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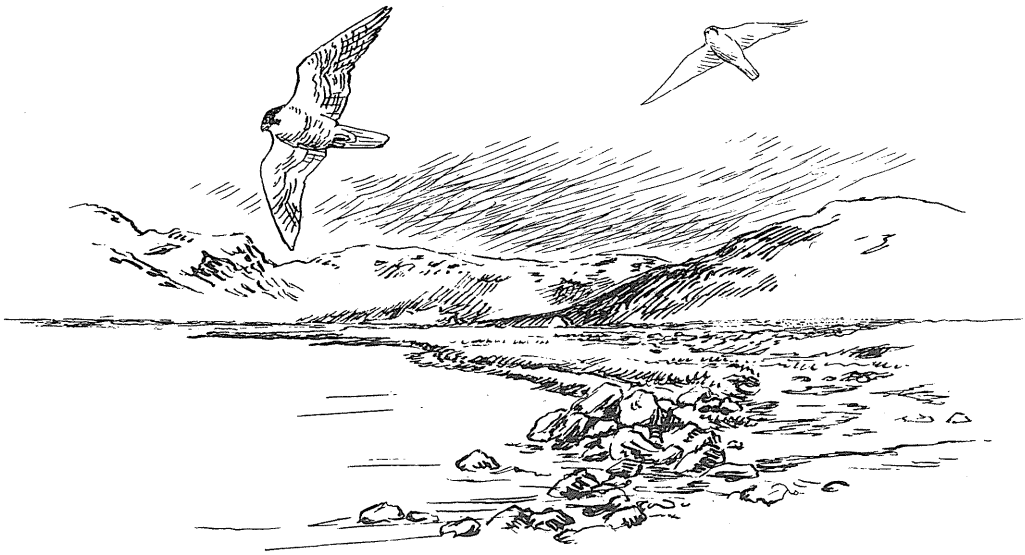
The Peregrine Falcon *Falco peregrinus* in South Greenland: Nesting requirements, phenology and prey selection

KNUD FALK, SØREN MØLLER and WILLIAM A. BURNHAM



(Med et dansk resumé: Vandrefalken Falco peregrinus *i Sydgrønland: Redevalg, fænologi og fødevalg)*

Introduction

Variations in landscape and climate along West Greenland may affect the breeding biology and ecology of the Peregrine Falcons *Falco peregrinus* inhabiting the low arctic parts of the country. From Greenland only general descriptions of the Peregrine have been available (Salomonsen 1950-51, 1967, 1981) until W. G. Mattox and coworkers initiated studies of the bird at Søndre Strømfjord (see Burnham & Mattox 1984).

This paper describes the falcons' nesting requirements, nesting phenology and prey selection in South Greenland, where previously no survey has been conducted. Results are compared with data from Sdr. Strømfjord, situated approximately 800 km north of the study area in South Greenland, in order to point out differences and similarities in the ecology of Greenlandic Peregrines.

The Peregrine is basically a cliff-nester (Ratcliffe 1980). Steep cliffs offer protection against mammalian predators, but also provide a view over parts of the hunting territory, and a launch location for attacks. The choice of cliff and nesting ledge may be important for the survival of offspring, and the nest appears carefully selected by the adults (Burnham & Mattox 1984). Exposure to the sun may especially affect the nest site selection: Results from several studies of raptor species (e.g. Porter & White 1973, Mosher & White 1976) may be interpreted as the birds either prefer or avoid heat from solar radiation in the nest – depending on latitude and altitude.

Birds of prey are believed to have their breeding timed with peaks of prey abundance (see e.g. the thorough examination of Sparrowhawk *Accipiter nisus* by Newton & Marquiss 1982); for Peregrines in Alaska, Cade (1960)

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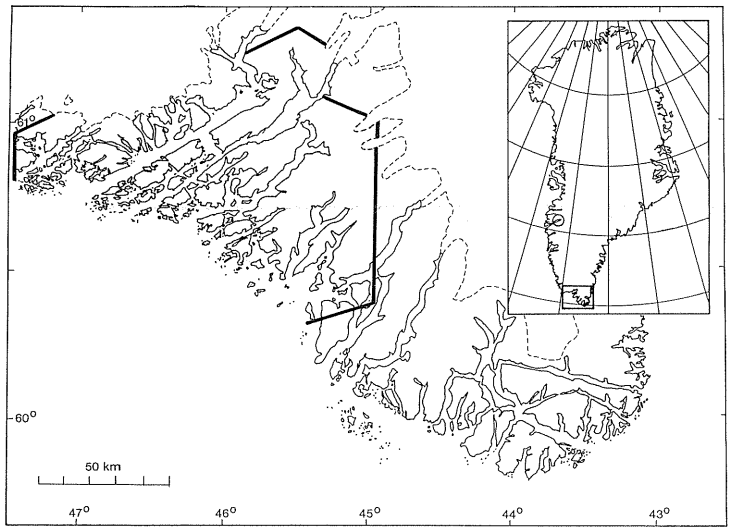

Fig. 1. Map of South Greenland. Solid black lines indicate approximate limits of the study area. Sdr. Strømfjord is indicated by a circle (inset).
Kort over Sydgrønland. Tyk sort linie angiver tilnærmede grænser for undersøgelsesområdet. På det indsatte kort er Sdr. Strømfjord angivet med en ring.

found the breeding cycle apparently to be synchronized with the arrival of the chief prey species. In West Greenland, Harris & Clement (1975) considered that »the timing of breeding cycle appeared to have a significant relationship with the breeding cycles of the falcons' prey« – but failed to develop the relationship. In this paper the nesting phenology of the Peregrine is compared with the fledging dates of prey species.

The Peregrine is known as a bird hunter par excellence (Cade 1982), preying upon a wide variety of avian species. Prey species are mainly taken according to their availability, and the bulk of the food is usually drawn from the most common birds in the immediate surroundings (Ratcliffe 1980). Knowledge of the food of the Peregrine in different parts of its range is important for evaluating the possible sources of pollutant residues in the falcons.

Study area

The study area is situated between 60° and 61° N in the southernmost part of West Greenland, including parts of Nanortalik, Qaqortoq/Julianehåb and Narsaq districts (Fig. 1). The ice-free land is up to 80 km in width and divided by several long fiords, of which many extend east to reach the glaciers from the central icecap. Compared to other areas in Greenland, the land is relatively low – the highest mountains, up to 1900 m, are in the southern part of the study area, but in the rest of the region peaks rarely exceed 1000 m. Most of the valleys are low-lying with bottoms around 100 m a.s.l. (above sea level). Lakes and small streams are numerous.

During early spring and summer the archipelago and fiords are periodically blocked by the polar ice drift. This causes low temperatures and foggy conditions along the outer coast of South Greenland (Putnins 1970, Feilberg 1984). Many depressions pass South Greenland causing rapidly changing weather conditions with rain, low clouds and strong winds. The annual precipitation and mean temperature for June, July and August at the two »extreme« weather stations in the region are: Narsarsuaq 696 mm, 9.8°C; Alluitsup Paa/Sydprøven 754 mm, 4.9°C (Feilberg 1984). On sunny days cold winds usually blow through the fiords from the outer coast towards the icecap (Putnins 1970). Foehns occur regularly. The climate is low arctic; eastwards from the outer coast it gradually becomes less maritime, and in areas close to the icecap it may be characterized as subarctic (Salomonsen 1981). The vegetation changes accordingly (Böcher 1981) from a thin cover of *Empetrum nigrum, Juniperus vulgaris* and scattered *Betula* spp. in the archipelago, to dense scrubs of *Salix* spp. and 2-10 m high *Betula pubescens* interspersed with areas covered by grasses, mosses and lichens in the subarctic areas near the icecap.

Of birds only the Wheatear *Oenanthe oenanthe,* Redpoll *Carduelis flammea,* Lapland Bunting *Calcarius lapponicus,* Snow Bunting *Plectrophenax nivalis* and Rock Ptarmigan *La-*

gopus mutus are widespread. The Black Guillemot *Cepphus grylle* is the only alcid breeding within the study area. A few colonies of Glaucous Gull *Larus hyperboreus,* Iceland Gull *L. glaucoides* and Great Black-backed Gull *L. marinus* are present near the outer coast. Waders and ducks are scarce. The Arctic Fox *Alopex lagopus* is the only terrestrial mammalian predator.

Methods

The data were primarily collected during the Peregrines' breeding seasons 1981-1984. A few data from 1979, 1980 and 1985 are included. An outboard-powered 16 foot boat was used for transportation in the survey area, and inland areas were checked on foot. At cliffs checked in the population survey (see Falk & Møller in press) active nests (sensu Postupalsky 1974) were visited, and physical data of the cliff and nesting ledge were collected as follows: The height of the cliff (not including the talus slope usually present below the near-vertical cliff), the height of the nest on the cliff, and the altitude in meters a.s.l. were estimated from topographic maps (1:80,000, 1:100,000 or 1:250,000) and measured by the »amount« of rope needed to gain access to the nest.

In order to measure nest site exposure, horizontal and vertical angles were measured with a compass (Silva 15T). With the compass the horizontal angle was measured »as far as one could see the sky«, because we think this is the best way to define the total exposure in the horizontal level. To determine the degree of overhang, the vertical angle was measured by the inclination scale on the compass – taken midway between the two horizontal extremes. The »sunset« and »sunrise« for the nest was evaluated by using data in List (1951) on solar altitude and azimuth for 60° N and the dates 21 May and 24 July. The first date roughly corresponds to the time the Peregrines select their nests and initiate laying, the second to the time successful pairs have nestlings.

The accessibility of the nest for humans and Arctic Foxes was classified as easy, difficult or impossible.

In the data collected as described above, a given nest may be represented more than once if it has been active in more than one year.

At visits to successful nests (sensu Postupalsky 1974), the age of the nestlings was estimated with an accuracy of ± 2 days. These data are the basis for the description of nesting phenology.

Prey selection was determined by 1) observed prey deliveries to the female, the nestlings or the fledged young, 2) prey remains at nests or plucking places, or 3) identifiable structures in pellets. Most attention was paid to method 1) since this method appears to provide less biased results than 2) and 3) (cf. Mearns 1983).

Results

The cliff and nest characteristics can be summarized as follows: As an average the nesting ledges are placed 234 m a.s.l. (SD=109, n=15), about 40% from the top (SD=22, n=15) (0%=top, 100%= ground below cliff) on a near-vertical cliff 119 m in height (SD=87, n=15) (Fig. 2). The nests are situated on ledges with only small, if any, overhangs: the vertical angle is 83° (SD=14, n=14). The average total horizontal exposure (»viewing angle«) is 159° (SD=38, n=11). The nests receive solar radiation for 7 hours and 6 minutes (range 5:00 – 8:00 hours, n=10). The directional exposure varies much between SE (130°) and NNW (330°) with the average near SW (228°), as depicted in Fig. 3b; for comparison the directional exposure of nests in West Greenland (Burnham 1975) is shown in Fig. 3a.

The nesting ledge usually gives good protection from man and fox; only one ledge was considered easy to reach (the breeding attempt on this ledge was not successful); 8 were difficult, while the remaining 6 were impossible to reach without the aid of mountaineering equipment.

The hatching dates for the first egg in 13 Peregrine Falcon clutches are shown in Fig 4b. Data from Sdr. Strømfjord are shown in Fig. 4a. For South Greenland the hatching dates for the first egg range between 23 June and 19 July, with the median at 4 July. From this, and using 28-33 days for incubation (Ratcliffe 1980) and 39-49 days for nestling periods (Sherrod 1983) respectively, the breeding time of Peregrines in South Greenland can be described: After arrival in the latter half of May (Salomonsen 1950-51, 1981) some pairs intitiate laying in the last week of the month, but most pairs lay in the first week of June. Most clutches hatch in the beginning of July, and most young will fledge in mid-August, although fledging may occur as early as 1 August and as late as 6 September.

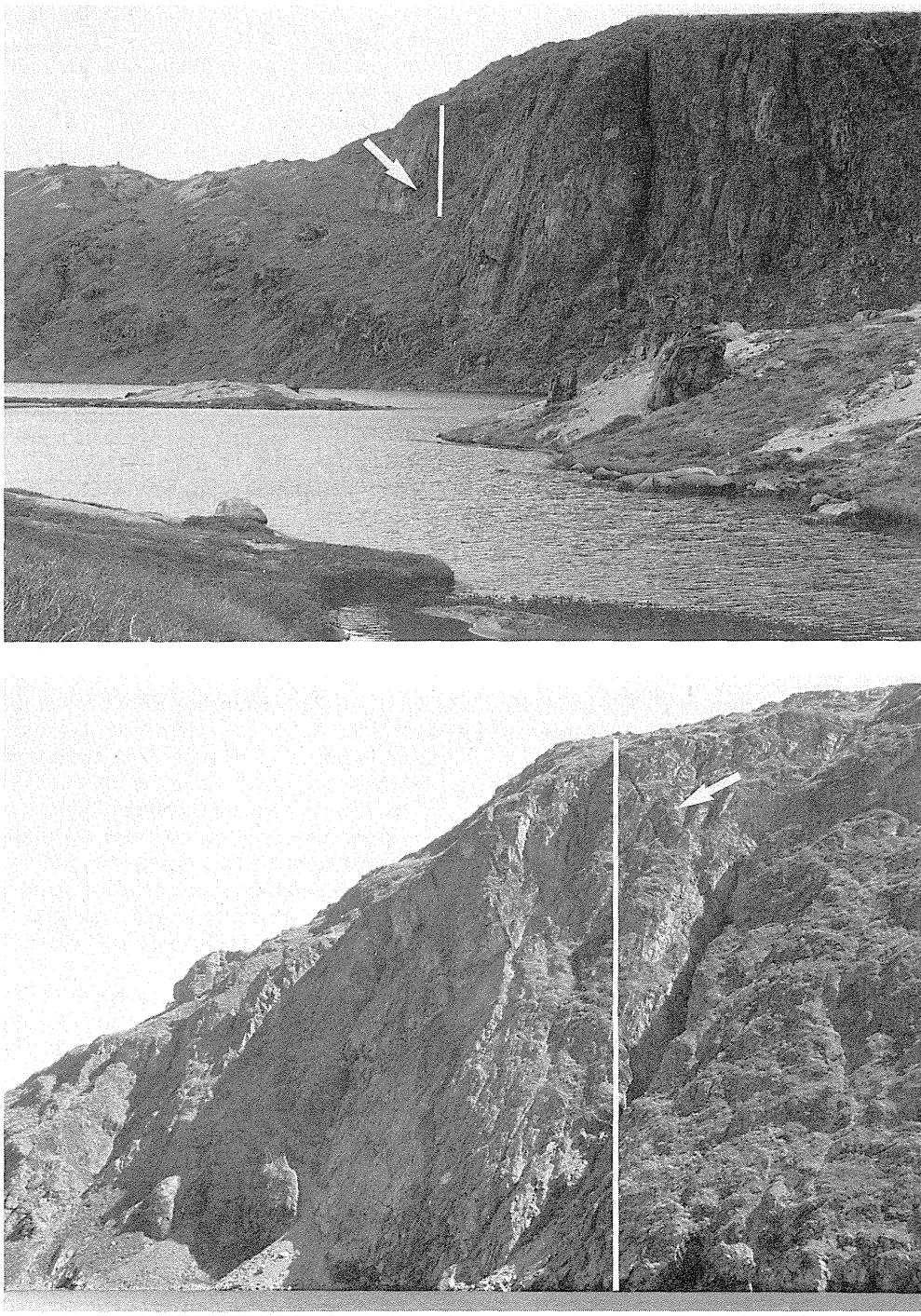

Fig. 2. Position of the nesting ledges (indicated by arrows) at two cliffs in South Greenland. a: Nest placed app. 75% from the top on a cliff-face app. 80 m in height, overlooking a lake. b: Nest placed app. 12% from the top on an app. 300 m high cliff overlooking a large fiord.
Redehyldernes beliggenhed (vist med pile) på to sydgrønlandske falkefjelde. a: Reden placeret ca 75% fra toppen på en ca 80 m høj klippevæg med udsigt over en sø. b: Reden placeret ca 12% fra toppen på en 300 m høj klippevæg med udsigt over en stor fjord.

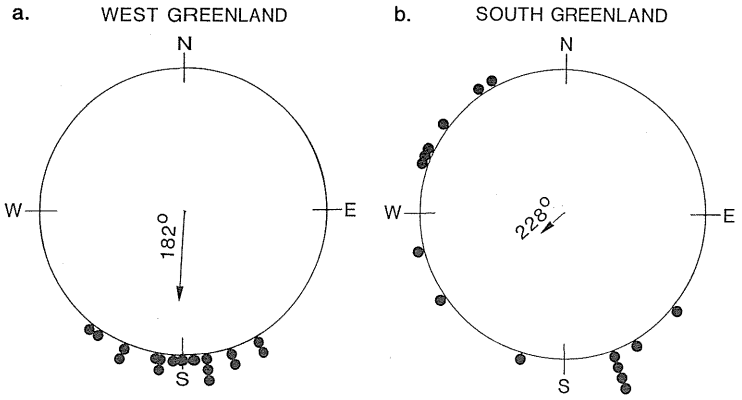

Fig. 3. Directional exposure of Peregrine nests in a: West Greenland (data from Burnham 1975), b: South Greenland. Average vectors are indicated. Each dot represent one active nest; dots in the same direction may indicate the same nest used in more than one year.
Orientering af Vandrefalkereder i a: Vestgrønland (data fra Burnham 1975), b: Sydgrønland. Gennemsnitsvektorer er angivet. Hvert punkt repræsenterer en aktiv rede; flere punkter i samme retning kan skyldes, at samme rede har været anvendt flere år.

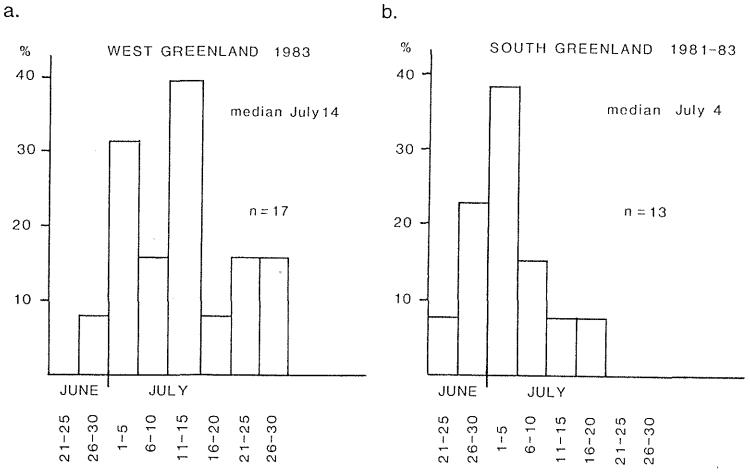

Fig. 4. Distribution – in five-day intervals – of hatching dates for the first egg in Peregrine clutches in a: West Greenland (data from Mattox 1983) and b: South Greenland. Median dates are given.
Fordelingen i femdages intervaller af klækningsdato for det første æg i vandrefalkekuld i a: Vestgrønland (data fra Mattox 1983), og b: Sydgrønland. Mediandatoer er anført.

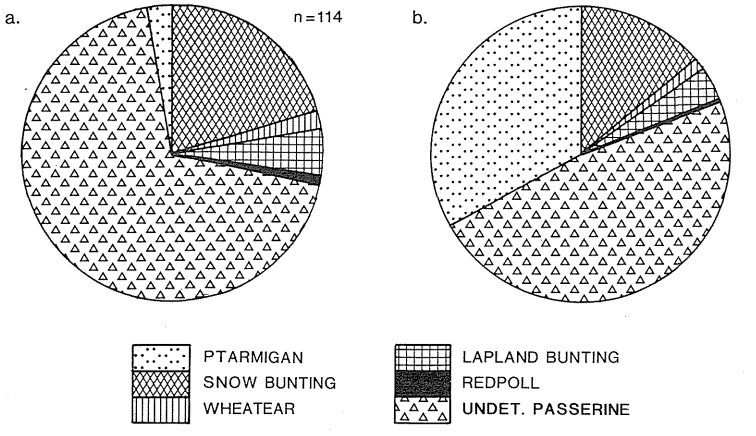

Fig. 5. Prey species taken by Peregrines in South Greenland during the breeding season. a: distribution by number, and b: by weight.
Byttedyrarter taget af Vandrefalke i Sydgrønland i yngletiden. a: fordeling efter antal, og b: efter vægt. I rækkefølge angiver signaturerne henholdsvis Fjeldrype, Snespurv, Stenpikker, Laplandsværling, Gråsisken og ubestemte spurvefugle.

In Fig. 5a the species distribution of 114 prey items is shown by number, and in 5b by weight, taking Ptarmigan as 550 g, Snow Bunting as 30 g (Cade 1960), Redpoll as 12 g (Mearns 1983) and Wheatear and unidentified passerines as 30 g.

Discussion

When comparing cliff and nest characteristics with data from West Greenland (Burnham 1975), both differences and similarities are apparent: cliff height in South averages 199 m vs 79 m in West Greenland, but this difference is not statistically significant (Mann-Whitney U-test, two-tailed, $p>0.1$ (Siegel 1956)). The Peregrines in South Greenland nest at lower altitudes than birds in West Greenland, 234 m vs 375 m a.s.l. (Mann-Whitney U-test, two-tailed, $p<0.002$), whereas the position of the nests at the cliffs is identical; 40 vs 41%.

Nesting at high altitudes may be unfavourable to the Peregrines due to cooler environment and to clouds covering the cliff. As a consequence the birds should be attracted to cliffs at low altitudes when available. The difference between nesting altitude in West and South Greenland could be due to a difference in availability of cliffs. Another consequence would be that Peregrines breeding at high altitudes should nest at lower parts of their cliffs, but this is not confirmed by the data. Burnham & Mattox (1984) suggest that the critical factor in nest site selection is a ready supply of prey.

The nesting ledges in the two study areas have the same degree of overhang, 83° vs 79° (Mann-Whitney U-test, two-tailed, $p>0.1$), and the same total horizontal exposure, 159° vs 160°. The statement by Salomonsen (1981), that the Peregrines in Greenland always place their nests in shelter of an overhang, is obviously not correct.

As seen in Fig. 3, there is much greater variation in the direction of exposure (orientation) in South Greenland, where the nest site may face almost any direction with an average about SW, while in West Greenland all nests face nearly due south (Burnham 1975) (Kolmogorov-Smirnov test, modified, $p<0.01$ (Batschelet 1965)). Also, the maximum possible amount of sunshine in the nests is different: average 7 hours and 6 minutes vs 9 hours and 13 minutes in South and West Greenland, respectively (Mann-Whitney U-test, two-tailed, $p<0.02$). As the total horizontal exposure is the same in both areas, and since hours of sunshine in South Greenland nests in only two cases were limited by »true« sunset (none by »true« sunrise) instead of the rock shadowing the nest, this difference between the two areas may be attributed to a difference in methods.

The differences and similarities in nesting requirements may reflect climatic conditions: for four weather stations in our study area, Conrad's index of continentality (C) ranges between 8 and 16, and de Martonne's index of humidity (H) between 59 and 81, while Sdr. Strømfjord has C=36 and H=25 (increasing values of C and H indicate more continental and more humid climate, respectively) (Feilberg 1984). These indices do not directly take into account the amount of sunshine, which has a strong influence on the temperature in the Peregrines' nests. The cliff functions as a heat sink (Williams 1984), and as the daily temperature range is greater in continental (Sdr. Strømfjord) than in coastal areas (South Greenland), the Peregrines in Sdr. Strømfjord – in combination with the breeding at higher altitudes – can be »forced« to use nesting ledges which receive maximum solar radiation. The birds in South Greenland are not equally urged to exploit the temperature buffering effect of the cliff and can use ledges facing any direction. This interpretation appears supported by the observation of Ratcliffe (1962), that Peregrines in Great Britain (a relative maritime area) are indifferent to directional facing. The matter is, however, open for discussion; an alternative simple explanation could be that in South Greenland the sunshine is so restricted that there is no advantage in choosing a ledge with a southern exposure.

The distance between the two study areas affects the timing of breeding. As depicted in Fig. 4 the Peregrines in South Greenland start hatching more than a week before their conspecifics further north, median 4 vs 14 July (Mann Whitney U-test, two-tailed, $p<0.02$). This corresponds to the availability of prey: in West Greenland, Harris & Clement (1975) noted the first fledging passerines on 2 July (Wheatear), 12 July (Redpoll), 14 July (Lapland Bunting) and 15 July (Snow Bunting). Our corresponding dates for South Greenland are: 5 July, 26 June, 7 July and 18 June. In Fig. 6 is shown the approximate fledging dates for Snow Bunting in relation to latitude along West Greenland. As expected, the young buntings fledge later in northern than in southern parts of the country.

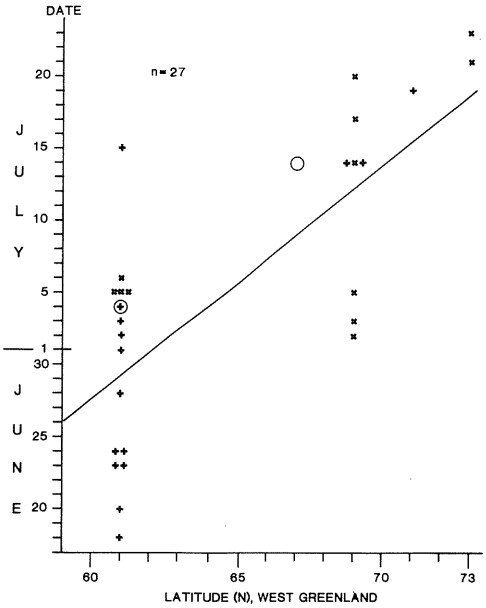

Fig. 6. Dates for observations of newly fledged broods of Snow Bunting in relation to latitude along West Greenland. Each dot represents one brood. Regression line indicated (r=0.76, p<0.001).
× = K. Kampp (unpubl.), + = K. Falk and S. Møller (unpubl.), o = median date for hatching of first egg in Peregrine clutches (see Fig. 4).
Dato for observationer af nyudfløjne kuld af Snespurv i forhold til breddegrad langs Vestgrønland. Hvert punkt repræsenterer et kuld. Regressionslinie indtegnet (r=0.76, p<0.001).
× = K. Kampp (upubl.), + = K. Falk og S. Møller (upubl.), o = mediandato for klækning af første æg i vandrefalkekuld (se Fig. 4).

The Peregrine young hatch when prey is abundant. The timing of breeding in South Greenland fits with data for Peregrines of the same subspecies in Alaska (Cade 1960), and is sligthly ahead of birds in arctic Canada (Poole & Bromley 1984). Further investigations of phenology of prey and predators in relation to latitude is desirable.

The many unidentified passerines in the Peregrines' diet (Fig. 5) are due to the method of collecting data: mainly observation of food deliveries, where the observer can tell a Ptarmigan from a passerine, but not the passerine species from one another. The small sample may skew the material: the large proportion by weight (one third) of Ptarmigan derives from only three specimens, and probably overestimates the importance of this species. Burnham & Mattox (1984) found that the four passerine species make up over 90% of the Peregrines' diet in total number and biomass. This may be closer to the truth for South Greenland as well, and the amount of small birds taken justify the remark by Kampp & Kristensen (1981) that the Peregrine has taken over the ecological niche of the Merlin *F. columbarius,* which is absent in Greenland. Peregrines living close to seabird colonies may, of course, exploit these sources. However, in our study area in South Greenland seabirds are few and scattered, and may thus rarely be available to the falcons.

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Resumé

Vandrefalken *Falco peregrinus* i Sydgrønland: Redevalg, fænologi og fødevalg

Klimatiske forskelle indenfor Grønland har antageligt indflydelse på Vandrefalkens biologi og økologi. Formålet med denne artikel er at beskrive redevalg, fænologi og fødevalg for Vandrefalke i et undersøgelsesområde i Sydgrønland (Fig. 1), og ved sammenligning med andre undersøgelser at påpege forskelle og ligheder i artens levevilkår i landet.

Ved redebesøg måltes falkereders højde over havet, højde på klippevæggen, orientering i forhold til verdenshjørner, eksponering – udtrykt ved de horisontale og vertikale vinkler, der begrænser udsynet fra reden – samt antal soltimer i reden. Fænologi bedømmes udfra falkeungers alder ved ringmærkning. Fødevalg er primært bestemt ved iagttagelser af bytteafleveringer nær reder, sekundært ved bytterester og gylp.

En vandrefalkerede i Sydgrønland er i gennemsnit anbragt 234 m o.h., lidt over halvt oppe på en 119 m høj klippevæg (Fig. 2). Reden har kun ringe eller slet intet overhæng, idet den vertikale vinkel er 83° (90°=lodret). Vandret »udsigtsvinkel« er 159°, og der kan være sol på reden i 7 timer og 6 minutter. Orienteringen af rederne varierer mellem SØ (130°) og NNV (330°) med et gennemsnit nær SV (228°) (Fig. 3b). Redernes placering på høje klipper yder beskyttelse mod ræve og mennesker, idet kun én rede var lettilgængelig.

Af de nævnte parametre afviger kun redens højde over havet, antallet af soltimer og orienteringen (Fig. 3a og b) signifikant fra forholdene i Sdr. Strømfjordsområdet (data fra Burnham 1975). Da den horisontale vinkel er ens i de to områder antages forskellen i sol-

timer at være forårsaget af forskel i metode. Forskel i redernes højde over havet skyldes sandsynligvis forskelle i udbudet af egnede redeklipper i de to områder. Den store forskel i spredningen af redernes orientering i Syd- og Vestgrønland (Fig. 3) kan forklares med at falkene har forskelligt behov for solens varme i reden til udligning af døgnsvingninger i lufttemperaturen. Det kontinentalt prægede klima ved Sdr. Strømfjord – hvor falkene også yngler i større højde over havet – vil tilskynde falkene til at vælge sydvendte, solvarmede redehylder, hvilket ikke er nødvendigt i Sydgrønland. Alternativt: der er slet ikke sol nok i det maritime Sydgrønland til at falkene vil have fordel af at vælge sydvendte redehylder.

Falkenes byttevalg fremgår af Fig. 5, hvor blot 3 ryper af de ialt 114 byttedyr (Fig. 5a) kommer til at udgøre en trediedel af fødemængden efter vægt (Fig. 5b). Rypen er sandsynligvis overrepræsenteret i materialet. Spurvefugle udgør hovedparten af føden.

Mediandato for klækning af første æg (Fig. 4) i kuld hos Vandrefalke er 4. juli i Sydgrønland og 14. juli i Vestgrønland (Sdr. Strømfjord, data fra Mattox 1983). Da også falkene i Vestgrønland primært lever af spurvefugle, søgtes en sammenhæng mellem klækningstidspunktet hos falkene og udbudet af føde. En sammenhæng mellem breddegrad langs Vestgrønland og dato for udflyvning af unger hos Snespurv fremgår af Fig. 6, hvor også mediandatoerne for Vandrefalkenes klækning er angivet.

Uanset hvilken årsagssammenhæng, der er mellem tidspunktet for falkenes klækning og småfuglenes udflyvning, er effekten den, at falkene har lettilgængeligt bytte fra starten af ungernes opvækst.

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