HOP, SKIP, OR JUMP? CONSTRAINTS ON MIGRATION OF ARCTIC WADERS BY FEEDING, FATTENING, AND FLIGHT SPEED

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This is a progress report on the research on spring migration strategies of arctic breeding waders wintering along the west coast of Africa. Three alternative travel schemes (Figure 1) provide a framework in which the constraints on migration by feeding, fattening, and flight (ground) speed are discussed.

Using the example of spring migrating Dunlins *Calidris alpina* through a coastal stopover area in Morocco, it is shown that food availability, foraging activity, staging time, and fattening rates are interrelated (Table 1). Fattening is discussed on the basis of data on body weight changes of male Bar-tailed Godwit *Limosa lapponica* during the 1985 spring migration (Figure 2). Fattening is much slower and departure weights are lower on the Banc d'Arguin (Mauritania) than in the Dutch Wadden Sea (Figure 3a), despite the fact that the distance to the goals after departure from the two sites is of comparable magnitude. Lower than average fattening rates at this last spring stopover site lead to a delayed departure to, or a small arrival weight on, the breeding grounds (Figure 3b). It is argued that limited fattening rates which lead to departure delays at the early staging areas, have strong effects on the required fattening efforts at later stopover sites (Figure 3c). This is called the "domino effect".

The possible effects of winds at ground level and at high altitudes during migratory flights are examined by seeing whether 80 gram fat (Figure 3a) is sufficient for male Bar-tailed Godwits to cover the distance between the Banc d'Arguin and the Wadden Sea. It is shown that in the case of the Bar-tailed Godwits leaving the Banc d'Arguin on 25 April 1985, 80 gram would have been sufficient if the godwits managed to fly in the most favourable winds at high (up to 5.5 km) and varying altitudes (Figures 5, 6).

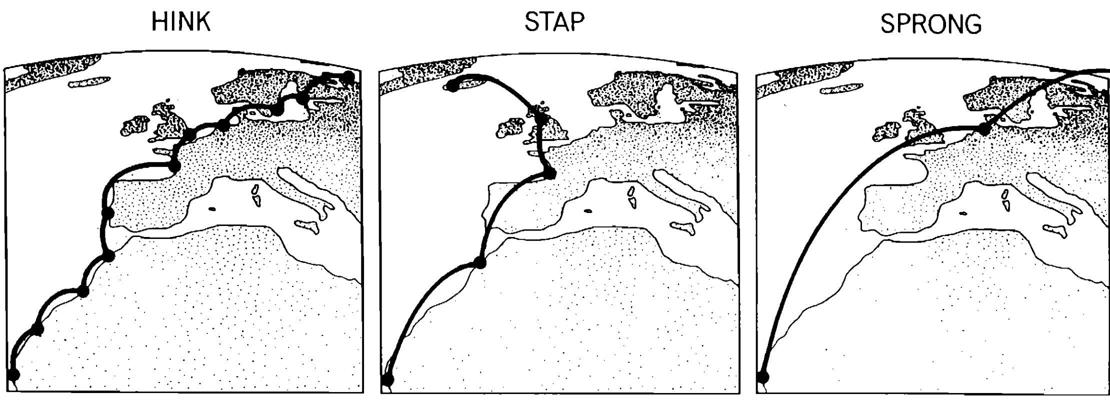

Figure 1. Illustration of three travel schemes for the spring migration of coastal waders from west Africa to the (sub-)arctic breeding grounds: hink (hop: e.g. early migrating Turnstones), stap (skip: Dunlins, Redshanks), or sprong (jump: Knots, Bar-tailed Godwits).

Table 1. Food availability, foraging activity, average staging time, and body weight increase of Dunlins in the Sidi Moussa estuary, Morocco, in March 1981 and April 1982. Food availability is given as biomass (g AFDW/m²) of their most important prey, the ragworm *Nereis diversicolor*. Foraging activity was scored in both years on the same plot during a number of low tide periods (within 3 h from the time of low water), as the percentage of Dunlins present that was foraging. The average staging time was calculated according to a modified capture-recapture method (see Kersten *et al.* 1983). The body weight increase (g/day) was calculated from weighings during the entire migration periods.

	March 1981	April 1982
Food (g/m)	5.4	14.9
Foraging activity (%)	88	80
Average staging time (days)	16	11
Body mass increase (g/day)	1.2	1.6

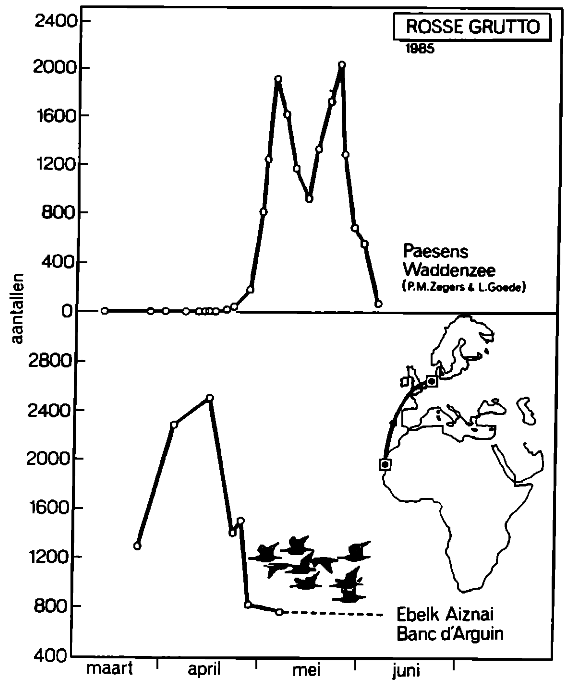

Figure 2. Changes in the numbers of Bar-tailed Godwits on a roost in the wintering area (Ebelk Aiznai, Banc d'Arguin) and in a staging area (Paesenserpolder, Dutch Wadden Sea) in spring 1985. The map shows the location of the two sites. The arrow indicates that two Bar-tailed Godwits, which were colour-marked on the Banc d'Arguin in 1985, were relocated near Paesens one month afterwards.

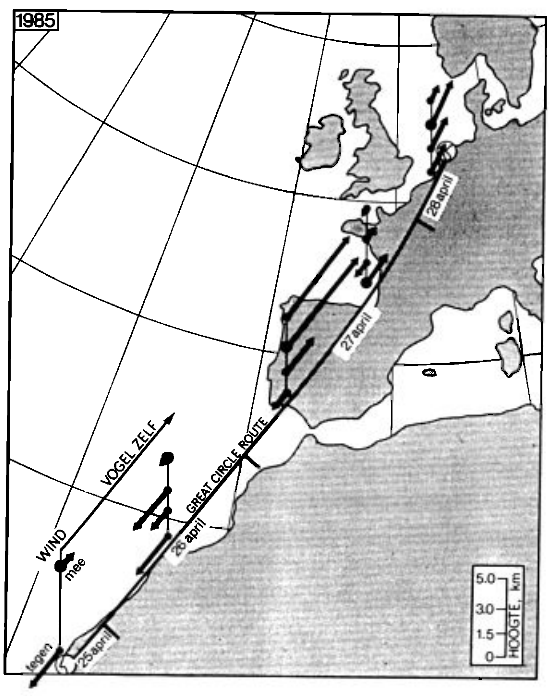

Figure 5. Calculated strengths of opposing *(tegen)* or following *(mee)* wind-vectors at different heights relative to the birds' own flight speed (56 km/hr), and direction. The picture applies to the migration of the Bar-tailed Godwits that left the Banc d'Arguin on 25 April 1985 (see Ens 1985). The thick dots indicate the best flight heights at each site.

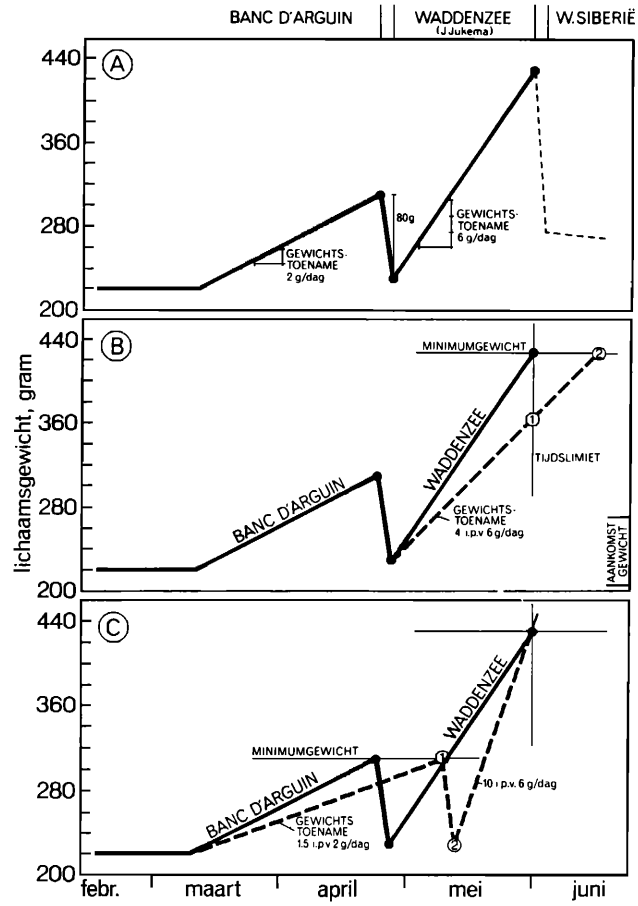

Figure 3. Average weight changes of male Bar-tailed Godwits during the spring migration of 1985. Thick lines indicate measured weight changes, striped lines estimated (A) and hypothetical (B,C) weight changes, respectively.

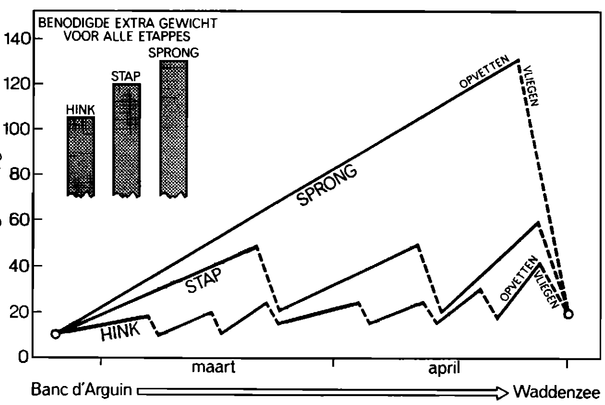

Figure 4. Scheme of the weight changes (g extra weight) during spring migration of a wader species from West Africa to the Wadden Sea according to three different travel schemes: ***hink*** (hop), ***stap*** (skip), or ***sprong*** (jump, see Figure 1). Hatched, incomplete bars (based on the x-axies) indicate the total extra (fat) mass required to cover the entire distance under the three flight regimes.

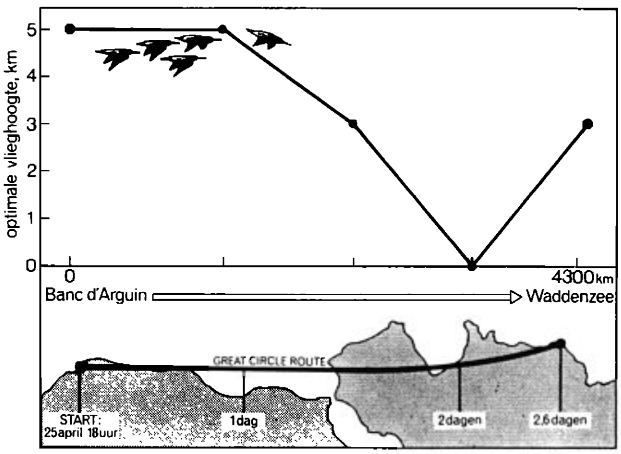

Figure 6. Hypothetical track of optimal flight heights of Bar-tailed Godwits which left the Banc d'Arguin on 25 April 1985 for a direct flight to the Dutch Wadden Sea (based on Figure 5).

Figure 4 shows that making a series of short flights is always energetically cheaper than covering the same distance in one long flight, due to the costs of transporting the extra fuel (fat). "Hopping" also entails smaller risks of fattening and timing delays. The reason that many waders nevertheless make very long flights, is thought to be due to a limited availability of high quality feeding (stopover) habitats along the flyways. In addition to the (species-specific) availability of good habitats, seasonal (high altitude) wind patterns may have a modifying influence on the timing and patterning of wader migration.

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THE IMPORTANCE OF SOUTH-EAST SUMATRA AS A SUMMERING AREA FOR NON-BREEDING WADERS, ESPECIALLY THE BAR-TAILED GODWIT *LIMOSA LAPPONICA*

Finn Danielsen & Henrik Skov

INTRODUCTION

Before 1983 almost nothing was known about the avifauna of the coastal wetlands of eastern Sumatra. Since then three surveys of waterbirds have been carried out; in October-November 1984, in July-August 1985 and in March-April 1986 (Silvius *et al.* 1986, Danielsen & Skov 1986, Silvius 1986).

These surveys have found that eastern Sumatra is a vital link in the East Asia/Australasia flyway for waders. This flyway population is considered to be the smallest and most threatened in the world with a total population of 4-6 million birds of over 70 species (Parish 1987). The three surveys demonstrated that several coastal wetlands in eastern Sumatra are of international importance for waterbirds according to the criteria of the Ramsar Convention.

This paper presents the results of the survey in 1985, when wader counts were carried out in the provinces of Jambi and Sumatra Selatan during the northern summer (for other details see Danielsen & Skov 1986). The aims of this survey were to find out the number and species of summering waders and the key sites of waders and their status.

STUDY AREA AND METHODS

The coastline of the provinces of Jambi and Sumatra Selatan in south-east Sumatra (103°5'E, 1°N - 2°5'S) consists mainly of accreting shores with 50-1000 m wide mudflats bordered by mangrove forest (Figure 1).

Fieldwork was conducted in late July in the province of Jambi and in early August in the province of Sumatra Selatan. In Jambi, a total of approximately 150 km of the coastline were

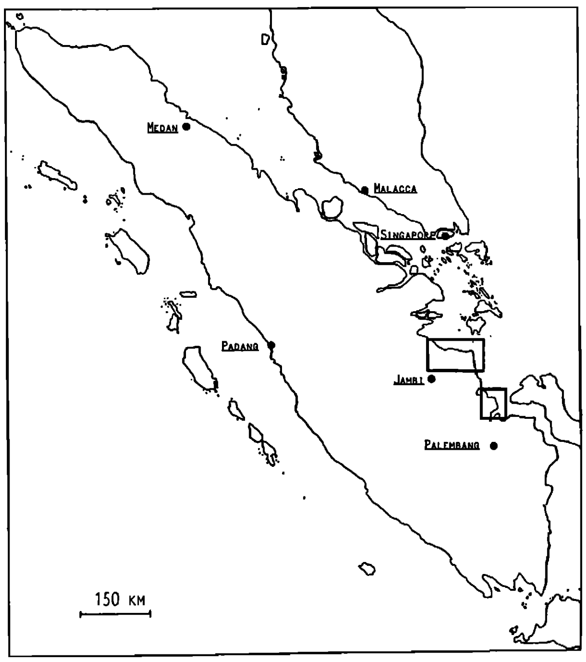

Figure 1. Map of South East Sumatra, showing the study areas at Jambi and Sumatra Selatan.

surveyed between Kuala Tungkal and Tanjung Djabung. In Sumatra Selatan, about 80 km along the peninsula between Sungai Sembilang and Banuyasin II estuary were surveyed.

We travelled eastwards and northwards along the coastline in patrol boats, together with guides from PPA (Directorat General for Forest Protection and Nature Conservation in Indonesia) to observe shorebirds migrating