighed været problemer med gennemførelse af en sikker og reproducerbar navigering og rutelægning på den relativt flade del af Jameson Land, og det har derfor - for at minimere chancerne for dobbelttælling - været nødvendigt at lægge ruterne med en forholdsvis stor indbyrdes afstand i området syd for Ranunkel Elv - Olympen (ca. 71° 25' N.

Denne suboptimale situation er der imidlertid blevet rådet bod på ved tællingen i 1985, hvor der blev anvendt en Partenavia Observer med Omega positioneringsudstyr ombord. Flyruterne i ovennævnte del af Jameson Land blev derfor udført ved hjælp af instrumentel navigering udelukkende af piloten efter forud fastlagt flyveplan, og der blev herved for forreste observatør mulighed for at anvende al flyvetid til observationsarbejde.

Dette arrangement fremmede i høj grad effektiviteten ved optællingen, og ruternes tættere indbyrdes placering muliggjorde en reel totaldækning af "Heden" - området mellem 71°25' N og Flakkerhug afgrænset af kystlinien til vest og vandskellet i øst (Fig. 4).

Den væsentlige forbedrede metode udmøntede sig i et større antal observerede moskusokser; nemlig 4139. Denne kraftige stigning i bestandsstørrelsen må ikke fortolkes som en faktisk øgning i antallet af dyr, men udelukkende som et resultat af en mere fuldstændigt dækkende optælling, end der tidligere har været tale om.

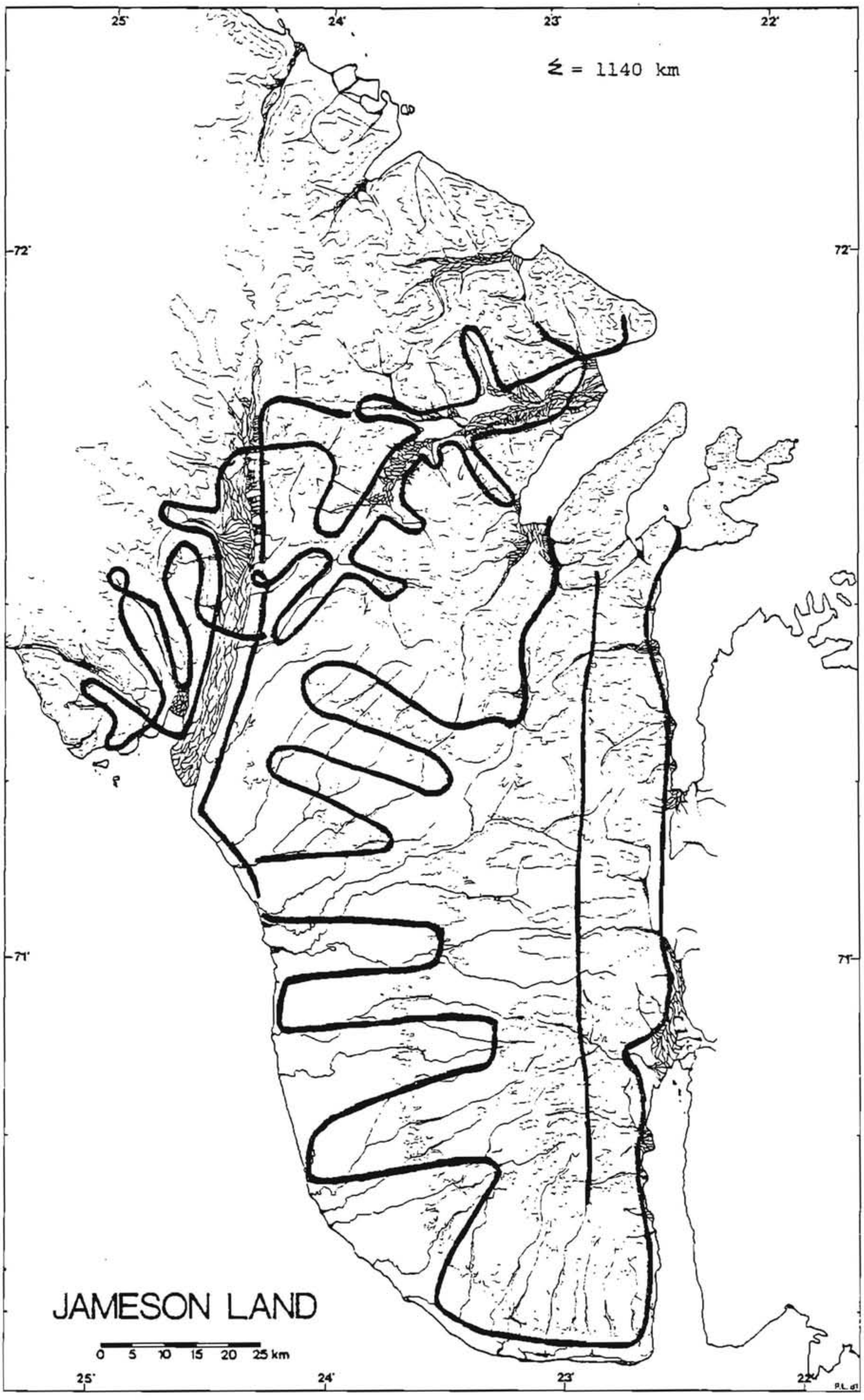

Fig. 2. Observationsruter ved flytælling 28-31/1 1984.

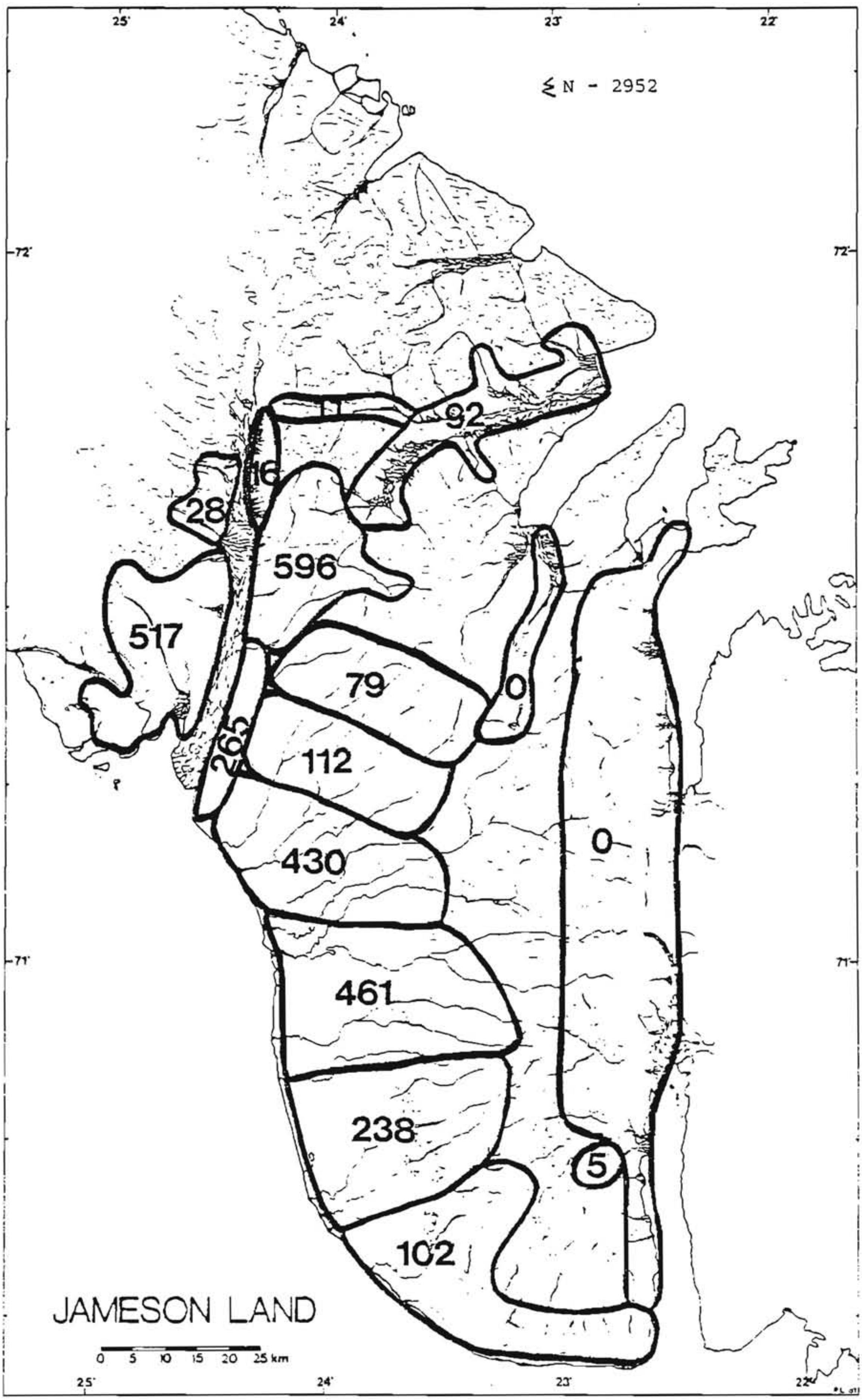

Fig. 3. Fordeling af observerede moskusokser 28-31/1 1984.

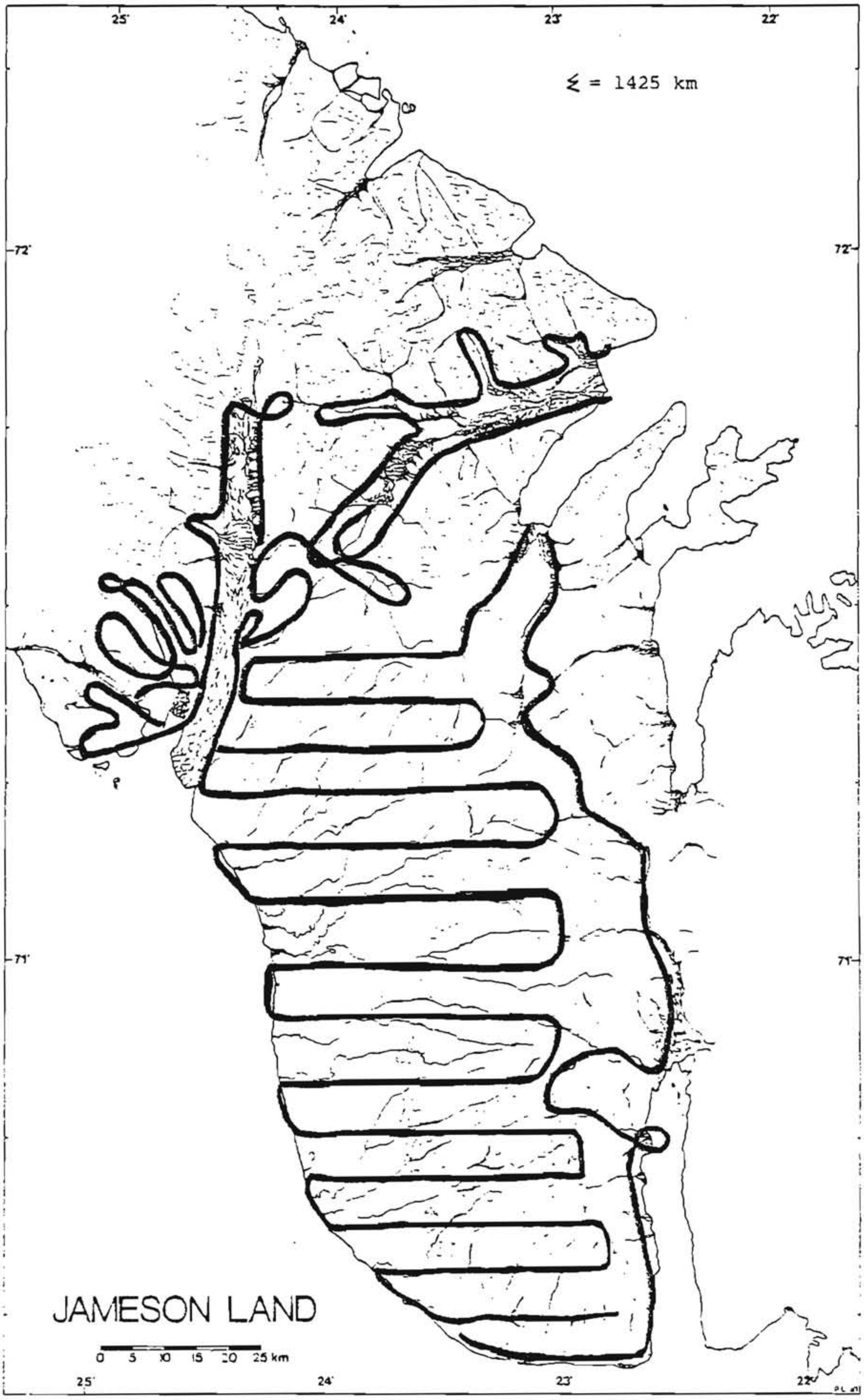

Fig. 4. Observationsruter ved flytælling 26/2-5/3 1985.

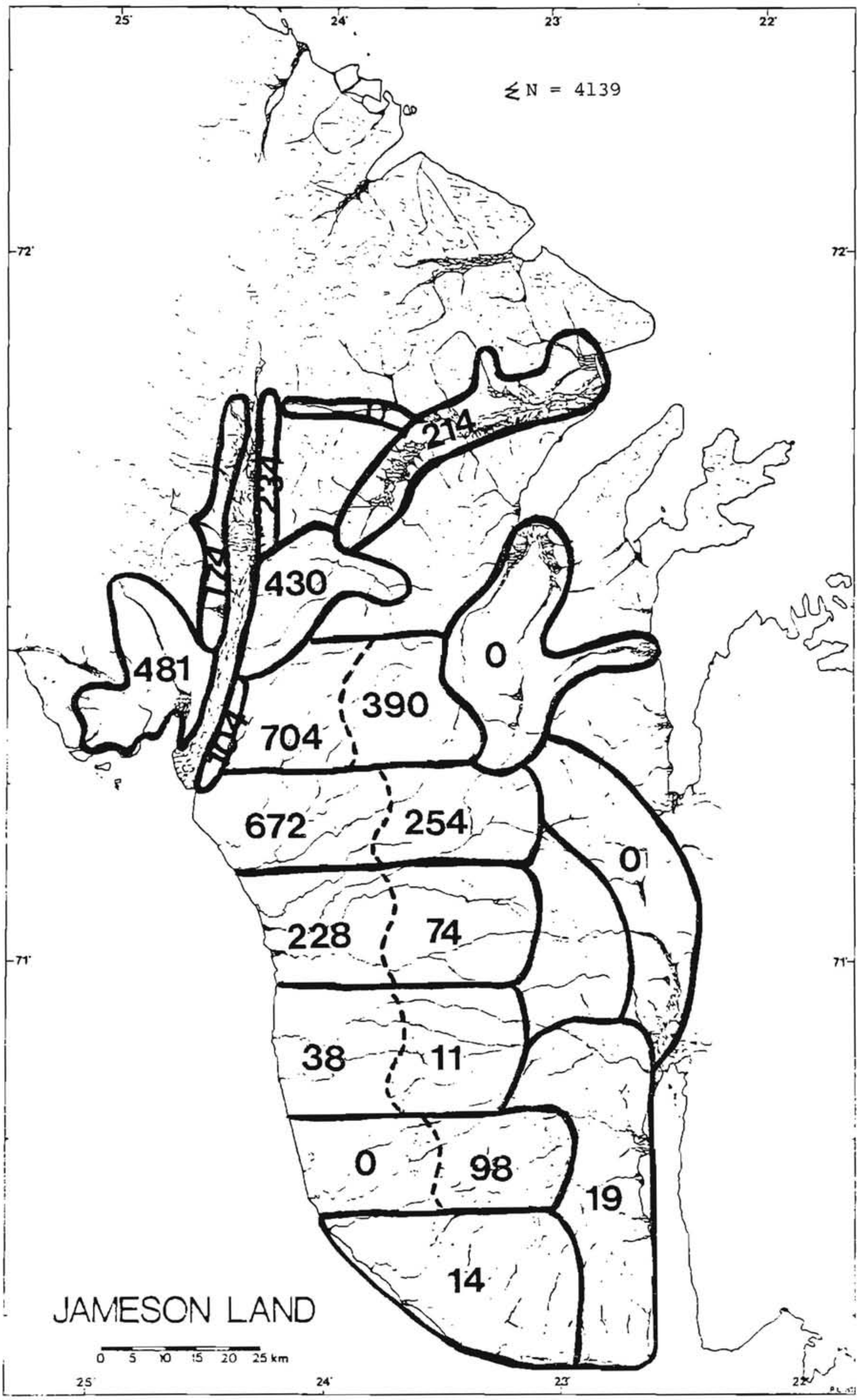

Fig. 5. Fordeling af observerede moskusokser 26/2-5/3 1985.

Indtil videre bør Jameson Land's moskusoksebestand således betragtes som bestående af godt 4000 dyr. Forandringer i jagttryk, klimatiske vilkår, fordelingsmønster samt forstyrrelsesniveau vil dog nemt kunne resultere i betydelige ændringer i bestandens størrelse og reproduktive potentiale, så der bør fremover foretages en senvinteroptælling fra fly for at overvåge udviklingen i populationen.

ECOLOGY OF MUSKOXEN IN JAMESON LAND, NORTHEAST GREENLAND.

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INTRODUCTION

The muskox (Ovibos moschatus) is an indigenous part of the Greenlandic fauna and its present range is north and northeast Greenland north of Scoresby Sund from 83°30'N to 70°N (Fig. 1). Recent concern over the potentially detrimental effects on the environment of oil exploration activities in Jameson Land, northeast Greenland has accentuated need for data on the ecology of the muskoxen in this area. To obtain this information a comprehensive study of the muskox population and its ecology was initiated in 1982. This paper is based on data collected during field work and aerial surveys from April 1982 to May 1985.

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STUDY AREA

The peninsula of Jameson Land, located from 70°30'N to 72°N, comprises 11,000km^2. It is bounded to the northwest, north, and east by fiords and alpine mountain ranges, and to the south-southwest by Scoresby Sund (Fig. 1). The study area is a plateau tilted 3° to 5° to the west forming 500 to 600 m cliffs along the eastern border and dipping gradually toward Scoresby Sund on the western side. In the northern and eastern parts of the peninsula broad valleys are common, whereas the

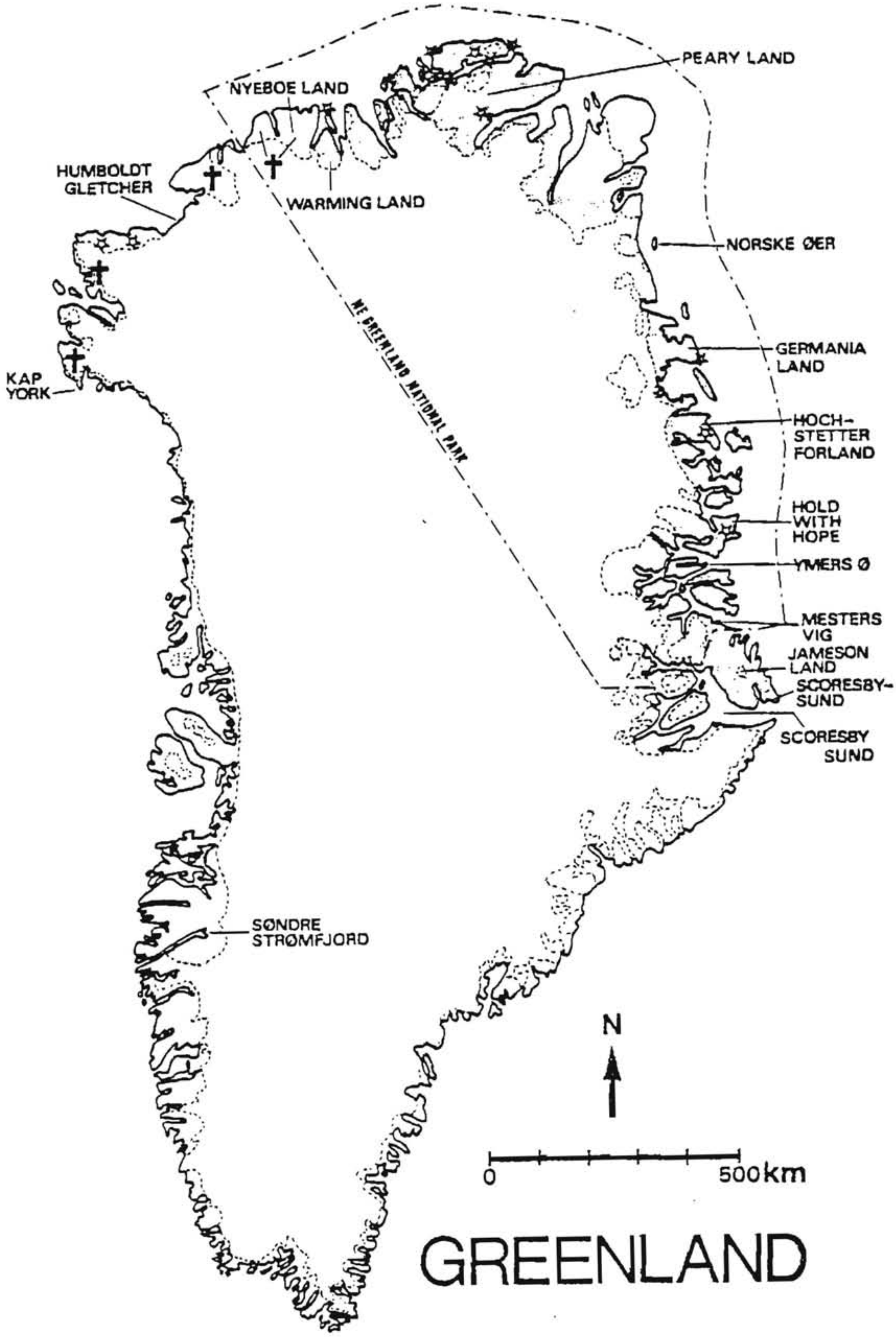

Figure 1. Map showing the distribution of muskoxen in Greenland and the relative location of the study area in Jameson Land.

rest of the study area is generally flat, with minor depressions around numerous drainages.

MATERIALS AND METHODS

Description of Vegetation:

The distribution, relative area occupied and proportions of plant community types in Jameson Land were measured through vegetation mapping from aerial photography and ground truthing. The quantitative numbers given are visual estimates from the vegetation maps (Figs. 2,3).

Distribution and habitat use:

Seasonal distribution of animals on the peninsula was recorded during 10 aerial surveys using various fixed-wing aircraft (Cessna 182, Cessna Skymaster, Britten Norman Islander, Partenavia Observer) and later related to vegetation characteristics. All parts of the study area were surveyed except for inaccessible mountain ranges in the northwestern corner. An altitude of 200-300 m above ground was maintained, routes were plotted on 1:250,000 maps. Observations of muskoxen were timed and recorded on tape. Ground surveys in March-October supplemented data on population distribution and specific habitat types within which undistrubed muskoxen that were observed were recorded.

Diet:

Data on the relative quantitative importance of plant species and types as muskox food were obtained through macroscopic analyses of rumen contents, and microscopic analyses of plant fragments in the fecal

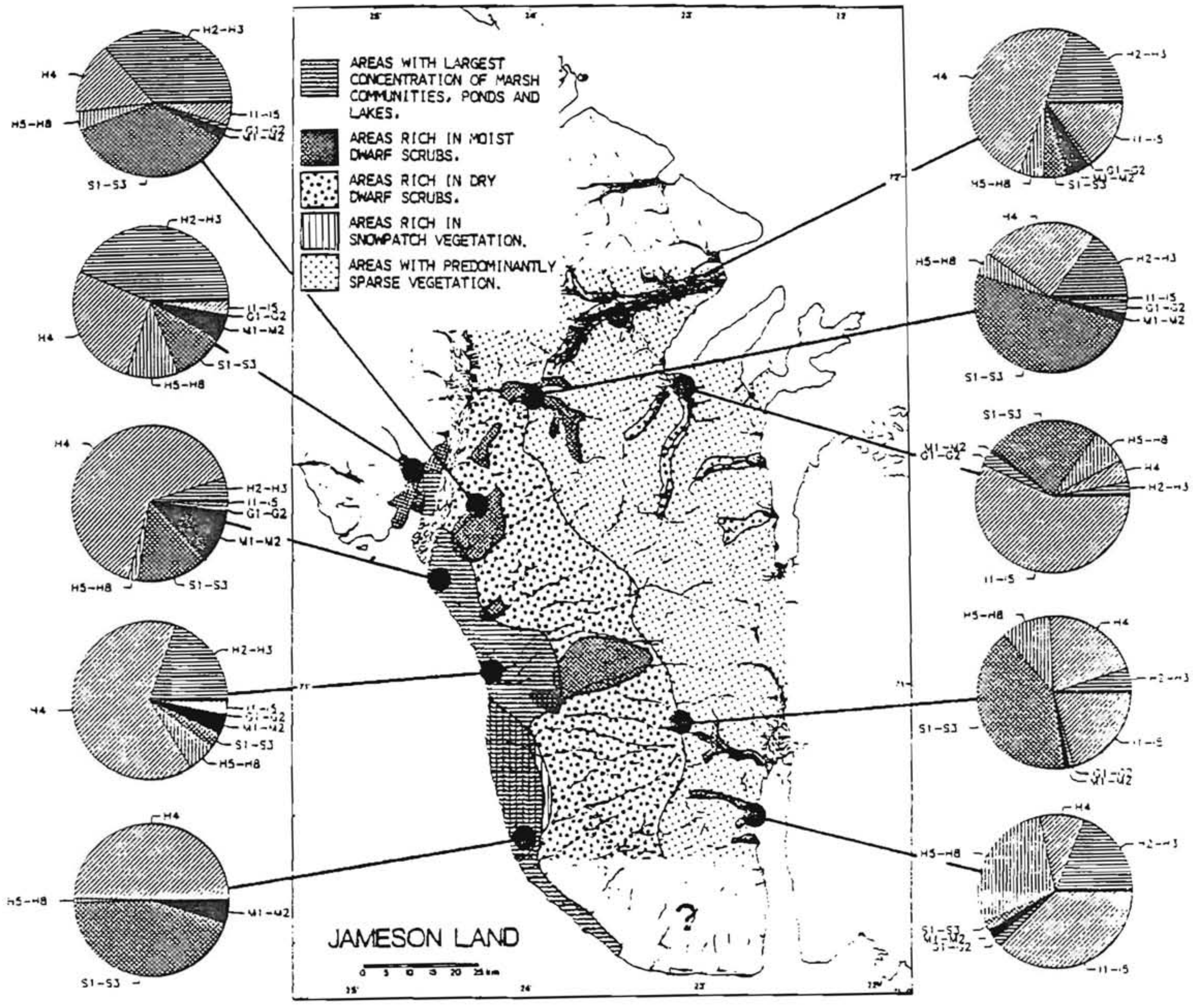

Figure 2. Map showing the main features of the vegetation of Jameson Land. (Revised from Bay and Holt 1984). The percentages of the main plant community types within a radius of approximately 50 km^2 from the dot have been estimated and are shown as pies. Hs-H3: moist dwarf scrubs; H4: dry dwarf scrubs; H5-H8: sparse dwarf scrubs; S1-S3: snowbeds and snowpatches; M1-M2: marsh and hommocky meadow; G1-G2: wet grassland and salt marsh; I1-I5: impediments.

Figure 3. An example of vegetation mapping shown on a print made from false color IR photo covering about 20km^2 of Coloradodal in the north-western part of Jameson Land with vegetation types delineated for key to plant communities.

pellets from specimens shot during the study (N=29), those killed by Inuit hunters of Scoresby Sund (N=33), and from fresh pellets collected in the field. Discerned fragments of plant species or groups in rumen samples were identified by examination of suspended material in a water bath in white plastic trays. Mean percent relative density of plant species fragments was determined through use of 10 randomly-selected rectangles (7.8cm x 4.6cm). Fecal samples were pulverized, homogenized and subsamples prepared as slides for microscopic identification of plant tissue fragments at the Composition Analysis Laboratory, Colorado State University, Ft. Collins, Colorado, U.S.A. Frequency of occurrence of plant fragments was recorded from examination of 100 microscope fields (20 fields from each of 5 slides). Additional information on diet composition was collected by means of direct field observations using spotting scopes or close examination of feeding craters.

Forage quality:

From late March until early October a total of 81 samples of arctic willow (*Salix arctica*) and graminoids were picked, oven dried, and subsequently analysed for N, fiber, Ca, K, Na, and P. During July-October plants were sampled every 8-10 days.

Mineral licks:

Samples (N=11) from six different mineral licks in four localities, plus control soil samples (N=5) were collected in July-August and analysed for pH and contents of N, P, K, Ca, Mg, Na, Cu, Zn, Mn, and Fe. Additional samples of feces from lick areas (N=2) and controls (N=26) were analysed for the same elements. Lick samples were also analyzed by x-ray techniques for mineral types.

Condition of animals:

Parameters describing the physical condition of the animals were recorded from 32 shot specimens (total body weight, kidney fat index, femur marrow fat, and depth of back fat; Langvatn 1977), and related to season, forage selection, and food quality. Data on calf production and recruitment rate were collected throughout the year during ground surveys. Individual muskoxen were classified as either calves, yearlings, subadults (2- and 3-year olds), adult bulls or adult cows based on differences in horn development, body size and pelage characteristics (Smith 1976, Henrichsen and Grue 1980). Behavior during nursing events was registered with respect to duration of suckling time, nursing position for calf and cow, and termination of the suckling event.

RESULTS AND DISCUSSION

Vegetation and plant communities:

The vegetation types present in Jameson Land, their dominant plant species, precent of ground cover, and snow depths are shown in Table 1. Dwarf shrub together with snowbed communities occupy the major portion of the vegetated area of Jameson Land. Generally the most productive plant communities are located in the western part of Jameson Land and in the larger valleys on the east side.

Table 1. Vegetation types in Jameson Land.

Code	Vegetation type and average % leaf cover	Dominant plants	Range of snow depths during late winter
H2-H3	Moist dwarf scrub (>75)	Betula nana Vaccinium uliginosum Cassiope tetragona	50 - 100 cm
H4	Dry dwarf scrub (25-72)	Cassiope tetragona Vaccinium uliginosum Betula nana	30 - 100 cm
H5-H8	Sparse dwarf scrub (<25)	Dryas octopetala Salix arctica Silene acaulis	0 - 30 cm
S1-S3	Snowbeds and snowpatch (5-50)	Salix arctica Carex bigelowii Poa pratensis Stereocaulon alpinum	100 - 250 cm
M1-M2	Marsh and hummocky meadow (95)	Carex spp. Eriophorum spp. Arctagrostis latifolia	0 - 100 cm
G1-G2	Grasslands (90)	Calamagrostis neglecta Poa pratensis Alopecurus alpinus Arctagrostis latifolia	0 - 100 cm
I1-I5	Impediments (<1)		0 - ? cm
T	Thicket (50)	Salix arctica	50 - 100

Dwarf shrub communities: In the vegetation mapping of Jameson Land, dwarf shrub was divided into six categories on the basis of moisture and biomass present. In order to simplify this description, these communities are here treated within the three main categories of moist, dry and sparse dwarf shrub. The moist dwarf shrub generally supports the highest quantity of graminoids compared to the drier dwarf shrub types. The presence of graminoid species and their abundance differ with soil moisture. Graminoids of importance as forage for muskoxen in the moist dwarf shrub are *Arctagrostis latifolia* and *Poa pratensis*. The cover of graminoids in the moist dwarf shrub usually ranges between 1-2%. In the dry dwarf shrub *Poa pratensis* together with *Luzula confusa* are the most frequent graminoids. Herbs exceed a cover of 2% only in the most luxuriant dwarf shrub which have a very limited extension in Jameson Land. During late winter muskoxen feed intensively on *Salix arctica* in the sparse shrub types located on wind swept ridges.

Snowbeds and snowpatches: Snowbed and snowpatch are the other major vegetation types in Jameson Land and are treated here collectively. Snowbed and snowpatch vegetation occurs respectively on south-facing slopes due to the predominantly northerly winter winds and in shallow depressions on level or gently sloping ground. Snow accumulation during winter often exceeds 2 meters and consequently these communities are inaccessible as feeding habitats during late winter. Initiation of plant growth in these communities is delayed compared to other communities due to the large accumulations of snow and later snow melt. The majority of snow-dominated communities are characterized by a cover of about 10% Salix and 1-2% graminoids. Usually herbs constitute about 1% cover.

Marsh and hummocky meadows: Marsh and hummocky meadow communities have a relatively limited extension in most parts of Jameson Land. The production of graminoids in these communities is high and consequently they are of considerable importance to muskoxen. These communities are most prevalent in the larger valleys and in the middle portion of the west coastal area of Jameson Land. Often a mosaic is seen within a single marsh community where the dominant species changes along the moisture gradient. The graminoid cover is usually about 10%. Salix arctica is the most common of the dwarf shrubs in these communities where it occupies about 2% of the cover. Several species of herbs occur in relatively small quantities, all of minor importance as forage for muskoxen. In areas where large goose concentrations occur during the moulting period, heavy grazing by geese has altered marsh communities adjacent to lakes, ponds, and rivers. Geese use marsh communities up to 100-250 meters from open water during this period (Madsen et al. 1984). In late winter at some locations where graminoids were penetrating the snow signs of muskox grazing were observed.

Grassland: Grassland has the highest frequency of occurrence in the north-western part of the area. This community often occurs in association with marsh communities and where it forms transitions to these. Grassland usually occupies level and slightly sloping ground with a continual water supply during the summer. There are large variations in the quantity of graminoids between locations, but average graminoid cover is approximately 10%. *Salix arctica* is the most abundant of the dwarf shrubs which collectively constitute 2-3% cover. Herbs are quantitively less important.

Impediments: This group includes bare ground, riverbeds, persistent snow and ice. The sporadic vegetation occurring in these areas are quantitatively unimportant. Impediments are more common in the northern, central and eastern parts of Jameson Land. Such areas serve as muskox resting habitats and refuges against insect harassment.

Thickets: Thickets are composed exclusively of *Salix arctica*. Only closed stands of *Salix* exceeding 20 centimetres in height are included in this category. Their occurrence is very scattered and limited to south-facing slopes in the larger valleys. The areal extension of thickets in Jameson Land is less than 0.1%, but they are of local importance for muskoxen.

Seasonal distribution and habitat use:

The variation in topography and vegetation on Jameson Land determines the seasonal distribution of muskoxen in the study area (Fig. 4 a-b). Areas with little terrain variation at low altitude (i.e. below 400 m.a.s.) and with a southerly exposure are preferred by muskoxen throughout the year. Most such areas are in the western half of the peninsula. Eighty percent of the total late winter population of 4100 muskoxen (H. Thing unpublished data) occupies only 33% in summer and 20% in winter of the total range (Fig. 4 a-b). Within these major summer

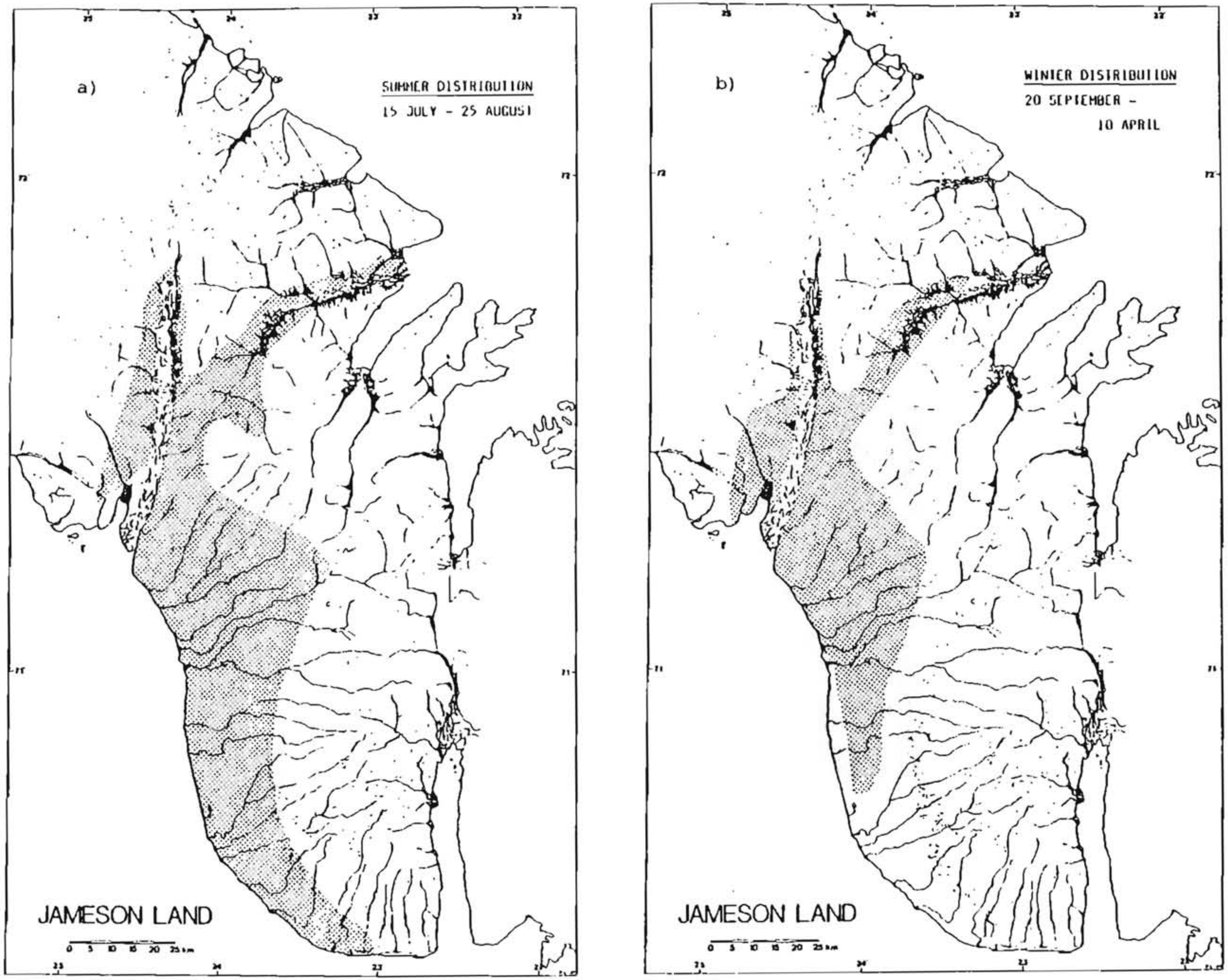

Figure 4. Seasonal distribution of muskoxen in Jameson Land.

and winter ranges population density averages 1.1 and 1.5 muskoxen·km^{-2}, respectively.

Selection of actual feeding and resting-rumination sites by the animals is influenced by snow cover, aspect and slope, floristic composition, and season. The observed pattern of habitat selection indicates that dwarf shrub heath received highest use in all seasons during the study period (Table 2). In late winter wind-exposed heaths are extremely important as feeding habitat.

During summer and the rutting period (1 July - 15 September) a much more varied usage of the different vegetation types occurs with snowbeds, supporting dense stands of prostrate arctic willow, being the second most utilized habitat.

Wet sedge-dominated marshes and meadows (equivalent to mesic tundra meadows of Robus 1981, Bos 1967, Russell et al. 1978) and grasslands are the main source of graminoids in the muskox diet. These vegetation types are situated in depressions in the landscape and most often are covered with deep snow during the mid- and late winter seasons; therefore they are available to foraging animals only during summer, the rut, and the early part of winter (July-October).

Willow thickets are sparse but are selected for where they are locally present. Impediment is frequented by muskoxen for rest, rumination, heat relief, and occasionally insect avoidance.

Table 2. Proportion of observed time spent by muskoxen in the major vegetation types in the main seasons of the year.

VEGETATION TYPE	LATE WINTER N=363	SUMMER N=2742	RUT N=917	EARLY WINTER N=627
Moist or dry dwarf shrub heath	88.2	44.9	38.7	38.8
Snowbed	-	19.1	26.2	23.6
Graminoid marsh - Hummocky meadow	9.0	16.5	20.7	19.1
Grassland	-	9.8	9.8	18.5
Impediment	2.8	6.1	2.2	-
Willow thicket	-	3.6	2.4	-

Diet:

On the basis of analysis of rumen contents the diet of muskoxen is dominated by graminoids and willow (Table 3, Fig. 5a). Their relative importance alternates, with graminoids dominating in winter (9 months of the year) and willow during summer (1.5 - 2 months). Diets during calving, post-calving, and rut fall within periods of transition and are characterized by wide individual variation. During winter muskoxen feed on grasses and sedges on the dry dwarf shrub heaths whereas the graminoid diet during summer and rut derives mainly from wet meadows and grasslands. Stems, terminal twigs, and dormant buds of arctic willow are eaten during winter on the dry heath habitats. In summer willow leaves and young catkins are highly preferred forage and are taken on moist heath habitats and in snowbed vegetation. As soon as willow leaves turn yellow in the second half of August preference quickly changes towards graminoids.

Plants other than graminoids and arctic willow are quantitatively unimportant in the muskox diet (5-7% of rumen contents; Table 3, Fig. 5a) but may be qualitatively important, especially during summer. Calves were often seen selecting dicot flowers and a few adults had a relatively high amount (13%) of fruticose lichens in the rumen.

During the period of high intake of young willow leaves a considerable portion (up to 28%) of the rumen contents consisted of spongy, spherical aggregations (2-5 mm in diameter) of fibrous plant material. These unique structures were made up solely of arctic willow, but their possible function in the digestive process is unknown.

Table 3. Comparative presence of plant tissue fragments in rumen and fecal samples collected from the same muskoxen based on microhistological analysis.

Plant Type		Date of collection: DEC	22 APR	13+20 JUL	JUL-AUG	26 AUG
GRAMINOIDS	rumen	81.8±10.6 (13)	85.1 (1)	33.7±6.5 (2)	39.1±19.2 (30)	48.9 (1)
	feces	57.9±15.4 (9)	31.0 (1)	5.1±4.6 (2)	3.7± 1.3 (4)	0.6 (1)
Salix	rumen	3.6± 4.0 (13)	2.2 (1)	58.1±6.8 (2)	48.9±21.3 (28)	33.6 (1)
	feces	36.9± 8.3 (9)	41.2 (1)	94.6±2.3 (2)	96.3± 0.9 (4)	98.5 (1)
WOODY DICOTS	rumen	3.8± 3.8 (10)	2.3 (1)	0.5±0.2 (2)	0.5± 0.2 (28)	0.4 (1)
	feces	4.0± 5.3 (9)	10.5 (1)	0	0	0.3 (1)
OTHER DICOTS	rumen	0.5± 0.8 (13)	0.2 (1)	0.6±0.1 (2)	1.0± 1.1 (30)	1.0 (1)
	feces	0	0	0	0	0.3 (1)
MOSSES AND LICHENS	rumen	0.6± 0.9 (13)	1.8 (1)	0.2±0.2 (2)	1.8± 2.3 (30)	3.4 (1)
	feces	1.2± 1.8 (9)	17.3 (1)	0.3±0.2 (2)	0	0.3 (1)
UNIDENTIFIED	rumen	9.4± 3.4 (13)	8.4 (1)	6.8±0.4 (2)	8.7± 3.6 (30)	12.8 (1)
	feces	-	-	-	-	-

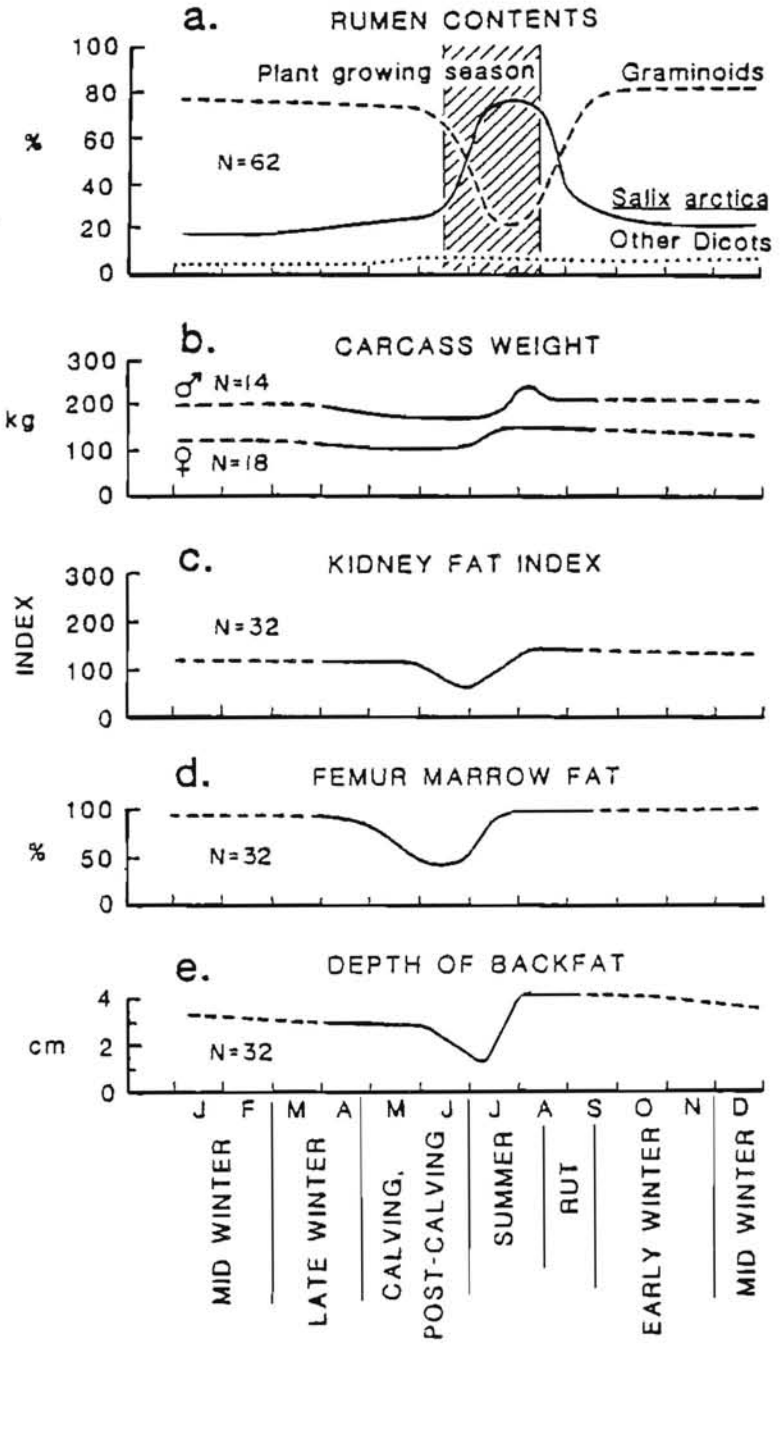

Figure 5. Annual variation in composition of the rumen contents (a) and of the body parameters, carcass weight (b), kidney fat index (c), femur marrow fat (d), and depth of back fat (e) of muskoxen in Jameson Land.

Initiation and duration of the plant growing season is indicated in Fig. 5a. Initiation of plant growth coincides with the sharp change in diet in spring (post-calving season), whereas the change in diet in late August coincides with the termination of plant growth.

Analysis of plant tissue remains in the fecal samples provides an additional indicator of dietary composition. An advantage of this technique is that a sample representing many animals can be readily collected in the field without the need to sacrifice animals. The problem of individual variation can be readily overcome. However, investigations of the reliability of fecal analysis techniques indicate that they yield a biased representation of the forage consumed due to differential digestibility of forage types (Stewart 1967, Varva et al. 1978). In order to measure the degree of bias in recontructing the diet based on analyses of muskox feces collected in this study we compared analysis of plant tissue fragments in the rumens of shot specimens against analysis of the feces collected from the same animals. Comparative values are shown in Table 3. It is apparent from this comparison that graminoids are greatly underrepresented in the feces in comparison to their relative presence in the rumen and this is most pronounced in summer apparently associated with their higher digestibility then. Conversely, willows tend to be overrepresented in the feces throughout the year. It is likely that during summer, forbs which have high digestibility, are underrepresented in the feces and this has been demonstrated in other studies (Duquette 1984). However, on the basis of rumen and fecal analyses forbs do not appear to be of as much importance in the diet of Jameson Land muskoxen as is the case of muskoxen in Alaska and the Canadian Arctic Islands (Tables 3 and 4). Fecal analyses in spite of their limitations do provide opportunities for comparisons of dietary trends between areas and seasons.

Results from analyses of pooled fecal samples from winter and summer collections in Jameson Land are compared in Table 4 with similar collections from muskox populations in Alaska; Bathurst Island; the mean of samples from Axel Heiberg, Melville, and Bathurst Islands in the Canadian Arctic; and the introduced West Greenland animals. These data suggest that willows play a larger role in the summer diet of muskoxen in Jameson Land and Alaska than in the Canadian Arctic where graminoids are a much more important component of the summer diet. In winter, graminoids became major components of the winter diet but there is a similar pattern of greatest presence in the Bathurst Island samples from the Canadian Arctic, followed by the West Greenland and Jameson Land samples, and only the Alaska samples reflecting a much lower presence of graminoids in relation to willows.

The relatively high presence of lichens in the winter feces of Jameson Land muskoxen may be an important contribution to the total available dietary energy. The relatively large proportion of mosses may be a reflection of their incidental intake during feeding on lichens and other forage, as well as their very low digestibility.

Forage quality:

To assess the qualitative importance of the forage it is critical to have information on the chemical composition of the various food plants. A very high seasonal variation in composition is apparent for most parameters in the four plant groups analysed (Fig. 6 a-d) with high

Table 4. Comparison of the winter and summer diets of muskoxen in Jameson Land with muskoxen in other areas based on microscopic analysis and frequency of occurrence of plant epidermal fragments in the feces.

Plant Type	Winter				Summer			
	Jameson Land[1]	West Greenland[2]	Alaska[3]	Bathurst Is.[4]	Jameson Land[1]	Canadian Arctic[5]	Alaska[3]	Bathurst Is.[4]
	X±SD	X±SD	X±SD	(Pooled Sample)	X±SD	X±SD	X±SD	(Pooled Sample)
Grasses	6.4±2.3	34.6±13.9	1.5±0.7	0.4	1.2±1.2	18.0±20.3	0.2±0.7	0.5
Sedges	24.1±19.0	12.6±5.4	11.4±9.9	90.8	3.9±2.7	42.6±5.6	5.9±2.3	23.3
TOTAL GRAMINOIDS	30.5±19.1	47.2±14.9	12.9±10.0	91.6	5.1±2.9	60.6±17.4	6.1±2.5	23.2
Salix sp.	43.0±26.1	26.7±20.1	80.1±11.7	4.1	96.4±2.3	32.5±14.0	92.8±5.0	56.5
Other woody dicots	9.2±4.4	2.0±3.4	1.2±1.3	-	6.4-	1.6±1.2	0.1±02.	-
TOTAL WOODY DICOTS	52.2±26.5	28.7±20.4	81.3±11.7	4.1	96.4±2.3	34.1±14.3	92.9±5.0	56.5
Other dicots (forbs)	0.9±1.0	22.0±12.4	1.1±0.6	2.4	-	4.9±5.7	3.4±0.8	17.7
Equisetum	-	2.2±3.2	-	-	-	-	0.3±0.6	-
Lichens	5.4±7.8	-	1.0±1.0	-	0.3±0.7	-	0.1±0.1	-
Moss	10.6±8.2	-	3.7±3.1	2.0	-	-	0.1±0.1	1.5

[1] This study; [2] Thing, unpub. data; [3] Jingfors 1980, Robus 1981, Klein unpub. data; [4] Jingfors 1980; [5] Parker 1978.

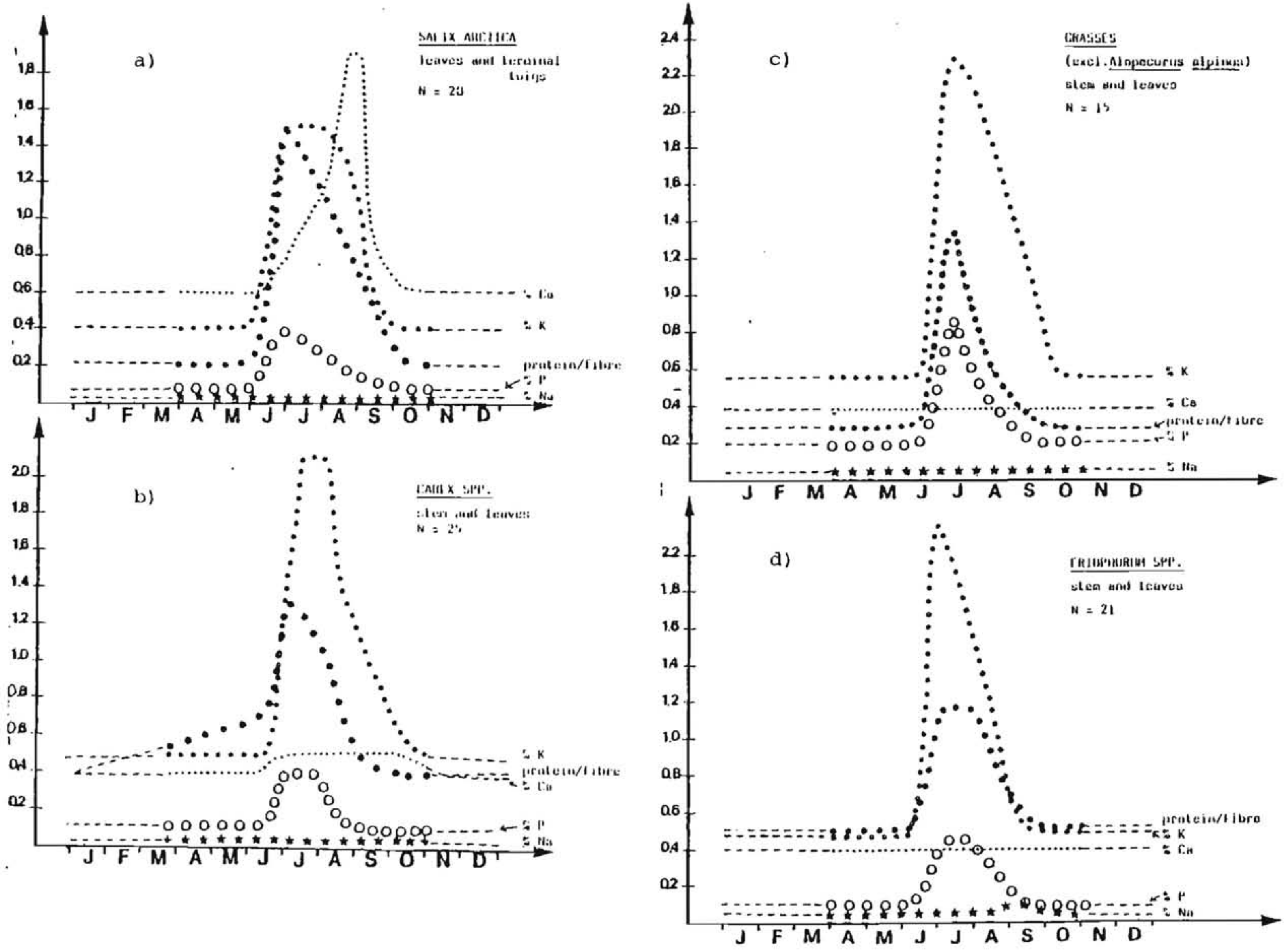

Figure 6. Annual variation in the protein/fiber ratio and chemical constituents of the major plant components _Salix arctica_ (a), _Carex_ spp. (b), Grasses (c), and _Eriophorum_ spp. (d) in the diet of muskoxen in Jameson Land.

values during the growing season (summer) and low values during the winter dormancy period. The ratio of protein/fiber is chosen as an indicator of relative quality (i.e. digestibility) of the forage. Seasonal variation in this ratio shows that relative quality of food plants in winter is increased by a factor of 3 to 8 during the peak of the growing season in late June - early August. The level for protein/fiber in the winter season is 50% lower in arctic willow than in the three graminoid groups while the value for the same parameter during summer is 20% higher in willow forage than in graminoids.

The content of Ca in forage plants shows a marked difference between willow and graminoids. In the latter, Ca ranges between 0.4 and 0.5% year round, whereas in arctic willow it increases three-fold from winter to summer.

These two pronounced differences between the dominant forage groups are believed to be of great importance for the alternation in diet between winter and summer (Fig. 5a) as a diet high in protein and Ca and low in fiber obviously is critical for the animals during summer when muscle and skeleton growth as well as lactation take place.

The contents of K, P, and Na show almost the same seasonal course in all four groups with only two differences to be noted. Graminoids have consistently higher K values, especially during summer, than arctic willow and the summer level of P content in grasses (Fig. 6c) is considerably higher than in sedges and willows.

Whereas both graminoids and willows dominate the winter and summer diets of muskoxen in Jameson Land, the use of other forage types, although relatively unimportant quantitatively may be of considerable importance from a qualitative standpoint. Lichens, as already mentioned, are a high energy forage that could be an important suppliment to the winter nutritional regime. forbs, although not an important component of the forage biomass of Jameson Land, are nevertheless selected for during summer. Most forb species such as Pedicularis spp., Polygonum viviparum, Saxifraga oppositifolia, and Epilobium latifolium are of extremely high nutritive value during their early growth and flowering stages (Robus 1984 and Klein unpub. data). Their very high protein/fiber ratio, high digestibility and high P value may make important contributions to the diet at the onset of the growing season when they have a high apparency and when nutritional requirements of the lactating female are highest.

Mineral licks:

Several mineral licks used by muskoxen were found in Jameson Land. Their presence was first suspected when occasional feces were observed of a reddish color similar to that of soils in some areas. Muskox observed in the lick areas and tracks and feces present indicate that the licks are used primarily during summer. The character of the licks vary but they are generally associated with seeps with soft clay-like soils and often with white encrustation of salts on soil surfaces. Muskoxen generally lick the encrusted salts and eat the associated soil. Tener (1954) observed similar patterns of muskox use of licks in the Canadian High Arctic.

Samples of lick material and control soil samples from unused areas adjacent to each lick were analysed for mineral composition. Results of these analyses are presented in Table 5 as ratios of the content of the minerals present in the lick sample to their content in the control soil samples. It is apparent Na is the only mineral consistently present in greater amounts in the lick samples than in the controls although in 10 of the 11 samples K and Fe are also more prevalent in the licks than in the adjacent soils. K is readily available in the forage at this time of year (Fig. 6a-d). It is possible that trace elements such as Fe, Cu, Zn or Mn are being obtained from the licks by muskoxen, however, the high metabolic demand for Na by growing and lactating animals and its relatively low presence in the forage (Fig. 6a-d) suggests that Na is the primary mineral being sought at the licks. This seems to be the case in the majority of natural mineral licks used by wildlife (Jones and Hanson 1985, Weeks 1978).

Analyses of feces collected at one of the lick sites that appeared to contain soil material from the lick are compared in Table 6 to analyses of fecal samples collected at random long distances from any known lick. Again, Na and Fe appear in much greater amounts in the feces from the lick areas than in the control samples.

X-ray analysis of mineral types was of a qualitative nature and was done to determine if specific high surface area, or hydroscopic minerals, such as bentonite, were present and being selected for by the muskox for some benefit to rumen fermentation (Jones and Hansen 1985). Bentonite and other rare earths were not detected in the analyses (Table 5).

Table 5. Ratio of mineral content of lick samples over mineral content of control samples from soil adjacent to the licks.

Source of Sample[1]	NH_4	NO_3	Total N	P	K	Ca	Mg	Na	Cu	Zn	Mn	Fe
Ø.D. I	0.59	5.3	3.4	35	4.6	1.8	23	35	1.8	1.8	0.71	1.7
Ø.D. II (Soil + white crust)	1.1	7.3	5.2	1.1	3.0	1.8	14	11	1.3	0.65	1.3	1.1
Ø.D. II (Soil - white crust)	1.0	6.8	4.9	0.88	2.3	0.95	9.4	5.6	0.57	0.94	0.45	0.63
C.D. I (Soil + white crust)	0.85	42	25	6.8	7.8	4.1	3.0	11	2.2	2.8	3.0	2.1
C.D. I (Soil - white crust)	1.6	1.6	1.6	5.1	2.8	2.3	1.9	6.0	4.3	5.1	5.1	4.9
C.D. II (Soil + white crust)	1.7	1.4	1.5	1.5	1.3	0.90	1.6	2.2	0.51	0.90	0.42	1.3
M.P.D. I (Sample a)	0.6	0.61	0.51	19	1.1	0.98	0.93	1.7	1.8	9.5	3.2	3.9
M.P.D. I (Sample b)	1.0	0.50	0.59	1.2	1.4	1.0	1.2	1.8	2.8	11	10	11
M.P.D. I (Sample c)	0.89	0.79	0.81	1.2	1.1	0.82	0.74	1.8	1.8	11	4.9	4.1
M.P.D. I (Sample d)	3.6	19	16	0.90	1.6	1.1	0.97	2.9	1.7	5.8	7.8	2.1
M.P.D. II	0.89	0.51	0.58	0.50	0.90	1.3	1.5	1.2	1.2	5.5	5.2	3.7
$\bar{x} \pm SD$	1.3±0.85	7.8±12.6	5.5±7.9	6.7±10.9	2.5±2.1	1.5±0.96	5.3±7.3	7.3±9.9	1.8±1.1	5.0±4.0	3.8±3.1	3.3±2.9

[1] Ø.D. = Østed Dal; C.D. = Coloradodal; M.P.D. = Major Paars Dal.

[2] Mineral types in the lick samples identified by x-ray techniques are: Serpentine $(Mg, Fe)_3Si_2O_5(OH)_4$; Analcime $NaAlSi_2O_6 \cdot H_2O$; Microcline $KAlSi_3O_8$; Plagioclase $(Na, Ca)Al_2Si_2O_8$; Calcite $CaCO_3$; Halite NaCl; Limonite $FeO \cdot OH$.

Table 6. Content of minerals present in muskox feces collected adjacent to a mineral lick compared to a control pooled sample of feces collected from areas considerable distances from known mineral licks.

Area	N %	P %	K %	Ca %	Mg %	Na %	Cu ppm	Zn ppm	Mn ppm	Fe ppm
Major Paars Dal lick N=2	1.8	0.21	0.53	2.84	0.93	0.50	22	271	599	12,828
Control Sample N=8	2.7	0.55	0.58	1.88	0.42	0.09	19	406	628	1,866
Lick Value/Control value	0.66	0.38	0.91	1.51	2.21	5.5	1.2	0.67	0.95	6.9

Physical condition:

The seasonal patterns of forage quality as well as habitat and food selection by muskoxen in Jameson Land imply a characteristic annual variation in body energy reserves (Fig. 5b-e). The five parameters reflecting the physical condition of the animals each show a somewhat different course from late winter through the rut (March-September). Carcass weight of adult bulls (5 years+) averages 176.8±35.8 kg (N=14) but undergoes great variation seasonally, reaching an annual low in May-June of 120 kg and a peak in early August (prior to the rutting season) of 230 kg. The corresponding values for total body weight are 248.0±47.8 kg and 320 kg. Bulls are in a negative energy balance during the rutting season because of the high level of activities other than feeding-resting (unpublished data), and they lose weight so that they enter winter with a total body weight almost equal to that of late winter.

Adult cows (4 years+) have an average carcass weight of 114.4±17.8 kg (N=18). In the post-calving season (mid-May to mid-June) the lowest value was recorded (93 kg) and weight was gained in early July until a high level was reached in late July (135 kg). The corresponding values for total body weight are 170.6±22.6 kg, 135 kg, and 202 kg. During winter (15 September - 20 April) carcass weight was reduced 10% in adult males and 25% in adult females. This reduction is believed to take place slowly over all winter months.

The degree of fat deposition around the kidneys (expressed as an index; Langvatn, 1977) is subject to considerable individual variation, but the average trend of this parameter is a decrease during June, an increase in July, with a maximal level in August. The period October-March apparently is responsible for a reduction in this energy deposit of only 17% on the average, whereas the decrease in June represents a further 43% reduction from the early winter level.

Fat content in the bone marrow in our samples showed no change from August through March but decreased rapidly in April-May to an annual low of 40% in June. Marrow fat deposits were subsequently built up to the fully stocked level (100%) by August.

Deposits of subcutaneous fat on the back vary greatly throughout the year. From an annual maximum in August-September, back fat is depleted by 25-30% during the winter seasons and more sharply from early June to mid-July by a further 45%. Regaining the expended part of this energy deposit appears to be completed in just three weeks by early August.

Interpretation of the above data leads to the following generalizations:

a) Body energy reserves are not fully depleted even after 9 months on a graminoid-dominated winter diet.

b) The weight loss observed in adults during April-May does not result in reduction of subcutaneous or kidney fat reserves. The decrease in total body weight is rather a result of catabolism of muscle tissue and omental-periintestinal fat.

c) While body fat reserves are decreasing or are at a minimal level the animals gain considerably in body weight. This may be achieved only with forage of very high quality and digestibility. The onset of the weight increase coincides with the shift from a graminoid diet to a high quality willow diet (Fig. 5a). Because fat reserves are still being mobilized at this time, weight gain must be closely related to dietary intake of protein.

Nursing behavior:

Calving begins at the end of April and lasts until 20 May; some calves may, however, be born until mid-August. Most calves are born during the first week of May. The calf commences suckling the cow within half an hour post-partum and the average duration of a suckling event is 98 s (N=133) for calves less than one week old (Table 7). Calves younger than three days have a suckling frequency of 3.1±0.7 events/hr (N=97), equivalent to 295±88s/hr or 8.2±2.4%. Suckling occurs significantly less frequently during night (2.4/hr) than during daylight hours (5.5/hr). Length of suckling events decreases rapidly in the first two months of life and the average duration of nursing varies from 33 s to 24 s during the summer period (N=24). At the ages of 4 months and 11 months calves are allowed to suckle their cow for an average of 21 s (N=17) and 16 s (N=6) per event, respectively. Some of the calves - apparently the largest ones- are weaned during September-October (5 months old) while other calves are nursed at the end of each lying/rumination period (i.e. 2-4 times/24 hours) throughout the winter. In some cases cows may even allow their yearlings (up to an age of 15 months) to nurse (N=4).

Late born calves appear to experience considerably longer suckling events than calves born in late April through mid-May. A calf estimated

Table 7. Nursing characteristics of muskoxen in Jameson Land.

	CALVING	SUMMER		RUT	EARLY WINTER	LATE WINTER
	28 Apr-10 May	7-14 Jul	28 Jul-16 Aug	21 Aug-13 Sep	18 Sep-4 Oct	25 Mar 27 Apr
	N = 133	N = 12	N = 12	N = 15	N = 17	N = 8
$\bar{x}$ suckling time (sec)	97.9±71.2	33.1±12.7	23.8±8.6	21.4±4.6	17.6±5.3	16.0±3.4
Suckling position (%):						
from side	68.9	100	100	100	100	100
from behind	3.7	0	0	0	0	0
under belly	27.4	0	0	0	0	0
Activity of cow while nursing (%):						
lying	10.2	0	0	0	0	0
feeding	49.0	16.7	8.3	0	0	0
standing	38.8	83.3	91.7	100	100	100
walking	2.0	0	0	0	0	0
Nursing terminated by (%):						
cow	88.2	91.7	100	100	100	100
calf	11.8	8.3	0	0	0	0

to have been born in mid-to late July suckled for 45 s and a calf born in mid-August averaged 75 s per suckling event (N=5) compared to the average of 24 s for three months old calves in the same period. This difference appears to be related to compensatory growth in late born calves to enable them to achieve a minimal body size and weight necessary for winter.

Suckling takes place almost exclusively from the side of the cow except for neonates which often suckle while standing directly under the cow and move backwards to continue suckling as the cow moves forward to feed (Table 7). Only during the first three months are some cows observed feeding while nursing the calf. Later, sucklings take place while the cow is standing inactively. Only 12% of suckling events performed by calves less than one week old are terminated by the calf itself. In almost all other cases the cow actively terminates the nursing by stepping forward and thereby knocking the calf away with its hind leg.

These data reflect that during the initial lactation period when milk production is high, nutritional demands require the cow to feed for as much time as possible. Even very young calves do not have ad libitum amounts of milk available and this indicates that food regime and physical condition of parturient cows probably is sub-optimal for maximal milk production in the post-partum period.

Calf production and survival:

The average composition of the population in 1982-85 was 24% adult bulls (4 years+), 37% adult cows (3 years+), 11% subadults, and a varying number of yearlings and calves. The calf/cow ratios in July-August averaged .57, .61, and .39 in 1982, 1983, and 1984 respectively (Thing and Lassen 1984, H. Thing unpublished data).

Calf production and relative mortality during the first 2 years of life may show considerable variation between years (Fig. 7). Calf crop was around 20% in both 1982 and 1983, whereas calf production was about 12% in 1984.

Assuming that similar living conditions prevailed in 1981 as in the study period the percentage of yearlings in April-May 1982 indicates that 1981 calf production probably was around 18% and the calf/cow ratio about 35% in July-August.

Registration of the various age classes throughout the study period permits an evaluation of cohort mortality. During the study mortality rates in the calf and yearling cohorts were low (Fig. 7). The average percent of calves in the population appeared to be reduced by 18% during the first 12 months and with a further 20% reduction during the following year.

Observations in the field during calving in 1982 indicate that initial mortality among post-partum calves probably is very low if adverse weather conditions do not interfere. A total of 491 individuals in the

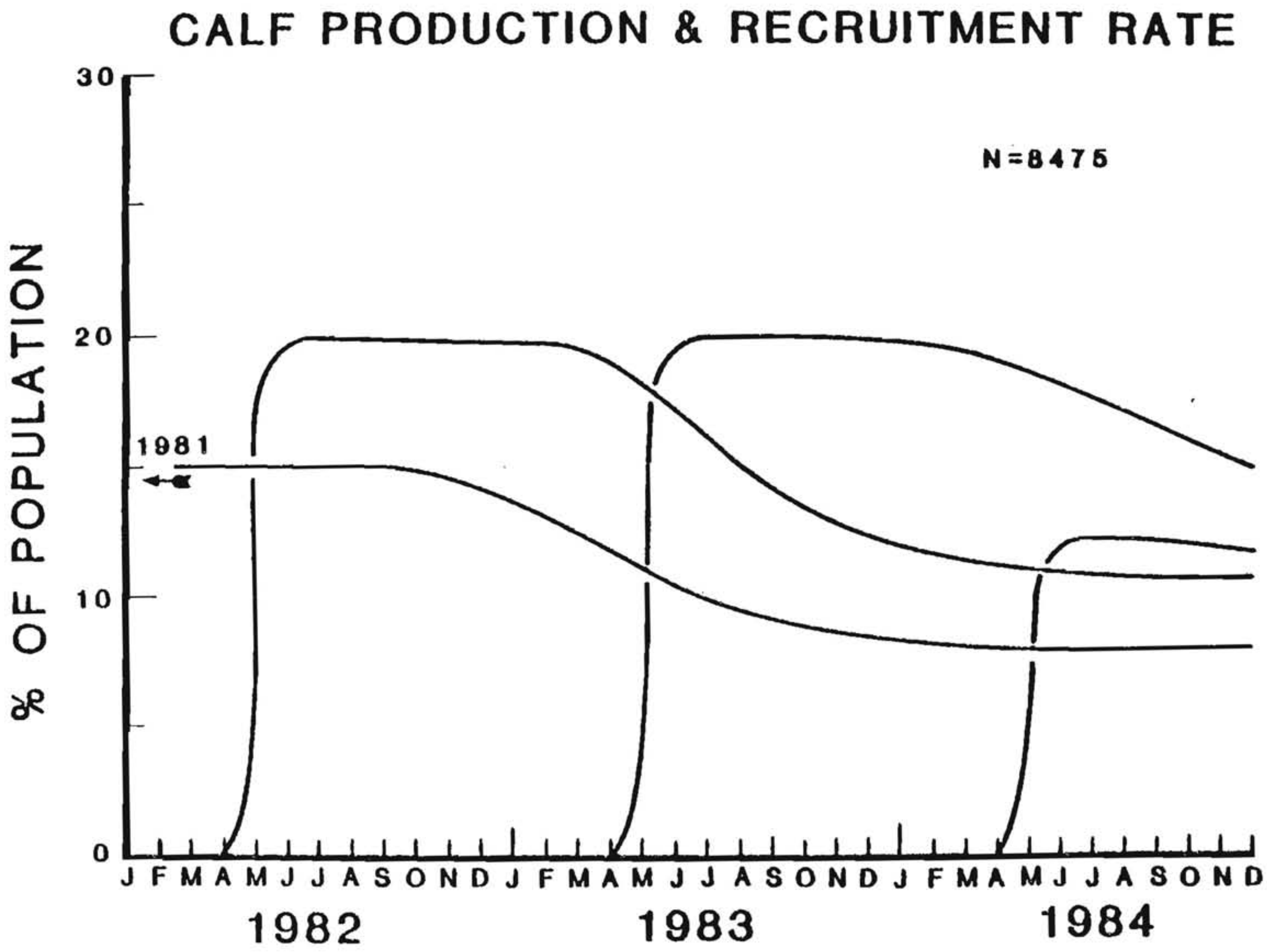

Figure 7. Curves showing annual calf production and recruitment to the muskox population in Jameson Land during 1982-1984.

population have been immobilized and eartagged (Clausen et al. 1984) and among 163 tagged adult cows (4 years+) it has been possible to establish the reproductive history in 1982 - 1985 for 34 individuals.

Based on whether cows were accompanied by a calf during July-August in 1982-84 and during April-May in 1985 these cows had the following reproductive data: 6 (18%) had no calves in two years; 21 (62%) had a calf in 1 out of 2 years; 2 (6%) had a calf in 2 out of 3 years; 3 (9%) had a calf in 2 out of 2 years; and 2 (6%) had a calf in 1 out of 3 years. These data indicate that even during favorable conditions, most cows on Jameson Land produce a viable calf only in alternate years. The observed calf/cow ratio in this sample was .48, not deviating significantly from the average (.52) in 1982-84 in the population as a whole. Alternate year calf production by cows may explain the differences between years in calf ratios as is evident in Fig. 7.

Although most muskox cows on Jameson Land produce calves in alternate years, 4% of all calves (N=1520) were apparently twins, as determined by extended observations of cow-calf pair interactions, nursing behavior, and long term affinity between individuals. This twinning rate is interesting because twinning has been reported only rarely in other wild muskox populations (Urquhart 1982, Alendal 1979, Lent 1978, Wilkinson 1971, Dinneford and Anderson 1984).

Based on population composition, ontogenetic age of carcasses and skeletons sampled in the field, and age-determination by tooth sectioning (N=364), annual mortality ($\varepsilon dx \cdot 100/\varepsilon lx$) in the 5 year+ age class is calculated as 8.6% for cows and 16.2% for bulls, with highest age-specific mortality (dx) among 18-year old cows and 8-9 year old bulls (H. Thing unpublished data).

Assuming the late winter population size is 4100 animals, the annual calf increment and yearling recruitment to the population varied between 492-820 and 403-672, respectively, in 1982-84. Hunting by Inuits from Scoresby Sund removes 300-500 animals (all age classes) from the population annually; a number which is almost identical with the recruitment. Assuming that present hunting pressure, natural mortality, recruitment, and environmental conditions remain unchanged the population would be expected to remain near the present level in the future.

COMPARISON TO OTHER AREAS

Habitat use and diet:

The predominance of graminoids and willows in the diet of muskoxen in Jameson Land is consistent with studies from other areas of muskox distribution (Tener 1965; Fisher and Duncan 1976; Wilkinson et al. 1976; Hubert 1977; Parker 1978; Rapota 1984). Their relative seasonal importance may vary depending on availability, snow cover and forage quality. In winter, when deep snow or icing can make low-lying, hydric meadows unavailable for foraging, muskoxen select drier upland sites where less effort is required to expose the forage. On Nunivak Island, where annual snowfall exceeds 135 cm (Bos 1967), muskoxen are mostly prevented from using the interior of the island and concentrate on the windswept marine escarpments or dune areas along the coast where beach rye grass (Elymus arenarius) is the dominant forage species in winter (Lent and Knutson 1971). Deeper than average snow conditions are also common in the Thelon Game Sanctuary on the Canadian mainland where muskoxen predominantly use willows that grow on exposed hummocks or protrude through the snow cover (Tener 1965). Willows continued to be important in the winter diet of muskoxen along the riparian habitats of Sadlerochit river in northeastern Alaska (Jingfors 1980). In the Canadian High Arctic, as in Jameson Land, graminoids dominate the winter diet as snow cover tends to be more shallow and the growth form of the arctic willow (Salix arctica) more prostrate and thus less available than in other areas.

In summer, forage quality appear to strongly influence the diet of muskoxen. Selective grazing on new willow growth, high in nutrients, was also observed on Ellesmere Island (Tener 1965) and Bathurst Island (Jingfors 1980) in the Canadian High Arctic. On Bathurst Island, peak use of Salix arctica was correlated with N content and a diet change to graminoids occurred as the N content in S. arctica decreased and the leaves turned yellow. The switch to graminoids in late summer was also evident in Jameson Land and on Ellesmere Island. In contrast, Parker (1978) found a dramatic reverse shift from graminoids to willow in mid-August based on plant species composition of muskox fecal samples collected at Bailey Point on Melville Island. Graminoids were less important in the summer diet of muskoxen along Sadlerochit River where N-rich legumes were mixed with abundant willow species to provide a high quality diet throughout the growing season (Robus 1984). The importance of phenology and selective grazing for rapidly growing, and nutritious, plant parts has also been described from muskoxen in Norway (Alendal 1971).

Physical condition:

Seasonal changes in forage quantity and quality combined with specific energy and nutrient demands for lactation, breeding, and growth appears to have pronounced effects on muskox activity budgets (Jingfors 1982), food intake (White et al. 1984), and body energy reserves as shown from Jameson Land. Few comparative studies have been made of seasonal fluctuations in body weight of muskoxen. However, the low total body weights found in cows during post-calving (mid-May to mid-June) correspond to observations by Wilkinson (unpublished; in Hubert 1977) from the Domestication Farm in Fairbanks where 5 lactating cows lost an average of 29 kg each in 3 weeks following parturition. Hubert (1977) used growth rates from captive muskoxen in Fairbanks to extrapolate seasonal changes in body weights of wild muskoxen on Devon Island. He postulated that the weight loss in cows continued until fall (Aug.-Sept.) and that cows reached their maximum weight in mid-winter (Jan.-Feb.). In Jameson Land, cows reached their maximum weight in late July and slowly lost about 25% of their carcass weight between September and April. For bulls, Hubert suggested a significant weight gain from mid-summer (June-July) until the rut (early Aug.) similar to what was found in Jameson Land. However, Hubert also suggested that the weight loss during and following the rut was partly compensated for by a weight gain in mid-winter (Dec.-Jan.). This was not apparent among bulls examined in Jameson Land where total body weight in early winter was almost equal to that of late winter.

The largest sample of muskox weights has been collected from commercial harvests on Banks Island during April-May 1981-83. Adult cows (3 yrs+) averaged 188 kg (n=83) in 1981, 162 kg (n=22) in 1982, and 167 kg (n=41) in 1983 (P. Latour, unpublished data). Adult bulls were harvested mainly in 1981 when total body weight averaged 253 kg (n=43). The muskoxen on Banks Island were reported to be in excellent physical condition at the time of harvests (P. Latour pers. comm.; Tessaro et al. 1984). In comparison, muskoxen on Jameson Land reached their lowest weight during the calving period (April-May) when bulls averaged 215 kg and cows 135 kg. On Devon Island, bulls averaged 266 kg (n=5) in May (Hubert 1974) and on Nunivak Island, weights from adult cows in late March and early April were also higher (mean: 172 kg, n=6; Lent 1978) than those recorded from Jameson Land.

Nursing behavior:

The peak of calving occurred during the first week of May which is consistent with reports from most other areas (Jingfors 1984a). Observations of nursing behavior in muskoxen can be useful when comparing range quality and animal productivity between areas and in the case of Jameson Land, the duration of nursing bouts are comparable to those recorded on Bathurst Island where some yearlings were also nursed (Jingfors 1984a). Earlier weaning of calves and longer nursing bouts throughout the post-partum period were recorded from Sadlerochit River in northeastern Alaska where an earlier onset of the growing season and a higher plant productivity likely allowed lactating cows to provide their calves with more milk. More nursing bouts were also terminated by young calves (<2 wks old) at Salderochit River than was observed among newborn calves (<1 wk old) in Jameson Land (20% versus 13%). It appears that the physical condition of cows in Jameson Land is more similar to muskoxen in the High Arctic (i.e. Bathurst Island) and thus sub-optimal for maximal milk production.

Calf production:

The proportion of calves in the Jameson Land population is high (20%) but corresponding calf/cow ratios are comparatively low (57-61 calves/100 cows) probably as a result of the skewed adult sex ratio in favor of cows and the probability of alternate year breeding. Calf productivity, as measured by the number of calves per cow of reproductive age, is lower than in introduced populations in Alaska (Jingfors and Klein 1982), Russia (Rapota 1984), and on West Greenland (Thing et al. 1984), and when compared with expanding populations on Banks Island (Urquhart 1973; P. Latour unpublished data) and Victoria Island (Jingfors 1984b). However, productivity in Jameson Land, at least in 1982 and 1983, was higher than has been reported for most muskox ranges in the High Arctic (Tener 1965, Freeman 1971, Gray 1973, Parker et al. 1975, Hubert 1977).

Recent studies have shown that alternate year breeding in muskoxen is the exception rather than the rule as breeding in successive years has been reported for most populations (Lent 1978, Gunn 1982, Jingfors and Klein 1982, Dinneford and Anderson 1984, Smith 1984, Tessaro et al. 1984, Uspenski 1984). Even in the Canadian High Arctic, where productivity estimates are generally lower, breeding in successive years has been documented (Miller and Gunn 1979; Jingfors 1980) suggesting a potential for rapid increase given favorable environmental conditions similar to the "boom-and-bust" rates of population change suggested by Hubert (1974). If most cows in Jameson Land only produce calves in alternate years, as observed among the marked muskoxen, the indication that twinning may occur is rather surprising. Twinning in free-ranging muskoxen has only been demonstrated conclusively from Nelson Island and Nunivak Island where Dinneford and Anderson (1984) found that 4% of the pregnant cows examined (n=107) carried twin fetuses. None of the 146 cows examined on Banks Island between 1981-1983 showed signs of twinning (P. Latour pers. comm.). Further observations of muskoxen in Jameson Land, including examination of hunter killed cows, are needed to verify to what extent twinning occurs.

Quantitative information on sex- or age-specific mortality rates in muskoxen is limited and usually inferred from annual composition counts. Calf mortality in Jameson Land (around 40%) is higher than the reported averages for northeastern Alaska (<5%; Jingfors 1980, Reynolds and Ross 1984), Nunivak Island (15%; Lent 1978) and Banks Island (25%; P. Latour unpublished data). On Devon Island, Hubert's (1977) estimates of annual calf mortality varied from 67% in 1970/71 to 22% in 1971/72 and 25% in 1972/73. Calf mortality rates, like natality rates, can be expected to vary greatly between years, particularly in the High Arctic where total reproductive failure can occur as a result of severe environmental conditions (Vibe 1967, Gray 1973, Miller et al. 1977). Using the population parameters observed on Jameson Land, i.e., age structure and age-specific survival and birth rates, and assuming a late winter population size of 4100 muskoxen with an annual harvest of 300-500, the population will remain stable.

CONCLUSION

Muskoxen in Jameson Land show characteristics of foraging behavior, plant species selection, productivity and nursing behavior that appear to be intermediate between the Alaskan muskox ranges and those in the Canadian High Arctic. This appears to be a function of the decreasing plant productivity and vegetation type diversity from south to north as well as the influences of length of plant growth season, duration of winter, and associated snow cover.

Specific characteristics of the ecology of muskoxen in Jameson Land include:

1) Graminioids dominate the winter diet but willows are an important component; less so than in Alaska and more so than in the Canadian High Arctic.
2) In summer willows are the major dietary component.
3) Elevated, wild-exposed dry dwarf shrub heath is the vegetation type favored for winter foraging whereas low-lying, moist meadows and snow bed vegetation are preferred during summer.
4) Relative quailty of forage (protein/fiber) in July is about five times higher than during winter.
5) Muskox suppliment dietary intake of sodium by eating sodium-rich soil at several mineral licks during summer.

6) Body energy reserves are only partially depleted by the end of winter. Decrease in total body weight over winter apparently includes catabolism of muscle tissue and omental-periintestinal fat reserves with minimal reduction of subcutaneous and kidney fat reserves. Muskoxen, especially females, possess considerable unused fat reserves at the onset of calving and these are drawn upon primarily during the post calving-early summer period. These fat reserves undoubtedly also contribute to the fitness of the animals under extreme winter conditions or when late snow melt delays initiation of plant growth.

7) Fitness of adult cows is also enhanced through alternate year breeding (or failure to breed), apparently in response to variation in environmental constraints.

8) Suckling behavior reflects the suboptimal habitat conditions that exist in Jameson Land. Neonates do not have ad libitum availability to milk post partum and calves are frequently not weaned before the end of their first winter.

9) Mean calf mortality (during 2nd through 12th month) is 18 percent whereas yearling mortality is 20 percent.

10) In the absence of significant predation, annual hunting removal of 300-500 muskoxen by Inuits from Scoresbysund nearly matches the annual increment to the population.

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