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PERSPECTIVES FOR SATELLITE TRACKING SWANS AND GEESE: A REVIEW

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Large birds may form a considerable risk for aviation traffic. Migratory waterfowl as ducks, geese and swans are among the species belonging to this risk category. Since geese and swans are fairly traditional in their migratory habits, their general migration pathways and stop-over sites are well known. Along with radar observations at nearby airports some risk avoidance is possible. However, detailed knowledge about timing of departure, duration of flight and flight altitudes in relation to weather conditions was hitherto lacking, and models predicting the three dimensional distribution of migratory waterfowl have not been constructed so far. Satellite telemetry has recently been developed for wider application in studies of bird migration. We review a number of tracking studies on geese and swans with respect to geographical and timing patterns in relation to energetic costs of migration, as well as factors triggering departure. Costs of flight increase with size of a bird species. Since large birds especially try to minimize energy costs during migration, positive changes in tailwind conditions explained timing of departure. We used flight mechanical models to predict flight ranges and physiological models for fat and respiratory water loss as well as for recovery times in order to refuel fat stores (= energy) for the next flight and tested these with empirical data from tracking studies. In-built pressure sensors in tracking devices allow also for tracking actual flight altitudes. Since winds are often stronger at higher altitudes, large birds could further reduce transportation costs by flying at higher altitudes. However, studies on swans have shown that these birds do not generally select high altitudes, but stay below 1000 m (Figure 1).

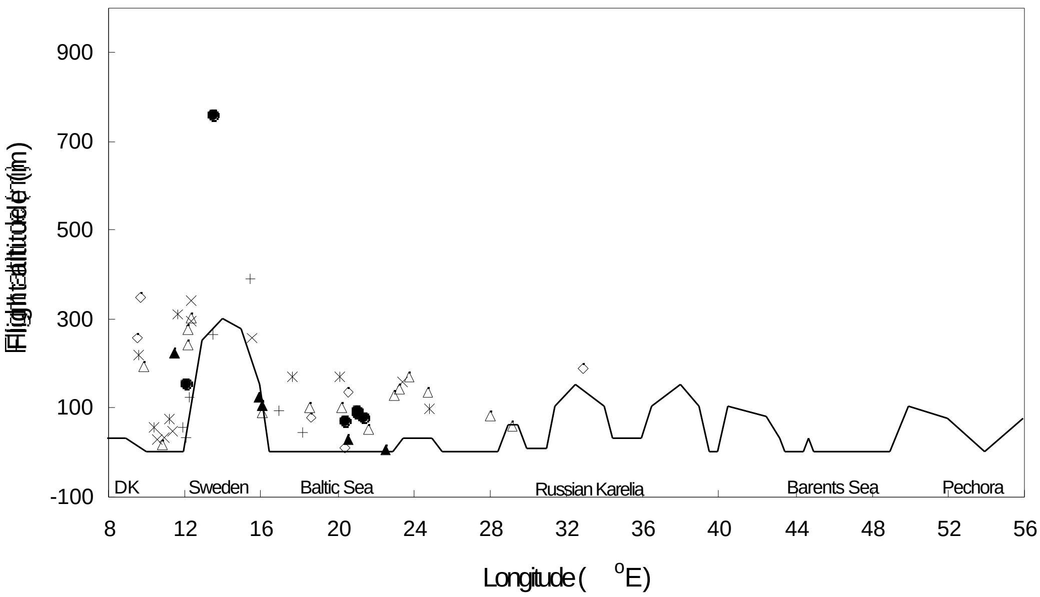

Figure 1. Flight altitude of eight Bewick's Swans equipped with satellite transmitters in relation to their location (eastern longitude) along the vernal migratory flyway from Denmark to the Pechora Delta in Northern Russia. Ground level is indicated with a heavy line.

Modelling the energetic costs and rate of ascent revealed that swan species are limited in lifting fuel deposits and that their specific climb speed is 1,300-1,700 $m.h^{-1}$ (Figure 2). Costs for climbing flight, risk for mechanical damage at high flying speeds and rapid dehydration at higher altitudes are believed to cause this behaviour. Exceptions are found when birds encounter lee waves that may carry them over altitudes with low visibility. Some species have to cross mountain ridges on their migratory journey which they seem to cope with special physiological adaptations. It can not be excluded that smaller sized geese are more apt to select higher altitudes.

We used Stochastic Dynamic Programming to predict migratory behaviour of Bewick's Swans. In this species, which depends mainly on aquatic food stocks, timing of ice break-up and size of food stocks and rate of food depletion were important determinants for timing of migration of the flyway population as a whole. Further tracking studies of more species in a larger size range and different feeding ecology strategies will allow for better understanding and predicting the migratory behaviour of waterfowl in a 3D perspective with weather data as model parameters.

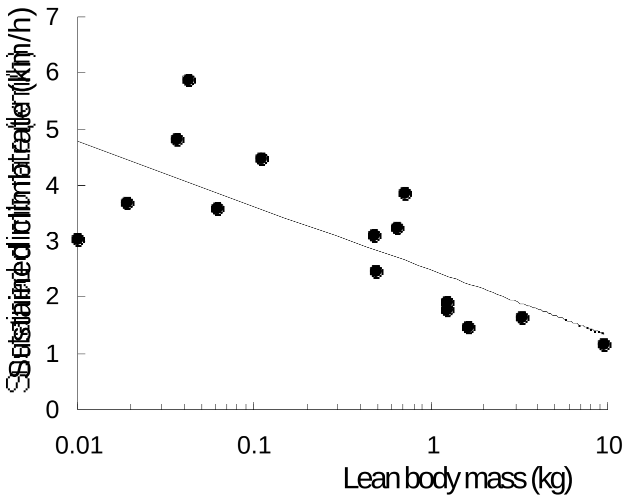

Figure 2. Sustained climb rate in relatrion to lean body mass for 15 bird species. Data from Hedenström & Alerstam (1992); Y = 0.69 - 0.14Ln(X), R^2 = 0.553, P < 0.05.

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