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Flapping rates of migrating and foraging Turkey Vultures *Cathartes aura* in Costa Rica

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Summary

Local and migrating populations of Turkey Vultures *Cathartes aura* co-exist in Costa Rica in autumn and spring (Stiles & Skutch 1989). We studied the flapping rates of individuals from these two populations to compare flight modes and the amount of energy invested in active flight. Migrants tended to fly higher in more stable air than local birds, which often fly low over the forest canopy while searching for carrion. Overall, migrants flapped at lower rates than did local, non-migratory birds. Migrants, but not local birds, flapped more on cloudy days than on sunny days, and more at the start and end of the day than at mid-day.

Résumé

Des populations résidentes et migratrices d'Urubus à tête rouge coexiste au Costa Rica en automne et au printemps. La recherche avait pour but de mesurer le taux de battements d'ailes des individus des deux populations et de comparer le type de vol et la quantité d'énergie investie dans le vol actif. Les individus migrateurs volent généralement à plus haute altitude dans une atmosphère plus stable que les individus résidents, qui volent à plus basse altitude à la recherche de nourriture. En moyenne, les oiseaux migrateurs battaient des ailes moins souvent que les oiseaux locaux. Finalement, les individus migrateurs, et non les individus résidents, battaient plus souvent des ailes les journées nuageuses que les journées ensoleillées, et aussi au début et à la fin de la journée comparer au milieu de la journée.

Introduction

Most vultures are sedentary or short-distance migrants (Mundy *et al.* 1992). Exceptions include western North American populations of Turkey Vultures *Cathartes aura meridionalis*, most of which are long-distance trans-equatorial migrants (Kirk & Mossman 1998). Concentrations of migrating birds occur along the Mesoamerican Land Corridor, the largest and most important raptor migration flyway in the New World (Bildstein & Zalles 2001). Each autumn, more than five million raptors, including well over one million Turkey Vultures, use this corridor, which extends for 4,000 km, from the south-western United States to north-western Colombia. Turkey Vultures migrating along the corridor travel in large flocks, many of which easily exceed 1,000 individuals, and there is no indication that birds feed during this part of their migration (Chapman 1933, K. Bildstein, pers. obs.). The flight is particularly concentrated along several portions of the Mesoamerican Land Corridor, including the Caribbean slope of south-eastern Costa Rica.

Birds, including vultures, fly differently depending upon the purpose of their flight. Here we report on the extent of these differences in long-distance migrating and local foraging populations of Turkey Vultures (*C. a. aura* and *ruficollis*) at the Kéköldi Indigenous Reserve, southeast of Puerto Viejo, Costa Rica, where close to one million vultures migrate each autumn (Porras-Peñaranda *et al.* 2004).

We predicted that migrants, which typically soar and glide within and between large thermals and thermal streets while migrating in the tropics (Smith 1985a,b) would have lower flapping rates than local birds, which, when searching for carrion, fly closer to and within the more turbulent boundary layer of smaller deflection updrafts.

Study Area and methods

Site description and location

We observed migrating and local foraging Turkey Vultures at 20–300 m above sea level at the Kéköldi Indigenous Reserve, southeast of Puerto Viejo, Costa Rica (09°38' N, 82°47'W), between 4 and 17 October 2003. The Kéköldi Indigenous Reserve is located in a 5 km wide coastal plain between the Talamanca Mountains and the Caribbean Sea. In autumn, close to three million raptors, including close to one million migratory Turkey Vultures, pass within sight of the reserve (Porras-Peñaranda *et al.* 2004). We recorded the flapping rates of vultures from a 10 m observation tower at the top of a 200 m hill in the reserve. Vegetation around the platform is second-growth rain forest and abandoned cocoa plantations (Branch & Robichaud 2001).

Observation techniques

All observations were made by one or two observers who watched each Turkey Vulture during 30 s sample periods using 7x35 or 12x50 binoculars. We recorded the time and number of wing flaps during each observation period and noted whether the bird was soaring or gliding. We determined whether a bird was a migrant or local forager by its behaviour. Birds travelling in large flocks of >100 birds were considered migrants. They also fly in a single coordinated direction for long distances or they ascended in circular soaring flight within thermals. In contrast, when a Turkey Vulture it seen flying alone, or in a small flock of <10 birds, it is consider a locally foraging bird. Those resident birds also exhibited non-directed flight as they circled over the forest canopy. Temperature, cloud cover, precipitation and visibility were noted hourly. Observations were made from sunrise to sunset.

Data analysis

Data were analysed using R statistical system analysis (R 1.5.1, 2002). Only complete 30 s bouts of soaring or gliding were used in the analysis. The data recorded during rain were excluded from the analysis because of the reduced visibility. Results were considered significant at $P<0.05$.

We used a Kruskal-Wallis non-parametric test to compare the mean flapping rates between foraging and migrating birds. When doing so, we only analyzed observations between 3 and 9 hours after sunrise to partially eliminate the influence of time of day. A correlation analysis was calculated with all the data for the foraging and migrating birds.

Results

We recorded the flapping rates of 312 local foraging Turkey Vultures and 1,045 migrants during the 10 days of study.

Overall, migrants flapped significantly less than local foraging birds (Hcorr = 43.90, df = 1, $p < 0.001$; Table 1).

Table 1. Mean (± SE) flapping rates of Turkey Vulture at different times of the day in Costa Rica in autumn 2003.

	Flapping Rate (flaps/30 sec)	
Type vulture	**3-9 h after sunrise**	**<3 h or > 9 h after sunrise**
Migrating	0.36 ± 1.75 n = 668	2.38 ± 5.47 n = 365
Foraging	0.44 ± 0.74 n = 261	0.76 ± 1.64 n = 50

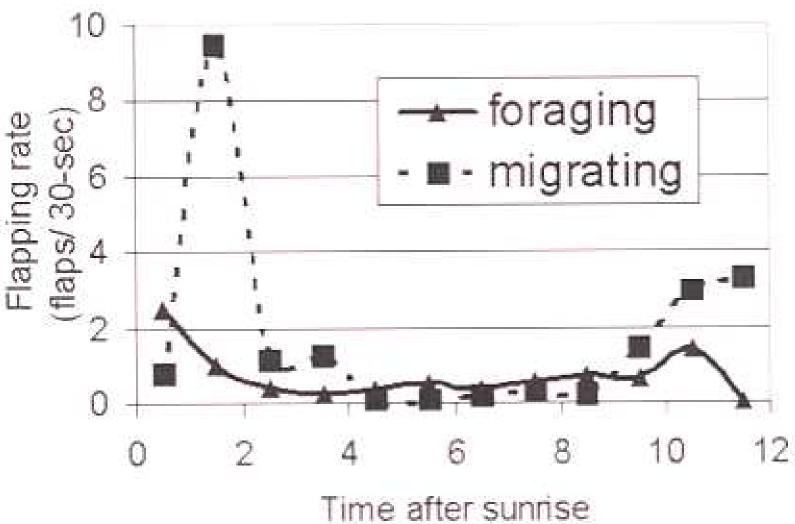

Figure 1. Mean flapping rate of migrating and foraging Turkey Vultures between sunrise and sunset in Costa Rica, autumn 2003.

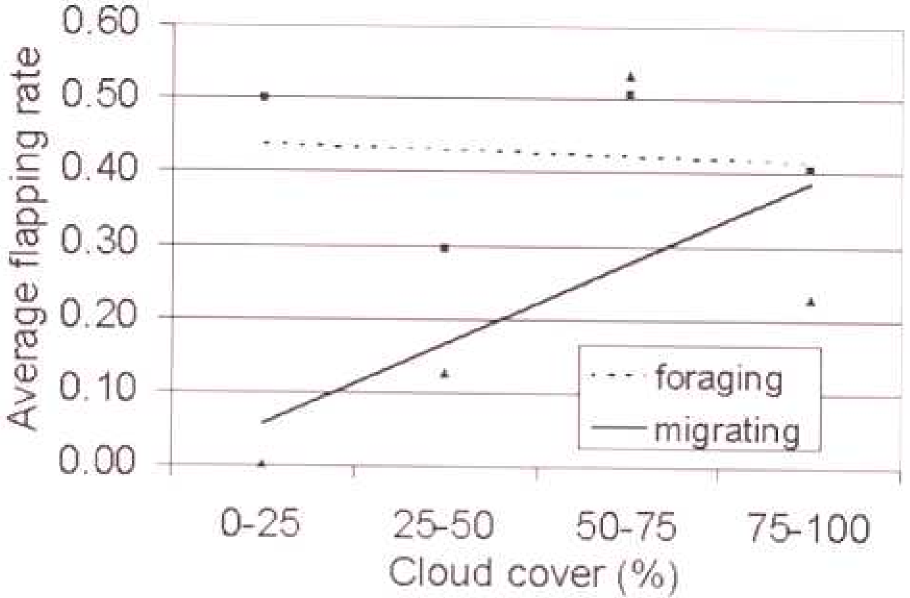

Figure 2. Flapping rate of Turkey Vultures as a function of cloud cover in Costa Rica, autumn 2003. Data are for birds flying three to nine hours after sunrise and are grouped for four cloud cover categories.

Flapping rates for migrants were higher at the beginning (< 3 h after sunrise) and end (>9 h after sunrise) of the day, compared with mid-day (3–9 h after sunrise) (Hcorr = 44.62, df = 1, $p < 0.001$; Figure 1; Table 1). Flapping rates did not differ by time of day for local birds (Hcorr = 0.39, df = 1, p = 0.53).

Migrating, but not local, birds showed a significant correlation between cloud cover and flapping rate. Migrating birds flapped more on cloudy days than on sunny days (Kruskal-Wallis $r^2 = 29.9$, n = 668, $p < 0.001$), but the same was not true for local birds (Kruskal-Wallis $r^2 = 13.9$, n = 424, p = 0.31; Figure 2).

Discussion

Our results show that migrating and foraging Turkey Vultures do not allocate the same amount of energy in their flight. This difference can be explained by the fact that a migrating bird has limited amounts of metabolic energy available, as it is not feeding during its migration (Chapman 1933, K. Bildstein, pers. obs.). Hence, migrants need to save energy, which selects for inexpensive flying behaviour. That is not the case for foraging birds that feed regularly and can invest more metabolic energy in its flight.

The differences in the energy spent in flight by migrating and foraging Turkey

Vultures also can be explained by the fact that these two groups were not flying in the same atmospheric conditions. Migrants flew higher and straighter than local vultures, which flew lower and frequently turned, while searching close above the forest canopy for carrion. These two different flying environments imply a different use of the available atmospheric conditions. Migrants are able to ascend in thermals to great heights and glide between them with little difficultly, whereas foraging birds need to remain closer to and within the boundary layer in order to search for food.

A third possibility for the differences we observed is that the migrants, which belong predominately, if not exclusively, to the *meridionalis* race, and local birds, which belong to the *aura* and *ruficollis* races, differ in wing shape, wing loading, or both, and that these anatomical differences were responsible for differences in flapping behaviour. And in fact, although we have yet to measure individuals for such differences, it appeared to us that migrants had longer and more pointed wings than did local birds. On the other hand, preliminary but fewer observations of migrants and foraging birds in Pennsylvania, USA, where both are members of the *septentrionalis* race, indicate almost identical, albeit non-significant, differences in mid-day flight behaviour.

Finally, it is interesting to note that the flapping rate of migrating Turkey Vultures was strongly affected by time of day whereas this was not the case for foraging individuals. This suggests that migrating Turkey Vultures are more affected by the presence and strength of thermals and are therefore more constrained in their flight mode than foraging individuals. It is well known that thermals are weak early and late in the day when incident solar radiation is weakest and strong at midday when solar radiation is intense (Shamoun-Baranes *et al.* 2003). Thus, when thermals are weak, migrating Turkey Vultures are forced to supplement gliding with energetically costly active flight in order to maintain cross-country travel. The increased rate of flapping has also been found for the effect of the cloud cover. Also, cloud cover, which is known to affect thermal strength (Heintzelman 1986), affected only migrating individuals.

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