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SYMP03: Linking flights and stopovers: Stopover ecology in the context of organisation of migration

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Avian migration is an alternation of flights and stopovers. Time spent during stopovers is probably by an order of magnitude larger than flight time. Stopover scenarios are thus crucial for understanding the main principles of migration organisation.

In the recent years, much work has been done in the field of stopover ecology and behaviour, both in developing theory and in obtaining field data. Novel field methods and refined analytical techniques permit more accurate and realistic estimates of stopover duration, fuel deposition rates and departure fuel loads. In addition to the analysis of multiple captures, ground-based VHF radio-tracking provides a powerful tool to study both stopover behaviour and migratory departures. Complex interactions between fuel deposition rate, stopover duration, departure fuel load, stopover behaviour, weather and temporal schedule of flight activity may be disentangled. It becomes (or will soon become) possible to test the theoretical models predicting stopover decisions against the relevant field data. Analyses of plasma metabolites and hormones during stopovers help to understand the physiological mechanisms, which enable the migratory birds to recover from endurance flight as well as to prepare the next leg whithin a short time. Moreover the nutritional needs of the resting birds become apparent and thus the importance of the stopover habitats in a physiological and conservational context.

In this symposium, papers dealing with stopovers of passerines, geese, and waders are presented. Problems of ecology and physiology of migrants at stopovers are discussed in order to achieve an understanding of ecophysiology of avian migration.

SYMP03-1 Migratory decisions in barnacle goose: How do environmental variation and learning affect stop-over site use?

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Reproductive performance of migratory birds is not only influenced by conditions at the breeding site but also by body condition and time of arrival. The latter are strongly affected by behavioural decisions made during migration between wintering and breeding ground, i.e. stop-over site use. Therefore, we developed a stochastic dynamic model for the spring migration of barnacle goose that investigates habitat use along the migratory flyway from the wintering sites in Scotland to the breeding sites on Spitsbergen.

We will present predictions on how this goose will respond to fluctuating environments and altered land use in their major migratory staging areas and how the decisions will be affected by the ability to anticipate such changes.

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SYMP03-2 Time of nocturnal departures of robins *Erithacus rubecula* from migratory stopover: radiotracking data

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Radiotracking of robins *Erithacus rubecula* at migratory stopover on the Courish Spit confirmed the data of ceilometer observations and the high nets method that the time of migratory departure in this species is not limited to a short period after sunset, but varies within 5,3 hrs in spring and 7,9 hrs in autumn. The results of radiotracking 36 birds in 2002 (16 in spring and 20 in autumn) suggest a relationship between departure time and season, stopover duration, and fuel stores at arrival.

1. In spring, with the mean duration of night ca. 9,6 hrs, robins departed between 70 min and 388 min (Me = 165 min) after sunset. In autumn, under longer nights (on average 12,4 hrs) the birds initiated flight on average 2,2 hrs later in relation to sunset than in spring (Me = 294 min, variation 146 – 618 min after sunset).
2. In spring, robins stopping for 1–3 days (mean 2,0 days) departed on average 2,7 hrs later in respect to sunset than those stopping for 5–12 days (mean 8,5 days): Me = 245 min (n = 8) and Me = 84 min (n = 8) after sunset, respectively (pooled data for birds with different fat stores at arrival).
3. In autumn, the birds with fuel stores at arrival exceeding 2 g (n = 6) departed on average 1,3 hrs earlier than those with fuel stores below 0,5 g (n = 12): Me = 243 min and 320 min, respectively. Lean birds (fuel stores below 0,5 g) which stopped for 3–11 days (mean 7,3 days) took off 0,6 hrs earlier than those stopping for 1–2 days: Me = 308 and Me = 345 min after sunset, respectively.

Physiological and ecological background of the control of flight activity during migration is discussed. This study was supported by a grant from RFBR to C.V.B. 02-04-48608.

SYMP03-3 The role of predation risk in the stopover ecology of migrating passerines

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Field studies and theoretical approaches of passerine migration largely deal with fuel, its storage during stopover and its consumption during flight. Much less attention was paid to predation as a factor determining migratory behaviour. Field studies with northern wheatears *Oenanthe oenanthe* on Helgoland showed that the decision about skipping or choosing the island as a stopover site is only weakly influenced by predation risk as expressed by the number of raptors flying over. An indoor experiment confirmed that refuelling conditions (mainly fuel deposition rate, FDR) override the effects of predation risk. However, northern wheatears respond to raptor occurrence with safety behaviour which may influence the energy intake and perhaps was responsible for the negative correlation between FDR and the rate of raptor flights. A decreased FDR can be regarded to have influence on the departure decision of time-minimizers according to optimal migration theory, because refuelling conditions experienced by the birds may fall below the expected average and the re-

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sulting low instantaneous migration speed would promote departure. Evidence for such an indirect effect of predation risk is the lower departure fuel load when risk per gain (i.e. rate of raptor flights compared to FDR) is high.

SYMP03-4 Can food composition influence the flight range of a migratory bird?

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Flight and stopover in migrating birds, the two alternating phases during migration, are energetically interdependent. Flight can only be fueled by stores acquired during previous stopovers and, conversely, the amount of fuel remaining after flight may determine the amount to be deposited during stopover. The metabolism of the two phases however, has been either studied separately or from the point of view how physiological deficits, which incur during flight, influence subsequent recovery and stopover.

But what about physiological effects of stopover on the flight metabolism? Are there effects of metabolic constraints during refueling on flight metabolism? To study this question, we measured metabolites of 18 species during spring and autumn migration and compared their carbohydrate, protein and fat metabolism. The results indicate that the type of food (insectivorous, frugivorous) determines the relative amount of fat and protein which is catabolized during migratory flight and therewith the flight range. A possible explanation, i.e. how the type of food influences the composition of fuel stores, will be discussed.

SYMP03-5 Stopover in time-minimizers: spring songbird migrants in the Mediterranean

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An early arrival to the breeding grounds has important advantages in reproductive output for spring migrants, and birds involved in return movements are therefore supposed to be minimizing time rather than energy or risk. We have investigated stopover behaviour of trans-Saharan spring migrants on the island of Ventotene (40.48N – 13.25E), placed at 60 km from the western coast of Italy and over 450 km from the coasts of North Africa. Here large numbers of migrants belonging to a wide range of species make short stopovers while heading to the breeding grounds. Landing migrants are represented by birds in variable physical conditions, including individuals with still a large residual flight range, who might therefore be expected not to stop, in order to minimize the overall time required to cross the ecological barrier represented by the Mediterranean. We investigated the physiological state of migrants in different conditions. We found that birds with appreciable fat stores are not stressed by endurance flights, but an increasing physiological stress is recorded in birds with progressively depleted reserves. We also observed protein catabolism during different phases of fat store loss, with a differential use of organs as source of proteins during lower or higher levels of stores depletion (flight muscles and digestive organs, respectively). A positive balance be-

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tween stopover and time-minimizing is represented by the study case of *Sylvia* warblers, which rely on nectar as a source of energy easy to absorb after an endurance flight, in which birds have incurred a depletion of energy stores and a reduction of the digestive tract. Our results suggest the importance of these short stopovers for large numbers of birds and species. Depending on their physiological state, and still within a general time-minimizing strategy, birds can rest, uptake glucose and shift from a catabolic state to an anabolic state, allowing them to counteract the strong adrenocortical responses related to the extreme stages of energy stores depletion. The conservation value of Mediterranean islands is confirmed by these results.

SYMP03-6 Interruption of autumn migration for molt in a Palaearctic passerine: the chestnut bunting *Emberiza rutila* case

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Among passerines, interruption of migration for molt is only known for several South American species. Bird banding in 1998–2002 permitted to locate a ground of mass molting of chestnut buntings in the utmost southeast of Primorye (Russian Far East) where this species is a transit migrant. The nearest nesting grounds are located >350 km to the north. A total of 6335 birds were banded: 2868 individuals were not in molt during initial capture, 2346 birds were captured only once. 522 of them have not started molt (1156 recaptures), the maximum measured stopover length was 37 days. 2561 birds in different stages of molt (beginning, intensive, completing and final stages) ranged as follows. 346 among the molting ones started molt only when they were captured for the 2nd – 5th time (maximal stopover before the onset of molt 17 days). October 11 was the latest date of starting of molt. The maximum length of stopover made by molting birds was 42 days (1435 recaptures, 2 – 9 per bird). Molt was short (about 30 days) compared to other *Emberiza* species molting at their nesting grounds. Chestnut bunting nests mostly in various larch forests on mountain slopes and foothills. In autumn, the birds leave their nesting grounds probably due to declining availability of small invertebrates, their main prey. Therefore birds migrate southward to the areas with much arable land and shift to nutrient-rich plant food. The majority of chestnut buntings undergoes a quick molt there and then continues migration to the wintering grounds.

SYMP03-7 Stop-over ecology of little stints (*Calidris minuta*) at Eilat, Israel

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More than 4900 little stints were banded at Eilat between the years 1984–2000. Autumn migration peaked in September and spring migration peaked in April. We found that sex ratio was male biased (ca. 60%), but females dominated among the birds that started the autumn migration earliest, in

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August, and among those birds that overwinter at Eilat. Owing to their unique mating-system, unlike other wader species, little stint males appear to be the first to leave the breeding grounds. Body mass varied greatly, with 90% of birds weighing between 19–29 g. Birds prepared for a long-distance flight and having fat stores exceeding 30% of their lean mass occurred mostly during August-October. In contrast, percentage of individuals apparently emaciated after a long non-stop flight (body mass below 19 g) was greatest on the return migration during March-May. This suggests that at least a proportion of little stints are crossing the arid areas of northeast Africa in a single non-stop flight. Body mass of individuals over wintering at Eilat remained low but stable. The comparatively high rate of retraps indicates that Eilat is an important staging site for little stints.

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