Alternate non-stop migration strategies of pied flycatchers to cross the Sahara desert

Janne Ouwehand and Christiaan Both

Conservation Ecology Group, Groningen Institute for Evolutionary Life Sciences, University of Groningen, PO Box 11103, Groningen 9700 CC, The Netherlands

Abstract

Each year more than two billion songbirds cross the Sahara, but how they perform this formidable task is largely unknown. Using geolocation tracks from 27 pied flycatchers, a nocturnally migrating passerine, we show that most birds made diurnal flights in both autumn and spring. These diurnal flights were estimated to be part of non-stop flights of mostly 40–60 h. In spring, birds flew across the Sahara, while autumn migration probably circumpassed part of the desert, through a long oversea flight. Our data contradict claims that passerines cross the Sahara by intermittent flight and daytime resting. The frequent occurrence of long non-stop flights to cross the desert shows migrants’ physiological abilities and poses the question why this would not be the general migration strategy to cross the Sahara.

1. Introduction

Surprisingly, little is known of how the billions of small avian migrants cross the Sahara desert, while migrating from their temperate and boreal breeding grounds to the African wintering grounds [1,2]. Moreau [2] presumed that most passerines cross the Sahara in a non-stop 40–60 h flight, implying that nocturnal migrants also migrate during daytime. More recent studies argued that most nocturnally migrating passerines exhibit an intermitted rather than a non-stop migration to cross the Sahara. Radar observations in the western Sahara during spring estimated that only 17% of songbirds (exclusively Hirundinidae) prolonged migratory flights during the day, while in autumn, this appeared even less common [3]. Direct observations of large numbers of individuals sheltering during the day against the heat, without water or food, but in good condition [4], support this notion of intermittent flight.

In contrast to radar studies, geolocator tracks yield species-specific tracking of individual movements and are thus less dependent on specific observation times and locations. Moreover, they provide insight into variation in migration strategies such as among seasons, species and individuals. Geolocation tracking revealed prolonged flights in small passerines of up to several days [5,6]: e.g. blackpoll warblers, Setophaga striata, of 12 g crossed the western Atlantic in a non-stop 2540 km flight of 60 h [6]. Given these remarkable flights, it would be rather surprising if migrants facing the Sahara do not use non-stop flights. Indeed, recent geolocation tracks showed prolonged night flights into the day over the Sahara in several passerines [7], but the authors of that study did not conclude that birds flew non-stop. However, an intermittent flight strategy probably increases the time individuals take to cross the Sahara, and hence requires larger reserves prior to migration. Here, we provide evidence from light-level geolocator loggers (hereafter, loggers) for an abundant, and presumed nocturnal long-distance migrant, the pied flycatcher Ficedula hypoleuca [8], that most individuals showed 1–2 day periods of diurnal flight. We argue that these diurnal flights are part of a non-stop flight strategy that reduces the costs of barrier crossing.
Diurnal flight is associated with large changes in twilight times, mostly at sunrise, indicating fast movements in a southwesterly direction in autumn and northeasterly direction in spring (electronic supplementary material, figure S1 and table S1).

3. Results and discussion

Of the 15 flycatchers with loggers recording data in spring, 14 showed 1–2 day cycles with higher and less erratic light levels, which directly documented non-stop diurnal migration (figure 1). These periods coincided with the start of spring migration in a northeasterly direction (range: March 23–April 29 [10], figure 2; electronic supplementary material, table S1). Days without shading are unlikely to have been caused by resting in the desert, because the six loggers recording temperature showed lower and more stable temperatures during these days than before and after diurnal flight (figure 1). The observed reduction in temperature amplitudes during daytime are in agreement with radar studies showing that birds cross the Sahara in spring while flying at high altitudes in cool anti-trade winds [13]. Some individuals ended their diurnal flight during the day, as visible in the reappearance of shading events and a sharp increase in temperature (figure 1, individual F272, 1 April).

In three birds, short temperature peaks at night occurred (e.g. figure 1, individual F384), which may indicate lower altitude flights or short nightly resting stops. For the one individual with ambiguous diurnal flight during spring, temperature profiles were inconclusive to support intermitted or non-stop flight (see the electronic supplementary material, figure S2).

The estimated maximum duration of the prolonged flight in spring was $45.3 \pm 5.89$ h ($n = 12$) and possibly even longer.
Flights lasted probably 23–25 h and the duration of autumn non-stop flights was variable: the shortest flight was on August 27, 2017, but most took 37–48 h (n = 24), most flycatchers can cover ca 2000–2600 km and thus reach the southern Sahara edge (figure 2). Along the coast south of the Sahara, suitable scattered vegetation seems to support further autumn passage, and pied flycatchers were mostly located in good condition at these stop-over sites [15]. More southwards, flycatchers likely changed direction eastwards towards their final wintering sites [12,16].

Our data are indirect but highly suggestive evidence that pied flycatchers from our breeding population commonly flew non-stop when migrating across the Sahara. This pattern contradicts claims that the general pattern of Sahara crossings in passerines is by intermittent flight. However, these claims are mainly based on the relative rarity of daytime passage on radar observations at few spots and the assumption that most migrants depart for spring migration from the southern Sahara edge. By contrast, our flycatchers departed directly from their more southern wintering grounds [10], and if they departed shortly after sunset, they likely passed these radar observation sites after ca 24–28 h flight, during the night. High departure fat loads [11,17] and relatively few observations of pied flycatchers resting in or near oases during autumn and spring migration [15,18] support a non-stop migration strategy. Observations with geolocators of diurnal flights in various small nocturnal migrants [6,7], suggest that the non-stop strategy is not limited to the relatively fast migrating pied flycatcher [10]. We argue that for many small migrants, like pied flycatchers, a non-stop flight strategy must be superior to an intermittent strategy both in autumn and in spring, probably because it reduces time, energy and risk of dehydration while passing the Sahara.

Our finding of non-stop Sahara crossing by a 12 g passerine challenges the view on the severity of such a barrier. Our observation that flycatchers in spring take off on a non-stop flight from at least 500 km south of the start of the desert suggests that physiology does not constrain a broader crossing. Furthermore, flycatchers seem to perceive barriers differently between seasons, as only in spring do they seem to fly directly over the desert. The next challenge is to compare species’ migration strategies, to unravel how variable these patterns are and their associated costs and benefits [19]. This is especially important as long-distance migrants face large changes at the wintering grounds [1] that may hamper their preparation for successful barrier crossings.

**Figure 2.** Longitudes (average, bold line; s.d.: thin line) of Dutch pied flycatchers before and after diurnal flight (see the electronic supplementary material, table S1) roughly indicate onset locations and destinations of non-stop flight. Latitudes prior to diurnal flight were chosen to include fuelling sites in autumn (Iberia, less so North Africa) or spring (wintering range). Latitudes after diurnal flight indicate possible destinations, assuming 15.3 m s⁻¹ flight speed and the maximal flight duration (electronic supplementary material, table S1). Wintering longitude (average ± s.d.) is depicted in white.

**Data accessibility.** Data supporting this article are included as the electronic supplementary material.

**Authors’ contributions.** J.O. analysed data. J.O./C.B. performed the experiment, wrote, approved and are accountable for the final content of the manuscript.

**Competing interests.** We declare we have no competing interests.
Funding. Financial support was provided by The Netherlands Organisation for Scientific Research (NWO-AlW-814.01.010 to J.O./C.B., VIDI-NWO-864.06.004 to C.B.) and KNAW Schure-Beijerink Popping foundation (to C.B.).

Acknowledgements. We thank J. Fox for data extraction, R. G. Bijlsma, R. H. G. Klaassen and two anonymous referees for valuable comments on the manuscript.

References


