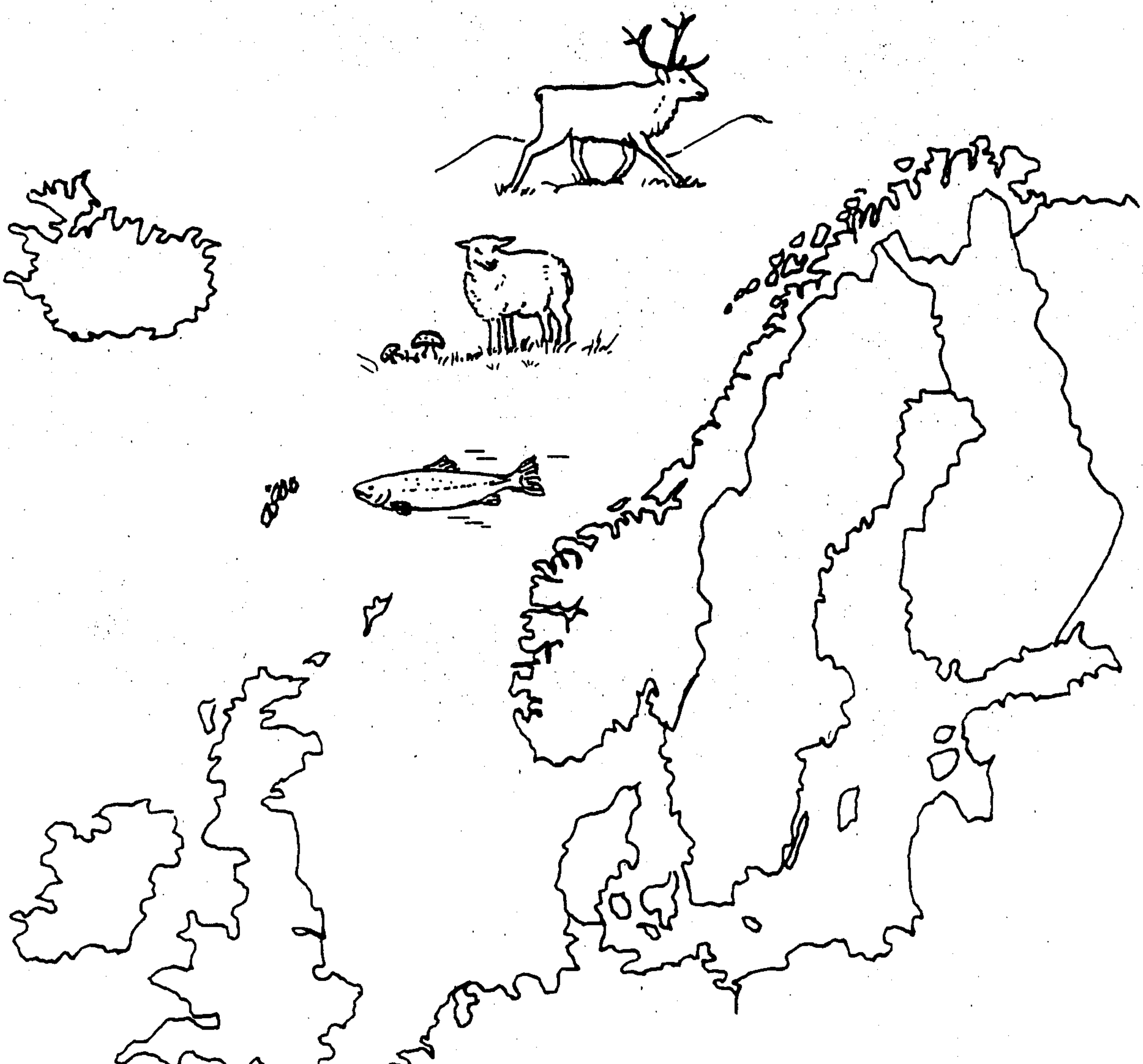
TECHNICAL REPORT EKO-2.1

THE SHEEP PROJECT 1996

TR-EKO-2(1997)1



NORDISK KJERNESIKKERHETSFORSKNING

INTRODUCTION

The EKO-2 project, "Long ecological half-lives in semi-natural systems", consists of three subprojects; sheep grazing on uncultivated pasture, mushroom and freshwater fish. The main aim is to identify the contribution from semi-natural systems, by determining ecological half-lives for specific foodstuffs from these areas, and thus determine dose to man.

The study of transfer of radiocesium and radiostrontium from soil to vegetation and sheep are performed in «the sheep-project». The soil - vegetation - sheep - system is studied in five countries; Iceland, The Faeroe Islands, Denmark, Sweden and Norway. Co-ordinated collection of soil, vegetation and meet samples have been performed every year since 1990 (in this framework since 1994). These time series give good basis for calculating the ecological half-lives in the different areas studied.

The recovery of Nordic ecosystems from contamination by ^{137}Cs originating from the Chernobyl accident is gradually slowing down, at the same time as areas vary widely in susceptibility and recovery rates. Accordingly, ecological half-lives are gradually increasing and cannot be treated as constants, over neither time nor space. Although it has not been easy to determine simple or general ecological half-lives, the projects have given us useful understanding of the mechanisms governing the transfer of radionuclides, and more knowledge about typical Nordic ecosystems.

Large differences in transfer are found, especially in the soil to plant transfer between the different locations, most of it can be described by the different soil types.

Sampling in the selected areas was performed also during the summer of 1996. The year 1996 did not turn out to be the "good mushroom year" we were hoping for. Results from the investigation of mushroom intake by sheep are therefore difficult to interpret. The change of the Icelandic site (after 1994) clearly demonstrates the inhomogeneity of uncultivated areas in Iceland.

This technical report consists of the results from the sheep project during the last year (1996).

Please do not refer to the results given in this report without prior consent of the authors. The material will later be published in an international scientific journal.

TONE

20.01.97

TABLE OF CONTENT

SOIL MOBILITY: LABORATORY STUDIES

Deborah Oughton, Egil Tronstad, Lindis Skipperud.
Laboratory for Analytical Chemistry, Agricultural University of Norway, P.O. Box 5026, 1432 Ås, Norway

Cs and Sr Mobility Studies

Objectives: To use ^{134}Cs and ^{85}Sr to study the rates of Cs and Sr fixation in soild from EKO-2 sites. The mobility of radionuclides in soils will influence soil-to-plant transfer factors. The rate at which radionuclides are removed to irreversibly bound sites in soils (i.e. rates in decrease of mobility) will influence the ecological half-life.

Work Carried Out: Tracer studies (^{134}Cs and ^{85}Sr) on Tjøtta (N) and Hestur (IS) soils are finished, studies on Blomhøjden (S) and Ribe (DK) soils are nearly finished. Experiments will be started on Faroe Island soils and the new Iceland site (Iceland-II) as soon as the Icelandic soils are available. Soil characteristics are summarised in Table 1 and 2.

Results: Tracer studies show clearly that radionuclide mobility in soils varies at the different sites and within different soil types at the same site. Both Cs and Sr are rapidly sorded to soil components, but whereas Sr remains in ion-exchangable, easily extractable forms, Cs is strongly bound to soil components. Organic content and pH seems to have the greatest influence on ^{85}Sr mobility. Mineral type and content is probably the most impotant factor for Cs mobility (Table 1). Modelling shows that long-term fixation rates of ^{134}Cs to irreversibly bound sites vary between the different sites and vary from a half-time of a couple of years to more than 30 yrs (Table 1).

Conclusions:

- Tracer studies suggest that the fraction of mobile Cs and Sr in soils can show considerable variation between the different sites. The lack of any strong correlation between soil characteristics and Cs mobility warn against trying to predict either the mobility of Cs or Cs transfer factors at other Nordic sites on the basis of soil characteristics.
- Fixation rates do not follow simple first order kinetics: the rates decrease with time. This both supports and stresses the importance of observations that ecological half-lifes need not be constant as a function of time. Of course, for modelling purposes, fixation rates are just one of the rate determining parameters that can influence ecological half-lifes.
- As Sr is not fixed in these soils, the rate-determining parameters for ecological half-lives would be expected to be transport down the soil profile and removal with produce and run-off.

Samples needed in 1997: None!

NAA (Stable Cs and Sr analysis) of Soil, Vegetation and Lamb

Objectives: To determine stable Cs and Sr and other trace element concentrations in soil, vegetation and sheep samples. Stable Cs and Sr transfer factors will give important information on the equilibrium transfer factors at the different sites, and will help to identify sites that are ecologically sensitive to Cs (i.e. high transfer factors). Activation analysis also provides helpful data on the behaviour of other trace metals in these ecosystems

Work Carried Out: Samples have now been received from each site for at least 1994 and/or 1995 (excepting Iceland-II).

Results: Available data is given in Tables 3-5.

Conclusions:

- Analysis of stable Cs shows a large variation in trace element concentrations and soil-to-plant concentration ratios between the different sites. Plant-to sheep concentration ratios are similar, apart from the Faroe Islands. This data could be of use when checking models. At equilibrium, soil-to-plant transfer factors should not be less than that for stable Cs.

Samples needed for 1997: Vegetation and Sheep meat from the new Iceland site. Otherwise, we will concentrate on soil ingestion and samples of faeces, vegetation and fungi for the rest of the project.

SOIL INGESTION

Objective: To investigate the use of NAA as a method of determining soil content in faeces, and thereby soil ingestion in sheep. Stable Cs and other trace element concentrations in faeces will also give important information on reliablity of sheep diet calculations based on vegetation data.

Work Carried Out: Faeces samples have been analysed from Blomhøyden (grab samples, 1995 and 1996) and Ribe sheep.

Results: Scandium is easily detected in the faeces samples, and the method is extremely sensitive. The "expected" concentration of trace elements in the faeces is calculated from the vegetation data. If the measured concentration is greater than the "expected" concentration then the sheep might not be eating what we think it is, i.e. soil or a diet different to "mixed vegetation". Elements which have a large difference in soil and vegetation concentrations (ie about three orders of magnitude) give the best estimate of soil ingestion (namely Sc, Fe, Cr). Hence, we can show that Blomhøyden faeces contain soil (Table 6). Calculations give what I consider to be a pretty reliable estimate of a *maximum* soil ingestion of about 20 ± 5 mg soil/g faeces. These estimations of soil ingestion can then be used to adjust the "expected" concentrations.

The Ribe sheep show very little evidence of soil ingestion. We have only analysed three vegetation samples from Ribe, and two showed high soil contamination. The sheep have a lower ingestion of soil than anticipated from soil contamination of the vegetation. They probably eat "cleaner" vegetation than that samples at Ribe! "Expected" concentrations in faeces have been calculated from the one clean vegetation sample. New samples from Ribe are counting at the moment.

In Blomhøyden sheep, calculated and "expected" concentrations in faeces concentration differ for elements other than Sc/Fe/Cr. This is evidence that the sheep are eating other vegetation or fungi species, or perhaps concentrations in water are high. For Cs, Sr and Zn we need an "extra intake" of *at least* between 50-100%. For Co we are "down" by 400%. (Rb is lower than expected which can be accounted by less than 100% extraction in faeces). Analysis of individual vegetation species from Blomhøyden suggests that this is not impossible.

Conclusion:

- NAA gives very promising results as a sensitive method for assessment of soil ingestion.
- The above calculations make a lot of assumptions, and hence there is room for both error and improvement (e.g., dry weight digestibility of the vegetation; faeces to urine excretion ratios, equilibrium status). We need to check the sensitivity of the soil ingestion estimate to these assumptions.
- Preliminary calculations suggest that collected vegetation doesn't reflect the sheep diet.

Samples wanted in 1997: Faeces (and fungi?) samples when available - after Morten's fungi spore tests.

Table 1: Soil Characteristics (Tracer Studies).

	pH (H_2O)	LOI (%)	Na	Mg	Ca	K	H^+	CEC	Base sat. (%)	MF (%)
Tjøtta 1	6.6	21.1	0.5	1.0	28.2	0.2	0	29.9	100	**<0.5%**
Tjøtta 2	5.2	61.4	1.5	5.3	42.1	1.1	38.6	88.7	56.5	**<0.5%**
Tjøtta 5	5.4	77.5	1.4	6.9	42.0	1.5	35.9	87.9	59.1	**1%**
Hestúr 1	6.0	35.5	1.1	7.5	7.0	1.1	17.6	34.4	48.9	**30%**
Hestúr 2	5.3	44.4	1.1	4.5	5.8	1.6	28.1	41.2	31.9	**25%**
Ribe 1	4.9	10.5	0.1	1.2	1.0	1.7	14.3	18.4	22.0	**28%**
Ribe 2	5.4	7.3	0.9	0.6	1.8	2.6	9.5	15.4	38.1	**10%**
Blom 3	5.5	44.4	0.4	2.1	5.5	15.0	26.0	49.0	46.9	**27%**
Blom 4a	5.9	28.7	0.2	1.2	2.2	7.8	11.7	23.1	49.5	**26%**
Blom 5	4.5	6.3	0.0	0.3	0.4	1.4	14.8	17.0	12.7	**5%**
Glubokva	5.7	2.2	0.1	0.3	0.6	4.1	2.2	7.1	69.5	**<2%**

MF: Mobile Fraction of ^{137}Cs (NH_4Ac extractable) after 200 days contact time.

Table 2: LOI and pH (Other Soils)

	pH water	pH $CaCl_2$	LOI %	CEC meq/100g	Base sat[n] %
Tjøtta 1*	6.6	-	21.1	29.9	100
Tjøtta 2*	5.2	-	61.4	88.7	56.5
Tjøtta 5*	5.4	-	77.5	87.9	59.1
Tjøtta 1	6.5	-	6.7		
Tjøtta 2	6.7	-	16.5		
Tjøtta 3	5.3	-	18.1		
Tjøtta 4	5.1		29.4		
Tjøtta 5	5.7		49.4		
Tjøtta 6	5.6		90.9		
Hestúr 1	6.0	5.3	35.5	34.4	48.9
Hestúr 2	5.3	4.8	44.4	41.2	31.8
Blomhöjden 1	4.7	-	26.6		
Blomhöjden 2	5.5	-	10.8		
Blomhöjden 3	5.5	-	44.4		
Blomhöjden 4a	5.9	-	28.7		
Blomhöjden 4b	5.4	-	29.6		
Blomhöjden 4c	4.3	-	37.7		
Blomhöjden 5	4.5	-	6.3		
Ribe 1	4.9	-	10.5		
Ribe 2	4.9	-	10.5		
Ribe 3	4.7	-	8.6		
Ribe 4	5.5	-	11.7		
Ribe 5	5.4	-	7.3		
Ribe 6	5.8	-	7.2		

*1993 samples

Table. Rates of *^{134}Cs fixation to Irreversibly Bound Sites.*

Site	T½ (y)
Tjøtta	> 30
Blomhøyden	3-6
Hestur	8-12
Ribe	10-15
Faroe Islands	
Iceland II	

NB: Half-lifes increase (fixation rates decrease) with contact time. These figures will be adjusted in 1997.

Table 3a: Trace Element Concentrations (µg/g) in Whole Soil Samples (NAA analysis). Mean ± SEM (range).

	Ce	Co	Cr	Cs	Eu	Fe mg/g	Rb	Sc	Se	Sr	Zn
Tjøtta n=12	60.1 ± 8.0 (27-104)	6.1 ± 1.0 (3.9-10)	96 ±13 (57-194)	1.31 ± 0.16 (1.12-1.91)	1.04 ±0.09 (0.42-1.5)	22 ± 3 (14-38)	32 ± 3 (26-42)	6.8 ± 1.0 (5.6-12)	1.3 ±0.5 (1.2-1.5)	206 ± 11 (149-263)	44.5 ± 4.5 (19-73)
Hestúr n=11	18.5 ±1.3 (10-25)	33 ± 5 (19-67)	73 ± 3 (49-85)	0.11 ± 0.01 (0.08-0.13)	1.00 ± 0.07 (0.63-1.4)	51 ± 8 (31-122)	ND	16.6 ± 0.8 (10-20)	1.4 ± 0.1 (1.0-1.7)	154 ± 23 (87-293)	176 ± 10 (127-215)
Blom-höjden n=19	15.3 ± 0.8 (9.5-20.6)	8.1 ± 1.3 (3.5-24)	98 ± 6 (59-152)	1.25 ± 0.07 (0.8-2.0)	0.56 ± 0.04 (0.36-1.1)	23 ± 1 (14-35)	46 ± 3 (28-66)	10.8 ± 0.5 (7-15)	0.9 ± 0.3 (0.7-1.3)[a]	192 ± 6 (148-255)	126 ± 13 (81-161)
Blom. 1995 n = 21	16.0 ± 1.8 (7.1-34)	6.9 ± 0.9 (2.0-20)	72 ±6 (21-150)	1.30 ±0.08 (0.9-2.2)	0.44 ± 0.03 (0.16-0.89)	23 ± 2 (9-42)	41 ±3 (21-67)	9.5 ± 0.5 (4-13)	--	112 ±7 (47-175)	61.2 ±8.6 (38-194)
Ribe n=12	25.3 ±7.7 (9.8-104)	1.2 ± 0.1 (1.0-1.7)	42 ±14 (15-186)	1.49 ± 0.15 (0.7-2.1)	0.23 ± 0.01 (0.16-0.30)	9.8 ± 3.1 (5.4-43)	36 ± 2 (29-44)	2.5 ± 0.2 (1.5-3.0)	--	47 ± 5 (35-56)	18.0 ±1.3 (12-27)
Faroe Is.[a] n=8	10.1 (6.2-18.3)	23.0 (9.2-35)	169 (69-449)	0.20 (0.07-0.36)	0.76 (0.52-1.2)			13.6 (6.9-17.7)	3.3 (1.1-5.7)	138 (75-254)	79 (40-130)

a - Average of all sites. Individual data below.

Table 3b: Trace Element Concentrations (µg/g) in Vegetation (NAA analysis). Mean ± SEM (range).

	Ce	Co	Cr	Cs	Eu pg/g	Fe	Rb	Sc	Se	Sr	Zn
Tjøtta n=8	ND	0.12 ± 0.06	ND	0.17 ± 0.03	ND	67 ± 11	26 ± 6	0.004 ± 0.001	ND	26 ± 9	90 ± 13
Hestúr n=10	0.16 ± 0.02 (0.08-0.24)	0.7 ± 0.1 (0.5-1.4)	ND	0.13 ± 0.01 (0.09-0.22)	5.9 ± 0.7 (2.6-9.3)	412 ± 63 (131-744)	11 ± 2 (4-20)	0.09 ± 0.01 (0.04-0.17)	ND	27 ± 1 (23-32)	23 ± 3 (14-45)
Blom-höjden n=24	ND	0.16 ± 0.03 (0.03-0.2)	ND	0.13 ± 0.02 (0.03-0.57)	ND	48 ± 3 (30-97)	38 ± 3 (15-66)	0.006 ± 0.001 (0.002-0.07)	ND	23 ± 2 (10-48)	83 ± 20 (19-351)
Blom 1995 n=5	ND	0.11 ±0.05	ND	0.13 ±0.04	ND	56 ± 10	46 ±5	0.007 ± 0.002	ND	17 ± 4	40 ± 9
Ribe n=	0.06 ± 0.03 (0.01-0.08)	0.19 ± 0.03 (0.15-0.26)	5.5 (1-15)	0.011±0.003 (0.004-0.017)	1.9 ± 0.2 (1.6-2)		2.2 ± 0.3	0.12 ± 0.004 (0.04-0.16)	ND		7.7 ± 1.2 (5.3-9.1)
Faroe Is. Mean	0.29 (0.09-0.62)	0.32 (0.13-0.73)	2.4 (0.6-8)	0.026 (0.004-0.069)	19 (3-24)		4.6 (2-9)	0.12 (0.06-0.23)	0.34 (0.16-0.38)	28.9 (19-34)	28.1 (18-44)

Table 4a: Trace Element Concentrations (µg/g) in Faroe Island Soil Samples (NAA analysis). Mean ± SEM (range).

	Ce	Co	Cr	Cs	Eu pg/g	Fe	Rb	Sc	Se	Sr	Zn
Velbastadur	18.3 ± 3.6	28.8 ± 0.9	144 ± 5	0.10 ± 0.01	1.17 ± 0.05			16.0 ±2.0	1.1 ±0.3	202 ±7	130 ±11
Skåli	9.7 ±0.8	17.7 ± 1.7	140 ± 12	0.22 ± 0.02	0.86 ±0.09			13.8 ±2.3	3.7 ±0.3	154 ± 8	88 ±11
Hvalik	7.8 ± 1.2	9.2 ±3.2	85 ± 29	0.17 ± 0.02	0.55 ± 0.13			6.9 ± 2.1	5.7 ±0.7	101± 23	40 ± 8
Bøur	10.2 ± 1.7	35.4 ± 2.5	449 ± 34	0.07±0.005	0.89 ± 0.06			17.7 ± 1.2	1.1 ±0.2	254 ±18	118 ±15
Hvalba	8.1 ± 1.0	24.7 ± 3.2	139 ± 29	0.18 ± 0.04	0.58 ± 0.07			11.6 ± 1.3	2.6 ±0.6	75 ± 15	54 ± 5
Nordoviri	6.2 ± 0.8	20.0 ± 3.0	201 ± 31	0.23 ± 0.01	0.52 ± 0.08			15.2 ± 2.5	4.3 ±0.4	144 ±29	70 ± 10
Sandur	12.1 ± 1.0	26.2 ± 1.9	123 ± 7	0.26 ± 0.02	0.90 ± 0.06			16.5 ± 1.3	5.1 ±0.4	92 ± 24	81 ± 9
Sumba	8.4 ± 1.3	22.1 ± 5.2	69 ± 12	0.36 ± 0.05	0.64 ± 0.1			11.0 ± 1.9	2.8 ±0.8	84 ±47	49 ± 6
Mean	10.1	23.0	169	0.20	0.76			13.6	3.3	138	79

Table 4b: Trace Element Concentrations (µg/g) in Faroe Island Mixed Vegetation Samples (NAA analysis). Mean ± SEM (range). n=4

	Ce	Co	Cr	Cs	Eu pg/g	Rb	Sc	Se	Sr	Zn
Vegetation										
Velbastadur	0.34 ± 0.04	0.48 ± 0.06	1.6 ± 0.2	0.069 ± 0.004	0.021 ± 0.004	5.8 ± 0.5	0.23 ± 0.04	0.38	31.6 ± 1.8	33.7 ± 3.1
Skåli	0.18	0.13 ± 0.02	0.85 ± 0.1	0.025 ± 0.003	0.008 ± 0.001	7.3 ± 1.5	0.07 ± 0.01	0.25 ± 0.03	33.5 ± 1.3	43.5 ± 3.2
Hvalik	0.62 ± 0.26	0.73 ± 0.35	7.9 ± 5.3	0.059 ± 0.011						
Bøur	0.55 ± 0.15	0.25 ± 0.04	2.3 ± 0.5	0.0042 ± 0.0011	0.024 ± 0.006	9.2 ± 1.8	0.14 ± 0.03	0.16 ± 0.01	30.1 ± 3.5	36.4 ± 2.6
Hvalba	0.14 ± 0.06	0.32 ± 0.09	1.6 ± 0.5	0.0063 ± 0.0009	0.0093 ± 0.0019	2.20 ± 0.02	0.12 ± 0.03	0.25 ± 0.04	31.6 ± 2.3	20.9 ± 0.5
Nordoviri	0.15 ± 0.02	0.22 ± 0.04	1.9 ± 0.5	0.017 ± 0.002	0.011 ± 0.002	1.9 ± 0.3	0.055 ± 0.012	0.51 ± 0.11	28.6 ± 0.6	18.0 ± 1.3
Sandur	0.09 ± 0.03	0.14 ± 0.04	0.63 ± 0.10	0.0093 ± 0.0016	0.0032 ± 0.0013	3.5 ± 0.7	0.057 ± 0.009	0.35 ± 0.06	19.4 ± 0.9	28.0 ± 1.0
Sumba	0.28 ± 0.03	0.26 ± 0.02	2.3 ± 1.0	0.021 ± 0.002	0.016	2.4	0.18 ± 0.02	0.51 ± 0.24	26.6 ± 4.4	16.8 ± 0.4
Average	0.29	0.32	2.4	0.026	0.019	4.4	0.12	0.34	28.9	28.1

Table 5: Concentrations and concentration ratios (CR) of naturally-occurring stable caesium in soil-plant-sheep system. Mean ±SEM (Range). Units: ug/g .

	Soil DW	Plant DW	Sheep FW	CR soil-veg	CR veg-sheep
Hestur 1994	0.107 ± 0.007 (0.08 - 0.13)	0.127 ± 0.015 (0.084 - 0.22)	0.069 ± 0.004	1.19 ± 0.23	0.54 ± 0.08
N Site 1995	Counting	Samples ?	Samples ?		
Blom. 1994	1.25 ± 0.07 (0.83 - 2.0)	0.107 ± 0.015 (0.038 - 0.29)	0.092 ± 0.012 (0.48 ewe)	0.086 ± 0.017	0.85 ± 0.23
Blom. 1995	1.30 ± 0.08	0.13 ± 0.04	Counting	0.10 ± 0.03	
Blom 1996	na	Counting	---		
Tjøtta 1995	1.31 ± 0.16	0.098 ± 0.019	0.076*	0.075 ± 0.017	0.78*
Tjøtta 1996	Waiting for Samples	Waiting for Samples	Waiting for Samples		
Faroe Is. 1994/5	0.20	0.019		0.095	
Velb.	0.10	0.069	0.037	0.60	0.54
Skåli	0.22	0.025	Counting	0.11	
Hvalik	0.17	0.059	0.027	0.37	0.45
Bøur	0.07	0.0042	Counting	0.06	
Hvalba	0.18	0.0063	Counting	0.035	
Nordov.	0.23	0.017	Counting	0.074	
Sandar	0.26	0.0093	Counting	0.036	
Sumba	0.36	0.021	Counting	0.058	
Ribe 1995	1.49 ± 0.15	0.004*	0.0040 ± 0.0008	0.002	1.0

* - Only one vegetation sample without soil contamination.

Table 6. Trace element concentrations in faeces, vegetation and soil from Blomhøjden, Sweden (ug/g ± SEM)

	Co	Cr	Cs	Fe	Rb	Sc	Sr	Zn
Soil (n=19)	8.7 ± 1.3	98 ±6	1.25 ± 0.07	22500 ± 1400	46 ± 3	10.8 ± 0.5	185 ± 12	127 ± 9
Veg (n=24)	0.16 ± 0.03	nd	0.12 ± 0.02	47.7 ± 3.3	38 ± 3	0.006 ± 0.001	23 ± 2	83 ± 20
Faeces - expected[a]	0.4	0	0.2[b]	120	95	0.015	58	200
Faeces - measured (n=17)	2.7 ± 0.1	2.3 ± 0.8	0.39 ± 0.03	637 ±17	48 ± 14	0.17 ± 0.07	122 ± 5	330 ± 21
mg soil/ g faeces	-	23 ± 7	-	23 ± 5	-	14 ± 7	-	-

[a] The amount in faeces calculated from vegetation concentration levels. This assumes that the animal is at equilibrium with respect to the stable element, that the dry weight digestibility of vegetation is 60%, and that 100% of the ingested element is excreted in faeces for all elements apart from [b], Cs, where I have used an excretion ratio of 2:1 faeces:urine.

Table 7. Trace element concentrations in faeces, vegetation and soil from Ribe, Denmark (ug/g ± SEM)

	Co	Cr	Cs	Fe	Rb	Sc	Sr	Zn
Soil (n=12)	1.2 ± 0.1	42 ±14	1.49 ± 0.15	9800 ± 3100	36 ± 2	2.5 ± 0.2	47 ± 5	18 ± 1.3
Veg (n=1)	0.18	0.5	0.004	17	2.1	0.004		5.3
Faeces - expected[a]	0.44	1.25	0.011[b]	44	5.3	0.01	-	13.3
Faeces - measured (n=3)	0.05	0.55	0.026	77	4.0	0.02	14.5	11.6
mg soil/ g faeces	-	-	-	3-8	-	4-8	-	-

Work done by Risø National Laboratory in 1996 on the NKS/EKO-2 Project

Consumption of lamb in Denmark

In 1995 a national survey was carried out on food consumption in Denmark (LST, 1996). The consumption of lamb for the age group 7-80 y was found at an average of 3 g d^{-1} corresponding to an annual intake of 1 kg y^{-1}. The average consumption of lamb in Denmark is thus quite low compared to the average consumption of meat and meat products which was found from the same survey at a value of 42 kg y^{-1} for adults.

LST (1996). Danskernes kostvaner 1995, Hovedresultater, Publikation 235. Levnedsmiddelstyrelsen, Søborg, Danmark.

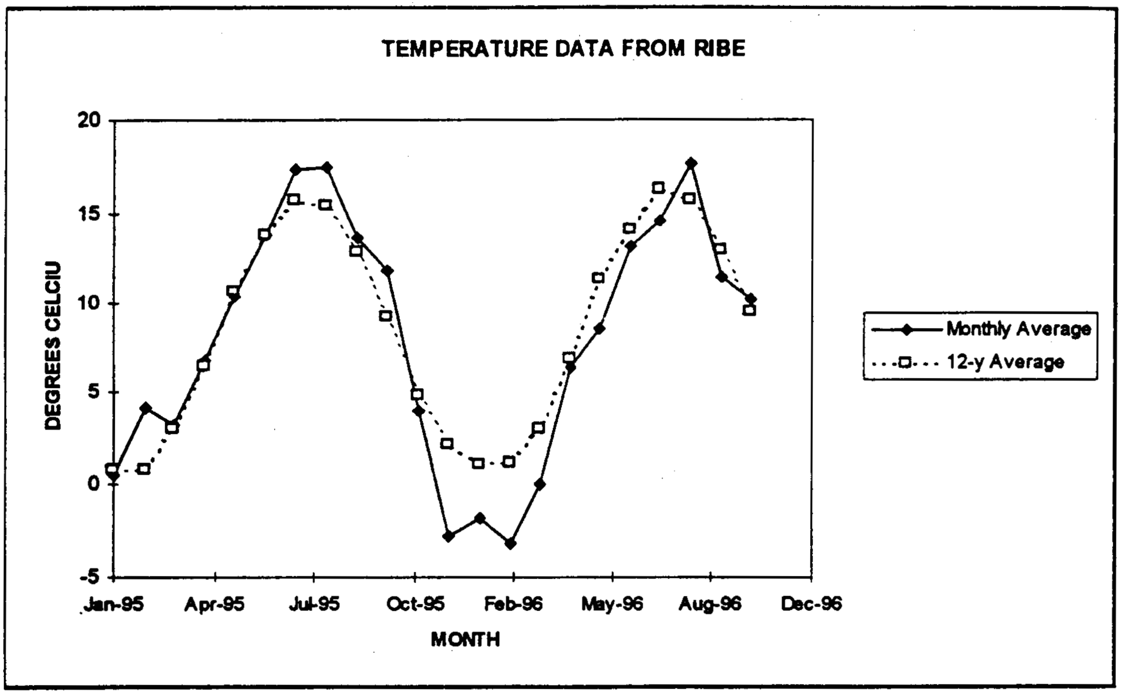
Influence of fungi

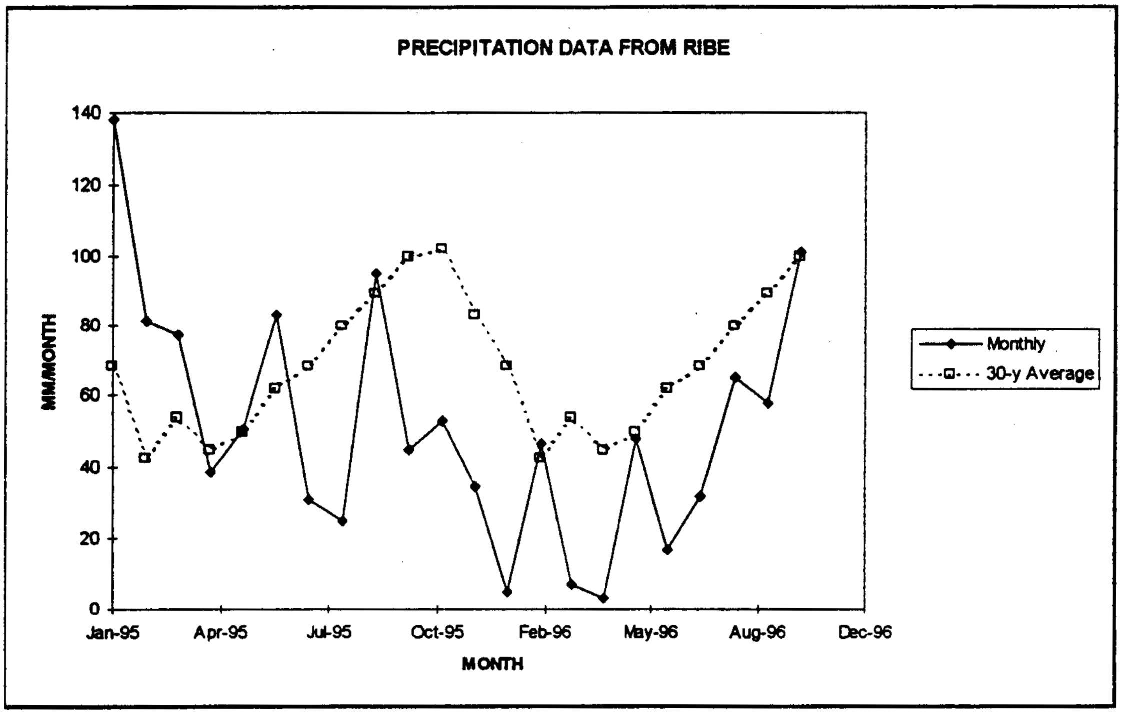
Faecal samples from sheep and lamb were obtained from several other project participants for the purpose of determining the importance of radiocaesium in fungi for the total radiocaesium intake by the animals. The faecal samples were analysed for their content of radiocaesium if this had not been done already and forwarded to Morten Strandberg, National Environmental Research Institute in Denmark, for analysis of fungal spores. The samples analysed in 1996 comprise 3 from Sweden, 26 from Iceland and 25 from Norway.

Danish Study Site, Ribe

The Danish study site is located in southern Jutland near Ribe, close to the coast of the tidal area. The farmer who owns the study site has informed that the site holds 60 ewes on a pasture area of 8.3 ha. Lambs are generally born in January-February and slaughtered in August-September. In autumn the pasture generally produces many mushrooms some of which may be eaten by the sheep, but this year proved not to be a good mushroom year.

Meteorological data are collected from Vester Vedsted close to the study site near Ribe and data since 1995 are shown in the two following graphs. The first graph shows data of monthly mean temperatures for the current year compared with monthly values averaged over the last 12 years and the second graph shows precipitation data of monthly values (mm) compared with monthly values averaged over the last 30 years. The temperatures for the period shown do not deviate significantly from the average, but precipitation has been significantly lower than the average since September 1995. The annual average temperature for 1995 was 8.4 °C compared with 8.0 °C for the previous 12-y period, and the annual precipitation for 1995 was 753 mm compared with an average of 844 mm for the last 30-y period. The annual average wind speed for 1995 at the site was 6.5 m s^{-1}.





Samples were collected in 1996 from the site in June (soil, grass and faeces), July (grass and faeces), September (grass, faeces and fungi) and October (lamb). Samples of soil and faeces were sent to Debbie Oughton, Agricultural University of Norway, for Sc-analysis, and samples of soil and grass were sent to Tone Bergan, Institute for Energy Technology in Norway, for soil texture analysis and nutrition content of grass. Analyses of radiocaesium were carried out for all samples, and analyses of radiostrontium will be made on a sub-set of these samples (soil, grass, lamb).

Modelling

The dynamic radioecological model for the transfer of radiocaesium through the soil-grass-lamb foodchain developed during the previous (1990-93) NKS/RAD programme was extended in 1996 to permit simulations to be carried out for more than a single growing season. Results were presented at the EKO-2 project meeting 13-15 May in Uppsala. The model will be used with observed data from the individual study sites in the Nordic countries covering the period 1990-96. Model parameters will be adjusted to obtain the best possible agreement between calculated and observed values. The application of the model to all the data from the previous years will give a more detailed picture than has been obtained previously of differences and similarities across the study sites with respect to radiocaesium transfer and dose consequences.

A questionnaire was designed to collect the information needed from each participant on relevant data for the model calculations. The questionnaire was distributed among the participants in September.

The modelling work was done in collaboration between Mette Øhlenschlæger, National Institute for Radiation Hygiene in Denmark, and S.P. Nielsen, Risø.

Analysis of mushroom spores in sheep faeces

Morten Strandberg
National Environmental Research Institute

EKO-2 November 1996

Analysis of spores

In deer it has been shown that fungi make up a large part of the diet during the mushroom season (Fraiture, 1992). Later it has been shown that mushrooms are responsible for an increase in the concentration of radiocesium in meat from roe deer, a finding which was made during studies of the occurrence of mushroom spores in faeces (Strandberg and Knudsen, 1994). Rafferty *et al.*(1994) found that among sheep grazing in the same area, the sheep with access to areas with fruitbodies of species having ectomycorrhiza with trees, had the highest levels of radiocesium in the meat.
If mushrooms with a high concentration of radiocesium are generally eaten by ruminants both in household and nature, a reasonable countermeasure would be to relate the season of hunting or slaughter to aseason when mushrooms are sparse.

From studies of the relation between the intake of mushrooms and the occurrence of spores in the faeces of sheep it can preliminary be said that one spore in faeces equals an intake of 12 g fresh mushrooms (Strandberg and Hansen in prep.) At present this is a rough estimate, and it is likely that further investigations will increase the information about the dependence upon the sporetype i.e. thickwalled spores are more likely to pass intact through the gastro intestinal tract (GIT) than spores with thinner walls. Hence it may be necessary to operate with more conversion factors than the one used in this study i.e. the more the spore is adapted to pass through the GIT the smaller the intake of fresh mushrooms per spore found in the faeces is.

Iceland 1990 (Table 1)

Only few mushroom spores (0 - 1, avg. 0.4 per preparate) were found in the samples from June and July 1990. In the samples from August and September 0 - 3, avg.1.7 spores per preparate were detected. This equals an daily intake of 4 g in June and July and 20 g in August and September. The spores were from typical grassland species of mushrooms; Stropharia semiglobata and probably Stropharia coronilla, Psilocybe sp. one species of Entoloma and probably Clitocybe and some Coprinus spp. (table 5) Most of the spores are from species commonly found associated with dung. The amount of spores found in the faeces gives only a rough indication of the amount of fungi eaten by Icelandic sheep in the mushroom season.
The intake of mushrooms increases over the season from June to July.
There was no difference between sheep and lamb as regards the amount and species ingested.
The most abundant spores are from the genus Stropharia which have thickwalled spores adapted to survive the passage through the gastrointestinal tract of ruminants.

There were no observations of spores from species known to concentrate radiocesium.

Larvekra 1995 (Table 2)

At Larvekra the daily intake was the highest in the beginning of the season with 28 g f.w.. In July and august the intake decreased to between 8 and 12 gram of fresh weight per day. The species eaten were ordinary grassland mushrooms, many of them associated with dung from ruminants (Table 5). None of the spores found were from species known to concentrate radiocesium.

Sweden 1994

On the locality Blomhöjden faeces were sampled twice during the mushroom season of 1994. Three samples were from the 25 of July and another three were from the 23. of August. From these samples the number of spores detected were between 0 and 1. Both in July and August, one of three samples contained one spore. Both were non-pigmented spores, the genus could be Marasmius and the spore from August could belong to the species Marasmius oreades, which commonly grows on grassland. Contrary to expectation no spores from any species of Boletus or related genera were found. The spores found are not from species that could explain an increased amount of radiocesium in the faeces.

The number of spores found in the faeces of the Swedish sheep in 1994 indicates a consumption of mushrooms less than 10 g of fresh weight per day during July and August

The relative high transfer of radiocesium to Swedish mutton should probably not be explained by an extraordinary high consumption of mushrooms by sheep. Rather the explanation could be that the diet of the Swedish sheep contains a lot of herb species other than grass. If Ericaceous species e.g. bilberry and cowberry are included in the diet it may explain a higher level of radiocesium in the meat than would be expected if the diet was grass only.

The Faroe Islands (Table 4)

From the Faroe Islands material sampled from 5 localities in June 1996 was analysed for the occurrence of spores. Only few spores were found in the faeces. Two different species of Agaricus, the one probably Agaricus campestris and the other not identified. A spore from the genus Inocybe was also found. This genus forms ectomycorrhiza with different tree species and also some herbs. The daily intake of mushrooms ranged between 0 and 30 g, depending upon locality. None of the species identified from spores are known to concentrate radiocesium

Table 1. Results from Iceland 1990

Location	Sample RISØ nr	Month	spores per preparate	Mean spores	SD	Daily intake (g)
Iceland	967036	Jun	0			
Iceland	967037	Jun	1	0.33	0.58	4
Iceland	967051	Jun	0			
Iceland	967055	Jul	1			
Iceland	967054	Jul	0			
Iceland	967038	Jul	1	0.50	0.58	6
Iceland	967039	Jul	0			
Iceland	967056	Aug	2			
Iceland	967042	Aug	1			
Iceland	967043	Aug	2	1.60	0.55	19
Iceland	967044	Aug	2			
Iceland	967045	Aug	1			
Iceland	967046	Sep	1			
Iceland	967047	Sep	3			
Iceland	967063	Sep	3	1.80	1.30	21
Iceland	967062	Sep	2			
Iceland	967061	Sep	0			

Table 2. Results from Larvekra 1995 (Norge)

Location	Sample RISØ nr	Month	spores per preparate	Mean spores	SD	Daily intake (g)
Larvekra	967073	Jul	2			
Larvekra	967074	Jul	0	2.33	2.52	28
Larvekra	967075	Jul	5			
Larvekra	967083	Aug	1			
Larvekra	967084	Aug	1	0.67	0.58	8
Larvekra	967085	Aug	0			
Larvekra	967093	Sep	2			
Larvekra	967094	Sep	1	1.00	1.00	12
Larvekra	967095	Sep	0			

Table 3. Results from Blomhöjden

Location	Sample RISØ nr	Month	spores per preparate	Mean spores	SD	Daily intake (g)
Blomh. 1994	942800	Jul	0			
Blomh. 1994	942801	Jul	1	0.33	0.57	4
Blomh. 1994	942802	Jul	0			
Blomh. 1994	942803	Aug	0			
Blomh. 1994	942804	Aug	0	0.33	0.57	4
Blomh. 1994	942805	Aug	1			

Table 4. Results from the Faroe Islands

Location	Sample	Month	spores per preparate	Mean spores	SD	Daily intake (g)
Hvalvik	9640601	Jun	0			
Hvalvik	9640601	Jun	2	1.00	1.41	12
Bøur	9610601	Jun	2			
Bøur	9610601	Jun	3	2.50	0.71	30
Velbastad	9690601	Jun	0			
Velbastad	9690601	Jun	0	0.00	0.00	0
Hvalba	9630601	Jun	1			
Hvalba	9630601	Jun	0	0.50	0.71	6
Sumba	9680601	Jun	0			
Sumba	9680601	Jun	0	0.00	0	0
Total			8	0.80	1.14	9,6

Table 5. List of species and genera so far recognized from spores found in faeces from the localities - those recognized to species should be regarded as likely to be this species.

Iceland 1990	Larvekra 1995	Blomhöjden 1994	The Faroe Islands 1996
Stropharia semiglobata	Stropharia semiglobata	Marasmius oreades	Stropharia sp.
Stropharia sp.	Stropharia sp.	Not identified 1	Agaricus campestris
Entoloma sp.	Psiilocybe sp.		Agaricus sp.
Clitocybe sp.	Omphalina sp.		Inocybe sp.
Coprinus sp.	Not identified 2		Not identified 1
Not identified 3			

Conclusions

The material so far analysed does not indicate that mushrooms plays a significant role in explaining differences in radiocesium concentrations among sheep in the Nordic countries. Further analyses especially the remaining samples from the Swedish locality Blomhöjden may alter this conclusion. There is probably a marked difference between years, i.e. in years with a long and rich mushroom season the animals learn to exploit this source of food. In normal years only few animals will spend time searching for mushrooms.

Literature

Fraiture, A. (1992) Introduction to the radioecology of forest ecosystems and survey of radioactive contamination in food products from forests.- CEC-Report series, Radiation Protection no. 57.

Rafferty, B., Dowding, P. and McGee, E.J. (1994) Fungal spores in faeces as evidence of fungus ingestion by sheep. Sci. Tot. Environ. 157.

Strandberg, M. and Knudsen, H. (1994) Mushroom spores and ^{137}Cs in faeces of the Roe Deer. J. Environ. Radioactivity 23.

Radioecology in Faroese terrestrial environment
Status report 1996

H.P. Joensen, T. Vestergaard, J. Zachariasen
University of the Faroe Islands
Dep. of Natural Sciences

Introduction

This is a summary report from the radioecological research in the Faroes, containing data from both RAD-3 and EKO-2. It gives the opportunity to make some estimates and statements about the decay of the Cs-137 activity in the terrestrial environment.

Material and Methods

The sampling in 1996 took place in late July and early August. The sampling method for soil and grass was the same as previous years, and as agreed upon in the RAD-3 and EKO-2 projects, i.e. using 4 microplots of 0.25m^2 in each pasture, from each of which the grass and 3 soil samples are taken (mixed). The meat (neck muscle) was collected each year when the lambs were slaughtered by the farmers, mainly in October, using 30-40 lambs each year. All activities are date corrected to 1 July each year. Only meat samples from three pastures in 1996 remain now to be analysed.

Faeces have been sampled in 1995 and 1996, but no results are included in this report.

Results

Deposition
The deposition of Cs-137 (Bq/m^2 in the 0-10cm soil layer) has not changed significantly in the period of investigation, although a declining trend is observed in some pastures.

Mixed grass
The concentration of Cs-137 (Bq/kg(dw)) in mixed grass has declined since 1990. All pastures show decreasing activity from 1990 to 1993/94, whereafter tend to be more scattering in the data, as if a kind of stabilization has occurred. The exponential fit is only acceptable in some pastures, giving halflives in the range 1.5-6.7 years. Based on annual mean activities for the whole country, an exponential fit gave the halflife 3.7 years with R^2= 0.673.

Lamb meat
The behaviour of the concentration (Bq/kg(fw) Cs-137) in meat is peculiar for pastures with the higher activities, i.e. Hvalvík, Skáli, Norðoyri and Sandur. The significant increase in the values in 1994 seems hard to explain. Exponential fitting of the data was only acceptable for Hvalba, Velbastað and Sumba with halflives 7.1 years (R^2=0.721), 4.3 years (R^2=0.891) and 3.2 years (R^2=0.652), respectively. The exponential fit was not acceptable when means for the whole country were considered.

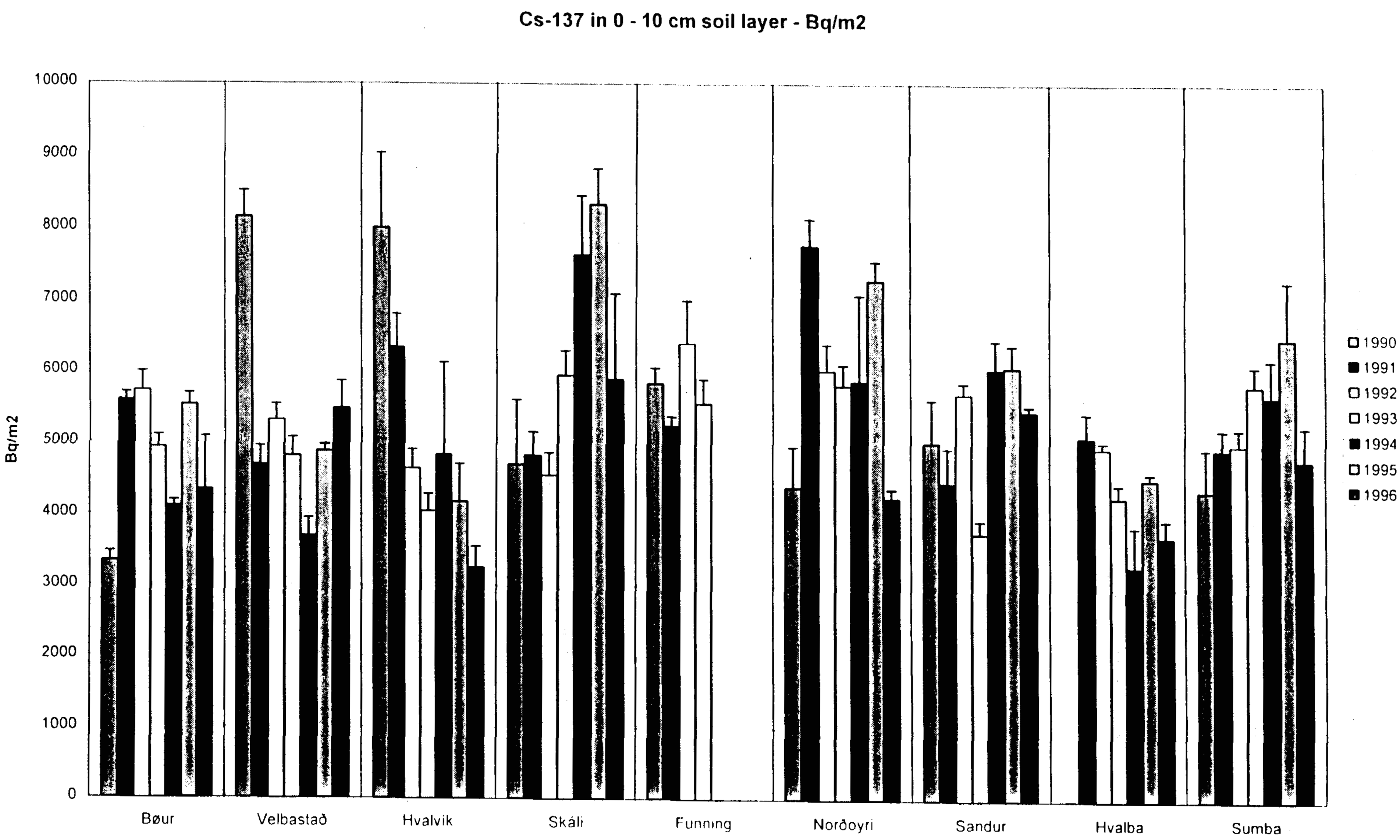
Concentration ratio
The observed grass/soil concentration ratio (conc. in dried grass/conc. in dried soil) tend to decrease until 1993-94, whereafter it is more constant. The results are based on calculations for each 0.25 m^2 microplot. Similar trend is found in the observed meat/soil concentration ratio, while the meat/grass concentration ratio tend to be more or less at the same level over the period of observation. In the latter ratios the activity

in each lamb in a pasture is related to mean values of grass and soil in the same pasture, whereafter averages are calculated for the whole country. There is highly significant variation in the observed concentration ratios within each year.

Transfer factor
The observed soil-grass transfer factor (conc. in dried grass/deposition in 0-10cm soil) and the observed soil-meat transfer factor (conc. in fresh meat/deposition in 0-10cm soil) show the same trend as mentioned above for, respectively, the soil-grass and soil-meat concentration ratio. The method of calculation is the same as for the concentration ratios.

Acknowledgement

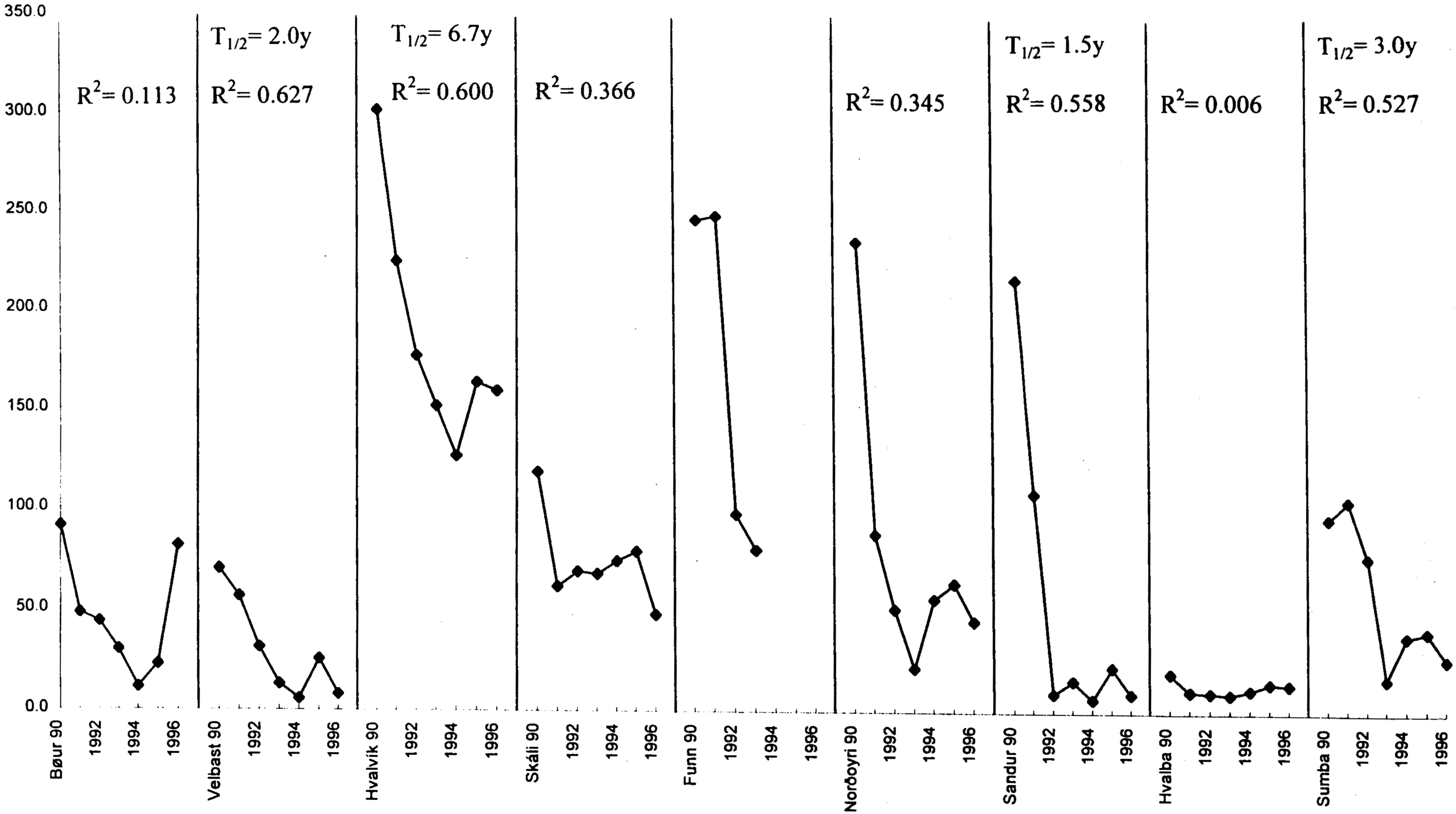
The authors would like to thank Anna av Kák for her professional work in the laboratory and for arranging the cooperation with the farmers, who deliver lamb samples for the project.


Cs-137 in 0 - 10 cm soil layer - Bq/m2
Bq/m2
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Bøur
Velbastað
Hvalvík
Skáli
Funning
Norðoyri
Sandur
Hvalba
Sumba
1990
1991
1992
1993
1994
1995
1996

^{137}Cs in 0 - 10 cm Faroese Soil Layers Bq/m^2										
		Bøur	Velbastað	Hvalvík	Skáli	Funningur	Norðoyri	Sandur	Hvalba	Sumba
1990	Mean	3338	8147	8004	4710	5845	4396	5029		4362
	STDV	377	1082	2927	1266	618	1135	1181		1016
1991	Mean	5592	4701	6344	4839	5247	7770	4466	5105	4944
	STDV	399	908	1632	958	458	1260	1676	1140	942
1992	Mean	5732	5320	4652	4563	6409	6031	5706	4956	5009
	STDV	923	769	923	1084	2098	1278	539	298	757
1993	Mean	4943	4829	4055	5957	5563	5824	3759	4270	5835
	STDV	578	876	828	1194	1186	1000	635	623	934
1994	Mean	4119	3700	4848	7641		5878	6052	3289	5678
	STDV	163	512	2572	1621		2423	809	1126	1029
1995	Mean	5530	4892	4186	8332		7297	6080	4521	6494
	STDV	284	122	1061	986		457	622	176	1597
1996	Mean	4348	5482	3254	5901		4251	5457	3710	4795
	STDV	1480	775	596	2406		256	139	491	925

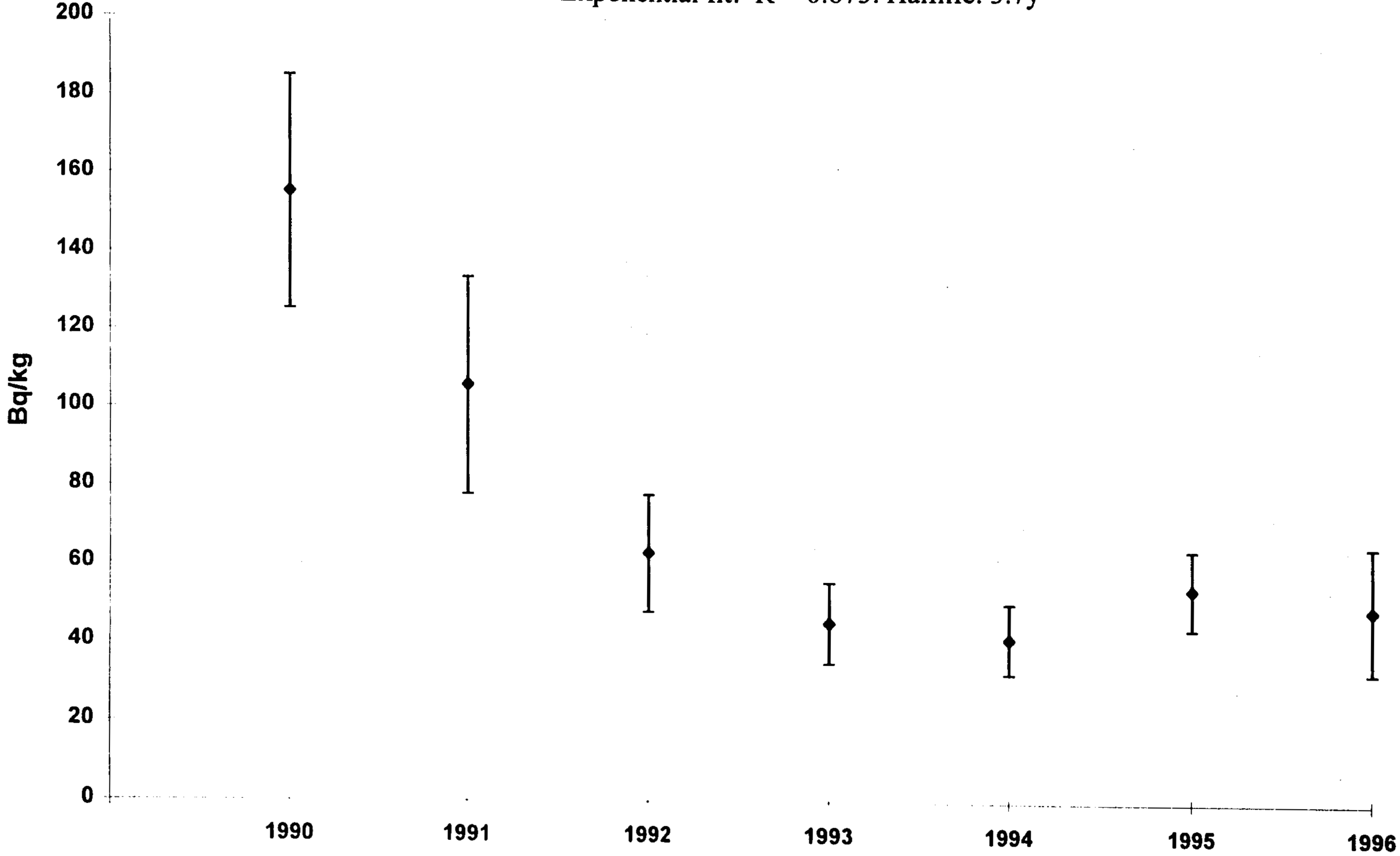
^{137}Cs concentration in mixed faroese vegetation Bq/kg								
	Hvalba	Velbastað	Bøur	Sumba	Sandur	Norðoyri	Sk[redacted]li	Hvalvík
1990	20	70	91	97	217	236	119	302
1991	11	56.5	48.2	106	109	88	61.8	225
1992	10.3	31.2	43.9	77.5	9.56	51.2	69.1	177
1993	9.6	13	30	17.3	16	22	68	152
1994	11.7	5.78	11.3	38.7	6.84	56.1	74.2	127
1995	14.9	25.5	22.8	41	22.7	63.9	79	164
1996	14.4	8.01	81.4	27.1	9.5	45.3	48.1	160

Grass, Bq/kg, in the Faroese pastures 1990-96

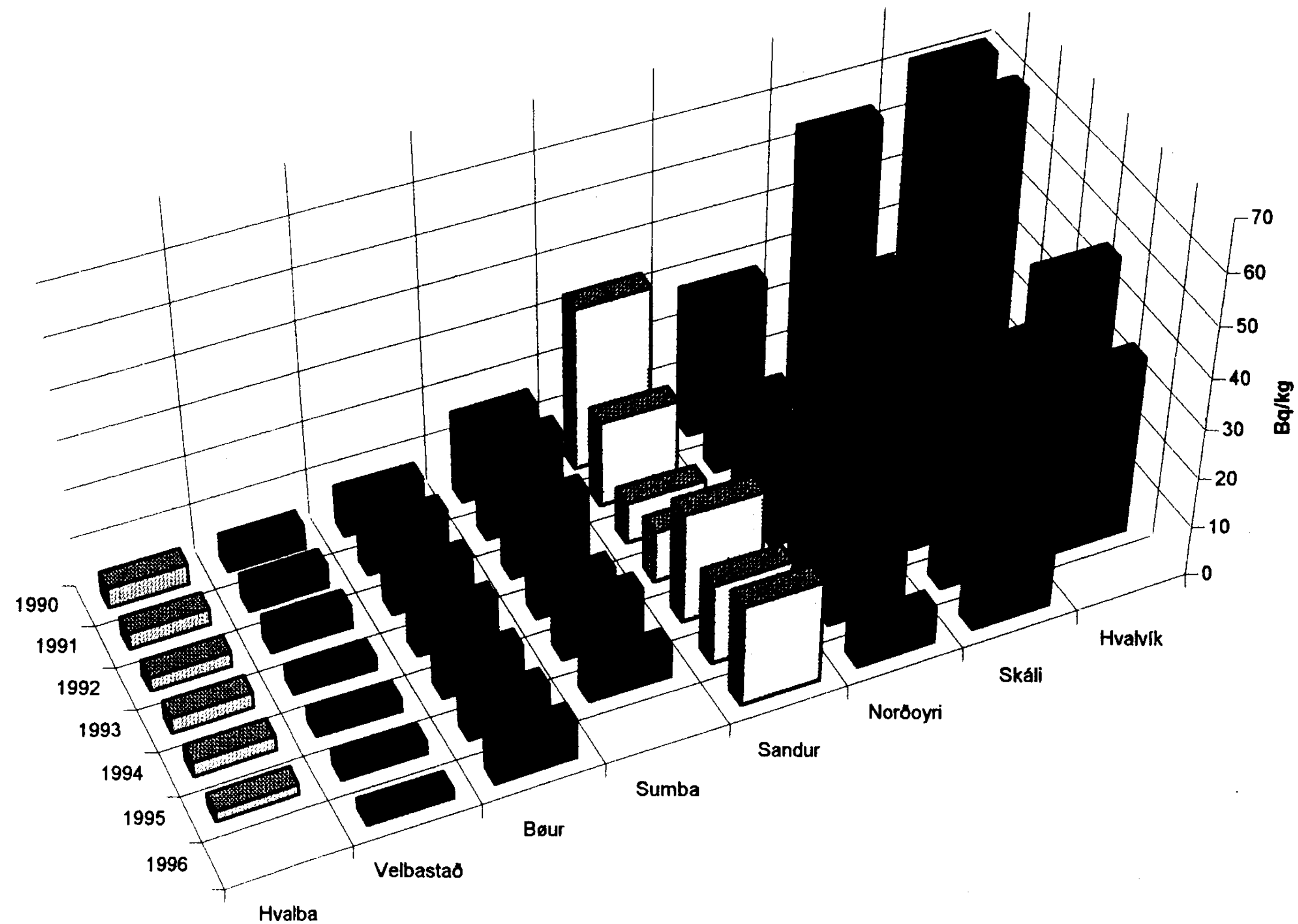


Grass - annual average - +/-1 sterr

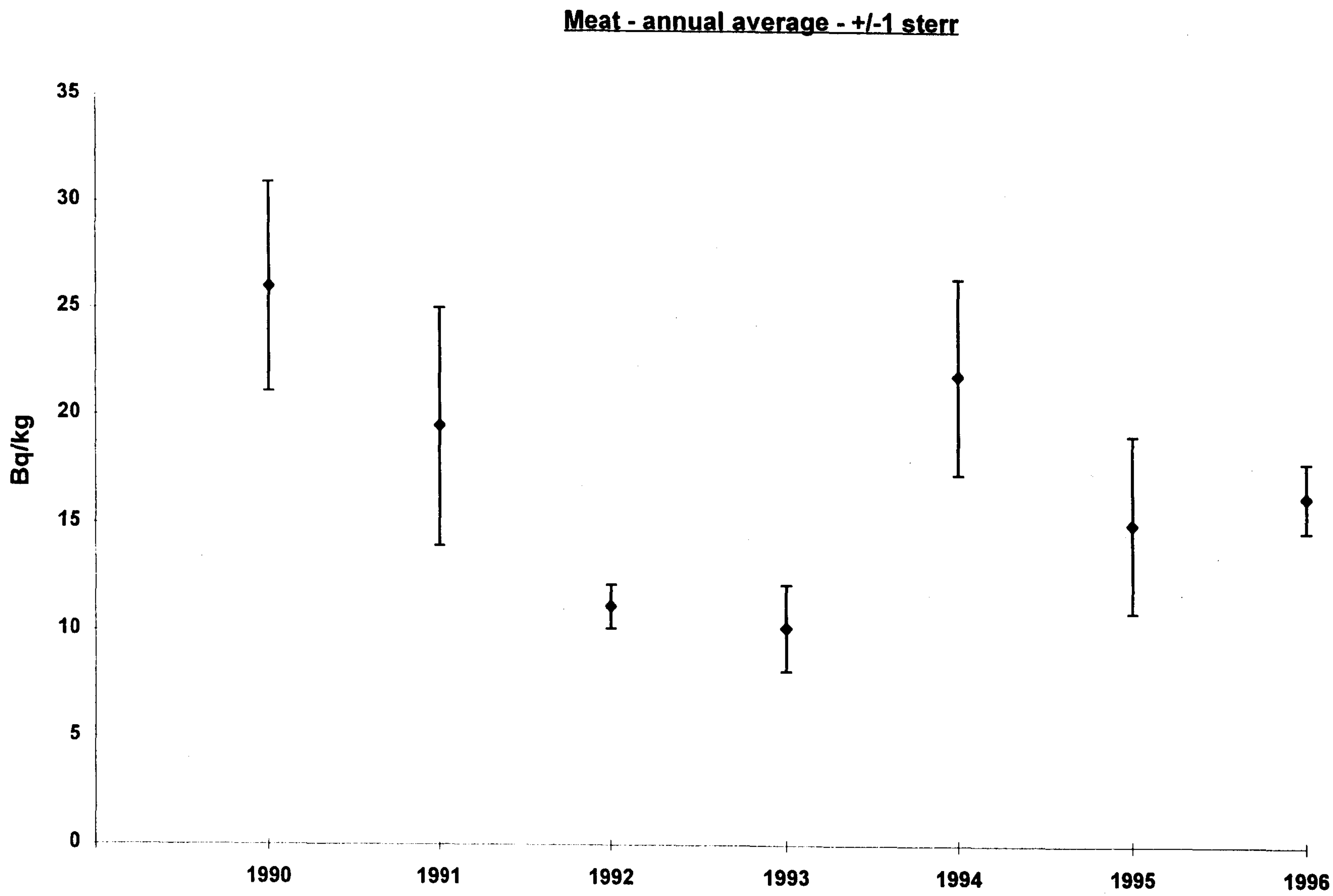
Exponential fit: R^2=0.673. Halflife: 3.7y

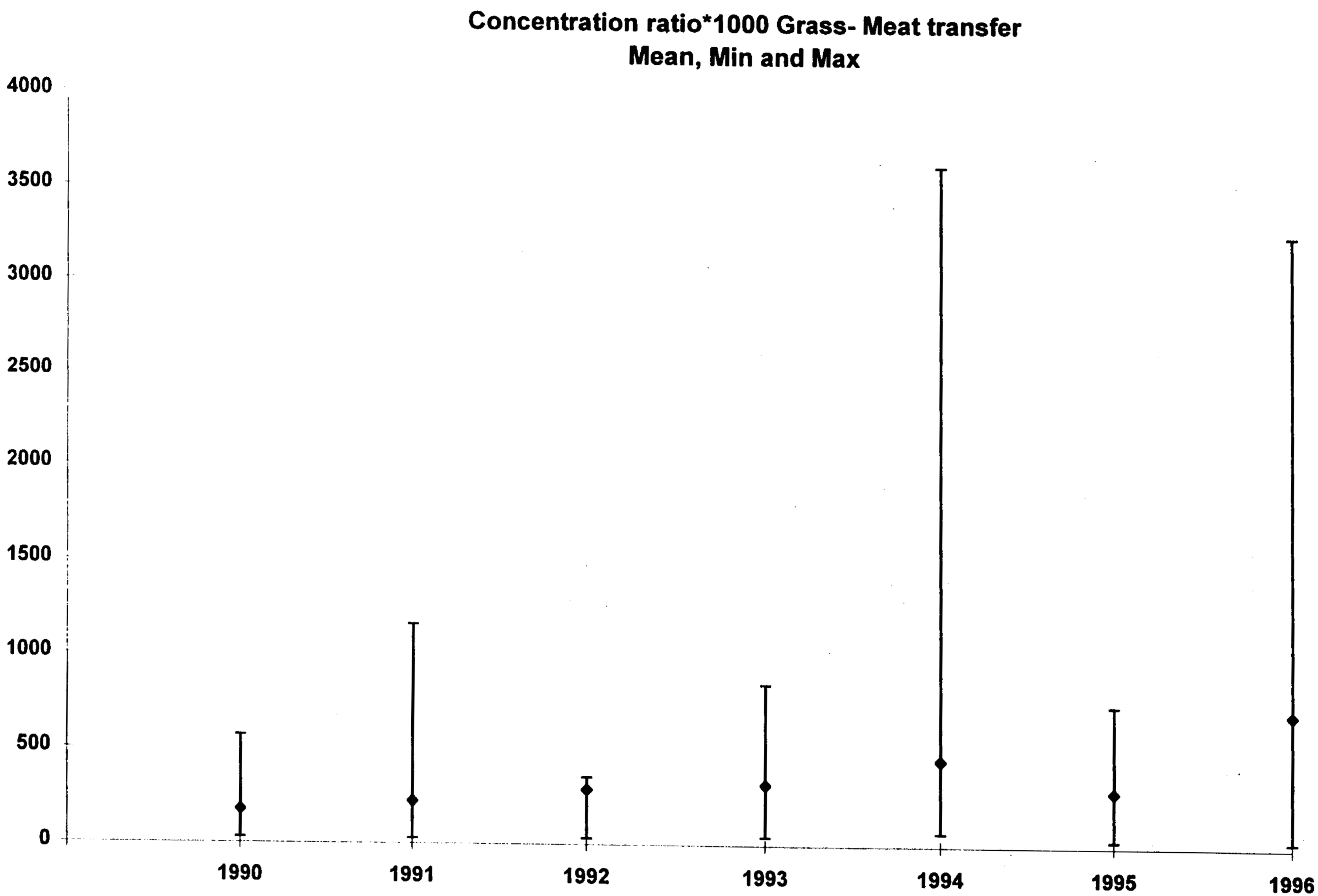


Mean 137Cs Concentrations in Faroese Mutton



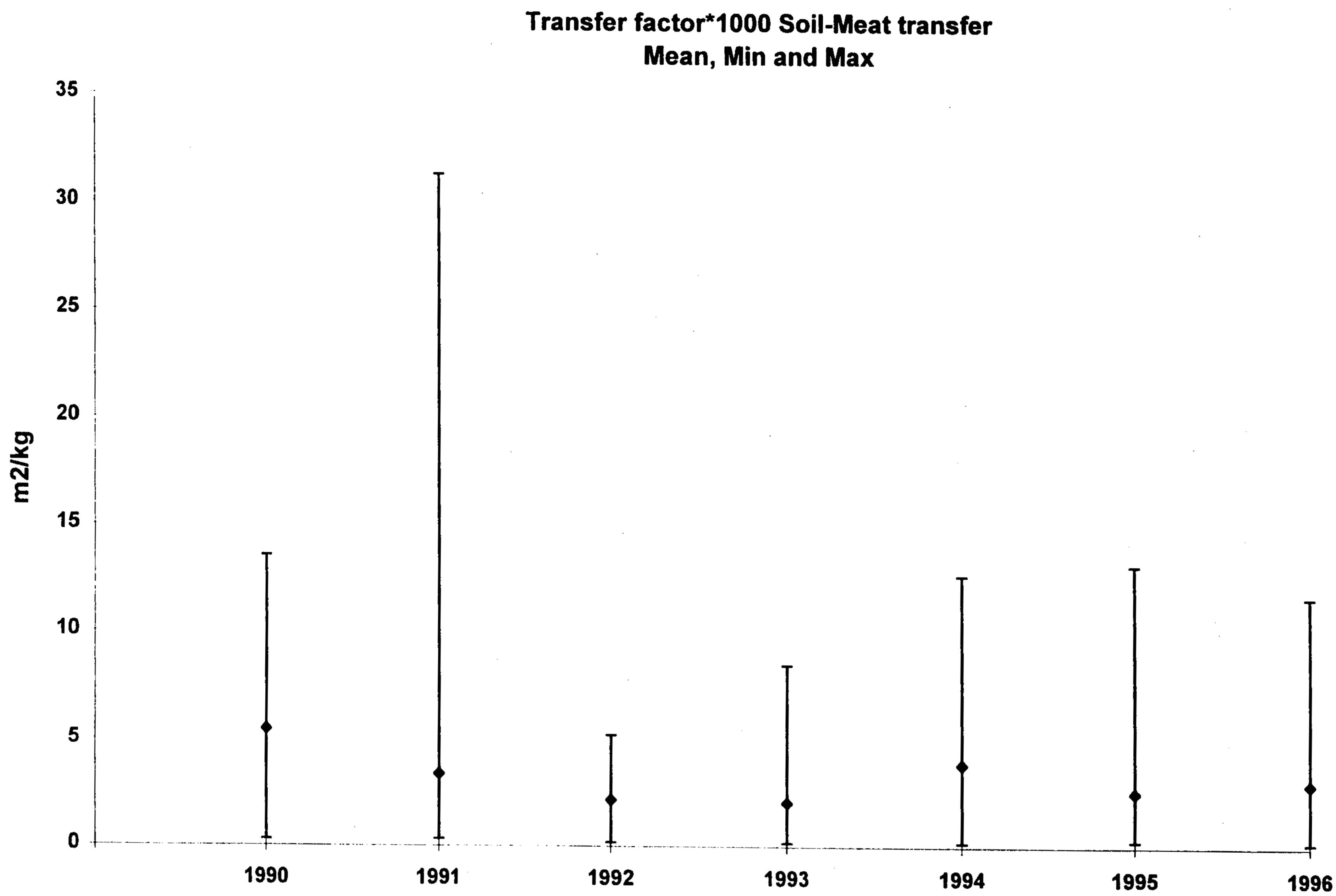
Mean ^{137}Cs concentrations in Faroese mutton Bq/kg								
	Hvalba	Velbastað	Bøur	Sumba	Sandur	Norðoyri	Skáli	Hvalvík
1990	4.1	4.8	7.6	16	33	28	54	61
1991	3.2	4.6	8.7	18.09	17.4	13.1	30.9	60.3
1992	2.85	4.33	7.28	13.67	8.5	13.76	21.52	17.47
1993	3.2	2.6	6.8	5.5	10.4	7.8	26	19.2
1994	3.01	2.75	5.54	9.5	22.14	40.73	43.79	47.88
1995	2.12	2.6	6.25	6.31	15.95	19.48	32.24	35.52
1996		1.83	7.93		20.12	7.12	44.67	

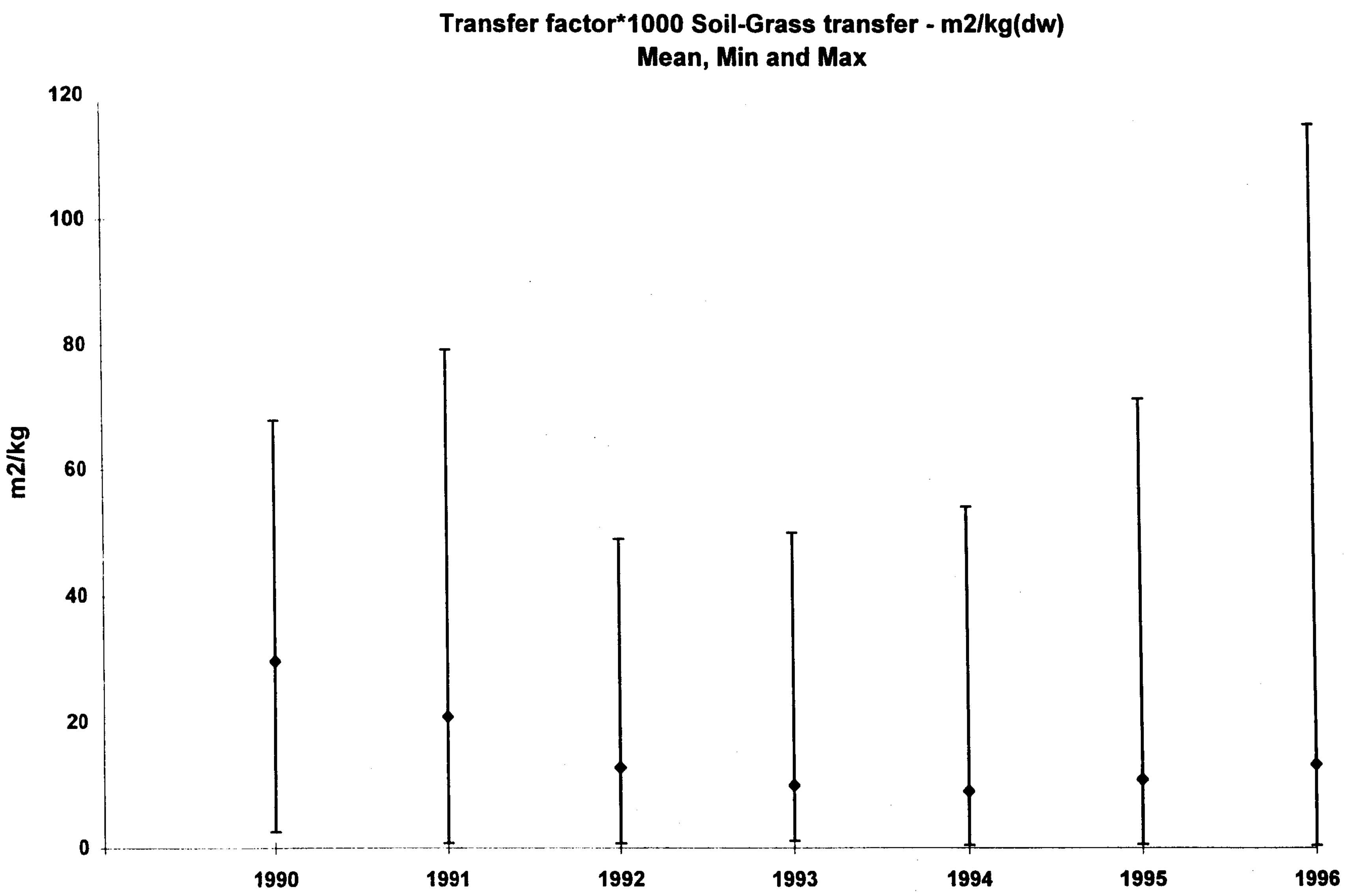

Meat - annual average - +/-1 sterr
35
30
25
20
15
10
5
0
Bq/kg
1990
1991
1992
1993
1994
1995
1996


Concentration ratio*1000 Grass- Meat transfer
Mean, Min and Max
4000
3500
3000
2500
2000
1500
1000
500
0
1990
1991
1992
1993
1994
1995
1996


Concentration ratio*1000 Soil-Grass transfer
Mean, Min and Max
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1990
1991
1992
1993
1994
1995
1996

Concentration ratio*1000 Soil-Meat transfer
Mean, Min and Max
450
400
350
300
250
200
150
100
50
0
1990
1991
1992
1993
1994
1995
1996


Transfer factor*1000 Soil-Meat transfer
Mean, Min and Max
m2/kg
35
30
25
20
15
10
5
0
1990
1991
1992
1993
1994
1995
1996



Transfer factor*1000 Soil-Grass transfer - m2/kg(dw)
Mean, Min and Max
m2/kg
120
100
80
60
40
20
0
1990
1991
1992
1993
1994
1995
1996

NKS / EKO-2.1

Status report for the Icelandic part of the EKO-2.1 project

Transfer of Radiocaesium from Soil to Vegetation and to Grazing Lambs in Iceland

Sigurður E. Pálsson, Elísabet D. Ólafsdóttir
Geislavarnir ríkisins (Icelandic Radiation Protection Institute, Reykjavík)

Jóhann Þórsson
Rannsóknastofnun landbúnaðarins (Agricultural Research Institute, Reykjavík)

This report contains material which will be used later in a scientific paper. Please do not refer to material in this report without prior consent of the authors.

Introduction

The Cs-137 encountered in the Icelandic samples stems almost entirely from the atomic weapons tests carried out in the atmosphere until the early sixties. The caesium has therefore been in the ecosystem for over three decades.

In 1996 as in 1995, the Icelandic part of the EKO-2.1 lamb project was carried out at the experimental farm Stóra Ármót, in southern Iceland. For the experiment the same 12 ha pasture was used as before. During the first year of the current NKS period (1994), the experiment was carried out at the experimental farm Hestur in Borgarfjörður, in western Iceland. This farm had also been used for investigations carried out during the previous NKS project period, under the RAD-3 project.

Following is a short description of each area. The conditions at the 2 experimental areas are described in greater detail in the EKO-2.1 annual report for 1995, TR-EKO-2(1995)1.

Hestur
At Hestur the study area is a 12 ha uncultivated lowland mire sloping a little towards west. The study area is hummocky, except for a small part of the area where there is an elevated gravel ridge with well drained soil.

Stóra Ármót
The study area at Stóra Ármót is a 12 ha uncultivated lowland pasture. The surface is level, but considerably hummocky and more so than the area at Hestur. The area is fairly homogenous, especially with respect to vegetation.

The analysis of samples collected in 1996 is being carried out at the time of writing. This report is therefore divided into two main sections:
- Analytical results for 1995
- Description of conduct of experiment in 1996

Analytical results for 1995

Most of the samples from 1995 have been analysed. These results from Stóra Ármót show a striking difference in Cs-137 concentration compared with Hestur for most types of samples. This difference is clearly displayed in Table 1, which summarises the results from Hestur in 1994 and Stóra Ármót in 1995.

Table 1. Concentration of Cs-137 in samples from "Hestur" and "Stóra Ármót" - Summary of results

	Hestur, 1994 Bq/kg	n	Stóra Ármót, 1995 Bq/kg	n
soil (0-10 cm)	84	*(21)*	101	*(25)*
composite plant sp[a]	88	*(12)*	(not yet compiled)	
composite plant sp[b]	3	*(3)*	7,4	*(4)*
Carex nigra	107	*(2)*	54	*(2)*
Agrostis sp.	5,1	*(1)*	4,3	*(1)*
Carex bigelowii	39	*(1)*	1,9	*(1)*
hay	32	*(2)*	1,3	*(3)*
faeces (ewes), indoor			4,4	*(6)*
faeces (ewes), outdoor	137	*(6)*	18,1	*(22)*
faeces (lambs), outdoor			13,8	*(14)*
milk (ewes indoor)	5,9	*(45)*	1,0	*(12)*
milk (ewes outdoor)	25	*(6)*	2,0	*(24)*
lamb meat	43	*(12)*	(not yet compiled)	

[a] wet and intermediate wet area
[b] dry area
The values given are average values, number of samples is given in parenthesis.

Soil

Soil samples generally show a great variability in Cs-137 concentration and the Icelandic samples are no exception. The average values for the two study areas are however fairly similar. Since the area at Stóra Ármót is considerably more hummocky than the area at Hestur, it was decided to carry out a special study on the effects of these hummocks on the concentration of Cs-137 in the soil and thus possibly account for one source of variation. The results are displayed in Figure 1.

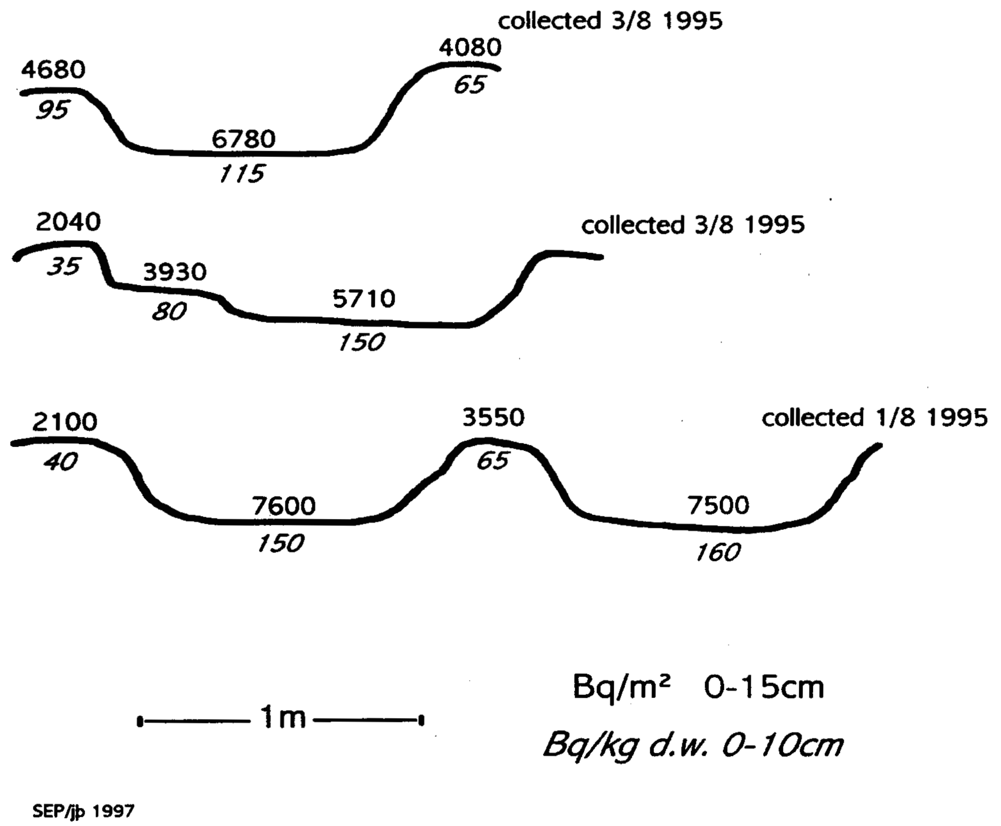


Figure 1 Variations in Cs-137 concentration in soil samples between top of hummocks and adjacent low areas. Above the line is concentration per unit area down to a depth of 15 cm. Below the line is concentration per unit mass (dry weight) down to a depth of 10 cm.

The results were quite striking. The concentration in a bottom area was in all cases much higher than the concentration in the adjacent top part. The same pattern was also visible in other samples not displayed here.

Plants

Table 1 shows values for composite plant samples and for samples of individual species found in both areas. Values are also included for hay taken from the barn. The samples were taken from the hay fed to the animals while housed. The hay values are included here for use when interpreting the concentration in milk.

The composite plants samples indicate a much higher transfer of Cs-137 from soil-to-plant in the wet areas at Hestur than in the drier areas at Stóra Ármót. An exception is the dry gravel ridge at Hestur which shows values of the same order of magnitude as Stóra Ármót.

The uptake from soil to plants can be described by the transfer factor B_v, the ratio of radionuclide concentration in vegetation and soil (in Bq/kg dry weight plant to Bq/kg dry weight soil). Using the composite plant samples values the following transfer factors can be calculated for Hestur and Stóra Ármót.

Table 2 Transfer factor from soil to plant for the Icelandic experimental areas

Area	B_v
Hestur, wet and intermediate areas	1,04
Hestur, dry area	0,036
Stóra Ármót	0,073

The IAEA published in 1994 a "Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments" (Technical Report Series No. 364). A reference value for peat soils (pH = 4) is quoted as 0,53 and the 95% confidence range is given as 0,053 - 5,3. The observed transfer factors agree reasonably well with these quoted values, with the dry gravel ridge showing by far the lowest and the wet areas the highest.

In Table 1 it can be seen that the individual plant species all show higher transfer from soil to plants at Hestur than at Stóra Ármót. This is especially noticeable for *Carex bigelowii.*

Faeces

Having obtained the different transfer from soil to plants for the areas, it is now of interest to study the transfer of Cs-137 through the sheep by calculating the concentration ratio between the observed concentration in faeces and the observed concentration in the diet of the sheep at the time. Samples of hay are used as an estimate of the diet while the sheep are still kept inside and composite plant samples as an estimate of the diet after they have been let out to pasture.

Table 3 Concentration ratio of Cs-137 in faeces relative to diet (Bq/kg dry weight faeces divided by Bq/kg dry weight vegetation)

Area	ewes or lambs	indoors or outdoors	Concentration ratio
Hestur	ewes	outdoors	1,6
Stóra Ármót	ewes	outdoors	2,4
Stóra Ármót	lambs	outdoors	1,9
Stóra Ármót	ewes	indoors	3,4

The concentration ratio is fairly even indoors as well as outdoors, for ewes and lambs and for both areas. Assuming that the concentration of Cs-137 in faeces should be proportional to the average levels in the diet suggests that the samples of diet chosen (composite plant samples, hay from barn) can be taken as fairly representative of what the sheep are eating. It is also of interest to see that no major difference can be seen between the two areas in this respect.

Milk

The transfer of Cs-137 from the ewes' diet to milk was estimated by calculating transfer coefficients, F_m. They are defined as the ratio of Cs-137 concentration in milk relative to the daily intake of the radionuclide. The daily intake was estimated by multiplying the Cs-137 concentration in the diet (composite plant samples or hay, values from Table 1) with 2,3 kg/d as an estimate for daily dry matter intake. This estimate is based upon studies at Hestur, data from Stóra Ármót will be studied for comparison. The value is higher than a reference value recommended by the IAEA publication, 1,3 kg/d, but within the quoted 95% confidence range of 1,0 - 2,5 kg/d. The Cs-137 concentration in composite plant samples at Hestur has been observed to rise during summer. Similar data has not yet been compiled for Stóra Ármót. Instead of using the summer average of 88 Bq/kg for Hestur as shown in Table 1, a value of 50 Bq/kg was used. This is an average value for the wet and intermediate wet areas based on samples collected at the end of June 1994. For Stóra Ármót the values represent samples collected later in summer. Using these assumptions produces the transfer coefficients shown in Table 4.

Table 4 Observed transfer coefficients for sheep milk

Area	Ewes indoors / outdoors	Transfer coefficients, F_m (d/L)
Hestur	indoors	0,08
Hestur	outdoors	0,2
Stóra Ármót	indoors	0,3
Stóra Ármót	outdoors	0,1

Reference values for transfer coefficients for sheep milk have been quoted in the IAEA handbook as 0,058 d/L with 95% confidence interval 0,006 - 0,12.

The values observed in this experiment are relatively high, 2 out of 4 are above the upper limit of the 95% confidence interval. Various factor are known to be able to affect observed transfer coefficients. Lack of equilibrium can also be a problem. A series of samples were taken to study the possible temporal variation in the concentration of Cs-137 in sheep milk. The results are displayed in Figure 2.

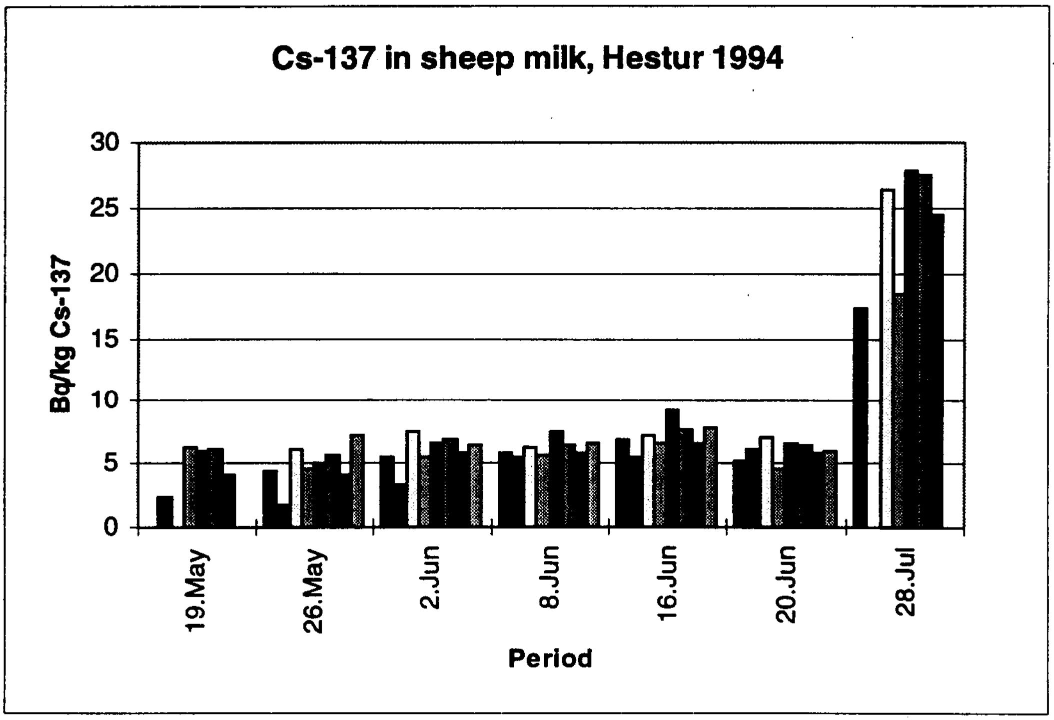


Figure 2 Cs-137 in sheep milk, Hestur 1994.

All the samples but the last were taken while the sheep were kept indoors. The results indicate that the concentration of Cs-137 was fairly even during that time. There is little variation between the ewes and little variation between the sampling dates. It was not feasible to sample milk frequently after the sheep had been let out to pasture because the difficulty in herding the flock. The last sample was taken some 4 weeks after the sheep had been let out to pasture. The increase in Cs-137 concentration is clearly noticeable.

Some samples were also analysed for Sr-90 at IFE, Norway. The results for Sr-90 are displayed in Figure 3.

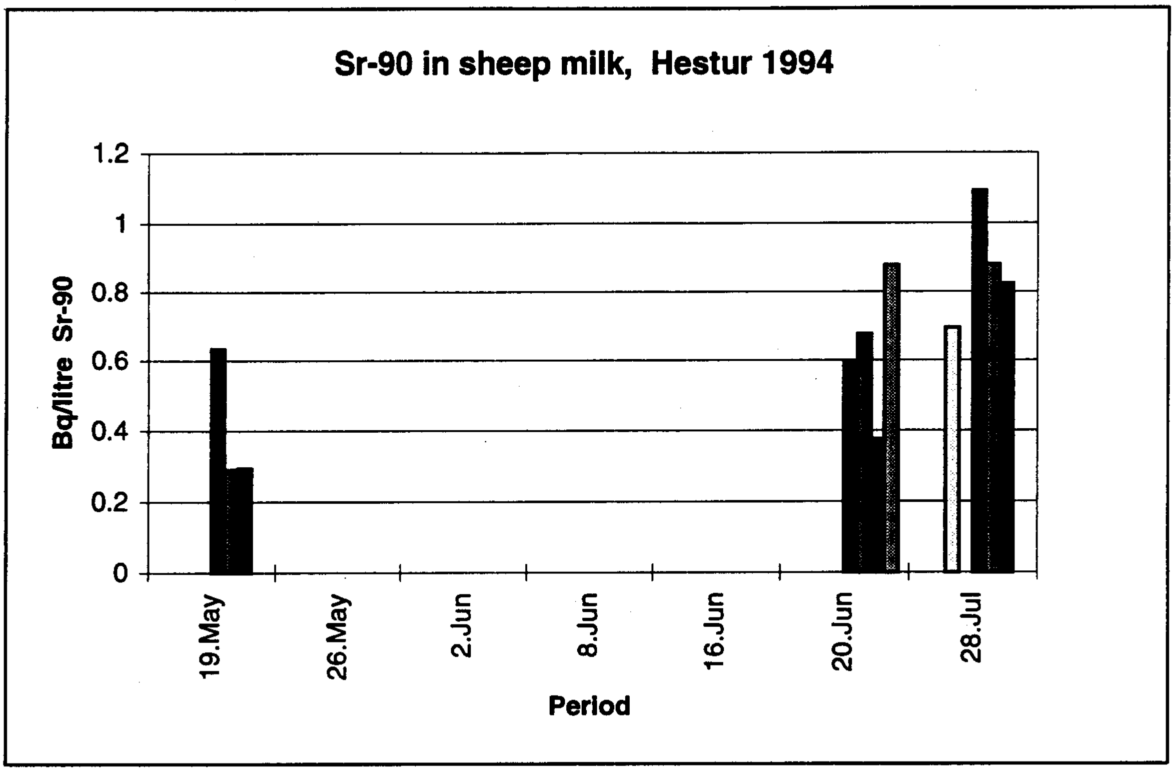


Figure 3 Sr-90 in sheep milk, Hestur 1994

The results show much less variation in the milk than for caesium. At present no analyses have been made for Sr-90 in the diet of the sheep.

What is presented here is just based on a preliminary estimate of the diet of the sheep. The concentration of Cs-137 in different plants available to the sheep differ a great deal as can be seen in Table 1. Individual and temporal changes in grazing behaviour can therefore affect greatly the daily intake of the sheep.

Conduct of experiment in 1996

As in 1995, the Icelandic EKO-2.1 lamb project for 1996 was carried out at the experimental farm Stóra Ármót. For the experiment the same 12 ha pasture was used as before. It has been described in the previous EKO-2.1 status report for 1995.

Five ewes with single lambs and two with twin lambs were used in 1996, which is lesser stocking rate than the year before, as biomass estimation for 1995 indicated that the stocking rate (ewes ha^{-1}) was to high. Table 5 shows number of animals used at Auðkúluheiði (1990-1991), Hestur (1990-1994) and Stóra Ármót (1995-1996), and respective stocking rate.

Table 5. Number of animals used in the RAD-3 and later the EKO-2.1 project in Iceland, and respective stocking rates (ewes ha^{-1})

year	location	number of: ewes	lambs	pasture size (ha)	stocking rate (ewes ha^{-1})
1990[1a]	Hestur	13	26	12	1,10
-	Auðkúluheiði	10	20	54	0,19
1991[1]	Hestur	8	16	12	0,67
-	Auðkúluheiði	8	16	54	0,15
1992[1]	Hestur	8	16	12	0,67
1993[1]	-	13	26	12	1,10
1994[2a]	-	8	16	12	0,67
1995[2]	Stóra Ármót	8	14	12	0,67
1996[2]	-	7	9	12	0,58

[1]Part of the RAD-3 lamb project [2]Part of the EKO-2.1 lamb project
[a]not all the animals were used for the RAD-3 project

The lambs used in 1996 were on average born on 28th May. Until 10th June, when they were released, the animals were kept indoors and thus brought directly onto the experimental pasture. They were removed from the pasture on the 6th October and slaughtered the next day. Meat samples (foreleg) were taken just after slaughtering. The grazing period was thus 118 days. All animals were weighed on 10th June, 1st August, 6th September and 6th October. Additionally lambs were weighed 29th May. Samples collected in summer 1996 can be seen in Table 6. Same procedures and methods have been used as last year.

Table 6. Samples taken at experimental farm Stóra Ármót in 1996

sample	29.5	10.6	13.6	21.6	1.8	6.9	6.10	7.10	total
milk	6	6	8	7	7				**34**
lamb meat								7	**7**
faeces		7			14	14			**35**
soil									
hay		3							**3**
comp. plant sp.[a]			5		5	3			**13**
plant species					7	5	3		**15**
mushrooms					1[b]	1[b]			**2**
harvest samples		1			1	2[c]	1		**5**

[a]composite plant species
[b]all species found collected
[c]experimental pasture and adjacent pasture harvested

Results

1. Standing herbage (biomass)

Biomass was estimated four times through the summer as can be seen in Table 6. Additionally adjacent pasture, ungrazed but similar in all other respects, was harvested on 6th September to get an estimation on how much might have been removed by grazing during the summer. Clipped frames (0,05m²) in both pastures were compared with Mann-Whitney U/Wilcoxon rank sum test and Kolmogorov-Smirnov test (t-test or ANOVA could not be performed as part of the data did not show normal distribution). Figure 4 shows biomass in the experimental pasture used in 1995 and 1996 and Figure 5 shows biomass in ungrazed vs. grazed pasture.

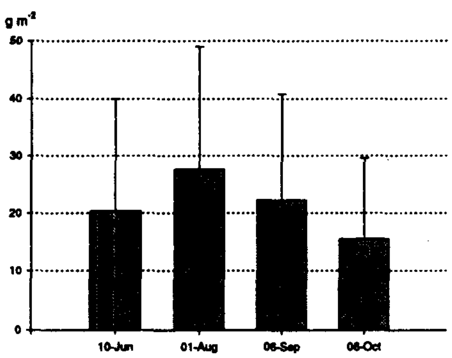


Figure 4. Standing herbage at Stóra Ármót 1996. Bars indicate standard deviation. Different letters indicate statistically significant difference (P≤0,01).

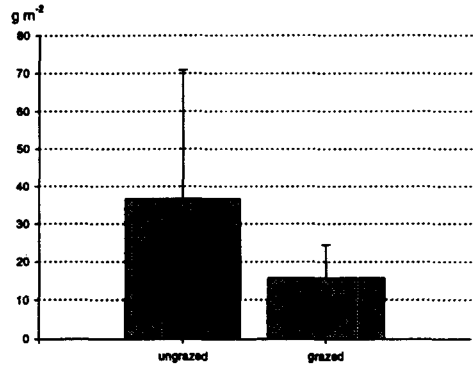


Figure 5. Standing herbage in ungrazed vs. grazed pastures, 6th September 1996, Stóra Ármót. Bars indicate standard deviation. Different letters indicate statistically significant difference (P≤0,02).

As might be expected from the type of land, the variation is relatively high but fairly consistent over the summer. From the data in Figure 5 it can be estimated that in September up to 60% of the biomass has been removed, or approximately 210 kg dm ha^{-1}.

2. Chemical composition of harvest

As last years, harvest samples have been analysed at the Agricultural Research Institute, but results for 1996 are not yet available. The analysis include minerals (ash), crude protein (cp), crude fat (cf), crude fibre (cfi), P, Ca, Mg, K, Na, Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and lignin.

3. Live weight and daily gain

Ewes were weighed four times during the summer, and lambs five times. The data was analysed with GLM ANOVA and Tukey-Kramer Multiple-Comparison Test. Figure 7 and Figure 6 show live weight of ewes and lambs during summer 1996.

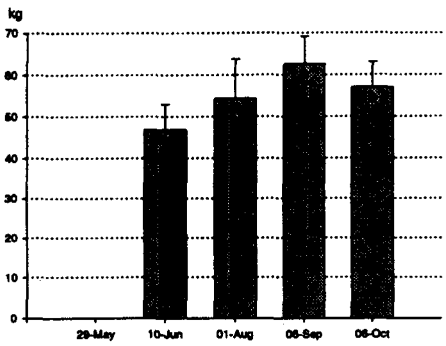


Figure 7. Ewes live weight at Stóra Ármót during summer 1996. Bars indicate standard deviation. Different letters indicate statistically significant difference (P≤0,01).

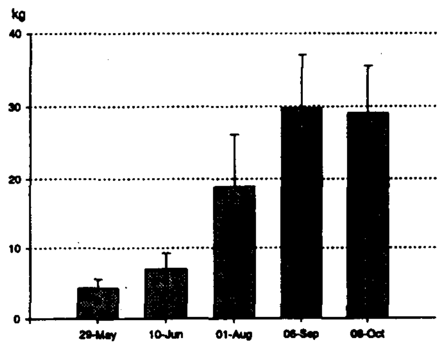


Figure 6. Lambs live weight at Stóra Ármót during summer 1996. Bars indicate standard deviation. Different letters indicate statistically significant difference (P≤0,01).

The pattern observed in Figure 7 reflects two things, a) decrease in milk yield over the summer (June - September) and b) rapid fall in vegetation quality (October) as winter approaches. Similar trend can be seen in Figure 6 (October) for the lambs.

Table 7. Grazing periods at Stóra Ármót 1996

period	description
0	Birth of lambs - sheep released (28th May - 10th June)
1	Sheep released - end of July (10th June - 1st August)
2	End of July - beginning of September (1st August - 6th September)
3	Beginning of September - beginning of October (6th September - 6th October)

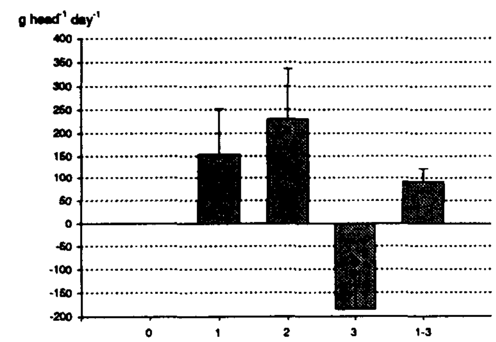


Figure 9. Average daily gain of ewes at Stóra Ármót 1996. Bars indicate standard deviation. Different letters indicate statistically significant difference (P≤0,001). Periods (see Table 7) are on the x-axis. The rightmost bar indicates average for the whole summer.

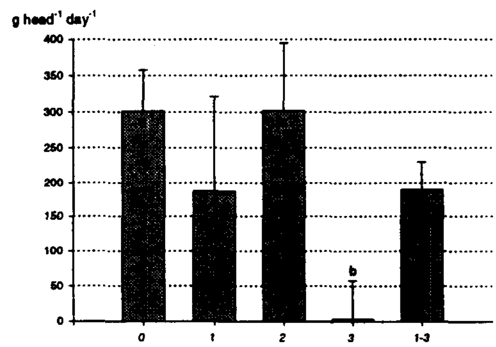


Figure 8. Average daily gain of lambs at Stóra Ármót 1996. Bars indicate standard deviation. Different letters indicate statistically significant difference (P≤0,001). Periods (see Table 7) are on the x-axis. The rightmost bar indicates average for the whole summer.

Average daily gain for 1996 is shown on Figure 9 and Figure 8 (see Table 5 for explanation of periods). As might be expected from Figure 7 and Figure 6, decrease is observed in late summer due to rapid fall in vegetation quality. Grazing pressure, carcass weight and meat dressing can be seen on Figure 10 and Figure 11.

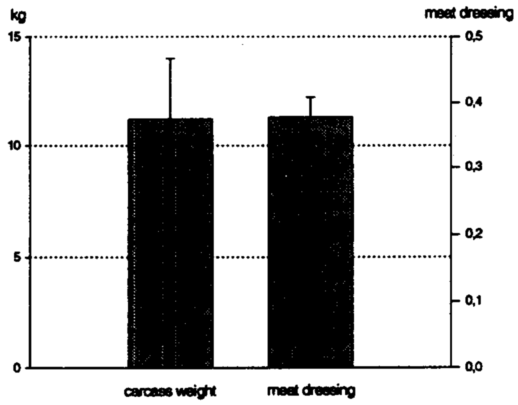


Figure 11. Carcass weight (left) and meat dressing (right) for Stóra Ármót 1996.

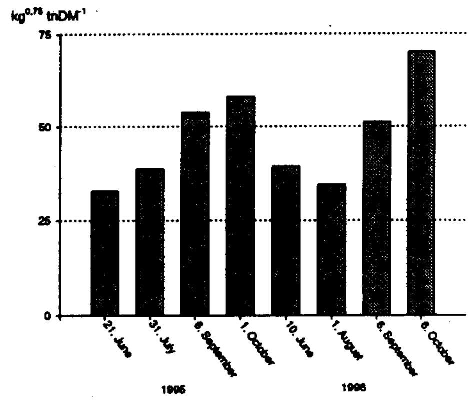


Figure 10. Grazing pressure at Stóra Ármót 1995 and 1996.

Arbeid utført på Tjøtta 1996
Innspill til EKO2 møte på Risø 2-3 .desember

NRPA, november 1996

Dyrene ble i år sluppet på beite 4. juni og beitet der til 3. september. Det var da svært dårlige beiteforhold på det inngjerdede området. Arbeidet har i år gått etter planen, og samarbeidet med Planteforsk, Tjøtta Fagsenter har fungert utmerket. Vi har i år besøkt prøveplassen to ganger. Undertegnede var der i begynnelsen av beitesesongen for å diskutere årets gjennomføring samt for å gjennomgå prosedyrene for måling på levende dyr. Knut Hove besøkte Tjøtta i august i forbindelse med høsting av beiteburene of prøvetaking av faeces. Endel av analysearbeidet er gjennomført, mens det også gjenstår noe arbeid som vil bli sluttført i 1996 eller tidlig i 1997. I år som i fjor ble det satt ut 12 beitebur for prøvetaking av jord og vegetasjon samt for å estimere biomasseproduksjonen og sanke sopp om mulig.

Følgende arbeid ble i år gjennomført på Tjøtta som en del av EKO2:

Levendedyr-målinger:
Lam og søyer ble målt ukentlig for innhold av radiocesium. Dyrene ble også veid. Måleresultatene ble presentert på Island.

Transfer jord-vegetasjon
Ved slutten av beitesesongen (20/8) ble det tatt 1 jordprøve 0-10 cm i hvert av burene 1-6. Vegetasjonen på toppen ble kuttet og målt for radiocesium.

Vegetasjon
Enkeltarter av vegetasjonen ble samlet fra burene 1-6. Det prosentvise vegetasjonssamensetningen ble bestemt visuelt. Det ble tatt en samleprøve (mixed species fra et gitt areal i burene). Alle prøvene måles for radiocesium.

Jordprofiler
Det ble tatt en jordprofil i hvert av burene 1-6. Profilen ble kuttet på stedet i 1 cm sjikt ned til 5 cm og deretter 2,5 cm sjikt.

Biomasseproduksjon
Vegetasjonen fra et areal på 0,8 m^2 ble kuttet i burene 7-12. Vegetasjon ble tørket og veid. Dette ble gjort fire ganger i løpet av sesongen for å se på variasjonen i biomasseproduksjon over tid. I tillegg ble det estimert biomasseproduksjonen totalt over hele vekstsesongen fra burene 1-6.

Klimadata
Det er innhentet klimadata fra værstasjone på Tjøtta er samlet inn. Disse viser bl.a månedsmiddel av temperatur og nedbør.

Faecesprøver
Det ble tatt faecesprøver direkte fra dyrene. Disse blir målt for radiocesium og sent Risø for sporanalyse samt Deborah Oughton for analyse av scandium.

Prøvetaking av sopp
Noen få sopp ble funnet på beitområdet, dog ingen i selve burene. Soppen viste relativt lave nivåer av radiocesium.

- Ingar Amundsen

Biomasseproduksjon, Tjøtta 1996

Bur nr.	14.Jun (g/m2)	11.Jul (g/m2)	14.Aug (g/m2)	02.Sep (g/m2)	SUM
7	129	72	69	91	362
8	152	63	69	50	334
9	111	81	54	31	277
10	133	95	114	65	406
11	14	13	27	16	70
12	16	54	27	28	125
SNITT	92	63	60	47	262

Bur nr.	22.Aug (g/m2)
1	421
2	365
3	350
4	186
5	230
6	133
SNITT	281

Temperatur og nedbør på Tjøtta vist som månedsmiddel. Normal referer til lokal normal på Tjøtta.

MONTH	Normal	1994	1994	1995	1995	1996	1996
	Precip. (mm)	Precip. (mm)	Temp (°C)	Precip. (mm)	Temp (°C)	Precip. (mm)	Temp (°C)
May	58,2	23,9	6,6	13,1	8,4	56,9	3,7
June	78,3	92,5	9,1	82,5	10,1	122,7	8,0
July	87,6	41,8	13,7	114,3	11,7	80,7	10,0
August	89,9	15,6	14,1	165,3	11,1	67,2*	13,6*
September	148,3	87,4	9,7	100,5	10,5		

* til og med 19.august

Year Coefficient	88	90	91	92	93	94	95	96
T_{ag} soil-meat	31	37	48	40	37	37	19	
TF soil-gras		61	72	77	60	46	14	25
CF grass-meat		0.6	0.7	0.5	0.6	0.8	1.4	

Table 3. Aggregated transfer factor; T_{ag} (10^{-3} m^2 kg^{-1}), transfer factor; TF (10^{-3} m^2 kg^{-1}) and concentration factor; CF.

Cs-137 i sopp på Tjøtta

Art	Bq/kg d.w.
Mild gulkremle	18151
Lundhette	4725
Rødskrubb	1067
Grønn anistrakt	6818
Sildekremle	1675
Brunskrubb	3200

Cs-137 i jord og vegetasjonsprøver på Tjøtta tatt 20/8 1996

Bur nr.	Bq/m2	Veg. (Bq/kg)	TF(10-3 m2 kg-1)
rute 1	31724	2266	71
rute 2	34727	77	2
rute 3	24538	439	18
rute 4	22882	233	10
rute 5	27042	403	15
rute 6	50342	1604	32
SNITT	32000	840	25

NKS EKO-2
Möte, MIL-114, Risø, Roskilde, Danmark 2-3 dec. 1996

ARBETSRAPPORT FRÅN SVERIGE ANG. "LAMMPROJEKTET" 1996

Inger Andersson, Hans Lönsjö & Klas Rosén, SLU (Sveriges lantbruksuniversitet), Alnarp och Uppsala.

Studierna med lamm på fjällbete, Blomhöjden, Jämtland, har fortsatts enligt uppgjorda planer. Arbetet med provtagning och registreringar (jord, betesvegetation, lamm, feces, svamp m.m.) utfördes i mitten av augusti. Lammen (8 st som vistats på fjällbete hela säsongen) slaktades i nära anslutning till dessa registreringar. Samtidigt slaktades 8 lamm som de sista veckorna hade vistats i en inhägnad betesfålla vid gården.

En stor del av det praktiska arbetet med aktivitetsmätningar, näringsvärdesbestämningar av betesvegetation, identifiering av svamparter m.m., är slutförd, men resultaten är inte ännu sammanställda i rapportform. Tabeller och figurer kommer att visas som overhead vid arbetsmötet.

Svampsporbestämningar i fecesprover från lamm återstår, liksom de analyser som skall göras betr. "Mobility of Cs in soil" (Morten Strandberg, resp. Deborah Oughton, se nedan).

Sammanfattning av utförda arbetsmoment

Provtagning

Jord.
Betesvegetation.
Enskilda betesväxter.
Svamp på betesmark.
Feces (rektalprov) från varje lamm.
Feces, prover insamlade från betesmark före och under svampsäsong.
Muskelprov från lammslaktkroppar.

Analyser (om inte annat anges föreligger uppgifter)

Jord: Cs-137. Uppgifter föreligger ej.
Jord: "Mobility of Cs in soil". Uppgifter föreligger ej.

Betesvegetation: Mängd torrsubstans per m^2.
Betesvegetation: Näringsvärdesbestämning. Ca och K.
Betesvegetation: Cs-137.
Enskilda arter av betesväxter: Cs-137.
Betesvegetation: "Mobility of Cs..". Jordinnehåll. Uppgifter föreligger ej.

"Live monitoring" av lamm: Cs-137
Muskelprov från lammslaktkroppar: Cs-137.
Muskelprov från lammslaktkroppar: "Cs in soil-plant-sheep system". Uppgifter föreligger ej.

Feces, rektalprov från individuella lamm: Cs-137. Jordinnehåll. Uppgifter föreligger ej.
Feces, rektalprov från individuella lamm och prov samlade på betesmarken före och under svampsäsong: Svampsporbestämning. Uppgifter föreligger ej.

Svamp: Identifiering av arter.
Svamp: Cs-137. Uppgifter föreligger eventuellt.

Övriga insamlade uppgifter

Betesperiodens omfattning.
Lammens slaktvikt.
Temperatur och nederbörd under 1996. Uppgifter föreligger ej.

Övrigt

Uppgifter från studierna 1990-1995 har lämnats till Sven P. Nielsen och Mette Øhlenschlæger att användas i fortsatta modelleringsberäkningar.

Ytterligare en fårbesättning har studerats under 1996. Besättningen finns på en gård i Uppsalatrakten i ett område med ungefär samma markdeposition (1986) som registrerades i Blomhöjdsområdet. Studierna har utförts på initiativ av Hans Lönsjö, som också helt har ansvarat för provinsamling och analysarbete. Närmare redovisning lämnas av Hans vid arbetsmötet.

Kongresspublikationer:

Andersson, I., Lönsjö, H. & Rosén, K. 1996. *Transfer of Cs-137 from Soil to Vegetation and to Grazing Lambs in a Mountain Area in Northern Sweden. Ecological Half-life of the Nuclide.* (Abstract. Poster session). International Symposium on Ionising Radiation: Protection of the Natural Environment. Organised by The Swedish Radiation Protection Institute (SSI) and The Atomic Energy Control Board (AECB) of Canada. May 20-24, 1996. Stockholm, Sweden.

Andersson, I., Lönsjö, H. & Rosén, K. 1996. *Transfer of Cs-137 from Soil to Vegetation and to Grazing Lambs in a Mountain Area in Northern Sweden. Ecological Half-life of the nuclide.* (Abstract. Poster Session. Föredragande: Hans Lönsjö). Det 11te Ordinære Møtet med Nordisk Selskap For Strålevern. Det Syvende Nordiske Radioøkologi Seminar. 26-29 augusti 1996. Reykjavík, Island.

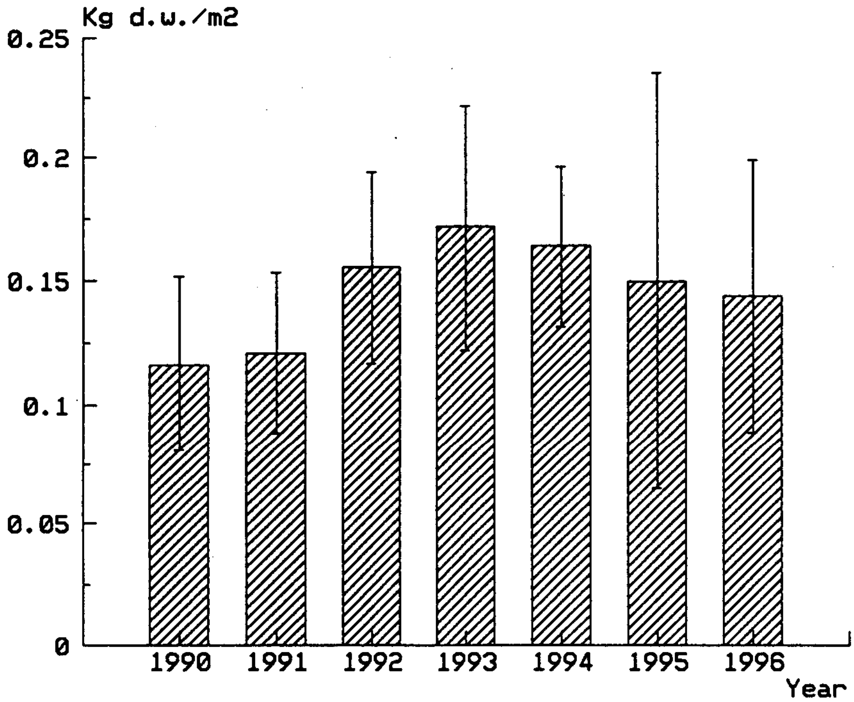


Fig. 1. Herbage density, kg dry weight/m^2, referring to the cut/sampling in August each year. Means and standard deviations for the sampling sites.

Eff ecol. half-life 1990-96 = 6.9 years

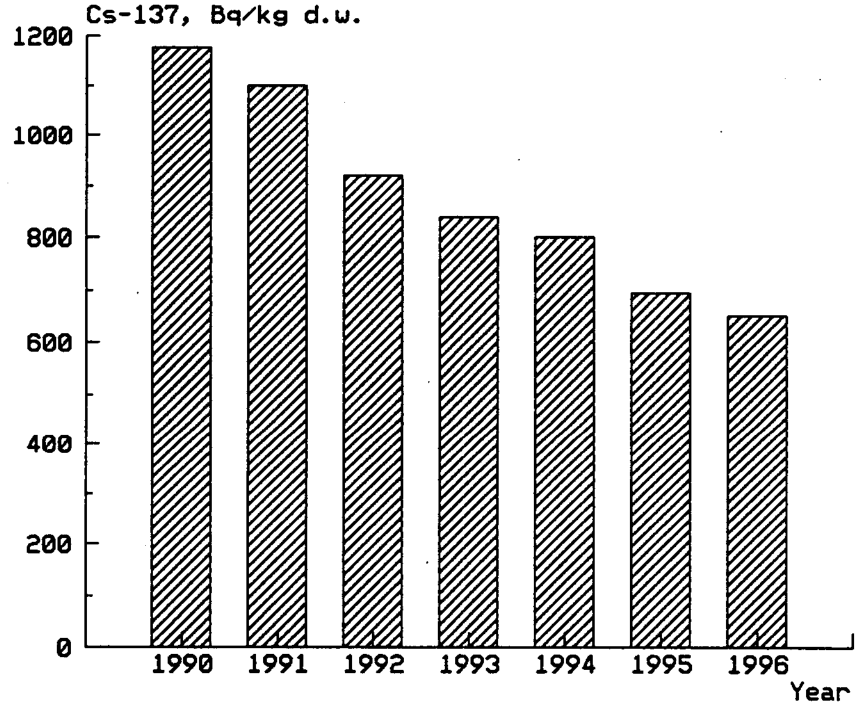


Fig. 2. Cs-137 concentration in herbage, Bq/kg dry weight, referring to the cut in August each year. Means for the sampling sites.

Ecol half-life 1990-96 = 6.9 years

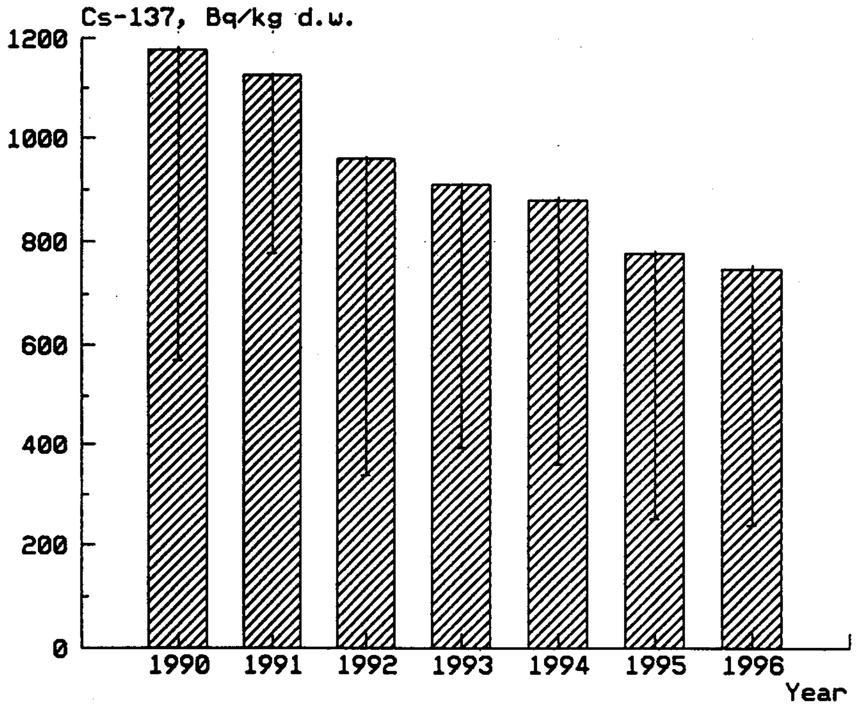


Fig. 3. Cs-137 concentration in herbage, Bq/kg dry weight, each year. Values are time-corrected to August 1990. Means and standard deviations for the sampling sites.

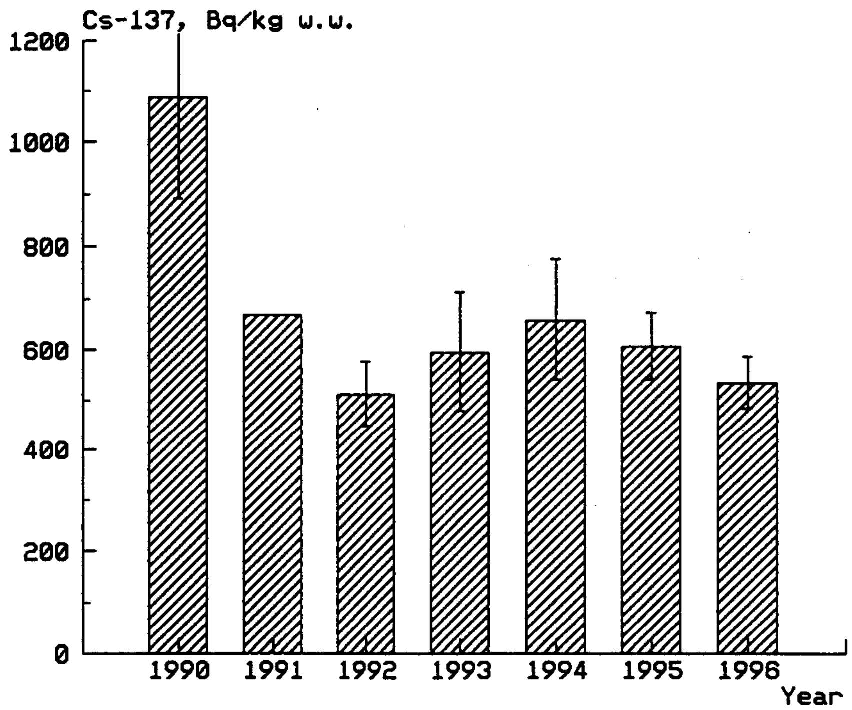


Fig. 4. Cs-137 concentration in abdomen wall muscle samples of lamb carcasses, referring to the date of slaughter each year. Means and standard deviations.

Ecol. half-life 1990-96 = 13.7 years
1991-96 = ∞

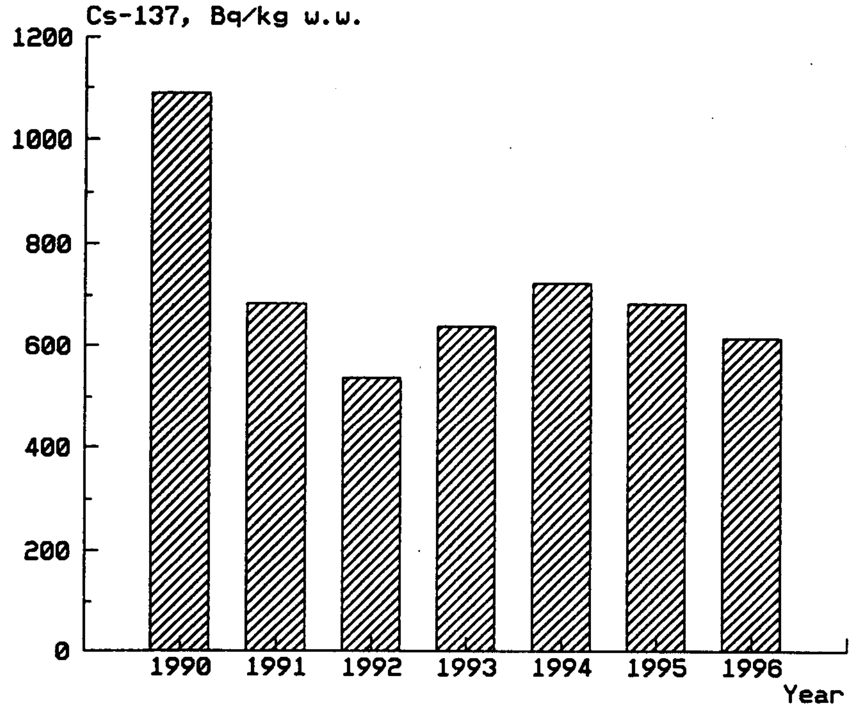
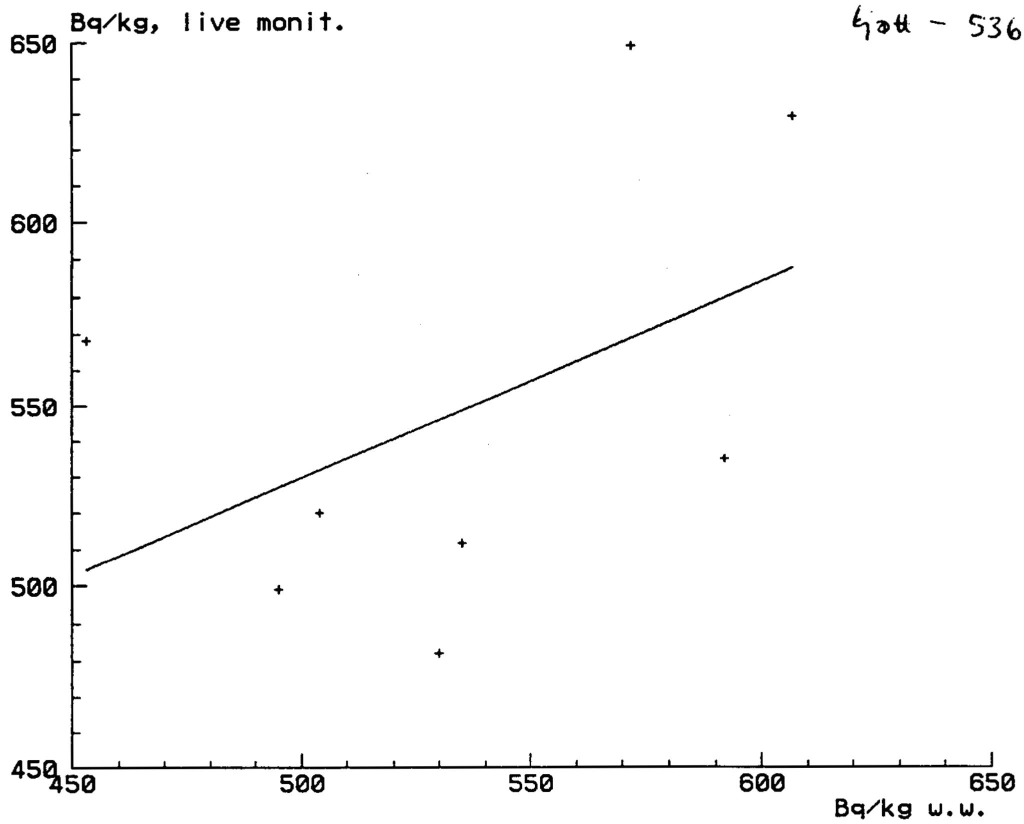


Fig. 5. Cs-137 concentration in abdomen wall muscle samples of lamb carcasses. Means for each year. Values are time-corrected to August 1990.

live – 549 ± 61
[illegible] – 536 ±



a/
Fig. 6. Relationship between Cs-137 concentration according to live monitoring (y) of the lambs with Canberra Series 10 and Cs-137 concentration in abdomen wall muscle samples of the carcass (x). 1996. Y=259.3+0.541*X1 N=8 S=58.54 R=0.4624

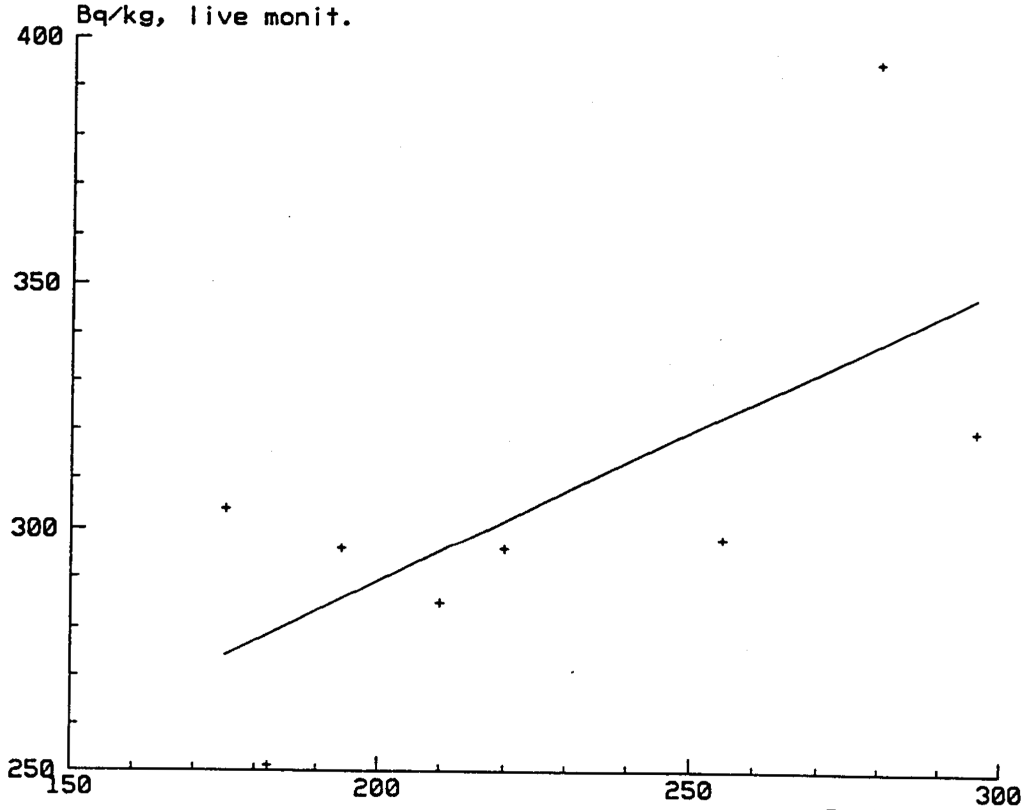


Fig. 6. Relationship between Cs-137 concentration according to live monitoring (y) of the lambs with Canberra Series 10 and Cs-137 concentration in abdomen wall muscle samples of the carcass (x)./996. Y=168.3+0.6061*X1   N=8   S=32.96   R=0.6707

TABLE 1. Transfer of Cs-137 in the soil-plant-lamb chain. Given mean values of Cs-137 concentration are corrected to August 1990. (Data of 1990-1993 according to Rosén *et al.*, 1995)

	1990	1991	1992	1993	1994	1995	1996	Mean
Cs-137 concentration in								
Soil, kBq/m^2	17.62	14.56	16.66	14.07	13.69	-	-	
Herbage, Bq/kg d.w.	1175	1125	960	900	879	779	748	
Muscle, Bq/kg w.w.	1090	684	538	640	724	684	615	
Transfer factors (TF)								
$TF_{soil\ to\ plant}$ (Bq/kg d.w. plant per kBq/m^2 soil)	74.3	72.3	64.7	57.2	68.6	-	-	
$TF_{plant\ to\ muscle}$ (Bq/kg w.w. muscle per Bq/kg dry w. plant)	0.93	0.61	0.56	0.71	0.82	0.88	0.82	
$T_{ag} = TF_{soil\ to\ muscle}$ (Bq/kg w.w. muscle per kBq/m^2 soil	61.9	47.0	32.3	45.5	52.9	-	-	

SVAMPARTER, INSAMLADE PÅ BETESOMRÅDEN, BLOMHÖJDEN, SVERIGE 20-21 AUGUSTI 1996. (NKS EKO-2)

Lokal	Art	Antal svampar	Färskvikt, g
5	*Leccinum scabrum*, Strävsopp /Björksopp	1	27,4
5	*Leccinum versipelle*, Tegelröd björksopp	1	142,9
5	*Russula....*, Kremla	2	32,6
1+2	*Russula....*, Kremlor	3	50,9
5	*Lactarius torminosus*, Skäggriska	2+ (>2)	59,9
5	*Lactarius vietus*, Gråriska	1	5,0
5	*Rozites caperata*, Rynkad tofsskivling (Rimskivling)	1	22,4
1+2	*Lactarius helvus*, Lakritsriska	1- (<1)	12,4
5	*Russula claroflava*, Mild gulkremla	1	11,4
1+2	*Cortinarius evernius*, Lila spindelskivling	3	25,1
1+2	*Piptoporus betulinus?* Ticka (björkticka?)	2?	27,8
?	*Xerocomus subtomentosus*, Sammetssopp	1	22,5
?	*Amanita vaginata*, Grå kamskivling	1	15,6
1+2	*Leccinum versipelle*, Tegelröd björksopp	1	69,1
1+2	*Cortinarius armillatus*, Rödbandad spindel-skivling	2	18,0
1+2	*Russula claroflava*, Mild gulkremla	3	33,7
5	*Russula.....*, Kremla (förväxt)	2	77,0
5	*Leccinum versipelle*, Tegelröd björksopp	1	123,0
?	*Russula.....*, Kremla	1	18,3
5	*Cortinarius.....* Spindelskivling.....	1	6,2
5	*Russula xerampelina*, Sillkremla	1	33,9
?	*Russula claroflava*, Mild gulkremla	1	2,8
?	*Lactarius torminosus*, Skäggriska	1	2,1
?	*Rozites caperata*, Rynkad tofsskivling (Rimskivling)	1	6,2

Totalt insamlat: 35 svampar, fördelade på 24 prov och 15 ? arter.

Svamparna identifierades 22 augusti 1996 av Svengunnar Ryman, Institutionen för systematisk botanik, Uppsala universitet, Uppsala.

Benämningar enligt: Ryman, S. & Holmåsen, I. *Svampar. En fälthandbok.* (Tredje reviderade upplagan) 1992. Interpublishing AB. Stockholm.