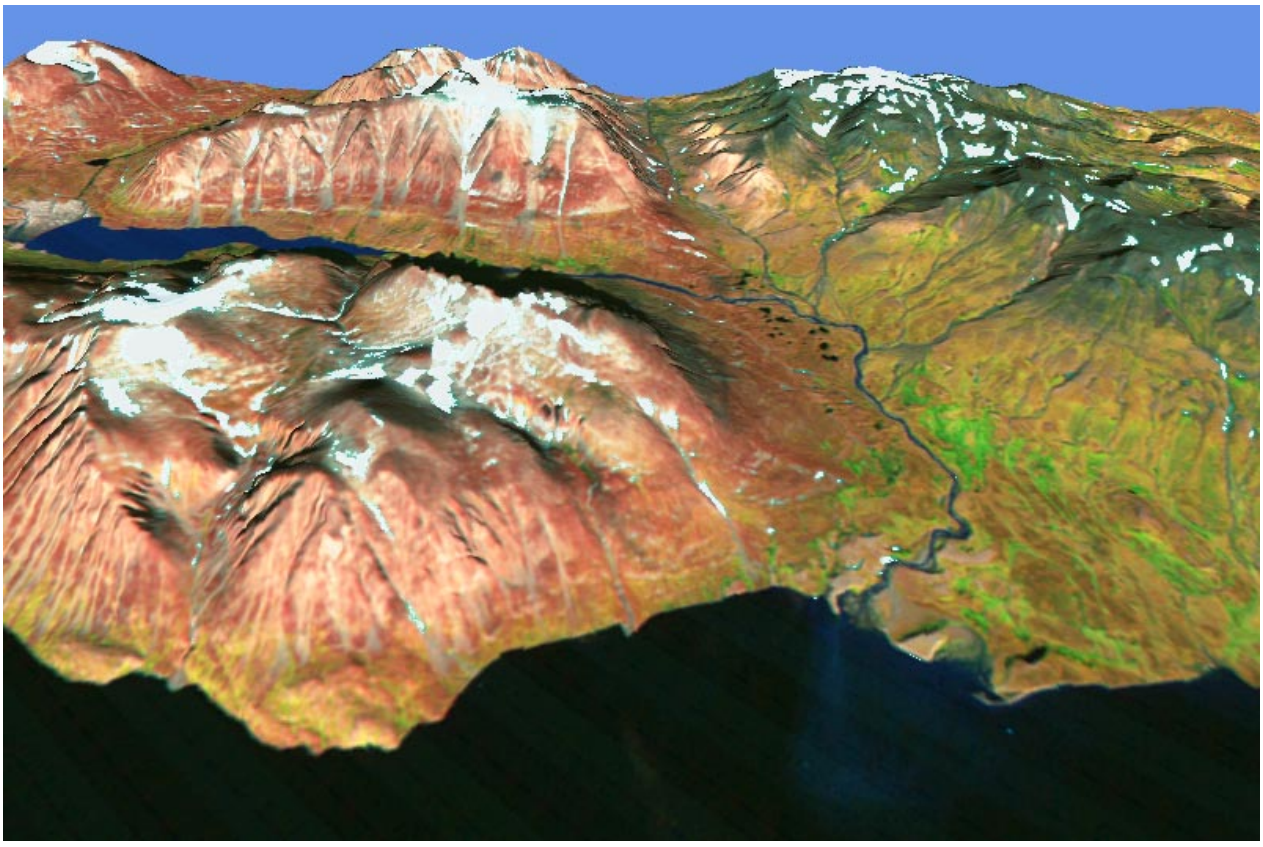
Zackenberg Ecological Research Operations

BioBasis

Conceptual design and sampling procedures of the biological programme of Zackenberg Basic

5th edition



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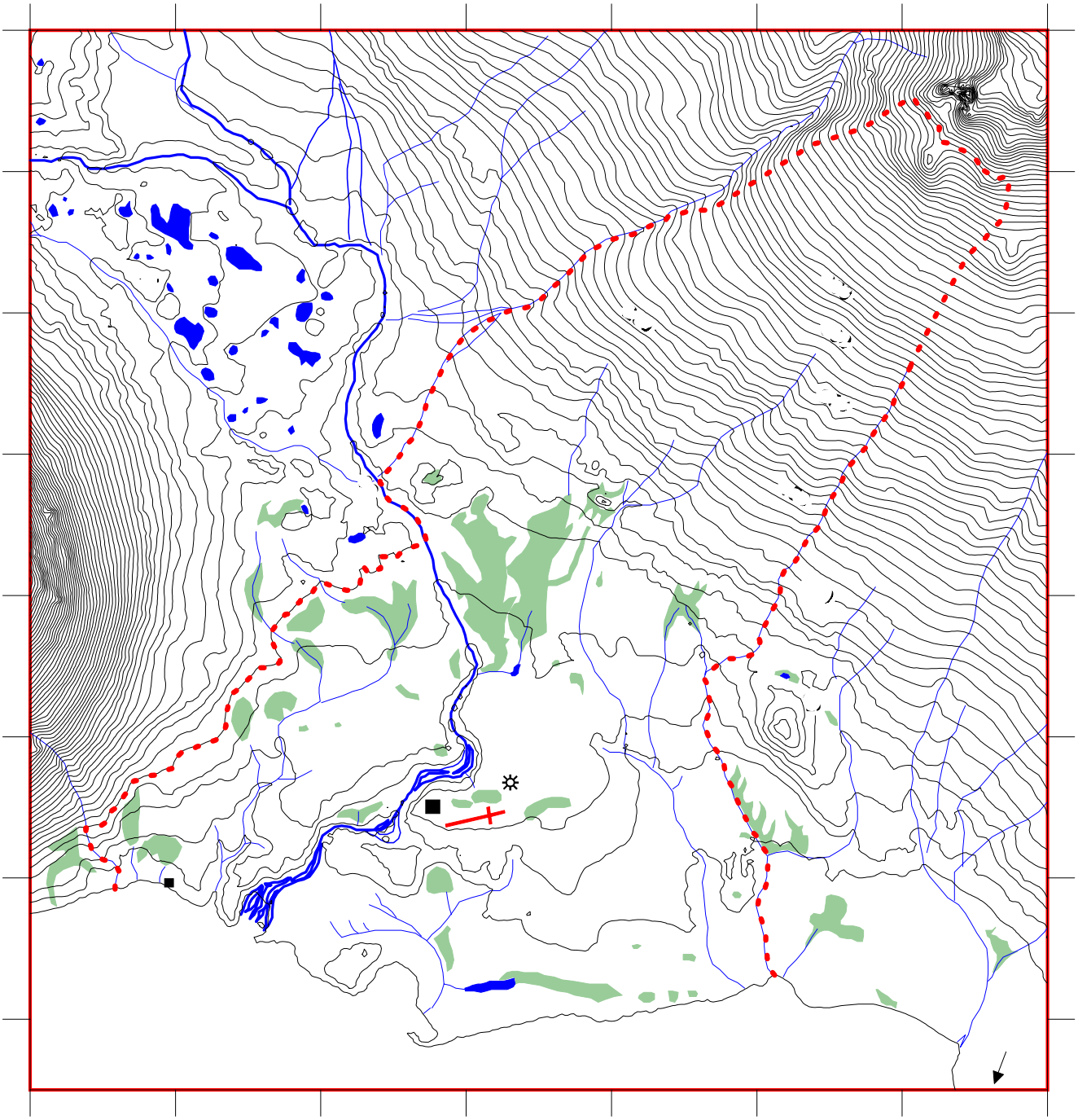
Front cover illustration

Manipulated satellite image of the Zackenberg mountain (front left) adjacent to the valley Zackenbergdalen, where most of the BioBasis monitoring takes place. (Photo courtesy by the Geographical Institute, University of Copenhagen.)

Content

Map of Zackenbergdalen with local site names usen by BioBasis



Superior notice on data handling and quality

It is of decisive importance that data obtained by BioBasis are handled with the greatest care. They all cost a lot of time, money and effort, and in many cases they can not be regenerated if lost.

While at Zackenberg, data files must be copied onto a floppy disc each time new data have been added. Use two alternate discs, so that any transfer error does not destroy the copy already worked up.

At the end of the season, the entire set of data files must be copied on two separate sets of floppy discs. Each set is kept separate during the homeward travel, so that one e.g. goes with the shipped goods, one with the personal luggage and the computer itself is kept with the hand baggage.

The same apply to hand written material such as plot maps etc.: Carry them home with the hand baggage, and photocopy them after arrival at the National Environmental Research Institute for storage in another place than the originals. Bring the copies to Zackenberg next year, so that a complete set is kept here as well.

At home with the National Environmental Research Institute, all data files are immediately copied to the main server, and these copies are updated each time the files have been supplemented or edited. The original floppy disc copies from the field season are kept in separate places until the annual data set is copied on a cd and delivered to the Danish Polar Center in accordance with the contract. Finally, all data files are printed out and kept as hard copies.

The quality of the data must be checked each year in connection with the final editing and preliminary analysis following each season. Any data diverging from expected values must be checked carefully and discussed with the observer.

BioBasis
Conceptual design and sampling procedures of the biological programme of Zackenberg Basic

2001 Edition

General outline of BioBasis

The long-term 'baseline studies' of BioBasis embrace the 40 elements listed below. They have been selected to cover a wide variety of trophic levels in the local ecosystem as well as for their suitability for standardised monitoring. Together, they aim to produce a coherent set of numerical and phenological data facilitating the understanding of the intricate dynamics of a terrestrial High Arctic ecosystem. In combination with the parallel climatological and physical geographical parts of Zackenberg Basic, ClimateBasis and GeoBasis, it will be possible to evaluate the effects of long-term changes that may emerge in the future.

Overview of monitoring elements

1. Plants

1.1. In 29 plots, ranging from early to late snow-free plant communities, reproductive phenology (flowering) is recorded for *Cassiope tetragona* (6 plots), *Dryas* spp. (8), *Papaver radicatum* (4), *Salix arctica* (4), *Saxifraga oppositifolia* (3) and *Silene acaulis* (4) on a weekly basis during the growing season (late May - early September).

1.2. In the study plots mentioned under 1.1, the number of flowers is recorded at a fixed time during the summer season. The same applies to four study plots with *Eriophorum scheuchzeri*.

1.3. A 8.8 km transect - the 'ZERO line' - running from sea level to 1040 m a.s.l. was established in 1992 and 1994. In connection with the establishment, all significant vegetation pattern changes along the line were recorded and marked, using numbered pegs. Future changes between competing plant communities can be measured by referring to these pegs. The transect will be re-examined by a specialist at 5-10 year intervals.

1.4. Three plant community plots (each 20 m x 20 m) are situated in selected vegetation types along the ZERO line (see element no. 1.3). Within each plot, the distribution of plant species has been mapped in detail, so that even minute changes can be detected. The checking of each plot will be done by a specialist at 5-10 year intervals, in connection with no. 1.3.

1.5. In each plot, mentioned under element no. 1.1, weekly Relative Vegetation Indexes (RVI) are measured.

1.6. Fourteen study plots to test changes in the cryptogamic vegetation were established in 1994. The plots will be re-examined by a specialist at 5-10 year intervals.

1.7. The number of berries etc. are recorded annually in three study plots with *Arctostaphylos alpina*, *Vaccinium uliginosum* and *Empetrum nigrum*, respectively.

1.8. In 1998, nine ITEX point frame study plots, each with five frame plots in typical plant communities, were established. These are planned to be reanlysed at 5-10 year intervals.

1.9. Annual Normalised Difference Vegetation Index (NDVI) analyses from satellite images are made for 10 sec-

tions of the study area in Zackenbergdalen.

1.10. Selected vegetation parameters will be monitored at a regional level by means of satellite data.

2. Arthropods (leddyr)

2.1. Faunistic and phenological collections are carried out by means of yellow pitfall traps placed in five different plant communities. The traps are emptied on a weekly basis throughout the summer season (early June - late August/early September). The catches are sorted into taxonomic groups, counted and preserved at the Zoological Museum, University of Copenhagen.

2.2. Two 'window traps' are placed at a pond near the station to monitor limnitic insect production and aerial activity. The traps are emptied on a weekly basis throughout the summer season (early June - late August/early September), and the catches are sorted into taxonomic groups, counted and preserved at the Zoological Museum, University of Copenhagen.

2.3. Predation by larvae of the moth *Sympistis zetterstedtii* on *Dryas* flowers is recorded weekly in six study plots (see element no. 1.1) during the summer season.

2.4. The occurrence of woolly-bear caterpillars *Gynaephora groenlandica* is recorded weekly in four Arctic willow *Salix arctica* study plots (see element no. 1.1) and generally during fieldwork during the summer season.

2.5. Predation by larvae of an unidentified Lepidoptera on *Salix arctica* ovules is recorded weekly in four study plots (see element no. 1.1) during the summer season.

2.6. The occurrence of bumble bees *Bombus* sp. is recorded.

3. Birds

3.1. Populations of all breeding bird species (12-15) are mapped annually during June-July in a 19 km^2 census area in Zackenbergdalen (0-600 m a.s.l.). More intensive studies are carried out on 3.4 km^2 of the census area west of Zackenbergelven.

3.2. Breeding phenology (first egg dates, hatching, fledging) is monitored annually in the census area mentioned under element no. 3.1.

3.3. Annual fledging success of waders (shorebirds) is monitored by counts of juveniles in the deltas of Zackenbergelven every third day during 20 July - 31 August.

3.4. Barnacle goose broods in Zackenbergdalen are monitored during the fledging period.

3.5. Each year in mid/late July, birds are recorded along a transect from Daneborg to Zackenberg and through the adjacent valley, Store Sødal.

3.6. Breeding common eiders, Sabine's gulls and Arctic terns are censused on Sandøen in late July.

3.7. Other bird observations are recorded throughout the entire field season, including flocks of moulting geese.

4. Mammals

4.1. Winter nests and summer burrows of collared lemmings are mapped annually in a 2.5 km^2 study plot. Nest size and amounts of faeces together with predation are recorded for each nest.

4.2. Muskoxen in Zackenbergdalen are counted each day from a fixed point at the research station, and the position of the individual groups are mapped.

4.3. A complete census of muskoxen is performed within 40 km^2 in Zackenberg-

dalen on a weekly schedule throughout the summer season. As many muskox groups as possible are identified for age and sex composition.

4.4. Fresh muskox carcasses are recorded each year, tooth, bone and tissue samples are taken, and leg bones are checked for marrow characteristics.

4.5. All Arctic fox dens in Zackenbergdalen are checked regularly during the summer field season for occupation and cups.

4.6. As long as the fjord is ice covered, the number of seals hauled out on the ice is recorded each day.

4.7. Each year in mid/late July, mammals (incl. offspring, winter nests of lemmings, muskox droppings and mammalian carcasses) are recorded along a transect line from Daneborg to Zackenberg and through the adjacent valley, Store Sødal.

4.8. Walruses hauled out on Sandøen are counted, sexed and aged in mid/late July.

4.9. Other observations of mammals are recorded throughout the entire field season.

4.10. Faeces from ermine, Arctic fox and Arctic wolf together with casts from long-tailed skua and snowy owl are collected at 29 selected perches at the end of each season. The material is dried and kept available for later examination (e.g. for annual variation in contents of lemming bones).

5. Lakes

5.1. Physical-chemical parameters, phytoplankton and zooplankton are each monitored 1-3 times per season in two lakes in Morænebakkerne, one with and one without Arctic char.

5.2. Fish (to be developed).

6. Microclimate temperatures in ITEX and arthropod study plots, snow and ice melt in study plots, etc.

6.1. TinyTag / TinyTalk dataloggers are recording microclimate temperatures in ITEX flowering and arthropod study plots (see elements 1.1 and 2.1) 5-12 times per day, year round.

6.2. In each plot, mentioned under elements no. 1.1, 1.2, 1.4 and 2.1, the snow-cover is estimated at weekly intervals during snow melt.

6.3. Snow cover in Zackenbergdalen is monitored photographically from the eastern slope of Zackenbergfjeldet (500 m a.s.l.) during snow-melt in June as a supplement to the automatic photo-monitoring year round run by GeoBasis.

6.4. Records are kept on snow and ice melt in the study area, particularly on ponds and lakes (see also section 5.1) and on the fjord, together with the start of running water in streams and rivers.

7. Disturbance

7. Records are kept of activities (man-days and ATV trips) in the different sectors of the study area, particularly in the 'low-use' study area east of Grænseelv and in the goose moulting area along the coast east of the old delta of Zackenbergelven. Records are also kept of aircraft operations in and around Zackenbergdalen, and of waste water and other discharges into Zackenberg-elven etc. Finally, records are kept of all manipulative research projects and of all studies involving take of organisms.

Detailed manual for BioBasis

All times given are GMT.

1. Plants

1.1. Reproductive phenology and relative vegetation index (RVI)

1.1.1. Species to be monitored

White Arctic bell-heather *Cassiope tetragona* (kantlyng)

Mountain/Arctic avens *Dryas integrifolia / octopetala* (fjeldsimmer)

Arctic poppy *Papaver radicatum* (fjeld-valmue)

Arctic willow *Salix arctica* (polar-pil)

Purple saxifrage *Saxifraga oppositifolia* (purpur-stenbræk)

Moss campion *Silene acaulis* (tue-limurt)

1.1.2. Frequency of sampling

At weekly intervals during late May / early June - late August / early September (see fixed dates in table 1.1.2). If inclement weather prohibits sampling, the work may be postponed to the following day.

Table 1.1.2. Sampling dates for reproductive phenology (flowering etc.). The plots on the slope of Aucellabjerg are sampled two days later, in connection with the muskox censuses (see 4.3.3).

27 May	01 July	05 August
3 June	08 July	12 August
10 June	15 July	19 August
17 June	22 July	26 August
24 June	29 July	3 September

1.1.3. Equipment to be used

Map with position of study plots

Dictaphone

Knee pads

RVI meter with sensor

Dataloggers

1.1.4. Location and marking of study plots

The position of the 29 study plots in the lowland is shown on Fig. 1.1.4, and the numbering follows the most practical route between them. Four more plots are situated on the slopes of Aucellabjerg, at c. 120 m a.s.l. (see table 1.2.2 and Fig. 4.3.4). Each plot is marked with angular aluminium bars in the corners and provided with a number plate. The plots are divided into four sections (quarters A, B, C and D separated by steel pegs) starting from the number plate and running either straight from there or clockwise around the centre. UTM co-ordinates, dimensions etc. appear from table 1.2.2.

1.1.5. Sampling method

During snow melt in June, per cent snow cover in each plot section is estimated at each sampling trip (including *Eriophorum* plots; see section 1.2). If any plant part is visible above the snow layer, the cover is given as 99%. If any ground/vegetation cover is free, no more than 98% can be stated.

At each visit, samples of a total of at least 50 flower buds, flowers and senescent flowers (or capsules with exposed seeds) are recorded within each plot section. This is done by counting the different phenological stages within appropriate group sizes of individuals and dictating subtotals to the dictaphone concomitantly until a total of over 50 is achieved. Check now and then that the dictaphone is recording (i.e. running and showing red light).

In general, flower buds are defined as flowers not yet open, flowers are open giving insects access to the reproductive or-

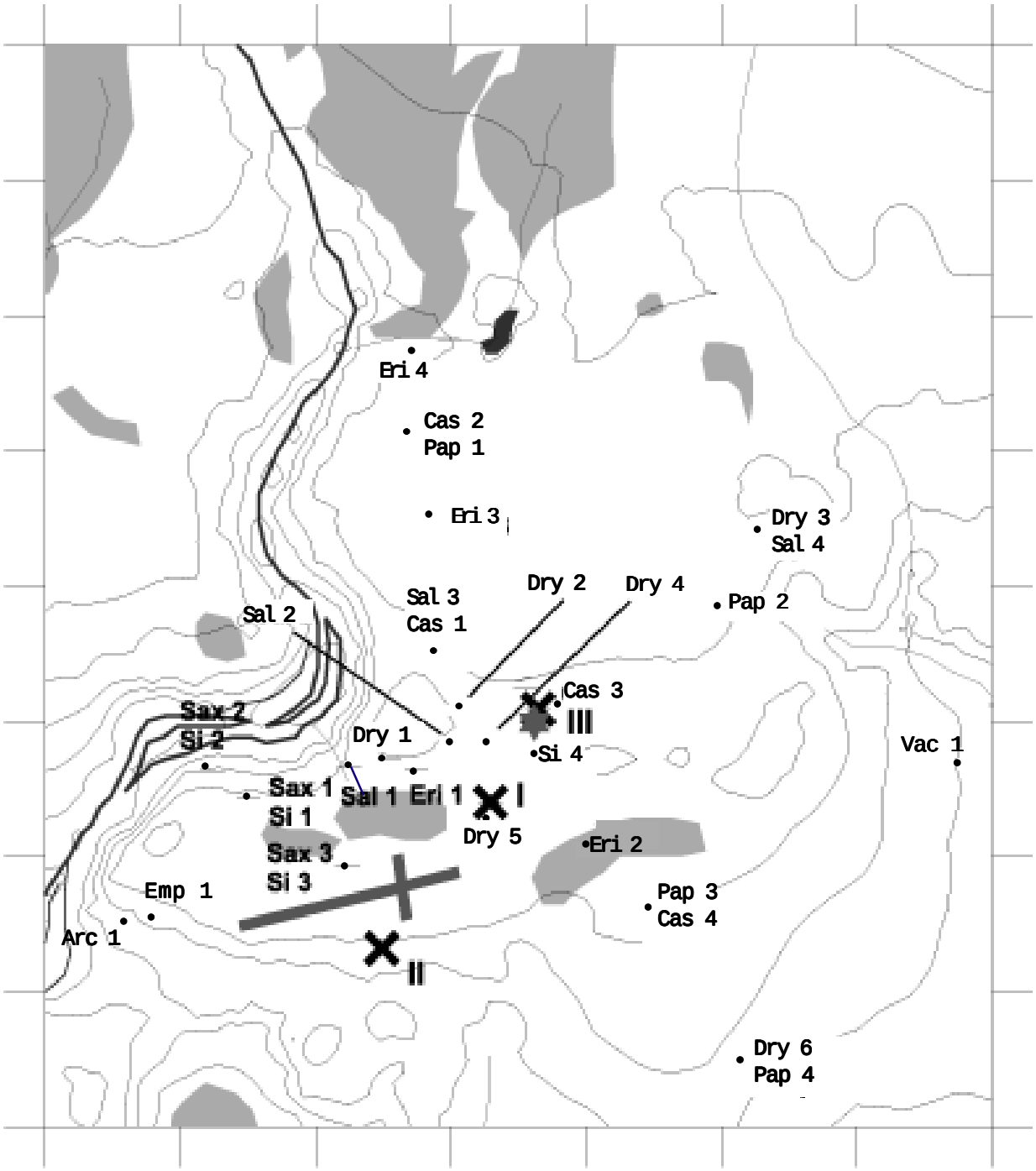


Fig 1.1.4. Position of the flowering study plots (dots) and plant community plots I-III (cross) together with the climate station (star).

gans, and senescent flowers as flowers that have lost all petals or with all petals almost or fully faded or brown. In some of the final stages, flower stems from the preceding year may interfere with the counts. However, such old stems are always dry and stiff, stems of this year are soft and fleshy.

For each species, the following sampling procedure apply in particular:

Cassiope: Most petals fall off as one unit before they wither. The ovules are still counted as senescent flowers.

Dryas: Apart from sampling of buds, flowers and senescent flowers, record also the

number of flowers where the reproductive organs have been partly or fully eaten by larvae (of *Sympistis zetterstedtii*). Such flowers must still be counted among the flowers. Also, the number of caterpillars in the sampled flowers must be recorded.

Papaver: Petals either fall off or turn dark green and fold around the capsule (late in the season). Both types are recorded as senescent flowers. Open capsules with exposed seeds must also be recorded. In cases where the petals are folded around the capsule, it may be necessary to remove the top of these to check if the capsule is open. Finally, the capsules may fall off. Such 'flowers' can still be separated from last year's stems by their hairy appearance, and they must still be recorded among the 'senescent flowers with exposed seeds'.

If the plot has been grazed by e.g. muskox, the ratio of missing capsules (represented by a flower stem from this year without a capsule) must be recorded together with the sampling of flowers etc. This only happens while the capsules are still green.

Salix: The sampling unit is catkins, not individual flowers.

Most flowers from one catkin emerge the same day, and they also wilt at the same time. Hence, catkins are recorded as buds when no stigmas or anthers are visible, and as flowers as soon as stigmas or anthers are visible (they are both red in the early stages). Buds can not be sexed, so male and female buds are pooled.

The transition to senescent flowers is not recorded, but female catkins must further be recorded as having exposed cutton from the time of exposure of the first seed hairs on top of the splitting capsules. Notice that fruits affected by sawfly Tenthredinidae larvae expose seed hairs from the bottom of the capsules (excreta from the larvae are often visible among the seed hairs). These capsules must not be recorded as having seed hairs exposed, but should be recorded separately (however, still included in the number of flowers).

Fruits infected by sponges (yellow and twisted) should be recorded separately (yet still included in the figure for 'flowers').

Also, the number of woolly-bear caterpillars *Gynaephora groenlandica* in the plots must be recorded (only for the part of the plot that is included in the sample).

If the plot has been grazed by e.g. muskox, this must be recorded as well (just yes or no).

Silene: A problematic species, since one or a few individuals may dominate the sample. Therefore, several individuals (preferably the same) must be sampled each week. Flower buds are reddish. Senescent flowers are defined as flowers with faded petals and empty pollen anthers.

Saxifraga: Flower buds are reddish. Senescent flowers are defined as flowers with faded petals. The ratio of open capsules (seeds exposed 5-8 weeks after senescense) is part of the sampling. New buds and even flowers may devellop in late autumn. These are not included in the calculation of reproductive phenology.

Finally, eight RVI measurements are taken in each plot (only four in the small *Dryas* and *Cassiope* plots). Two measurements are taken in each quarter (section) of the plot: one at the corner of the first quarter starting at the plot no. sign, and the next at the first corner of the next quarter - and so on. In the small *Dryas* and *Cassiope* plots, measurements are only taken at each corner - or start of each quarter, when they are on line.

Put the meter in the mode 'Ratio' and hold the sensor as horizontally as possible in a straight arm in over the plot and about one metre above the ground. Avoid measuring over your own shade. Read the value onto the dictaphone. The values should vary between 0.1 and 1, with the highest values for the least vegetated areas. Switch off the meter between each plot.

1.1.6. Handling of dataloggers (see 5.1)

1.1.7. Laboratory work

Writing out the dictaphone recordings (see data forms in Appendix).

1.1.8. Input of data into database (to be produced)

The data from the weekly checks of the plots are entered into separate Excel data files with columns relevant for each species. The basic data are: Year, Month, Day, Observer, Plot (e.g. Dry1), Sample (sector A, B, C and D), Snow (per cent per sector), RVI (see below), Buds (give true numbers counted, not per cent), Flowers, Senescent (flowers), Total (sum of buds, flowers and senescent flowers at the annual count), and Remarks. Specific columns for individual species appear from the database files.

For RVI measurements, the ratios recorded in the field must be transformed into indeses by calculating the reciprocal values. For presentation in the annual reports, the RVI-values are transformed into NDVI-values by the equation NDVI= (RVI-1)/(RVI+1).

1.2. Total flowering

1.2.1. Species or taxonomic groups to be monitored

As in 1.1 plus Arctic cotton-grass *Eriophorum scheuchzeri* (polar-kæruld) and 'dark' cotton-grass *Eriophorum triste* (mørk kæruld).

1.2.2. Frequency of sampling

Once per season (table 1.2.2). The optimal time is when most or all flower buds have bursted.

1.2.3. Equipment to be used

Map with position of study plots

Pieces of cord totalling 100 m

Flower sticks

Dictaphone

Knee pads

Dataloggers

1.2.4. Location and marking of sampling plots

See map Fig. 1.1.4 and table 1.2.2. Each plot is divided into four sections, denoted A-D clockwise or straight, starting from the number plate.

1.2.5. Sampling method

Tighten a cord around each section of the plot. In large plots, subsections are established by placing two additional cords with about 1 m intervals from one end of each section, whereupon the lumped number of flower buds, flowers and senescent flowers are counted between each cord. Move one cord at a time and repeat the process until the entire plot is covered. In small plots, sticks may be used instead of cords. Dictate the results to the dictaphone at least for every 100 recordings.

In *Pavaver* plots, any white flowers shoud be counted and given under Remarks. In the *Salix* plots, catkins that have been grazed, but can still be sexed, are included.

In the *Eriophorum* plots, both the number of *Eriophorum scheuchzeri* and *Eriophorum triste* inflorescenses must be recorded. Furthermore, in *Eriophorum scheuchzeri* they must be separated into fertile and infertile flowers. Infertile flowers have poorly develloped white hairs and the stem turns brown long before the stems of the fertile flowers.

1.2.6. Laboratory work

Writing out the dictaphone recordings.

1.2.7. Input of data into database

See section 1.1.8.

Table 1.2.2. Position, dimensions, orientation and approximate counting period for flowering study plots. The different counting periods within the species are determinded by snowmelt.

Plot no.	UTM- co-ordinates		Dimensions	A corner	Counting period
	Easting	Nording	(m)		
Cassiope 1	513,292	8,264,815	1x2	SE	mid/late July
Cassiope 2	513,236	8,265,297	1x3	SE	mid/late July
Cassiope 3	513,542	8,264,757	1x2	E	mid/late July
Cassiope 4	513,584	8,264,370	1x3	NE	mid/late July
Cassiope 5	514,245	8,267,228	1x2.5	SW	mid/late July
Cassiope 6	514,234	8,267,210	1x2	SW	mid August
Dryas 1	513,113	8,264,713	1x4	N	early July
Dryas 2	513,321	8,264,775	6x10	E	late July/August
Dryas 3	513,797	8,265,076	1x2	N	early/mid July
Dryas 4	513,345	8,264,701	2x3	N	early/mid July
Dryas 5	513,317	8,264,548	2x3	NW	early/nid July
Dryas 6	513,782	8,264,089	7x13	S	late July/August
Dryas 7	514,184	8,267,206	3x4	W	early/mid July
Dryas 8	514,212	8,267,228	3x4	S	early/mid July
Papaver 1	513,231	8,265,289	7x15	W	late July/early Aug
Papaver 2	513,716	8,264,963	10x15	E	late July/early Aug
Papaver 3	513,584	8,264,364	9x10	W	late July/early Aug
Papaver 4	513,782	8,264,110	7x13	S	late July/early Aug
Salix 1	513,044	8,264,646	6x10	W	mid/late **June**
Salix 2	513,243	8,264,735	15x20	W	mid/late July
Salix 3	513,289	8,264,815	6x6	S	late **June**/mid July
Salix 4	513,774	8,265,070	10x15	E	early/mid July
Saxifraga 1	512,867	8,264,607	2x3.5	W	mid **June**
Saxifraga 2	512,881	8,254,652	2x3	NE	mid **June**
Saxifraga 3	512,996	8,264,485	2x5	NW	mid/late **June**
Silene 1	512,867	8,264, 607	2x3,5	W	early/mid July
Silene 2	512,881	8,254,652	2x3	NE	early/mid July
Silene 3	512,996	8,264,485	2x5	NW	mid/late July
Silene 4	513,585	8,264,696	1x1	NW	early/mid August
Eriophorum 1	513,176	8,264,660	3x5	N	late July/late August
Eriophorum 2	513,492	8,264,584	3x5	NW	late July/late August
Eriophorum 3	513,237	8,265,113	2x3	E	late July/late August
Eriophorum 4	513,240	8,265,419	2x4	SE	late July/late August
Arctostaphylos 1	512,648	8,264,418	?	W	late August
Vaccinium 1	513,968	8,264,752	?	W	late August
Empetrum 1	512,673	8,264,414	?	S	late August

1.3. The ZERO-line

Text is still in progress, but the following publication is available from DPC:

Fredskild, B. & Mogensen, G. 1997. ZERO line. Final Report 1997. A description of the plant communities along the ZERO line from Young Sund to the top of Aucellabjerg and the common plant communities in the Zackenberg valley, Northeast Greenland. - Greenland Botanical Survey & Botanical Museum, University of Copenhagen, 36 pp.

1.3.1. Species or taxonomic groups to be monitored

1.3.2. Frequency of sampling

1.3.3. Equipment to be used

1.3.4. Location and marking of the transect line

1.3.5. Description of the sampling method

1.3.6. Description of laboratory work

1.3.7. Input of data into databases. To be produced

1.4. Plant community plots

Text is still in progress

1.4.1. Species or taxonomic groups to be monitored

1.4.2. Frequency of sampling

1.4.3. Equipment to be used

1.4.4. Location and marking of sampling plots

1.4.5. Description of the sampling method

1.4.6. Description of laboratory work

1.4.7. Input of data into database. To be produced

1.5. RVI measurements in flower plots

See section 1.1.

1.6. Cryptogam study plots

Text is still in progress

1.6.1. Species or taxonomic groups to be monitored

1.6.2. Frequency of sampling

1.6.3. Equipment to be used

1.6.4. Location and marking of sampling plot(s)/transect line(s)

1.6.5. Description of sampling method

1.6.6. Description of laboratory work

1.6.7. Input of data into databases. To be produced

1.7. Production of berries

1.7.1. Species or taxonomic groups to be monitored

Alpine bearberry *Arctostaphylos alpina* (bjerg-melbærris)

Arctic blueberry *Vaccinium uliginosum* (mosebølle)

Crowberry *Empetrum nigrum* (revling)

1.7.2. Frequency of sampling

Once per season, i.e. in late August.

1.7.3. Equipment to be used

Same as in 1.2.3.

1.7.4. Location and marking of sampling plots

See map Fig. 1.1.4 and table 1.2.2. Each plot is divided into four sections, denoted A-D.

1.7.5. Description of sampling method

As in 1.2.5. Besides berries, buds, flowers and senescent flowers are recorded separately.

1.7.6. Description of laboratory work

Writing out the dictaphone recordings.

1.7.7. Input of data into databases

As in 1.2.7 except that buds, flowers, senescent flowers and berries are given separately.

1.8. ITEX point frame plots

Text is still in progress

1.8.1. Species or taxonomic groups to be monitored

1.8.2. Frequency of sampling

1.8.3. Equipment to be used

1.8.4. Location and marking of sampling plot(s)/transect line(s)

1.8.5. Description of sampling method

1.8.6. Description of laboratory work

1.8.7. Input of data into databases

1.9. Normalised Difference Vegetation Index (NDVI) analyses from satellite images

See special reports (e.g. Bøcker, C.A. 1999: Detaljeret analyse af NDVI for udvalgte vegetationszoner, Zackenberg 1998. - Asiaq.) and the map of the zones (Fig. 1.10).

1.10. Regional vegetation parameters

See special reports (to be produced).

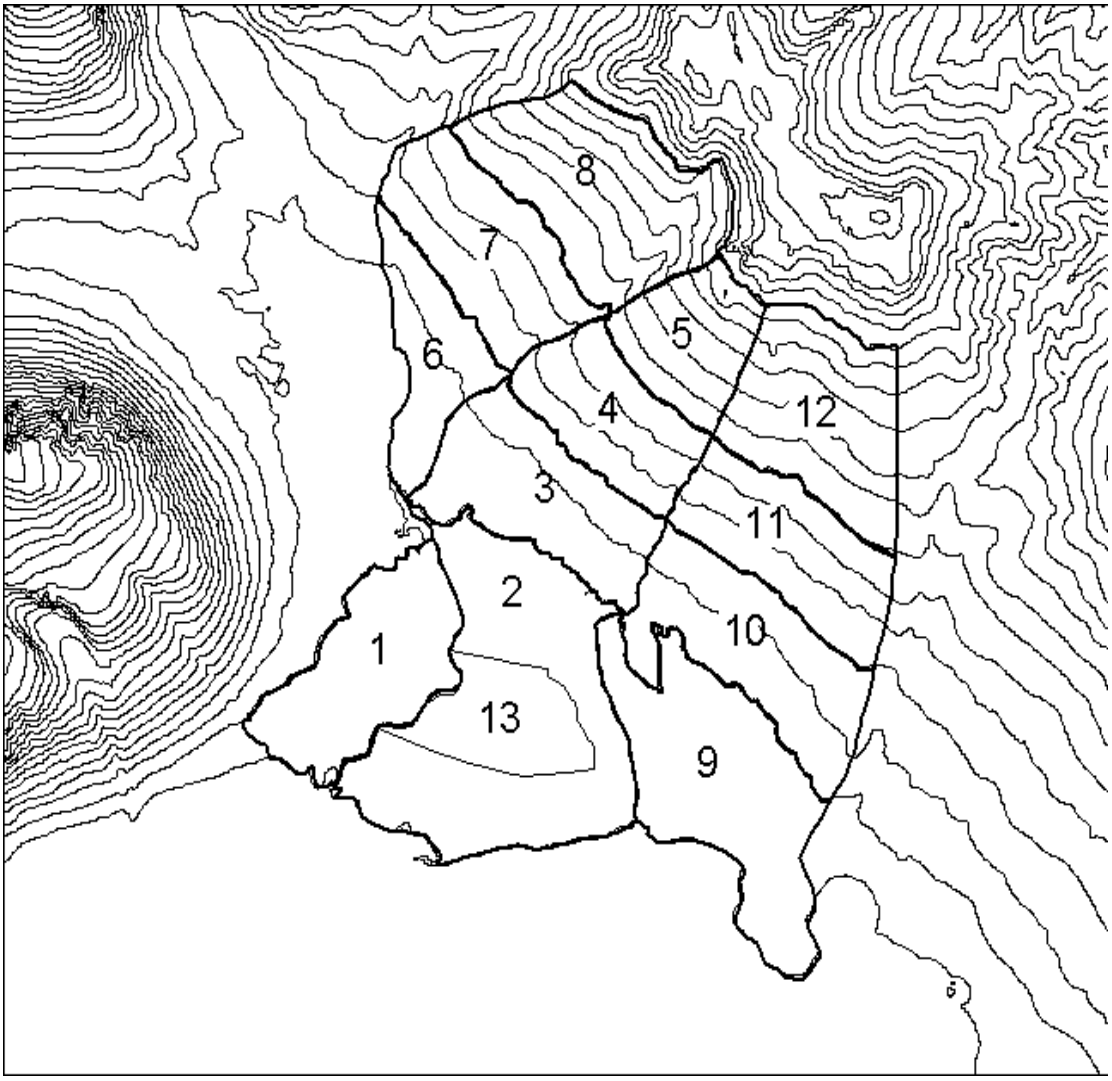


Fig 1.10. Map of Zackenbergdalen with 13 NDVI-zones demarkated.

2. Arthropods (leddyr)

2.1. Yellow pitfall traps

2.1.1. Species to be monitored

All taxonomic groups of arthropods

2.1.2. Frequency of sampling

The traps are emptied weekly on fixed dates (see table 1.1.2). If bad weather prohibits proper handling of the samples, the traps may be emptied on the following day.

2.1.3. Equipment to be used

For field work:

Map showing position of study plots

100 yellow (Pantone no. 108U) plastic cups, 10 cm in diameter and 8 cm deep

A thermos

A garden trowel with sharp edge

1, 5 and 10 l containers for water

Odourfree detergent (Tween 20 from Merck Eurolab, 43868788, info@merckeurolab.dk, www.merckeurolab. dk)

Salt (NaCl) - not from the kitchen!

50 metal pegs

Knee pads

A small aquarium net with the outer 10 cm of a lady's stocking as bag (make a new one each year and clean it in fresh water after each sampling day)

A pair of pointed and angled tweezers

500 ex. 10 cl plastic containers with lids

75 l of 70% alcohol

An ear syringe (with a rubber bulb and tube)

Alcohol resistant labels

Alcohol resistant pens

Alcohol resistant speed marker

Dataloggers

For sorting:

Binocular microscope

Pointed tweezers

Alcohol resistant pens

Preprinted alcohol resistant labels from the Zoological Museum, Univ. of Copenh.

70% alcohol

Data sheets (see Appendix)

and the following literature:

Brændegård, J. 1966: Edderkopper. - Danmarks Fauna, Bind 72.

Chinery, M. 1993: Insects of Britain and Northern Europe. - Collins.

Goulet, H. & J.T. Huber (eds.) 1993: Hymenoptera of the world: An identification guide to families. - Agriculture Canada.

Larsson, S.G. 1966: Insekter. - Danmarks Fauna, Bind 71.

Lyneborg, L. et al. 1960, 1963 & 1965: Tovinger II-IV. - Danmarks Fauna, Bind 66, 68 & 70.

Roberts, M.J. 1995: Spiders of Britain and Northern Europe. - Collins.

2.1.4. Location and marking of sampling plots

The position of the study plots appear from Fig. 2.1.4 (nos 2-7 and table 2.1.4). Each plot measures 10 x 20 m^2 and is made up of eight 5 x 5 m^2 squares marked with a white nylon stick (15 in total) in each corner. Each plot is identified with a number plate, and each section (with one trap each) is denoted A-H clockwise from the number plate.

On Station 2, the traps are marked with a nylon stick at each trap. Each stick is further marked with metal bands around the top (A-D) or the middle (E-H):

One band: A and E
Two bands: B and F
Three bands: C and G
Four bands: D and H

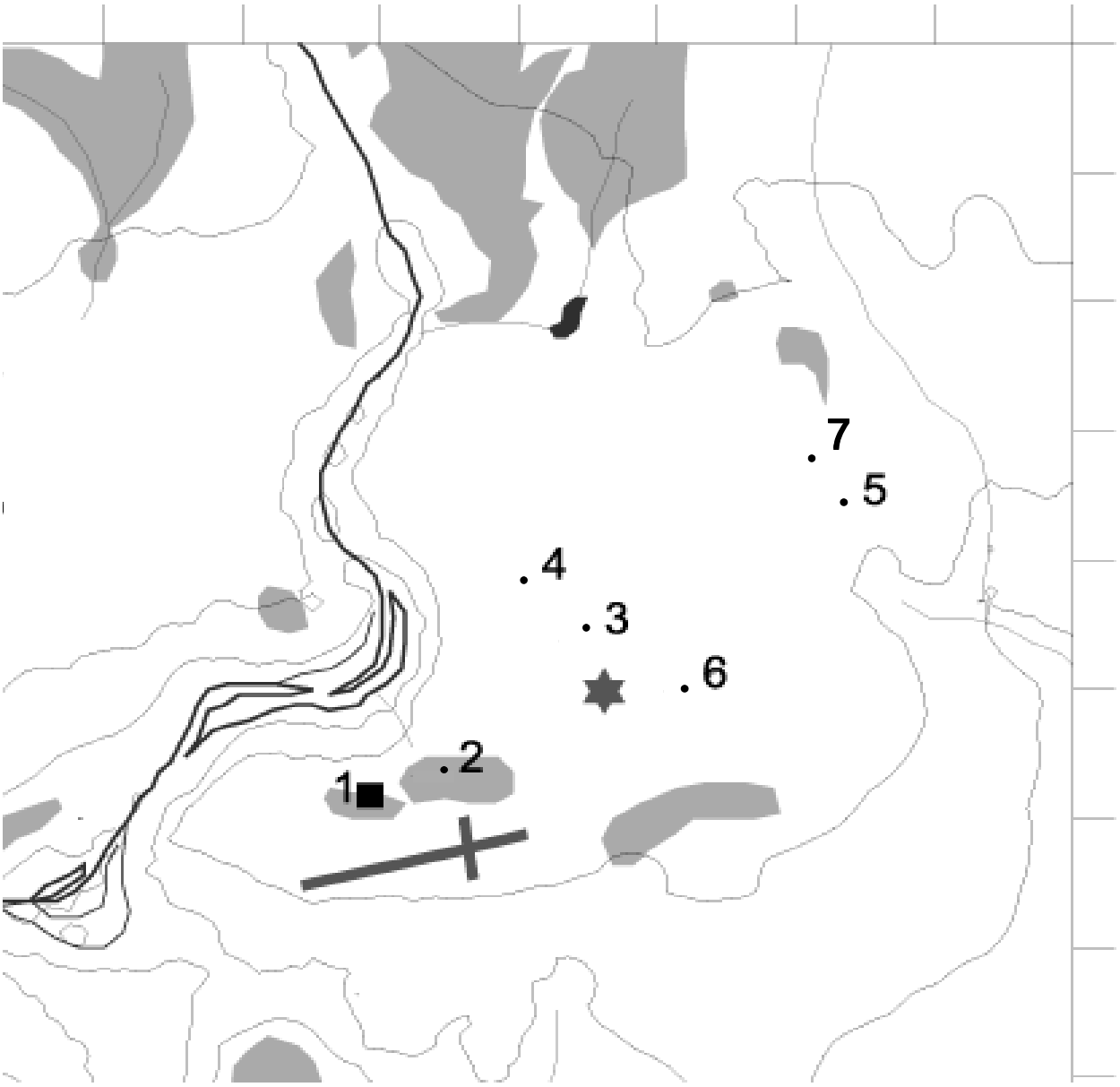


Fig. 2.1.4. Position of arthropod sampling plots 1-6 (square = window traps, dot = pitfall trapping station) and the climate station (star).

Table 2.1.4. UTM-coordinates of arthropod sampling plots.

Plot no.	Easting	Nording	A-corner
1	512,968	8,264,539	-
2	513,094	8,264,600	-
3	513,309	8,264,858	SE
4	513,176	8,264,960	E
5	513,815	8,265,085	S
6	513,549	8,264,733	w
7	513,789	8,265,131	w

Plot 6 is inactive (from 2000).

2.1.5. Sampling method

2.1.5.1. Establishment of the traps

New traps for the following season are established late each summer, when a set of eight pitfall traps are established in each plot. Each trap is composed of two plastic cups fitting into each other, so that the upper one can be lifted and emptied without disturbing the surrounding soil. The traps are positioned randomly within each of the 5 x 5 m^2 squares by turning your

back to the square and throwing an item over your shoulder. The trap is then dug down on the nearest reasonably level and 'elevated' site (so that it is not flooded during the snow melt) and carefully sunk into the soil, so that the upper rim levels exactly with the soil surface. Place the turf and the removed soil about a meter away from the trap. Do not disperse it, since it must be repositioned after the season, when the traps are removed.

The new traps are covered with a plastic lid and a stone during the winter. At the start of the season (i.e. on the round when the traps have appeared from the snow), new clean (washed with a little Tween 20) upper cups replace the 'wintering' ones. Bring hot water in a thermos in case the two cups are frozen solid.

If there is any risk that cups will float up due to water in the lower cup, two metal pegs must be placed along each cup to keep them in position.

The upper cup of the trap is then filled 2/3-3/4 with water (2 l needed per station) added three drops of detergent and a spoonful of salt as killing agent, preservation and to prevent freezing.

The traps on Station 2 are not removed from year to year as they are positioned on the only 'elevated' mounds on the site that are not flooded during spring. The traps on this station are only made up of one cup, as they otherwise would float during the snow-melt. Still, they may need pegs to keep them in position.

2.1.5.2. Emptying the traps

Catches from each of the eight traps are kept separate. Prepare 50 ex. 10 cl containers in advance by filling them 4/5 with 70% alcohol. Alcohol resistent labels with date, plot numbers and sections (A-H) written with an alcohol resistant pen are prepared from home and kept in order by a paper clip. Do not write on the containers.

When the traps are emptied, the trap liquid is poured through the aquarium net into a spare cup, whereupon the liquid is poured back into the repositioned upper cup. Check the cup carefully for small arthropods before repositioning it. Mites, especially, often remain in the cups. Take care that liquid from the net does not fall on the soil around the trap by keeping the net over the cups all the time. The catch is then emptied into the 10 cl container with alcohol by turning the net inside out in the container. All remaining invertebrates must be removed carefully from the aquarium net by the tweezers and put into the container.

Note the full hour of the day, when the traps in each plot are emptied. After emptying all traps, extra water must be added to the traps to compensate for evaporation since last round (up to 1 l needed per station). In the middle of each season, a little salt and detergent must be added to compensate for loss during the season.

Bring an extra pair of cups on each round, together with equipment for setting up traps, in case a trap has been destroyed, e.g. by a fox or muskox. Any failures such as flooded or floating cups, fox faeces etc. must be recorded. This includes occurrence of fungi in the water. In that case a new cup and new water must be established.

At all visits at the arthopod stations during snow melt, the snow cover (%) is estimated for each section of the plot (see 1.1.5). At station 2, this only apply to the individual traps (i.e. the trap covered = 100%, the trap snow-free = 0%).

Never touch the traps with mosquito repellent or suntan oil on you fingers!

2.1.5.3. Ending the season

At the termination of the catching season on 26 August or 3 September, the trap liquid must be collected from all the traps and poured into Zackenbergelven. All the

'old' traps are gathered, and the turfs put back into the hollows.

2.1.6. Handling of dataloggers

(see section 6.1).

2.1.7. Laboratory work

Specimens are sorted to different taxonomic levels (see data sheets in Appendix and section 2.1.3 for relevant literature) using a binocular microscope with a magnifying range of 6 to 40. Specimens from each taxa from each trap and date are kept in separate glass tubes with 70% alcohol. A pre-printed label written with an alcohol resistant pen stating date and year of collection, station and section no., and taxa (latin only) must be located inside the tube. Glass tubes with specimens sorted in Zackenberg are closed with a plastic stopper, and brought back to the Zoological Museum in Copenhagen. Here the stopper is removed, and the tubes are closed with a cotton stopper and kept in glass containers with 70% alcohol together with the samples sorted at the museum. Each glass must only contain samples of one taxon and year. The collection is organised in accordance with the instructions from the curator at the museum. After emptying the plastic containers, clean them with water to get rid of alcohol and dirt.

2.1.8. Input of data into database

After sorting, the total number of individuals per group is entered into an Excel data file named Art2-7 and holding the following columns: Year, Month, Day, Hour, Plot, Fieldwork, Sorting, Snow A (per cent in the sector), Snow B, Snow C, Snow D, Snow E, Snow F, Snow G, Snow H, Days A (trap days for the trap in the sector), Days B, Days C, Days D, Days E, Days F, Days G, Days H, Taxon, A (no. of individuals in trap A), B, C, D, E, F, G, H and Remarks. Under Remarks, date of opening and closing together with relevant observations on the traps are stated. This include any disturbance that may influence the efficiency of the traps such as flooding, drying out, ice, dirt, faeces and vandalism by foxes.

2.2. Window traps

2.2.1. Taxonomic groups to be monitored

Same as in section 2.1.

2.2.2. Frequency of sampling

Same as in section 2.1.

2.2.3. Equipment to be used

Two window traps each with a 'window' of 20 x 20 cm^2

A cloth

A bucket with a notch

Otherwise same as 2.1.3

2.2.4. Location and marking of sampling plot

On an islet in the eastern pond of Gadekæret (station 1 on Fig. 2.1.4), two angular aluminium bars make up the holders for each trap. The traps are positioned with the windows in a right angle to each other, so that they catch in 'all' wind directions.

2.2.5. Sampling method

The 'basins' of each trap must be filled 3/4 with water, detergent (10 drops) and salt (15 spoonfuls).

At each visit during ice melt in spring the ice cover (per cent) on the pond must be estimated.

When emptying the traps, the aquarium net is used to 'fish' the catch from each basin. The catch from the two traps is pooled in one 10 cl plastic container. Refill the traps at each visit (5 l of water needed),

and add a little salt in the middle of the season to compensate for loss. Keep the windows absolutely clean from salt water and salt.

Empty them together with the other traps on 26 August or 3 September. Use a bucket when you empty them. The traps must be stored in-house during winter.

2.2.6. Laboratory work

The samples are handled in the same way as described in 2.1.7.

2.2.7. Input of data into database

After sorting, the total number of individuals per group is entered into an Excel data file named Art1 and holding the following columns: Year, Month, Day, Hour, Plot, Fieldwork, Sorting, Ice (per cent cover on surrounding pond), Days A+B (sum of trap days for both traps), Taxon, No. (of individuals in both traps combined), and Remarks. Under Remarks, date of opening and closing together with relevant observations on the traps are stated. This include any disturbance that may influence the efficiency of the traps such as ice, dirt and vandalism by muskoxen.

2.3. Predation by larvae of *Sympistis zetterstedtii* on *Dryas* flowers

See section 1.1.5: *Dryas*.

2.4. Occurrence of woolly-bear caterpillars *Gynaephora groenlandica*

See sections 1.1.5: *Salix*, and 3.7: 'Random' observations.

2.5. Predation by larvae of sawfly Tenthredinidae on *Salix arctica* ovules.

See section 1.1.5: *Salix*.

2.6. Occurrence of bumble bees *Bombus* sp.

See section 3.7.

Text of preprinted labelS:

NE GREENLAND, Zackenberg,

74°28'N, 20°34'W

Station: Date:

NATIONAL ENV. RES. INSTITUTE

ZOOLOGICAL MUSEUM, COPENHAGEN

3. Birds

3.1. Breeding bird census

3.1.1. Species to be monitored

Red-throated diver *Gavia stellata* (rødstrubet lom)

King eider *Somateria spectabilis* (kongeederfugl)

Long-tailed duck *Clangula hyemalis* (havlit)

Rock ptarmigan *Lagopus mutus* (fjeldrype)

Great ringed plover *Charadrius hiaticula* (stor præstekrave)

Red knot *Calidris canutus* (islandsk ryle)

Sanderling *Calidris alba* (sandløber)

Dunlin *Calidris alpina* (almindelig ryle)

Ruddy turnstone *Arenaria interpres* (stenvender)

Red-necked phalarope *Phalaropus lobatus* (Odinshane)

Long-tailed skua *Stercorarius longicaudus* (lille kjove)

Northern wheatear *Oenanthe oenanthe* (stenpikker)

Snow bunting *Plectrophenax nivalis* (snespurv)

Plus other species that may breed in the census area.

3.1.2. Frequency of sampling

Annually during June and July

3.1.3. Equipment to be used

Binoculars

Topographic maps of sections of the census area mounted on a clip-board

Dictaphone

Altimeter

Skis

Snowshoes

3.1.4. Location and marking of sampling plots

The borders of the census area in Zackenbergdalen is marked on the field maps (Fig. 3.1.4), and they generally follow visible features in the landscape. Sub-area 1 makes up an intensive study area of 3.4 km^2 west of Zackenbergelven, while Sub-area 2 is the 15.4 km^2 area east of the river, which is more extensively covered.

3.1.5. Sampling method

During mid-late June, both sub-areas must be surveyed. At that time, territories are being established, egg-laying is initiated, and the birds are concentrated on the relatively limited areas of snow-free ground.

During the survey trips, the area must be covered in such a way that no snow-free spot is passed by the observer at a distance exceeding 100 m. Minor snow free spots may be searched carefully with the binoculars at a little more distance. Use the first days with good weather to cover Rylekærene, Oksebakkerne and the slopes of Aucellabjerg, as a minimum of four days is needed to cover these. Start with the most important areas below 300 m a.s.l.

On each survey trip, all bird observations are marked on the maps using specific symbols for each species and type of behaviour (see table 3.1.5).

On the slopes of Aucellabjerg it may be somewhat difficult to plot the observations on the right positions on the map. The combination of rivulets, snow drifts and the altitude provided by an altimeter gives the best clues. Remember to adjust the altimeter before leaving the station (35 m).

In the intensive study area west of Zackenbergelven (Sub-area 1), registrations continue during the rest of June and early-mid July, so that the area is covered at least once every 10-day period.

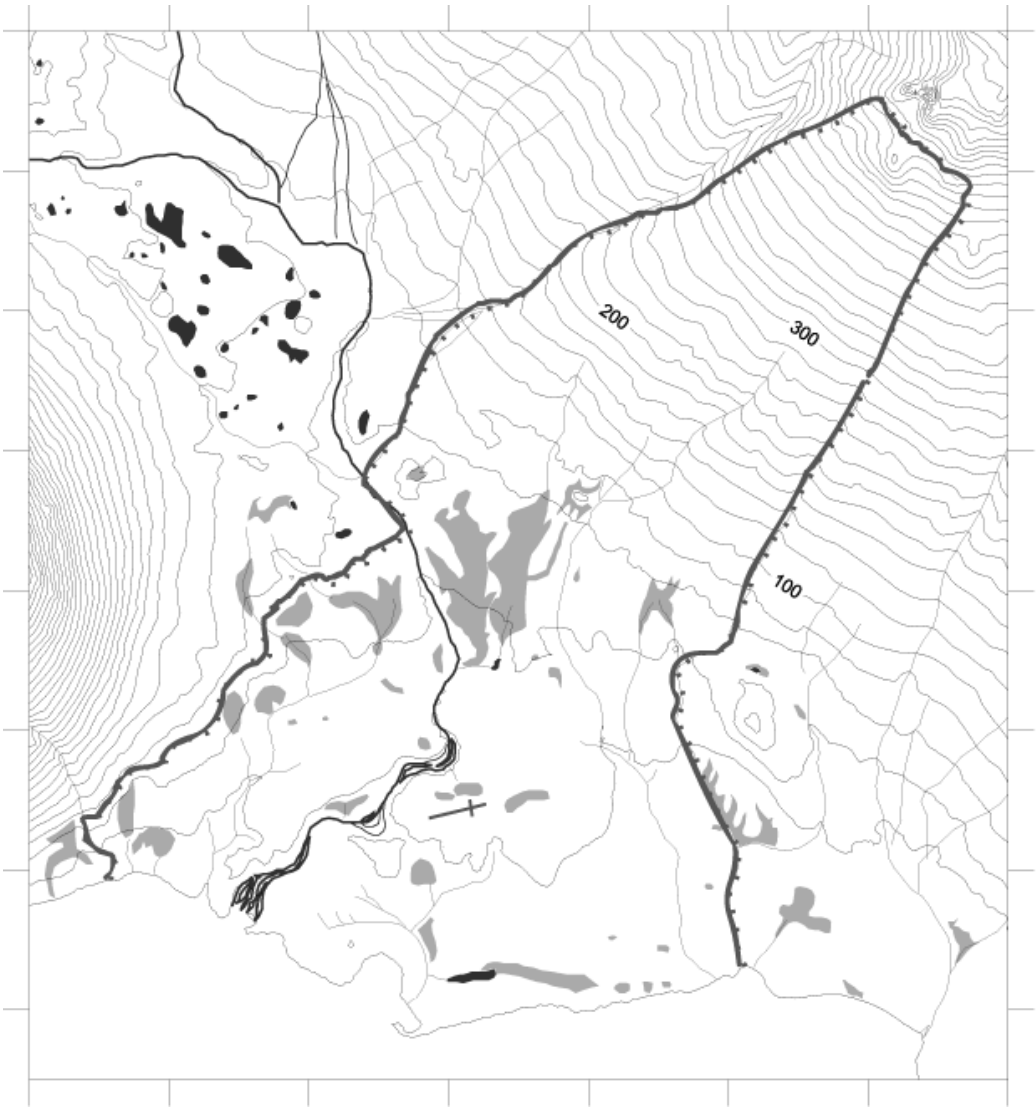


Fig. 3.1.4. Map of the breeding bird census area in Zackenbergdalen.

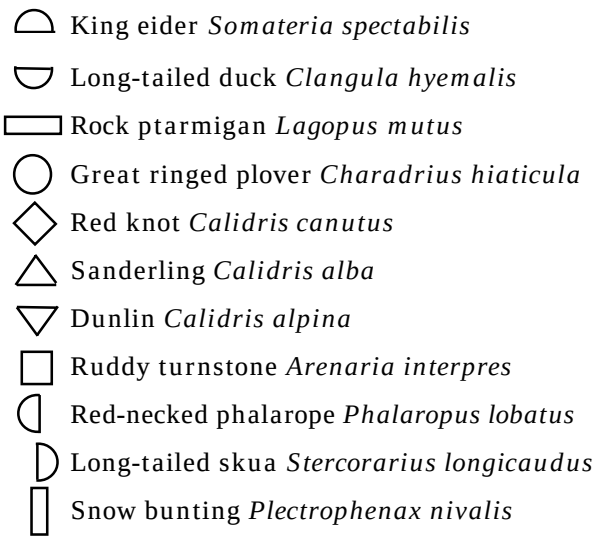
Until late June or early July (varying from year to year), it is advantageous to use skis in most of the lowland, and snowshoes may be used to pass large snow drifts. During mid June, Rylekærene may be difficult to pass due to extensive water-soaked snow. The watershed south of Kamelen, along the western side of Kærelv, is then the best place to pass.

Observations of single individuals are plotted as open symbols, while pairs are filled. Nests are shown as a pair/individual (dependent on the presence of the parents) with a circle around, while broods are marked as a pair/individual with a dashed circle around. The number of eggs/young is stated at the symbol.

Breeding behaviour is given a symbol as follows:

s	Singing individual (or individual in a pair)
ag	Aggressive individual/pair (towards conspecifics)
v	Alarm calling individual/pair (incl. aggressive behaviour towards predators such as skuas and foxes)
y	Distraction behaviour or other display that clearly indicate breeding (incl. nest building and food collecting in passerines)
Purs	Flight pursuit between two or more birds.

Table 3.1.5. Symbols for marking of bird observations on field maps.



Other species are written i full.

Remember to estimate the ice cover on Langemandssø and Sommerfuglesø at each visit on the upper slopes of Aucellabjerg (see section 5.1.2).

3.1.6. Laboratory work

After each season the results of the field records are evaluated and concluded by a map of all territories found in the census area. All site claiming pairs/individuals are considered full members of the population, whether breeding or not. Hence, all records of pairs, singing (or otherwise territorial) and alarm calling individuals are considered as 'territories'. Records that do not fulfil these criteria, but still may indicate the presence of a territory (e.g. stationary single but silent individuals), are plotted as additional territories with a question mark. The same is done with possible double registrations. In the area west of the river, the maximum number of territories recorded *simultaneously* in appropriate parts of the area are accepted.

The initial census in mid-late June is considered the basis for the evaluation, but pairs may be added to these results if they are found in areas where no pairs were recorded nearby or in areas that were poorly covered during the initial census, or territories may be upgraded from a question mark if better records at the site are obtained later. Otherwise, later records of nests and small young together with stationary and clearly breeding pairs are just counterbalanced by repositioning a nearby 'territory' from the initial census. For the red knot, even pairs and singing individuals recorded during early June are included in the evaluation. In both sub-areas, great care should be taken not to double record pairs and individuals that move from one areas to another following snow melt. Territories, in which nests or broods have been found, are specifically marked (see 3.1.5).

3.1.7. Input of data into database

The position of each territory is entered into an Excel data file named 'Bird territories' and holding the following columns: Species, Year, Serial no., UTM East, UTM North, Status, and Remarks.

Territories in which nests or young have been found, must be allocated the same serial number as in the bird nest and bird brood data files, respectively (see 3.2.7). Such territories are given status as N for nest found or B for brood found. Other territories are given status T for territory or ? for uncertain territory.

For territories in which nests have been found, the UTM co-ordinates must be the same as in the bird nest database. For territories with broods this only apply to brood finding places that are considered representative for the actual territory (and hence, the UTM co-ordinates of the finding place of the brood is given in both databases). Others are given separate UTM co-ordinates for territory and finding place, and the B in status is given in brackets.

Under remarks, you may note e.g. that this brood may originate from nest no. x, ect.

3.2. Breeding phenology of birds in Zackenbergdalen

3.2.1. Species to be monitored

Same as in section 3.1

3.2.2. Frequency of sampling

Annually during June, July and August

3.2.3. Equipment to be used

A clapsack chair

White nylon sticks

A thermos

A 0.5 l vessel with a mm scale on the side

Paper towels

30, 100 and 500 g Pesola spring scales

Fabric bags

Bird rings from the Zoological Museum, University of Copenhagen

Tongs for bird rings

Notebook

Otherwise same as 3.1.3

3.2.4. Marking of sampling plots

Each nest found must be marked with a white nylon stick or a small stone cairn situated 10 metres from the nest in the direction away from the tall antenna of the Zackenberg station.

3.2.5. Sampling method

During the second half of June and the first half of July wader nests are spotted by keeping an eye on birds lifting from nests and by 'walking back' from intensively alarm calling or distraction displaying individuals. From a point with good overview (use the clapsack chair in flat areas), the bird is watched moving back to the nest. If both individuals of a pair are alarm calling, keep track of the least vocative bird usually located in the periphery of alarming individuals. It may also be productive just to sit down and search an area with your binoculars. Nests of other species are located opportunistically.

Spend half the sampling time on each side of the river, so that the effort per area is largest in Sub-area 1.

Eggs of waders and skuas are checked for incubation stage by floating two eggs of the clutch in the 0.5 l vessel 2/3 filled with 20ºC-30ºC water from the thermos. The angle between the egg axis and the bottom of the vessel or the extent of the egg that is above water and the angle towards the water surface is recorded. Use your watch to estimate angles. The eggs must be carefully dried with the paper towels before repositioned in the nest.

Do not visit nests again until about thre days before the estimated date of hatching, as tracks to and from nests may guide predators to the nest. From then on, eggs are checked for cracks in the shell at each visit- i.e. whether they are 'starred' or 'pipped'. An egg is recorded as 'starred' when there are small hatching cracks in the shell, and as 'pipped' when there is a hole in the shell. An egg is starred 2-4 days prior to hatching and pipped within 1-2 days before hatching.

Nests found empty must be checked for signs of hatching (shell fragments in the bottom nest material) or predation (predated shells, smell of fox, faeces). Nest cups, from which pulli have left, are often broad and flat as compared to depredated nests.

All wader and skua chicks found must be weighed to enable ageing. Furthermore, in skua young the wing is measured flattened and straightened on a ruler. Newly hatched wader chicks are weighed after they have been ringed by 'hanging' them in the ring from the spring balance. Larger chicks are weighed in a fabric bag (remember to weight the bag immediately afterwards and subtract the weight from the

Table 3.2.6.1. Records of angle and float height of wader and skua eggs in relation to stage of incubation (given as days after start of incubation, but calculated from day of hatching).

Angle (º)	Floating above surface (mm)	Great Ringed Plover	Sander-ling	Dunlin	Ruddy Turn-stone	Long-tailed skua
Bottom						
0-10						
10-20		3				
20-30		1	4		1	
30-40						
40-50			4	4		
50-60				6		
60-70		5			4	
70-80			6	5		6
80-90			6	7	6	9
Weightless		>9	8	7		
Floating						
90	0-0.5		8			
80-90	0.5-1		10		11	12
70-80	1-2	6	13-15	13	13-16	
70-80	2	14	15	14-15	14-16	
60-70	3		17			
60	3		19		19	
45	>3					

weight of the young). Keep all young of a brood in a fabric bag until they can be released simultaneously. Avoid handling eggs and chicks with mosquito repellent or sun lotion on your hands.

Chicks that are only observed at a distance, are 'aged' by comparing them with the state of development of chicks experienced at previous occasions. Newly fledged wader and skua young, still with downy head and neck and still accompanied by an adult, are recorded too. These can only by aged (cf. Table 3.2.6.2) if no periods of inclement weather have prevailed during the possible fledging period.

Nests of divers, ducks and ptarmigan are checked from a distance to record hatching date, brood size and possible predation. Do not flush incubating waterfowl to check the nest. If incubating ducks are accidentally flushed from the nest, the eggs are counted, whereupon they are covered with the nest down. Observations of young of these species are similarly recorded.

In years with many foxes, skua nests should not be approaced closer than 5 m, but close to hatching, eggs may be floated in the same way as wader eggs to estimate hatching time.

Breeding phenology of snow bunting and wheatear is monitored by records of calling young and observations of fledged juveniles.

3.2.6. Laboratory work

The incubation stage of wader and skua eggs is estimated by using the criteria stated in table 3.2.6.1 (see also van Paassen et al. 1984: A simple device for determination of incubation stages in eggs. - Wildfowl 35: 173-178).

The age of wader and long-tailed skua young are similarly determined by means of species specific growth curves (Figs 3.2.6.1-6). The estimated hatching date of the largest young in a brood is recorded as the hatching date of the brood.

Table 3.2.6.2. Egg laying, incubation and fledging periods (days) of waders and skuas. Add 1-2 days for fully fledged, but still downy-necked wader young.

Species	Egg-laying (4 eggs)	Egg-laying + incubation	Fledging
Great ringed plover	5	29	24
Red knot	4	26	19
Sanderling	4	26	17
Dunlin	4	26	20
Ruddy turnstone	4	26	20
Long-tailed skua	2 (2 eggs)	24 (1 egg)	25

First egg dates are consequently calculated using the egg laying, incubation and fledging periods given in table 3.2.6.2.

After the season, ringing reports are mailed to the Zoological Museum, Ringing department, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark.

3.2.7. Input of data into database

All observations and controls of nests and young are entered into the Excel data files 'Bird nests' and 'Bird broods', respectively. The file with bird nests gives the following columns: Species, Year, Serial no., UTM East, UTM North, Month, Day, Observer, Nest building (Yes, or no. of individuals), Bird incubating (0 or 1), Bird(s) attending (incl. neighbours attracted by alarm calling parents), No. of eggs, Bottom angle (for the most developed egg), Float height (for the most developed egg), Float angle (for the most developed egg), No. starred, No. pipped, No. wet pulli, No. dry pulli, Band no. I, Band no. II, Band no. III, Band no. IV, Weight I (of pullus), Weight II (of pullus), Weight III (of pullus), Weight IV (of pullus), Shell fragments (from hatching eggs: Yes or No), Predated shells, Smell of fox, Fox tracks/faeces, No. of cold eggs, 1st egg date, Accuracy, Pulli hatched (give known or estimated number), and Comments.

The serial number simply follows the cronology in wich the nests and broods were found. Nests and broods are numbered consecutively, so that they can be entered into the Bird territories database with the same numbering. Broods that are too old to be associated with a specific territory, together with nests and broods that are encountered outside the census area, have 100 added to their number to indicate that they do not appear in the Bird territories database. The same apply to observations of newly fledged juveniles.

The 'Bird broods' data base gives the following columns: Species, Year, Serial no., UTM East, UTM North, Month, Day, Observer, Bird(s) attending (incl. neighbours attracted by alarm calling parents), No. of pulli, No. of juveniles, Band no. I, Band no. II, Band no. III, Band no. IV, Weight I, Weight II, Weight III, Weight IV, 1st egg date, Accuracy, and Comments. Under Comments you may e.g. note that this brood possibly could be the same as x brood (when not cought or only part of the possible number of young have been found.

In the 'Bird nest' database, 1st egg date, Accuracy and number of Pulli hatched are filled in as a conclusion record after the dated records of each nest. This is indicated by stating 'Conclusion' in the 'Observer' column. The 1st egg date must be given as yyyymmdd (e.g. 20000615 for 15 June 2000). In the Accuracy column, codes 1-6 denote the kind of data that the 1st egg date estimate was based upon (Table 3.2.7; next page). The known/estimated number of pulli hatched from a nest e.g. includes all starred and pipped eggs from nests that later were found empty with no sign of predation. Under comments you may e.g. note that this nest may have been a relay of x (failed) nest.

Table 3.2.7. Codes denoting accuracy categories of estimated first egg dates in waders etc. The codes represent the different kind of data that the estimates and calculation are based on.

Code 1: record of incomplete clutch

Code 2: record of starred and pipped eggs or young still in nest

Code 3: record of pulli weights

Code 4: record of egg floating

Code 5: age estimates of chicks that were not caught and measured

Code 6: observations of newly fledged juveniles (e.g. with downy head and neck) that were still in company with alarm calling adults.

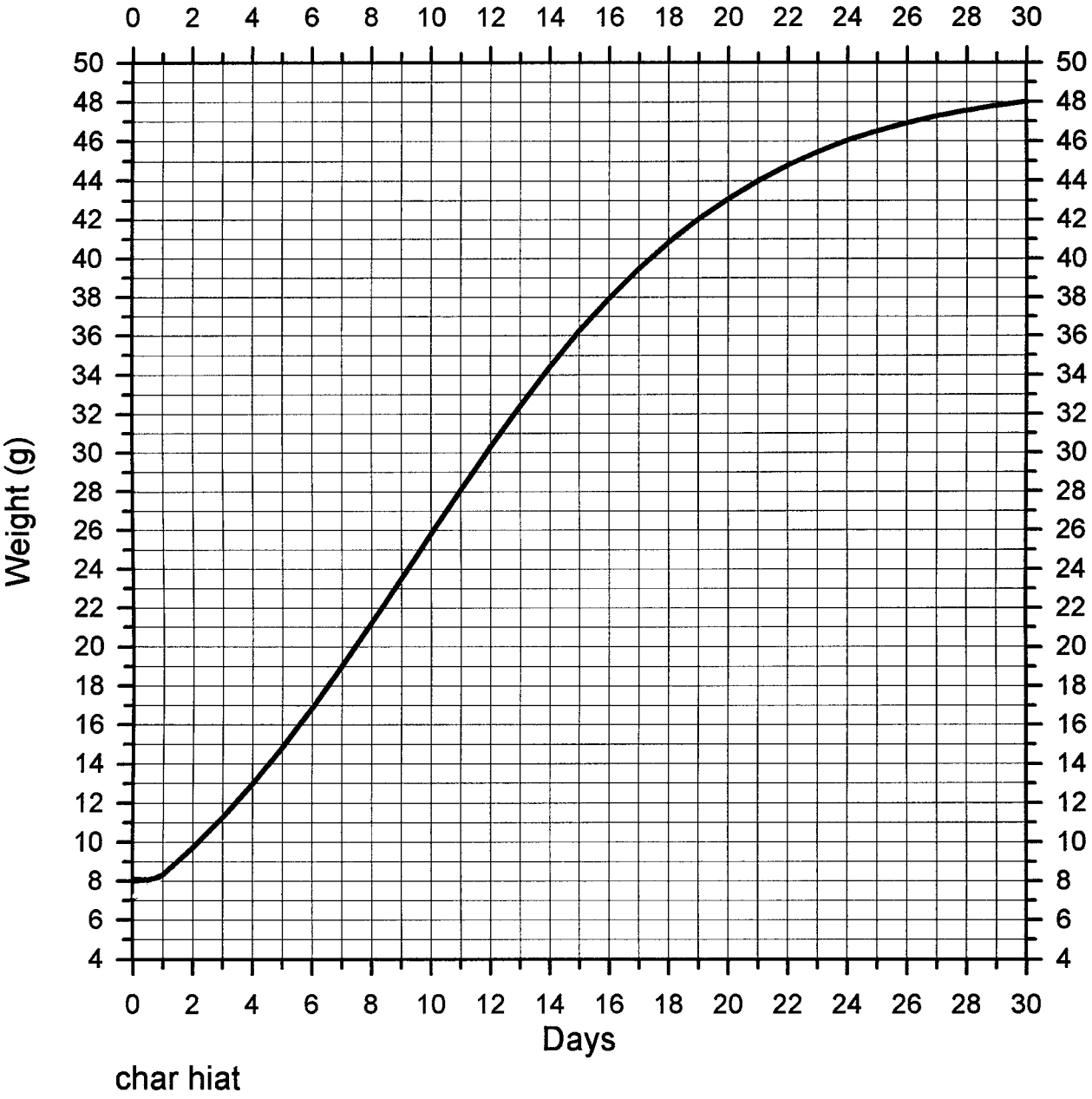


Fig. 3.2.6.1. Growth curve for great ringed plover chicks (modified from Hans Schekkerman in litt.).

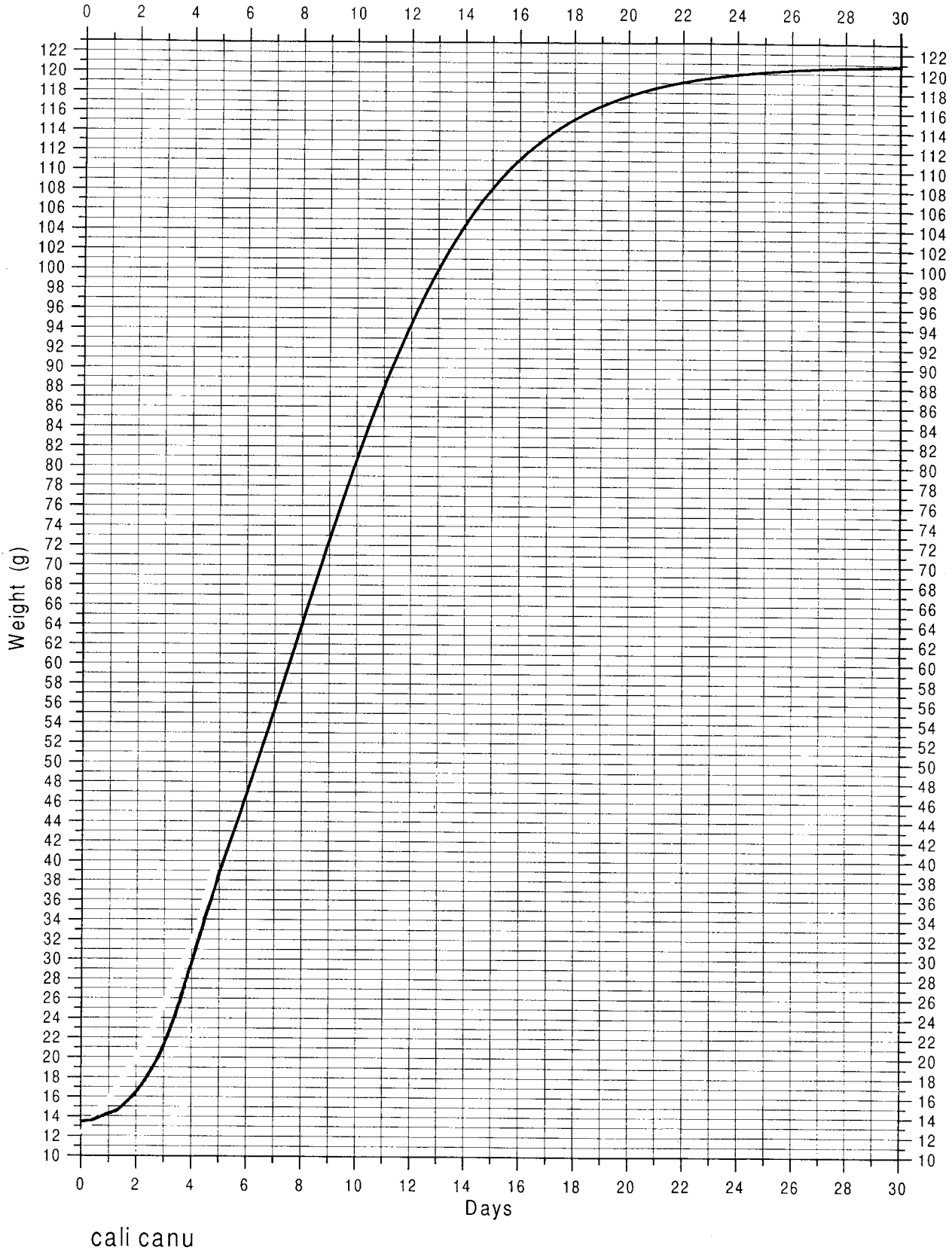


Fig. 3.2.6.2. Growth curve for red knot chicks (modified from Hans Schekkerman in litt.).

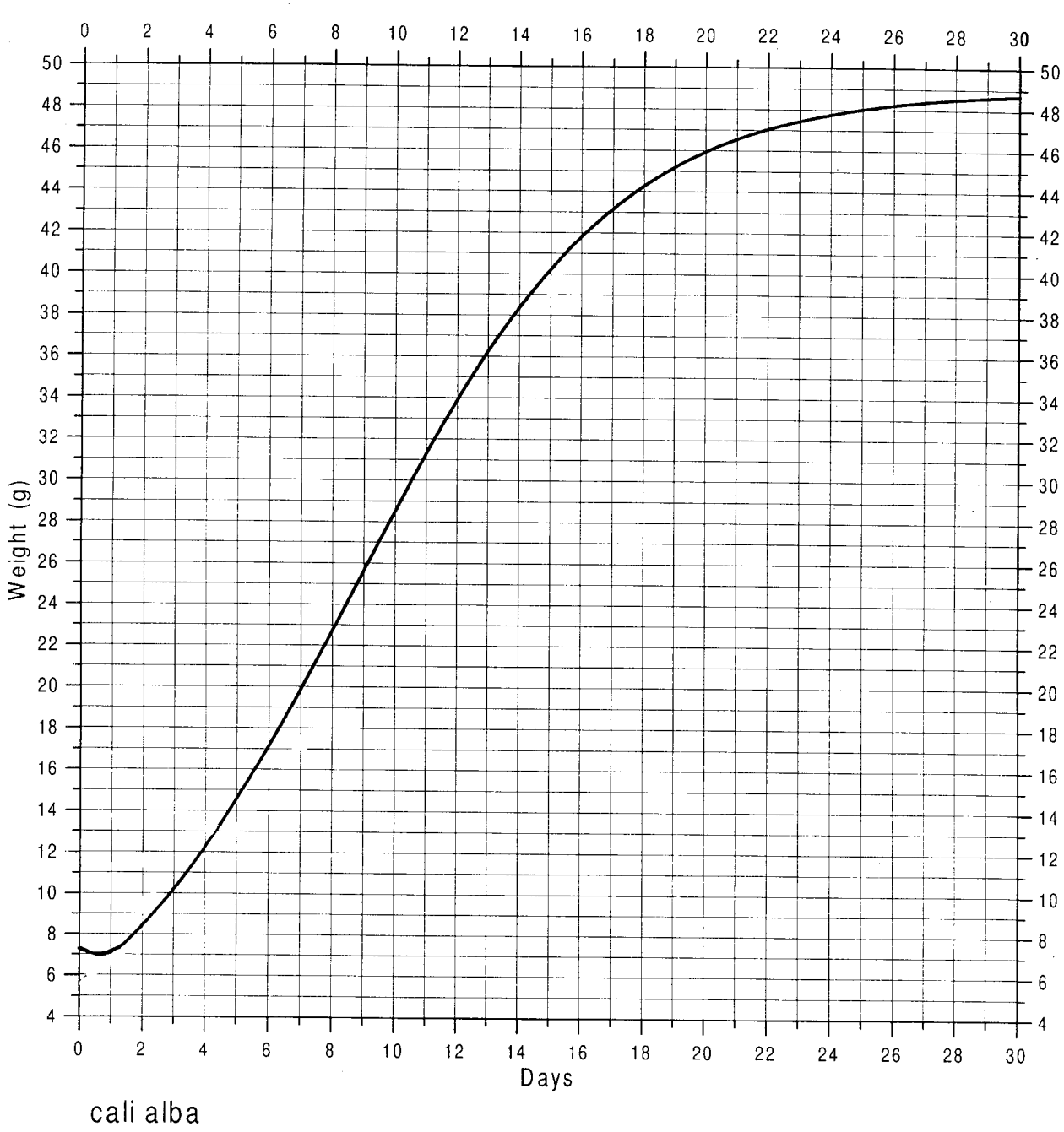


Fig. 3.2.6.3. Growth curve for sanderling chicks (modified from Hans Schekkerman in litt.).

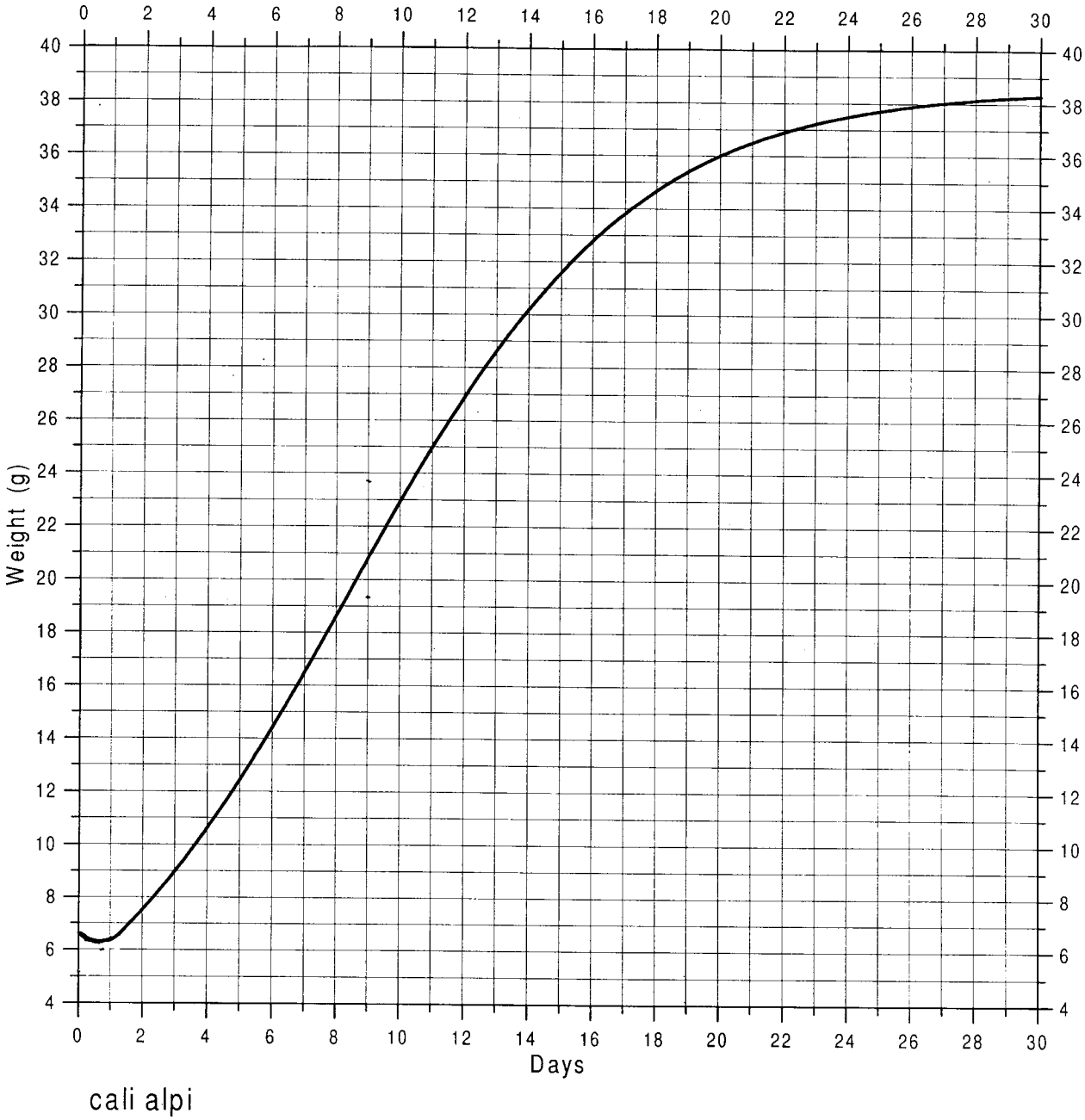


Fig. 3.2.6.4. Growth curve for dunlin chicks (modified from Hans Schekkerman in litt.).

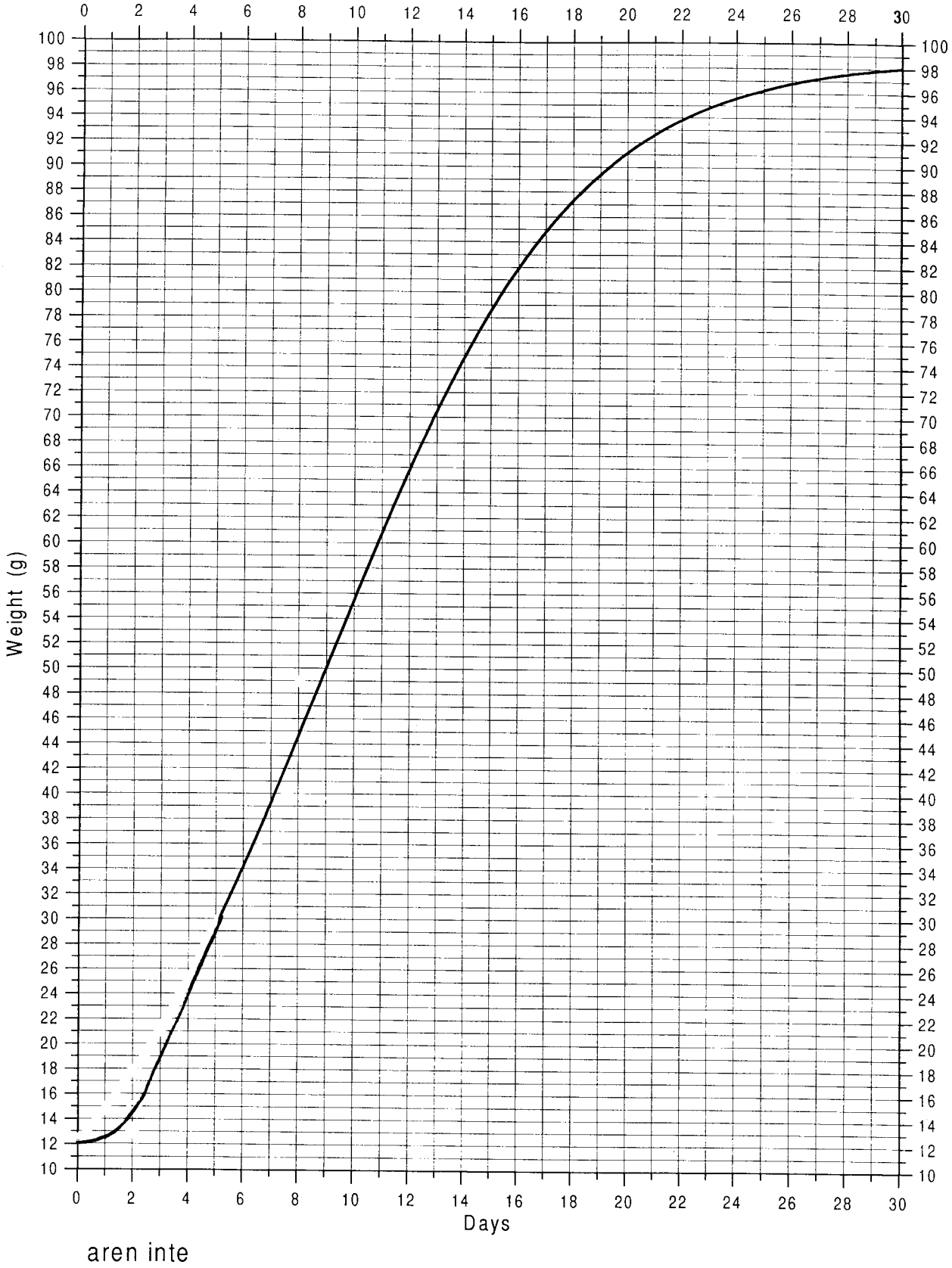


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Fig. 3.2.6.5. Growth curve for ruddy turnstone chicks (modified from Hans Schekkerman in litt.).

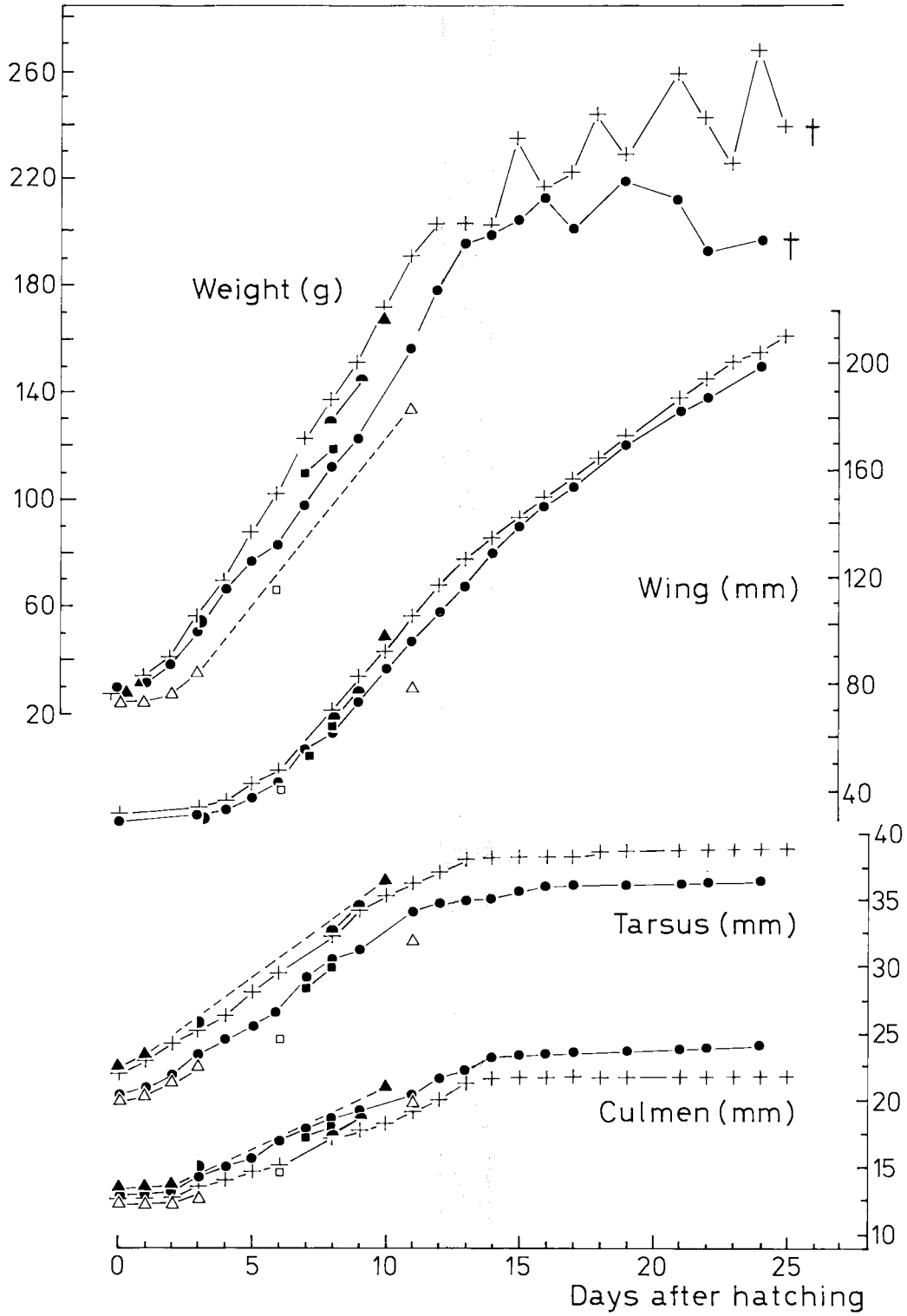


Fig. 4. Weights and measurements of eight chicks at Kærelv 1975, including those depicted in fig. 3, in relation to age; + indicates penned single chick; ● ◗ ◓ indicate free single chicks; ▲ ■ indicate senior sibling chicks; △ □ indicate junior sibling chicks; † indicates day of death.

Fig. 3.2.6.6. Growth curves for long-tailed skua chicks (from de Korte 1986)

3.3. Fledging success in waders

3.3.1. Species to be monitored

Great ringed plover *Charadrius hiaticula* (stor præstekrave)

Red knot *Calidris canutus* (islandsk ryle)

Sanderling *Calidris alba* (sandløber)

Dunlin *Calidris alpina* (almindelig ryle)

Ruddy turnstone *Arenaria interpres* (stenvender)

3.3.2. Frequency of sampling

Every third day between 20 July and the termination of the field season. In case of rough weather or coincidence with sampling dates for flowering phenology and invertebrates (see table 1.1.2), the count may be performed one day earlier or later.

3.3.3. Equipment to be used

A tide table

Binoculars

Spotting scope

A tally counter (kliktæller)

Dictaphone

Hip boots

3.3.4. Location of the sampling plot

The former and the present deltas of Zackenbergelven. The separation between the two deltas is defined as the western end of the raised plateau, Trekanten, between the two areas.

3.3.5. Sampling method

The waders in the two deltas are counted during low tide. Begin the count at the time of minimum tide. On sunny days, counts should not be performed at low tides after 15 hrs, due to unfavourable light. Instead, use the morning low tide.

For each species, the individuals present are separated into adults and juveniles.

In the present delta of Zackenbergelven, most waders are often found on the muddy spit on the western side of the main course of the river. This area may be a bit difficult to cover, but it can be done from the westernmost sandbank in the delta. Waders behind the gravel 'cliff' can only be recorded at very low tides, when it is possible to count from a vantage point in the south-western part of the delta. Beware that the substrate in certain places in the present delta is extremely muddy and sticky.

Other species of waterbirds are counted as well, including separation into age (and sex) classes.

3.3.6. Laboratory work

Writing out the dictaphone recordings.

3.3.7. Input of data into database

Count results are entered into the Excel database 'Waterbird counts' giving the following columns: Year, Month, Day, Time (starting time of the count in the old delta), Low tide (time of low tide according to tide table), Water level (at low tide according to tide table minus 0.9 m), Species, DGD ad. (adults counted in the old delta), DGD juv. (juveniles counted in the old delta), DGD usp. (non-aged individuals counted in the old delta), DND ad. (adults counted in the new delta), DND juv. (juveniles counted in the new delta), DND usp. (non-aged individuals counted in the new delta), and Remarks. Under Remarks you may e.g. note the sex of eiders and other waterfowl).

If a count is missed, interpolated bird numbers from the previous and the following cunts are entered into the database, clearly stating under Remarks that data are interpolated.

3.4. Census of barnacle goose broods in Zackenbergdalen

3.4.1. Species to be monitored

Barnacle goose *Branta leucopsis* (bramgås)

3.4.2. Frequency of sampling

The presence of broods in Zackenbergdalen is monitored during late June, July and August.

3.4.3. Equipment to be used

Binoculars

Spotting scope

Dictaphone

3.4.4. Location and marking of sampling plots

None.

3.4.5. Sampling method

Broods are recorded whenever they are encountered in Zackenbergdalen. The traditional brood rearing site at Lomsø must be checked regularly by spotting scope from a roof of a station building or from the gravel plateau SE of the runway.

3.4.6. Laboratory work

Writing out the dictaphone recordings.

3.4.7. Input of data into database

Data are entered into the general bird observation database 'Fugleobservationer etc.' (see section 3.7) giving as many details as possible on brood sizes, location, reactions to disturbance etc.

3.5. Line transect between Daneborg and upper Store Sødal

See section 4.6.

3.6. Census of breeding eiders, Sabine's gulls and Arctic terns on Sandøen

3.6.1. Species to be monitored

Common eider *Somateria mollissima* (ederfugl)

Sabine's gull *Larus sabini* (Sabinemåge)

Arctic tern *Sterna paradisaea* (havterne)

Other waterbird species breeding in the colonies

3.6.2. Frequency of sampling

Annually in mid or late July, when the ice in Young Sund has broken up and it fits into the schedule of the line transect (see section 3.5).

3.6.3. Equipment to be used

Binoculars

Map of Sandøen showing census sectors (to be produced)

Bird rings from the Zoological Museum, University of Copenhagen

Tongs for bird rings

Notebook

Dictaphone

3.6.4. Marking of sampling plots

The separation between census sectors are marked on field maps (to be produced) and they follow visible features in the terrain.

3.6.5. Sampling method

In mid or late July the number of nests of eiders, Sabine's gulls and Arctic terns on Sandøen are counted per sector. All nest cups that are or have been in use during the season are accepted as occupied nest cups. The number of eggs or young in each gull and tern nest is recorded. If incubat-

ing eiders are accidentally flushed from the nest, the eggs are counted, whereupon they are covered with the nest down.

Identification:
Sabine's gull: Eggs subelliptical, smooth and slightly glossy; olive to buff-olive, variably marked darker olive-brown, sometimes concentrated in zone around broad end. 44 x 32 mm (41-47 x 30-33). Clutch: 2 (1-3). Incubation: 23-25 days by both parents. Young have much longer tarsi than Arctic terns. Fledging period: Unknown.

Arctic tern: Eggs subelliptical, smooth and not glossy; pale buff to olive, rarely brown, also variably blotched, spotted, and scrawled black and dark brown. 41 x 30 mm (36-46 x 26-33). Clutch 1-3. Incubation: 20-24 days. Young have so short tarsi that there is hardly room for a ring. Fledging period: 21-24 days.

All young of Sabine's gull and up to 100 young of Arctic tern are ringed.

3.6.6. Laboratory work

Writing out dictaphone recordings.

3.6.7. Input of data into data bases

Count results are stored in a data base (Excel) referring to each sector. Numbers of eggs and young per nest are similarly stated per sector.

3.7. 'Random' observations

3.7.1. Species to be monitored

All bird species (plus lemmings, woolly-bear catarpillars and bumble bees)

3.7.2. Frequency of sampling

Continuously during entire field season.

3.7.3. Equipment to be used

Binoculars

Spotting scope

Dictaphone

3.7.4. Marking of sampling plots

Entire activity area

3.7.5. Sampling method

Keep watch for everything with feathers. Record flock size, sex and age, special behaviour, geographical position etc.

Especially, Gadekæret, Sydkærene Kystkærene, Lomsø and the deltas should be checked every day e.g. in connection with the muskox census.

Around 20 July, the moulting pink-footed and barnacle geese around Halvøen and along the remaining part of the coast off Zackenbergdalen should be recorded. Bring a spotting scope and make the count around Halvøen in the afternoon, if it is a sunny day. Cover the lakes in Morænebakkerne and west of Lindemanselven in the same period.

Additionally, record all observations of foxes, lemmings, woolly-bear catarpillars and bumble bees together with other unusual occurrences during the bird census work.

3.7.6. Laboratory work

Writing out dictaphone recordings. All records are kept in a journal (Excel files named 'Fugleobservationer etc.') together with general information on snow and ice conditions, weather etc.

3.7.7. Input of data into data bases

See section 3.7.6. The file should hold the following columns: Date, Species etc., Observations.

4.1.4. Location and marking of study plot

The study plot covers 250 ha between Zackenbergelven and Kærelv. The northern and southern borders are marked by permanent white poles (see Fig. 4.1.4; map M1).

4.1.5. Sampling methods

East-west running transect lines are walked with 15 m intervals throughout the study plot starting along the north border. Poles are placed with regular intervals to ensure a straight transects. At least two poles should be visible in a row backwards from a given pole. When reaching a pole on the way back, the pole is moved 15 meters southwards to the next parallel transect leaving a straight row backwards.

Winter nests and summer burrows are examined following S1 and their spatial distribution is given co-ordinates according to map M1 (Fig. 4.1.4) referring to a specific 100 x 100 m quadrate. Fresh and old winter nests must be separated. A typical fresh winter nest is characterised by a light yellow to light grey colour, a fresh smell of hey and a fluffy appearance. Old nests are flat and dark. The study plot has been examined since 1995 and is considered almost emty for old nests. Only active summer burrows are recorded. They are characterised by at least one of the following signs: fresh soil digging, well worn pathways in the surrounding vegetation, eating marks on the vegetation close to the entrance of the burrow system (Figs. 4.1.5.2 & 4.1.5.3).

Fig. 4.1.5.1. Fresh winter nest.
Photo: Aurora Photo/Thomas Bjørneboe Berg

Fig. 4.1.5.2. Active summer burrow with fresh escavations. After snow melt lemmings move from their winter quarters under the snow to their burrow system in the soil. Some burrows are cleaned up and/or enlarged.
Photo: Aurora Photo/Thomas Bjørneboe Berg

Fig. 4.1.5.3. Active summer burrow witout soil excatations, but with a clear pathway in front of the hole. These burrows are recognised by well worn pathways in the surrounding vegetation and no signs of green vegetation in the entrance.
Photo: Aurora Photo/Thomas Bjørneboe Berg

For each winter nest the following data are recorded: i) record no., ii) nest co-ordinates, iii) size category (1: ≤10 cm 2: 10<x≤15, 3: 15<x≤20, 4: 20<x≤25 and 5: x>25 cm), iv) amount of faeces (category: 1: ≤500 pellets, 2: 501-2000, 3: 2001-4000 and 4: >4001), v) posission of nest (dug into the vegetation or soil or losely placed on top of the vegetation), vi) breeding expressed as the presence of small slender fecal pellets (length< 2mm) close to the nest, vii) signs of predation by ermine or fox, predation by ermine is recognised as

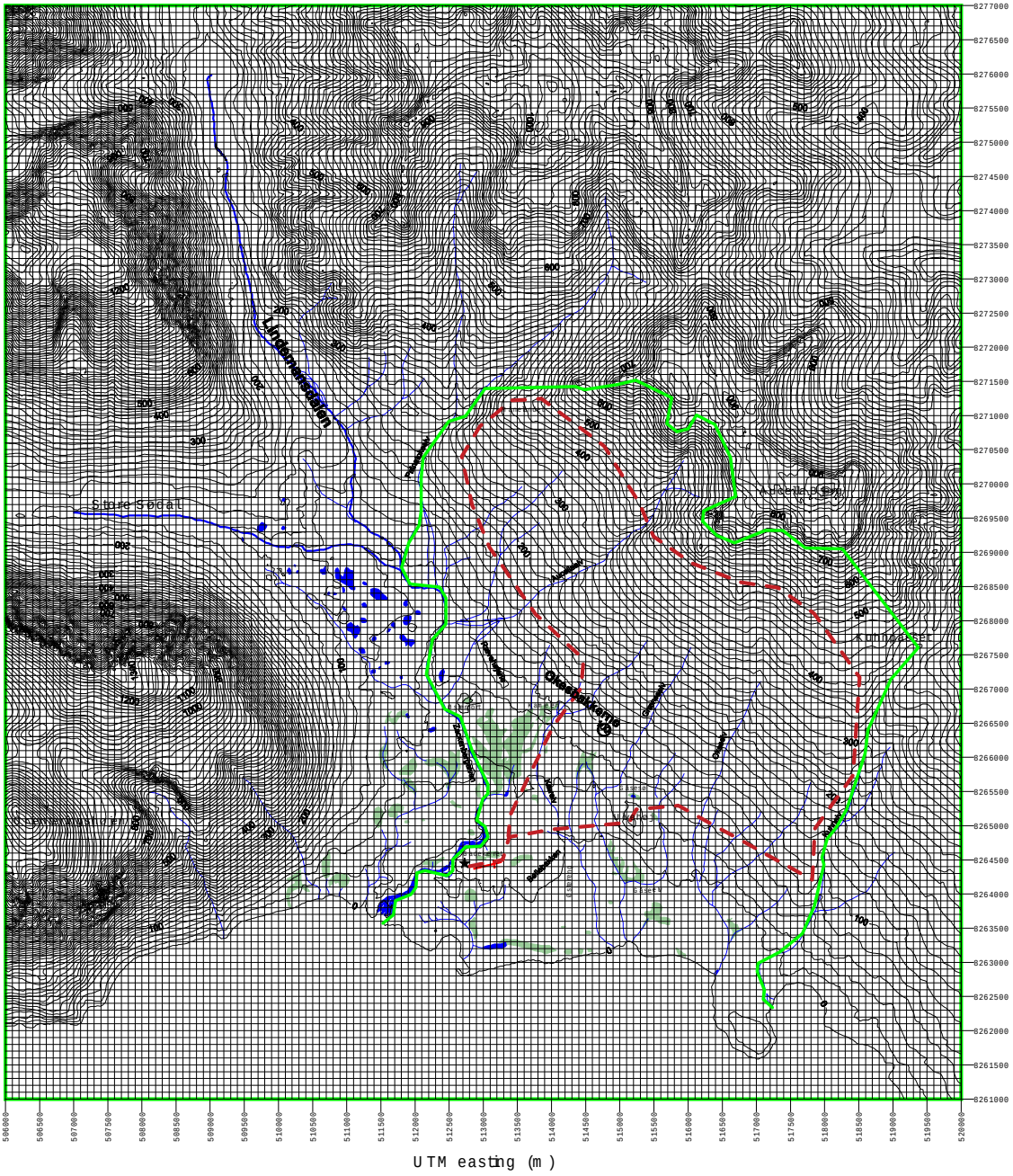


Fig. 4.2.4. Map M2. Musk ox census area (dotted area) with the basic route (solid line) for the total count. Also the position of four botanical plots is marked by a circle along the route (se section 1.1 and 1.2).

Data on herd size and their respective UTM co-ordinates (read from M2) is entered into an Excel datfil a named "Musk ox Roof count" holding the following columns: Year, Month, Day, Full hour, Observer, Cloud cover x/8, Min. visibility, Max. visibility, Record no., UTM easting, UTM nording, Altitude, ISCAR, OSCAR East, OCSAR West, Herd size, and Remarks.

4.3. Total counts of muskoxen

4.3.1. Species to be monitored

Muskox *Ovibos moschatus*

4.3.2. Frequency of sampling

Total counts are made throughout July and August one or two days after the weekly flowering and invertebrate sam-

Camera
GPS
Eppendorf tubes for tissue samples
Plastic bags for bone and tooth samples
Scalpel
A pair of tweezers
Alcohol
Labels
Blackboard
Chalk

4.4.4. Location and marking of study plot

Primarily the muskox census area (M2), but fresh carcasses found in Zackenberg-dalen outside this area and along the two transects (see 4.6.4) are recorded as well.

4.4.5. Sampling methods

Carcasses from the previous winter are given UTM co-ordinates and are recorded following S4. The ID (yyyy-xx) of the carcass is painted on a free spot on the cranium. One incisor (front tooth), one molar (inner back tooth) and one femur (hind thigh bone) are collected and stored in plastic bags. A tissue sample of flesh or skin is taken. The scalpel and the tweezers are cleaned i alcohol before taking the tissue sample. Prevent touching the sample by hand. A small piece of tissue is cut loose and is placed in the Eppendorf tube before the top part is cut off. Use the tweezers if necessary. All samples should be labelled with the carcass ID-number.

Fig. 4.4.5.1. Cross cut of a leg bone filled with bone marrow. Photo: Thomas Bjørneboe Berg

Fig. 4.4.5.2. Upper left front leg without marrow. Photo: Aurora Photo/ Thomas Bjørneboe Berg

One of the humerus or femur bones (front leg/hind leg) are sawed through to check for bone marrow. If marrow is present, the consistency (solid, jelly, or liquid) and colour (white or light yellow) should be described. If however the bone is filled with flie pupae, bone marow has been present, and eaten by the larvae. Remarks on horn and mandible are made.

Finally pictures of the carcass are taken with the blackboard showing the ID-number of the carcass.

4.4.6. Description of laboratory work

Eppendorph tubes containing samples are stored in the freezer at the station until departure. Collected bone material, teeth and tissue are shipped to the National Environmental Research Institute, att. Mads Cedergreen Forchhammer, by the return to Denmark.

4.4.7. Input of data into database

Data from S4 are entered into Excel data fil named "Musk ox Carcass" holding the following columns: Year, Month, Day, Observer, ID no., UTM East, UTM North, Sex, Estimated age, Samples each with separate columns (1: sample taken): Femur, Incisor, Molar, DNA, Bone marrow description, Horn remarks, Mandibel remarks, General remarks.

4.6.5. Sampling method

The sea ice is searched carefully by means of the spotting scope. The monitoring may be canseled if there is too much sun haze. Records of total number of seals are stated on S2.

4.6.6. Laboratory work

None

4.6.7. Input into data bases

Data from S2 (seals only) are entered into Excel data fil named "Seals" holding the following columns: Year, Month, Day, Full hour, Observer, Cloud cover x/8, Min. visibility, Max. visibility, No. of Seals, and Remarks.

4.7. Transect census of mammals and birds between Daneborg and upper Store Sødal

4.7.1. Species to be monitored

All species of mammals and birds.

4.7.2. Frequency of sampling

Mid July (week 28).

4.7.3. Equipment to be used

Binoculars (10 x)

Spotting scope (30 x)

Monopod or tripod for the spotting scope

Topographic map with transect route and census sections delineated (M3)

Dictaphone

Neoprene boots

Walking stick for crossing rivers

Observation sheets S4 and S6

Pencil

A small note book

Musk ox Field Guide

Two trip controls for counting musk ox pellets

Eppendorf tubes for tissue samples

Plastic bags for tooth samples

Scalpel

A pair of tweezers

Alcohol

Labels

Camping equipment and provisions for four days (only on transect “S”, see 4.7.4)

4.7.4. Location and marking of study plot

The transect census of mammals and birds consist of two separate transect lines, one from Daneborg to Zackenberg (DZ) and from Zackenberg to the bottom of Store Sødal (S), i.e. point “Valhall”. Each transect line is divided into a number of fixed way-points: five along the DZ-transect and 17 along the S- transect (Fig. 4.7.4 (M4), Table 4.6.4).

Table 4.7.4. Topographic description of the fixed way-points. Confer also with M3.

Way-point #	Topographic description
S-1	Where Palnatokeelv meets Zackenbergelven.
S-2	Below the first long crevice on the south-facing slope of Dombjerg.
S-3	At the eastern end of Store Sø.
S-4	At the large river delta in the western end of Store Sø. Base camp is established on the southwest side of the delta.
S-5	At the first round lake, i.e. “Mimers Brønd” in upper Store Sødal. The lake is on a straight line between the glacier towards northwest and Moltke Bjerg towards southeast on Clavering Ø.
S-6	Below the large hanging crevice/ avalanche on the slope towards northwest.

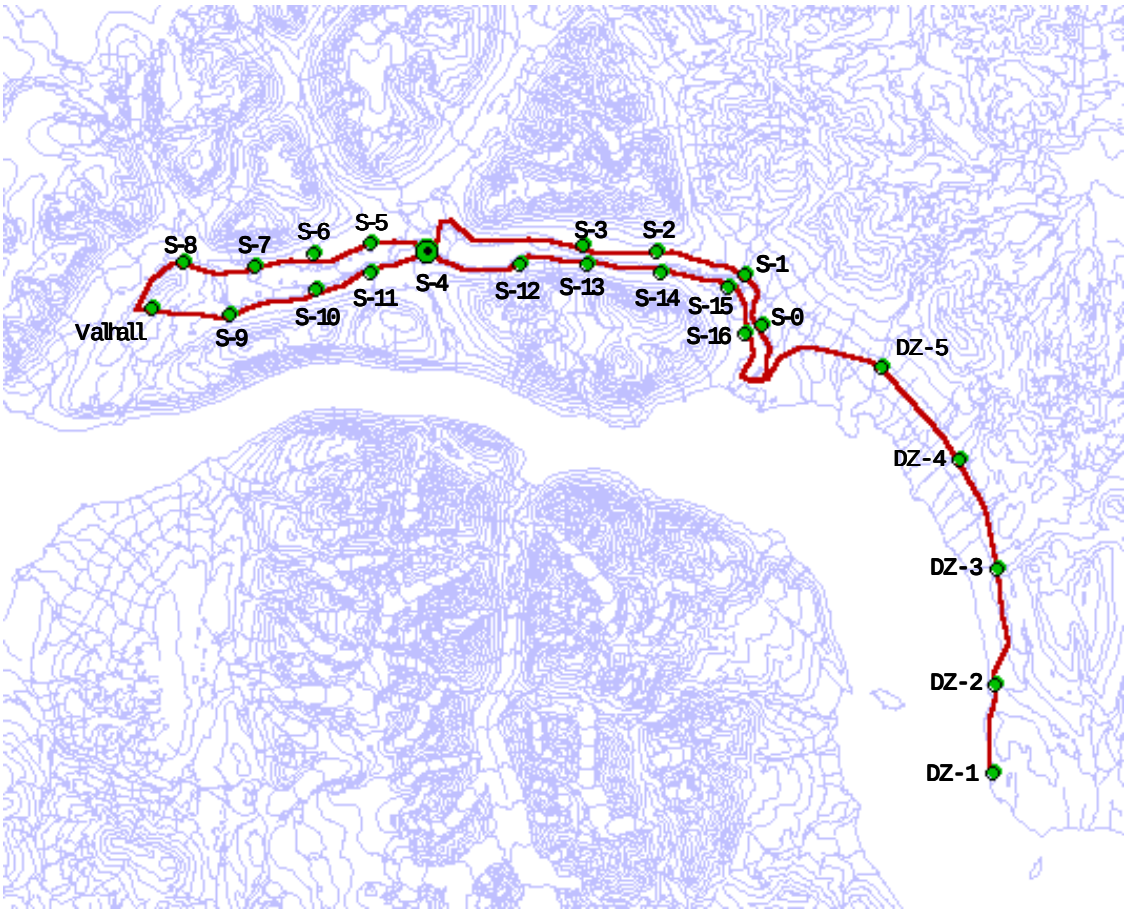


Fig. 4.7.4. Map (M3) of the transect census route between Daneborg and upper Store Sødal. The fixed way-points are given by the red green and the line between these indicate the approximate transect route. Way-points related to the Store Sødal transect are proceeded by "S", whereas those related to the Daneborg-Zackenberg transect is proceeded by "DZ".

UTM co-ordinates) and noted under remarks.

The number of musk ox faecal pellet heaps from last winter and this summer are recorded per transect section by both observers. Count only the pellet groups encountered within 1 m on both sides of you. Fresh winter and summer pelltes are characterised by a brown-black colour. Older pellets turns grey (Figs. 4.6.5.1. and 4.6.5.2.). Arctic hare pellets are slightly eliptic, light-brown and have more visible fibres.

Fig. 4.7.5.2. Winter pellets from past winter. The winter pellets are round and can be found in piles like this or a few pellets together, droped while the animal was walking. Photo: Aurora Photo/ Thomas Bjørneboe Berg

Lemming nests from the previous winter and the present summer are noted when encountered within 3 m to each side of the transect. Characteristics of nests are recorded according to standards given in section 4.1.5 (Figs 4.1.5.1 - 4.1.5.4).

Breeding colonies of geese, in particular barnacle goose, are positioned and censused as accurately as possible. So far no colonies have been detected.

New muskox carcasses (i.e. from the previous autumn/winter period) should be recorded with UTM co-ordinates and de-

Year	Month	Day	Obs 1	Obs 2	WPT	Start	End	Cloud	Wind	Species	Adults	Pulli	Remarks	Section	Species no.
	7				1-2					Red-throated diver				Outer Store Sødal	Bird 01
	7				1-2					Pink-footed goose				Outer Store Sødal	Bird 02
	7				1-2					Barnacle goose				Outer Store Sødal	Bird 03
	7				1-2					King eider				Outer Store Sødal	Bird 04
	7				1-2					Long-tailed duck				Outer Store Sødal	Bird 05
	7				1-2					Rock ptarmigan				Outer Store Sødal	Bird 06
	7				1-2					Gyr falcon				Outer Store Sødal	Bird 07
	7				1-2					Great ringed plover				Outer Store Sødal	Bird 08
	7				1-2					Red knot				Outer Store Sødal	Bird 09
	7				1-2					Sanderling				Outer Store Sødal	Bird 10
	7				1-2					Dunlin				Outer Store Sødal	Bird 11
	7				1-2					Ruddy turnstone				Outer Store Sødal	Bird 12
	7				1-2					Long-tailed skua				Outer Store Sødal	Bird 13
	7				1-2					Glaucous gull				Outer Store Sødal	Bird 14
	7				1-2					Arctic tern				Outer Store Sødal	Bird 15
	7				1-2					Snowy owl				Outer Store Sødal	Bird 16
	7				1-2					Northern weathear				Outer Store Sødal	Bird 17
	7				1-2					Common raven				Outer Store Sødal	Bird 18
	7				1-2					Arctic redpoll				Outer Store Sødal	Bird 19
	7				1-2					Snow bunting				Outer Store Sødal	Bird 20
	7				1-2					Gynaephora larvae				Outer Store Sødal	insect 1
	7				1-2					Clossiana sp.				Outer Store Sødal	Insect 2
	7				1-2					Bumblebee				Outer Store Sødal	Insect 3
	7				1-2					Arctic hare				Outer Store Sødal	Animal 01
	7				1-2					Collared lemming				Outer Store Sødal	Animal 02
	7				1-2					Summer burrow				Outer Store Sødal	Animal 02b
	7				1-2					Winter nest				Outer Store Sødal	Animal 02n
	7				1-2					Blue arctic fox				Outer Store Sødal	Animal 03b
	7				1-2					White arctic fox				Outer Store Sødal	Animal 03w
	7				1-2					Ermine				Outer Store Sødal	Animal 04
	7				1-2					Muskox M4+				Outer Store Sødal	Animal 051.1
	7				1-2					Muskox M3+				Outer Store Sødal	Animal 051.2
	7				1-2					Muskox M2				Outer Store Sødal	Animal 051.3
	7				1-2					Muskox M1				Outer Store Sødal	Animal 051.4
	7				1-2					Muskox F4+				Outer Store Sødal	Animal 052.1
	7				1-2					Muskox F3+				Outer Store Sødal	Animal 052.2
	7				1-2					Muskox F2				Outer Store Sødal	Animal 052.3
	7				1-2					Muskox F1				Outer Store Sødal	Animal 052.4
	7				1-2					Muskox calf				Outer Store Sødal	Animal 053
					1-2					Muskox usp.				Outer Store Sødal	Animal 054
	7				1-2					Summer faeces				Outer Store Sødal	Animal 05s
	7				1-2					Winterfaeces				Outer Store Sødal	Animal 05w

Fig. 4.7.5.3. Example of Excel data base for the Line ransect Store Sødal. The waypoint column (column no. 6) indicate the distance on which the observations are made (in this case between waypoint 1 and 2.

Table 4.10.4. UTM co-ordinates for the 29 stones

Stone	UTM East	UTM North
1	513685	8264794
2	513750	8264760
3	513795	8264908
4	513960	8264832
5	513875	8264815
6	513857	8264664
7	513835	8264695
8	513835	8264676
9	514030	8264670
10	514192	8264688
11	514338	8264622
12	514293	8264514
13	514369	8264427
14	514444	8264238
15	514441	8264144
16	514483	8264068
17	514445	8264046
18	514361	8264106
19	514261	8263957
20	514164	8264165
21	514124	8264159
22	513992	8264109
23	514000	8264145
24	513869	8264054
25	513739	8264407
26	513813	8264359
27	513640	8264098
28	513600	8264057
29	514260	8263970

4.10.6. Laboratory work

The paper bags are stored open until the samples are completely dry. Material are shipped to the NERI Dept. of Arctic Environment.

4.10.7. Input of data into data bases

Data from S5 are entered into Excel data fil named "Faeces and Casts" holding the following columns: Year, Month, Day, Observer, Stone no., UTM East, UTM North, No. of Fox faeces, Ermine faeces, Skua casts, Owl casts, respectively, and Remarks.

4.11. Monitoring of Arctic hares

4.11.1. Species to be monitored

Arctic hare (*Lepus arcticus*).

4.11.2. Frequency of sampling

Along with the the daily counts of musk oxen (see 4.2.).

4.11.3. Equipment to be used

Spotting scope (30 x)

Tripod

Observation sheet S2

Pencil

4.11.4. Location and marking of study plot

The slopes of Zackenbergfjeldet

4.11.5. Sampling method

Records are made from the roof of the ZERO building of the Zackenberg Station. Survey carefully the slopes of the Zackenberg mountain from the foothills to the top by means of the 30 x spotting scope. Each record of a flock or a single animal is given a number on the map (M2) and on the field sheet (S2). Records are quoted in the "OSCAR West" column and marked "hare(s)" under remarks.

4.11.6. Description of laboratory work

None

4.11.7. Input of data into data bases

Data on flock size and their respective UTM co-ordinates (read from M2) is entered into an Excel datfil a named "Arctic hare Roof count" holding the following columns: Year, Month, Day, Full hour, Observer, Cloud cover x/8, Min. visibility, Max. visibility, Record no., UTM easting, UTM nording, Altitude, Flock size, and Remarks.

5. Lakes

5.1. Physical-chemical parameters, phytoplankton and zooplankton

5.1.1. Parameters and species to be monitored

Ice cover

Water temperature

Water transparency

pH

Conductivity

Chlorophyll

Total Nitrogen

Total Phosphorus

All taxonomic groups of phytoplankton

All taxonomic groups of zooplankton

5.1.2. Frequency of sampling

Three times per year, during late July, early and mid August, respectively. Preferably, sampling should take place with c. 10 days intervals, in the middle of each period.

Ice cover on the two lakes is estimated and recorded whenever possible during June and July, both at visits at the lakes and from the slopes of Aucellabjerg.

5.1.3. Equipment to be used

5.1.3.1. Equipment for field work

A rubber dinghy with oars, rope and anchor*

A pump for the rubber dinghy*

A water sampler with two weights*

A 30 l tub*

A Secchi disc with a tape measurer*

Two plastic containers with rope for buoys*

A thermometer with a 0.2º scale

Waders

Life-jacket

Four 250 ml plastic bottles per sampling

Two 1 l plastic bottles per sampling

A bottle with acid lugol solution and a 5 ml plastic pipette

A 20 µm plankton net mounted on the end of a tube (only in mid August)

One 100 ml brown glass bottle (only in mid August)

A squeeze bottle (only in mid August)

*) permanently based in a metal box on a hilltop between the two lakes

5.1.3.2. Equipment for laboratory work

Glas fiber filters Whatmann GF/C, 1.2 um, ø47 mm from Frisenette Aps., phone 8634 2244, e-mail agf@frisenette.dk.

Otherwise equipment already used by GeoBasis, which you may also ask for advice on the analysis.

5.1.4. Location and marking of sampling plots

The two sampling lakes, Sommerfuglesø og Langemandssø, are situated in the northeastern part of Morænebakkerne (see map p. *iv*). The sampling stations are in the deepest central parts of the lakes. In Sommerfuglesø, which is 1.8 m deep, this is close to the center, while in Langemandssø, which is up to 6.1 m deep, this is a little to the northeast of the center (Fig. 5.1.4). At the first sampling each year, the deepest place is marked with a small plastic container tied to a rope and a stone for anchor.

5.1.5. Sampling method

At each sampling, full hour, cloud cover (x/8), wind force (m/s) and per cent ice cover are recorded for each lake.

When still on land, tie the anchor rope and the water sampling cord to the boat! Bring the Secchi disc, the water sampler and the 30 l tub in the dinghy and row to the deepest place in the lake. When anchored on the sampling station, the transparency is measured with the Secchi disc on the sunny side of the dinghy. Lower it in the water until it disappears, and then pull it gently up again until it is just visible. The depth of the disc is then taken from the tape measurer (to 0.1 m). Often the disc will be visible right to the bottom.

Take a total of 5 l (20 l in mid August) of water equally distributed from different depths of the lake. Start with samples from right under the surface, then from 1 m, 2 m etc. The bottom samples should be taken 0.5 m over the bottom, as it is very important not the have sediments in the samples. If the lake sediment accidentally is disturbed, you have to wait 5-10 minutes or move a little away before taking a new sample.

On the shore, stir the water and measure the temperature (to 0.1º) with the thermometer held in the water. Take one sample of 200 ml (fill only the bottle 3/4) for total N and P. Take one more sample of 200 ml, which is preserved with 5 ml lugol for phytoplankton analysis. Finally, take a sample of 1 l for pH, conductivity and chlorophyll measurements. Stir the water between each sampling. Wrap all samples in black plastic to protect them against sunlight, and write lake name (LS or SS) and date on all bottles with an alcohol resistant pen.

At the sampling in mid August, 15 l of stirred water (record the exact volume) are funnelled through the plankton net, whereupon the plankton net is turned around and the content carefully is sprayed down into a brown bottle (max. 80 ml of water). Finally the sample is preserved with 1 ml lugol.

After each sampling of the lakes, the rubber dinghy must be de-inflated and stored together with the rest of the gear in the metal box to prevent foxes etc. from harming it. At the last sampling, the dinghy must be dried as much as possible with some cloth or kitchen paper, and the edge of the lid should be taped to the box to prevent snow from blowing into the box during winter. Cover the box safely with rocks to protect it against wild beasts!

5.1.6. Laboratory work

pH is measured (to nearest 0.1) after calibration of the meter with two buffers that have a pH around the value of the lakes i.e. pH 4 and 7 (see the specific manual for pH measurements). In the same sample, conductivity is measured (to nearest 0.1 µS).

For chlorophyll measurements, 1 l of water (record exact volume) is filtered through a 47 GF/C filter, whereupon the filter is folded, wrapped in alufoil, put in a zip plastic bag and frozen (-20ºC). Write lake name (LS or SS), date and filtered volume (very important) on each bag.

Besides the marking of lake name and date on the bottles, each bottle must be labelled with Manilla labels giving the same information.

The 200 ml samples for total N and P are frozen. All samples are brought to the National Environmental Research Institute at the end of the season. Frozen samples must be kept frozen (or at least below +5ºC and in darkness) during the transport. The samples are sorted and analysed on relevant laboratories.

Store the thermometers in an upright position for the winter to avoid bubbles in the tubes.

5.1.7. Input of data into database

All recorded data are entered into separate Excel data sheets for each lake and year. After sorting of the samples, the results are added. Each sheet holds the following columns: Year, Month, Day, Hour, Cloud (cover), Wind m/s, Lake, Ice, Temp,

Secchi (put the depth in brackets, if it is the bottom), pH, Conduc (Conductivity), Chlorophyll vol. (ml), Chlorophyll (to 0.01 µg/l), TN (µg/l), TP (µg/l), Taxon, No./l (to 0.1 individual per l) and Notes. All phyto-plankton and zooplankton taxa should be stated for each sampling (including early data on ice cover), but “No sampling” should be added under Notes, when the actual taxon was not sampled at that date.

Fig. 5.1.4. Map of lakes (to be added).

6. Abiotic parameters

6.1. Microclimate temperatures in ITEX and arthropod study plots

6.1.1. Parameters to be monitored

Micro climate temperatures in ITEX and arthropod monitoring plots

6.1.2. Frequency of sampling

Automatically 5-12 times per day year round. Data are tapped once a year, at the end of the season.

6.1.3. Equipment to be used

30 active Tinytag Plus data-loggers and a few spare ones

Silicon

Plastic pegs

6.1.4. Marking of sampling plots

Dataloggers are situated under a small pile of stopes at each of the monitoring plots. In some occasions, one datalogger 'covers' two or three plots close together. Arthropod plot 1 (window traps) has no datalogger, as the water temperature in the surrounding pond is monitored by GeoBasis.

6.1.5. Sampling method

As soon as the datalogger appears from the snow, it must be checked that the thermistor is in place in the vegetation and fixed with a peg, that the cable is OK (covered by earth and not destroyed e.g. by foxes) and that the datalogger looks OK.

Each year in the second half of August, the dataloggers are brought home to the station for tapping, whereupon they are put in position again. Leave the thermistor and cable in position during the process. Record the exact time of removal as well as re-establishment. Seal all cable entrances inside the datalogger with silicon before reestablsihment.

6.1.6. Laboratory work

See the GeoBasis manual.

6.1.7. Input of data into databases

Date and time of removal and re-establishment is stored in an Excel file named 'Datalogger dates', giving Plot, Logger no., Removal (date and time), Restart (date and time), Re-establishment (date and time), and Remarks. Under Remarks it is e.g. stated if the datalogger has been replaced by another (give type and no.) and why.

The data file names give Plot no. and year (e.g. Sal1-98.ttd). Add defect to the year, if data are invalid, or 1 and 2 to the year if data have been tapped more than once during the season.

6.2. Snow melt in vegetation and arthropod study plots

See 1.1.5, 1.4.5 and 2.1.5.2.

6.3. Photographic snow monitoring

6.3.1. Parameters to be monitored

Snow cover in the main study area in Zackenbergdalen

6.3.2. Frequency of sampling

On days with fine weather around 1 June, 10 June, 20 June and 30 June, respectively. On sunny days, the pictures must be taken in the afternoon (>16 hrs). It takes about two hours to walk up to the photo site (see 6.3.4).

6.3.3. Equipment to be used

Nikon F50 camera marked 'Snefotos' and with the 35-80 zoom lenth marked with a cross on the inner ring (important, since only this camera has been measured for distortion)

64 ASA colour slide films

6.3.4. Marking of sampling site

Pictures are taken from the top of 'Nansenblokken', a prominent rock 480 m a.s.l. on the east slope of Zackenbergfjeldet, where also the automatic snow camera is mounted (see GeoBasis manual).

6.3.5. Sampling method

Activate the automatic photo dating system (put it in the order day, month, year) on the back of the camera.

Put the focusing on manual (M), turn the focus to max. distance and turn the zoom to max. wide angle (35 mm) - and make sure that it stays there! Put the photo programme in "Landscape" mode.

Take three photos of the valley starting from the south with the Simpson hut at the right edge of the frame, the next from the research station northwards and the last covering the leftmost visible part of the slopes of Aucellabjerg (see sample in Appendix).

Keep the mountains in the horizon in the absolute uppermost part of the pictures, so that even the slope of Zackenbergfjeldet below you is covered by the photos.

Turn the zoom to max. magnification (80 mm) and repeat the procedure, this time with five photos covering only the main census area (the horizon is not included).

Repeat the process preferably with another film in the camera.

6.3.6. Laboratory work

The films are develloped, whereupon they are stored for later analysis.

6.3.7. Input of data into data bases

(To be develloped.)

6.4. General observations

5.4.1. Parameters to be monitored

Weather

Snow cover and snow melt

Snow and ice on ponds and lakes

Start of flow in rivers and streams

Melt and break up of fjord and sea ice

Drying up of ponds

6.4.2. Frequency of sampling

Continiously during entire season

6.4.3. Equipment to be used

Binoculars

Dictaphone

6.4.4. Sampling sites

Keep record of snow cover and snow melt in the main study area, snow and ice on ponds around the research station (Gadekæret, Teltdammen, Sydkærene, Lomsø and Kystkærene) together with the lakes in Morænebakkerne (see 5.1.2) and Store Sø, start of flow in Zackenbergelven and the streams on the slopes of Aucellabjerg, and the formation of open water off the delta of Zackenbergelven, land water along the coast, open water in the mouth of Young Sund (e.g. as seen from Zackenbergfjeldet during snow monitoring photo trips - see 6.2), the break up of the fjord ice, and finally drying up of the ponds in Sydkærene, Gadekæret and Teltdammen.

6.4.5. Sampling method

Keep record of general weather conditions (cloud cover, hard wind, precipitation etc.). Record major patterns of snow cover and snow melt in the lowland and on the slopes of Aucellabjerg. Record occurrence of new snow e.g. in the upper part of the study area (give lower limit and duration of snow cover). Record progress in snow and ice melt on the ponds and lakes (give estimates of percent open water at appropriate intervals). Record the start of water flow in rivers and streams (separate between water soaked snow in stream beds, running water on the snow and fully develloped channels). Record the formation of open water off the delta of Zackenbergelven (give area or estimated extent of open water) and along the coast. Record the date when the fjord ice in Young Sund breaks up (ice floes moving away from their original position) and the disappearence of the ice from the fiord. Record major inputs of drift ice into the fiord. Record drying up of ponds and tarns (Teltdammen, Sydkærene, Gadekæret) during August.

6.4.6. Laboratory work

Writing out dictaphone recordings.

6.4.6. Input of data into data base

All records are kept in a journal (Exel files with date, theme, and observations) together with records of birds, mammals etc. (see section 3.7).

7. Disturbance

7.1. Parameters to be monitored

'Person-days' spent in the different research zones

ATV trips in the different research zones

Aircraft activities to and from and over Zackenbergdalen

Discharges

Manipulative research projects

Take of organisms

7.2. Frequency of sampling

Concomitantly during entire field season

7.3. Equipment to be used

None

7.4. Marking of sampling plots

None

7.5. Sampling method

Record arrival and departure of field active personnel together with visits in research zones other than 1A (see the ZERO Site Manual). Record all trips with the ATV separated on driving on snow and bare ground, on or off the 'road' etc. Record all visits by fixed wing aircrafts and helicopters together with aircrafts passing over Zackenbergdalen at low altitude. Record discharges other than ordinary waste water from kitchen and bathrooms. Record research project manipulations of any kind, together with other interferences with the local environment. Record any collection of individuals of plants and animals.

7.6. Laboratory work

None

7.7. Input of data into database

None. The records are summarised for each season in the annual ZERO reports.

Field work schedule

See the calendar below for recordings that must take place on fixed dates.

Daily or almost daily during all or part of the summer field season:

Map breeding birds in the census area in Zackenbergdalen during June - July (no. 3.1).

Keep record of bird nests and broods (i.e. breeding phenology and hatching success) in the census area in Zackenbergdalen during early June - mid August (no. 3.2).

Monitor barnacle goose broods that appear in Zackenbergdalen during late June - August (no. 3.4).

Count and map all musk oxen in Zackenbergdalen daily during the entire field season (no. 4.2).

Count all seals hauled out on the fjord ice and all Arctic hares on the east facing slopes of Zackenberg mountain daily during June - mid July (nos. 4.6 and 4.11).

Record all 'random' observations of birds and mammals during the entire season (nos 3.7 and 4.9).

Keep record of snow and ice melt in the study area and on the fjord during June and July (no. 6.3).

Keep record of human activities in the different sectors of the study area including all aircraft operations in and around Zackenbergdalen (no. 7.1).

Every third day during 20 July - 31 August:

Count all waterbirds in the old and the present delta of Zackenbergelven (no. 3.3).

Weekly during the summer field season:

Record snow cover, RVI, flowering phenology and herbivore insect occurrence in each of the 22 botanical plots together with snow cover in the four cotton grass plots and the three plant community plots (nos 1.1, 2.3, 2.4, 2.5 and 6.2).

Empty the 48 pitfall traps for land arthropods (no. 2.1).

Empty the two'window traps for freshwater insects at the pond in Gadekæret (no. 2.2).

Perform a complete census of muskoxen within the 40 km^2 census area in Zackenbergdalen, including sex and age classification (no. 4.3).

Check fox dens for occupation and cups every first and third week from June to September (no. 4.5).

Every tenth day during June:

Take photogaphs from 500 m a.s.l. on the eastern slope of Zackenbergfjeldet of the snow cover in Zackenbergdalen (no. 6.3).

Once (or a few times) during the summer field season:

Count flowers etc. in the 25 botanical plots once between early/mid June and early August (depending on species and plot) (no. 1.2).

Record and map winter nests of lemmings in the census area in Zackenbergdalen after snow melt (no. 4.1).

Walk the transect line between Daneborg and Zackenberg and through Store Sødal in mid July for recording of mammals and birds (nos 3.5 and 4.7).

If appropriate, record numbers of breeding eiders, Sabine's gulls and Arctic terns together with walruses on Sandøen and at Daneborg in mid July (nos 3.6 and 4.8).

Sample Langemandssø and Sommerfuglesø in Morænebakkerne for physico-chemical characteristics and phytoplankton in late July, early and mid August, besides zooplankton in mid August (no. 5.1).

Record and sample all fresh muskox carcasses found during the summer (no. 4.4).

Count berries etc. in the three berry production plots (no. 1.7).

Collect ermine, Arctic fox and Arctic wolf faeces together with snowy owl and skua casts at 30 selected perches at the end of each season (no. 4.10).

Tap dataloggers in ITEX and arthropod study plots and renew batteries at the end of each season (no. 6.1).

Collect information on waste water and other discharge into Zackenbergelven, together with manipulative research projects and collection of organisms (no. 7).

With intervals of five years:

Record changes in vegetation composition and coverage along the ZERO tran-sect line (no. 1.3) (by specialist).

Record detailed changes in the vegetation within each of the three study plots along the ZERO transect line (no. 1.4) (by specialist).

Check the 14 study plot for changes in the cryptogimic vegetation (no. 1.6) (by specialist).

Check the nine ITEX point frame plots for changes in species compostion and cover (no. 1.8).

List of scientific and technical consultants

Botany:

Christian Bay, Ph.D., Botanical Museum, University of Copenhagen

Eric Steen Hansen, Cand. scient., Botanical Museum, University of Copenhagen

Per Mølgaard, Lic. agro., Danish School of Pharmacy

Zoology:

Jens Böcher, D.Sc., Zoological Museum, University of Copenhagen

Mads Cedergreen Forchammer, Ph.D, senior scientist, National Environmental Research Institute, Dept. of Terrestrial Ecology

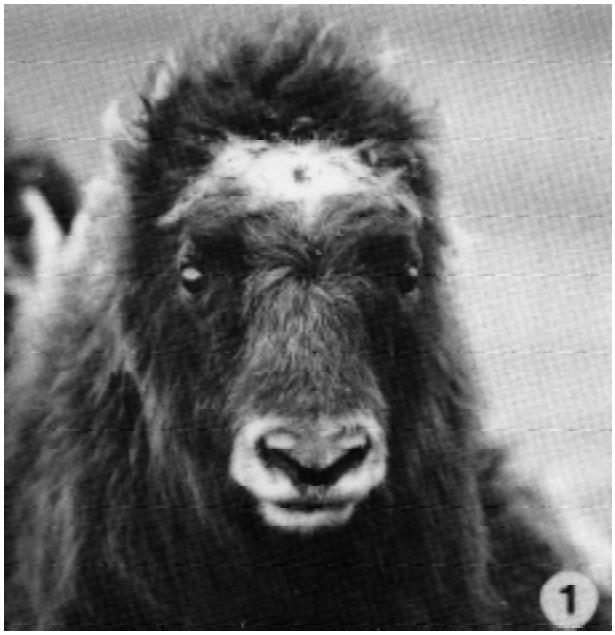
Date	June	July	Au
1	Snow photos from Zackenbergfjeldet	Flowering phenology and invertebrate traps	Delta waterbird census
2			
3	Flowering phenology and open invertebrate traps	Musk ox totalcount	
4			Delta waterbird census
5			Flowering phenology and invertebr
6			
7			Musk ox totalcount/Delta water
8		Flowering phenology and invertebrate traps	
9	Snow photos from Zackenbergfjeldet		
10	Flowering phenology and invertebrate traps	Musk ox totalcount	Delta waterbird census
11			
12			Flowering phenology and invertebr
13			Delta waterbird census
14			Musk ox totalcount
15		Flowering phenology and invertebrate traps	
16			Delta waterbird census
17	Flowering phenology and invertebrate traps	Musk ox totalcount	
18			
19			Flowering phenology and invertebr
20	Snow photos from Zackenbergfjeldet	Delta waterbird census	
21			Musk ox totalcount
22		Flowering phenology and invertebrate traps	Delta waterbird census
23		Delta waterbird census	
24	Flowering phenology and invertebrate traps	Musk ox totalcount	
25			Delta waterbird census
26		Delta waterbird census	Flowering phenology and invertebr
27			
28			Musk ox totalcount/Delta water
29		Flowering phenology and invertebrate traps /Delta waterbird census	
30			
31	Snow photos from Zackenbergfjeldet	Musk ox totalcount	Delta waterbird census

Fixed dates of BioBasis elements

Appendix

Muskox Field Guide to sex and age classification on East Greenland populations

Calf.

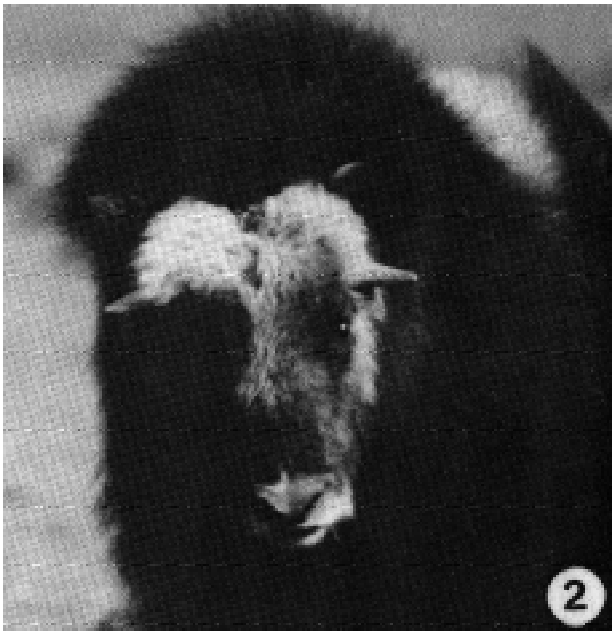


Calf *Photo: Palle Uhd Jepsen*

No horns are visible. Through the winter the white hairs on the forehead become more woolly and appear to cover the horns. The neonate coat colour is dark brown with light brown underwool (qiviut). There is no light coloured area (saddle) on the back as in yearlings and older animals., Guard hairs are not developed and the lower part of the legs is covered with short caramel-coloured hairs. Through the first summer the dark coat colour achieves a lighter shade.

Yearling

The short horns project straight out with a very slight for- ward curve. The length of the visible part of the horns depends on the development of the white curly hairs on the forehead. At the end of the second winter the yearling horns have reached a length of 10—15 cm. The body size is larger than of the calf. Blackish guard hairs reach the ventral part of the abdomen but do not cover the legs. The horns

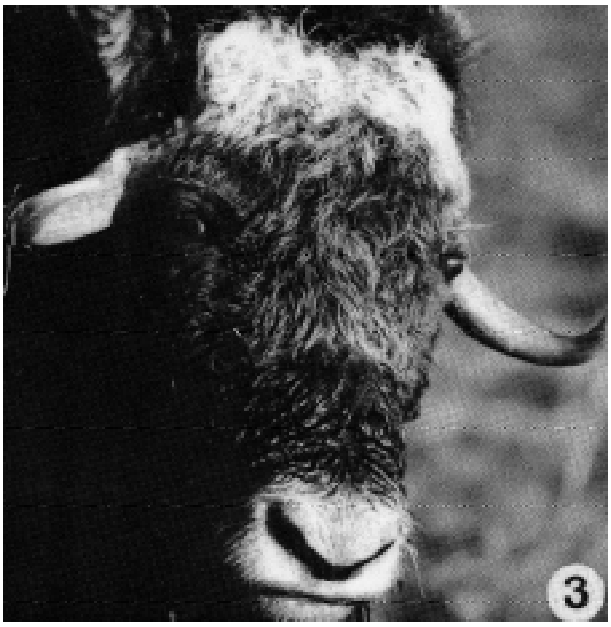


Yearling *Photo: Henning Thing*

of a male yearling are a little thicker, longer, and less curved than the horns of a female of the same age.

Two-year-old female

Horns are slender and appear in frontal view to project laterally straight out. In profile they are bent straight forward with with white woolly hair and no horn bases are visible Coat colour varies some- what with the season, as in other age-classes, being lightest in fall and darkest in late winter. Guard hairs reach down just distal of the joint to the lower legs. This cohort loses the under- wool (qiviut) earlier than older animals and appears to have a smooth-looking coat throughout most of the summer, when older individuals are still shedding the qiviut Body size is significantly larger compared with yearlings and distinctively smaller than in 3-year-old females.



Two-year-old female *Photo: Henning Thing*

Two-year-old male

The horns of a 2-year-old male are thicker and more conical than in a female of similar age. The proximal two-thirds projects laterally from the head at a 45° angle and the distal part is curved sharply forward Horn ends appear very pointed. These characteristics are best seen in the profile view. Between the horns, white woolly hair covers the forehead and no horn bases are present. Guard hairs of the coat reach down proximal to the joint to the lower legs. Body size is usually slightly less than that of an average-sized adult female.

Two-year-old male *Photo: Henning Thing*

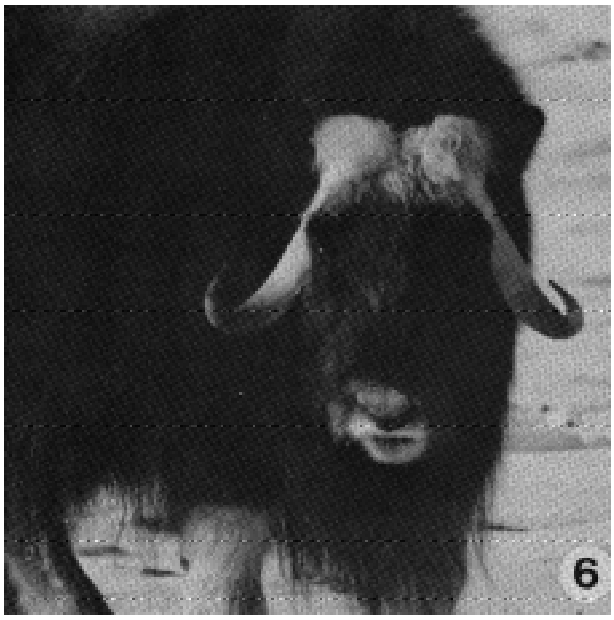
Three-year-old female

In this age-class, horns reach their full length, but are still slender and have black pointed ends. Both in frontal view and in profile the curved appearance of the horns is apparent. The forehead still has cream-coloured woolly hair covering the developing horn bases. Body size is near its maximum and guard hairs of the coat may be long enough to cover half of the lower legs Females often reach sexual maturity at this stage.

Three-year-old female *Photo: Carsten Riis Olesn*

Three-year-old male

Horn development in this age-class is characterised by a pronounced downward orientation of the proximal two-thirds of the horn and a distinct upcurving of the distal part. Except for the black ends the horns have a characteristic yellowish colour easily recognisable in the field.



Three-year-old male *Photo: Carsten Riis Olesen*

Four-year-old+ female *Photo: Carsten Riis Olesen*

The horn bases extending dorsolaterally from the forehead with a decreasing amount of white woolly hair appear as two fluffy structures at the proximal end of the horns. Horn diameter at the orbital level is greater than that of adult females, but horn spread is similar. Guard hairs of the coat may cover half of the lower legs. Body size is a little bigger than for an average adult cow.

Four-year-old and older female

At the age of 7—10 years the whitish woolly hair on the forehead has partially disappeared exposing the horn bases, thus allowing the observer to the best characteristic of a mature older female. Horn bases may increase to 6—7 cm in width, and therefore are much smaller than those of mature bulls. The coats of older females are often characterised by a fleece of shed qiviut loosely attachcd to the guard hairs throughout the summer. In very old females guard hairs may be worn so short that the cream-coloured legs again are mostly exposed.

Four-year-old and older male

During the fifth summer and fall the forehead patch of white woolly hair is reduced considerably and the massive developing horn boss becomes evident. When the animal turns 5 years old (Fig. 8) the horn boss has increased to a near-maximal size,

Four-year-old+ male *Photo: Carsten Riis Olesen*

leaving only a narrow (the width of a finger) hair-filled space in the midline. At this age the horns are longest with the greatest forward curve and with black-coloured

pointed ends. The horn boss is a massive structure with a somewhat cracked surface. It may increase to a width of 20 cm (measured as a straight line parallel to the midline between horns). Especially during winter, the massive boss may appear very light coloured when observed at a distance This could lead the observer to misinterpret the boss as the whitish forehead hair of a cow or a subadult bull and consequently to misclassify the adult male, particularly when no cow or subadult bull is nearby for comparison.

As the muskox bull grows older than 8-9 years the horns are worn down or broken so that the curved ends and black tips disappear.

As seen from Fig. 9, muskox skulls can be sexed and aged with the same accuracy as with living individuals.

The guide is edited from

Olesen & Thing (1989: Can.J.Zool. 67: 1116-1119)

and

Henrichsen & Grue (1980: Danish Rev. Garne Biol. 11: 1-18)

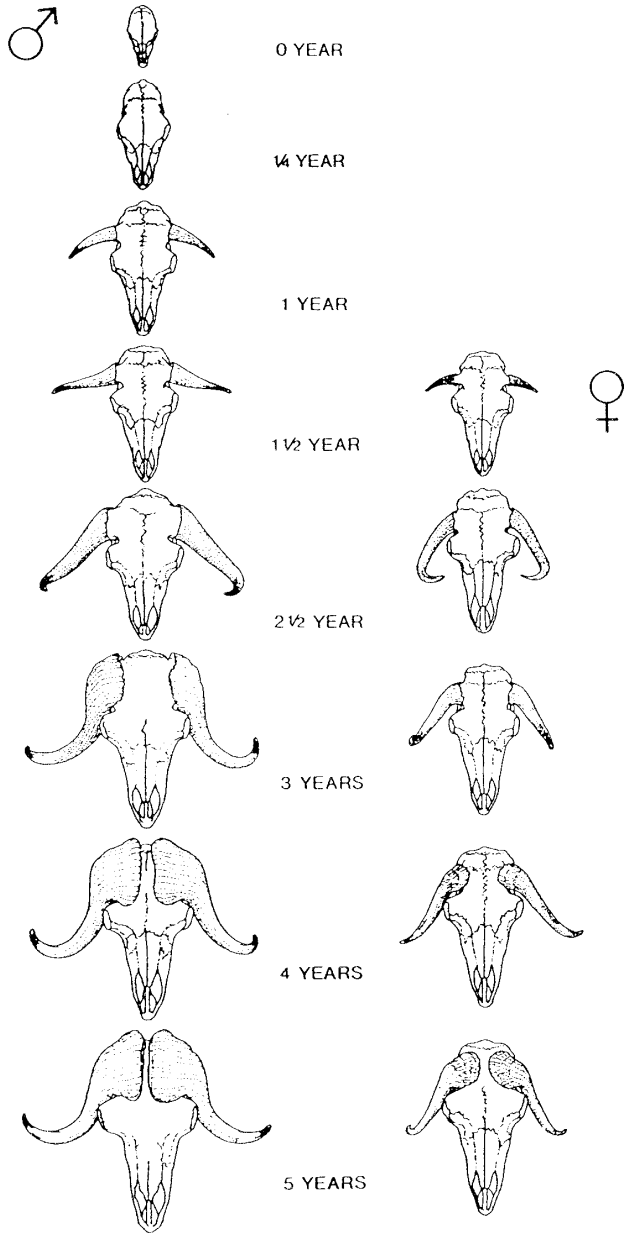


Fig. 9 Muskox skulls

Lemming nest survey Year: Observer: Page no.: Sheet no. S1

ZIP-code			Nest data								
Rec.no.	Easting	Nording	Size: 1-5	Pellet cat. 1-4	Placement: in:1; on:2	Breeding nest	Predation: Ermine: 1, Fox: 2	Pellet: with: 1; filled: 2	Fur: grey: 1; white: 2, ox: 3	Cat.: Fresh:1; Old:2; Summer:3	Excavation

Roofcounts S2			Year:		Date		Fullhour
Observer			Cloud cover /8		Visibility -		
Obs.No.	UTM East	UTM North	m a.s.l.	ISCAR	OSCAR East	OSCAR West	Remarks

Further observations recorded from the roof:
Seals ssp. on the sea ice in Young Sund:
Pink-footed geese
Barnacle geese
Divers
Others

Totalcounts S3		Year:	Date:		Start:		End:		Cloud: /8		Visibility: -			Observer:	
Obs.no.	UTM East	UTM North	Altitude	Herd size	M 4+	M 3	M 2	M 1	F 4+	F 3	F 2	F 1	Usp.1	Calf	Remarks

Carcass sheet S4				Year									
Month	Day	Observer	ID no.	UTM East	UTM North	Sex	Estimated age	Femur sample	Front incitor sample	Molar sample	Bone marrow sample	DNA sample	General remarks

Field Sheet S4, Muskox carcass survey

Fox den survey, S5						Year:				
Month	Day	Observer	Den no.	UTM East	UTM north	White juvenile	White adult	Blue juvenile	Blue adult	Remarks

Field Sheet S5, Fox den survey

Field Sheet S6, Transect census

Year	Month	Day	Obs 1	Obs 2	WPT	Start time	End time	Cloud (x/8)	Wind	Species	Adults	Pull/juv.	Rema
										Red-throated diver			
										Pink-footed goose			
										Barnacle goose			
										King eider			
										Common eider			
										Long-tailed duck			
										Rock ptarmigan			
										Gyr falcon			
										Great ringed plover			
										Red knot			
										Sanderling			
										Dunlin			
										Ruddy turnstone			
										Long-tailed skua			
										Glaucous gull			
										Arctic tern			
										Snowy owl			
										Northern wheathear			
										Common raven			
										Arctic redpoll			
										Snow bunting			
										Gynaephora larvae			
										Colias sp.			
										Colias crocea			
										Bumblebee			
										Arctic hare			
										Collared lemming			
										Summer burrow			
										Winter nest			
										Blue arctic fox			
										White arctic fox			
										Ermine			
										Muskox M 4+			
										Muskox M 3+			
										Muskox M 2			
										Muskox M 1			
										Muskox F 4+			
										Muskox F 3+			
										Muskox F 2			
										Muskox F 1			
										Muskox calf			
										Muskox usp.			
										Summer faeces			
										Winter faeces			

Random observations of ma in 1997					adulte=voksen, juv. (juvenile)=unge)												
Obs.	Observer	Locality or		Lemming	Arctic hare		Arctic fox (blue)		Arctic fox (white)		Ermine		Arctic wolf		Muskoxen (out side Zacken		
date		UTM co-ordinates					(dark)		(white belly, dark back)		Hermelin						
					adulte	juv.	adulte	juv.	adulte	juv.	adulte	juv.	adulte	juv.	adulte	1 year	calf
dd/mm	Name(s)	easting	nording		white	grey	fluffy tale	slender tale	fluffy tale	slender tale	25 cm					small horn	no horn

Field Sheet S7, Random observations

Faeces and Casts, S 7			Year:		August		Day: Observer:
Stone	UTM East	UTM North	No. of fox faeces	No. of ermine faec	No. of skua casts	No. of owl casts	Remarks
1	513685	8264794					
2	513750	8264760					
3	513795	8264908					
4	513960	8264832					
5	513875	8264815					
6	513857	8264664					
7	513835	8264695					
8	513835	8264676					
9	514030	8264670					
10	514192	8264688					
11	514338	8264622					
12	514293	8264514					
13	514369	8264427					
14	514444	8264238					
15	514441	8264144					
16	514483	8264068					
17	514445	8264046					
18	514361	8264106					
19	514261	8263957					
20	514164	8264165					
21	514124	8264159					
22	513992	8264109					
23	514000	8264145					
24	513869	8264054					
25	513739	8264407					
26	513813	8264359					
27	513640	8264098					
28	513600	8264057					
29	514260	8263970					
		Totals					

Field Sheet S 8 ,