Implications of Recapture Data for Migration of the Rufous Hummingbird (*Selasphorus rufus*) in the Rocky Mountains

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Recapture or recovery of banded hummingbirds is rare. We report the longest of five point-to-point recaptures of migrant hummingbirds, one that spans the shortest elapsed time between long-distance recoveries. Calculation suggests that this travel could have been accomplished in a single flight. Some hummingbirds migrate across vast expanses of inhospitable environment. Ruby-throated Hummingbirds (*Archilochus colubris*) that cross the Gulf of Mexico must fly at least 735 km nonstop. Rufous Hummingbirds (*Selasphorus rufus*) make the longest migrations of any of the Trochilidae and, in proportion to size, one of the longest bird migrations (Johnsgard 1983, Calder 1987). They fly over western deserts and grasslands when appropriate flowers are not available. Miller (1963) described one such migrant's tragic end: "We had . . . seen the bird actually fail during a migratory flight in hot sun through an area without water or nectar sources." Travel is even more hazardous for inexperienced juveniles that migrate alone (Gass et al. 1976, Kodric-Brown and Brown 1978, Hixon et al. 1983, Calder 1987, Willimont et al. 1988).

The mechanisms for dealing with these realities are crucially important. Successful analysis of the migrations of even a single species will require information on the seasonal distribution, routes used between breeding and wintering ranges, orientation or navigation mechanisms, and the energetics of migratory flights. These data are mostly unavailable for hummingbird migration. Routes have been inferred from seasonal distributions (Phillips 1975), with no information on itineraries and distances flown by individual hummingbirds. Recaptures of banded hummingbirds are common at banding locations, but only 4 recoveries are from distant points on migratory routes (Table 1). This is primarily due to the fact that <70,000 individuals of all species of hummingbirds have been banded. In contrast, banding of several larger species is an order of magnitude greater (e.g. 1.6 million *Junco hyemalis* and 850,000 *Molothrus ater*; Klimkiewicz and Futcher 1987).

On 25 July 1988, Jones banded a juvenile female Rufous Hummingbird on the shore of Swan Lake, in northwestern Montana. The bird was the lightest female banded that evening (3.5 g). On 9 August 1988 (at 1915) she was recaptured at the Rocky Mountain Biological Laboratory (RMBL) at Gothic in west-central Colorado, 1,202 km directly southeast along the Rocky Mountains. She weighed 3.70 ± 0.01 g (Scientech 3300 electronic balance).

Willimont et al. (1988) suggested that the Ruby-throated Hummingbird has a migration pattern "that is based on daily 'short-hop' flights southward" over land. The three shortest distances (735, 825, and 850 km) across the Gulf of Mexico, which is overflown by at least some Ruby-throats, are similar to the overland distance reported by Baumgartner (1986), but it was not possible to determine if the latter distance was traversed in only one flight. Lasiewski (1962) calculated a maximum flight range of 975 km (24.3 h at 40 km/h) for a female Ruby-throat.

Pennycuick (1969) calculated that a Ruby-throated Hummingbird with 50% of its weight as fat would have a no-wind range of 2,300 km. This would be reduced to 1,000 km against a 5 m/s headwind. Using the weight-gain values of Carpenter et al. (1983), Pennycuick's equation 50 predicts a no-wind range of 1,442 km for a Rufous Hummingbird. A female adult Rufous, banded in 1985 at RMBL, returned there 1 August 1988, with a body mass of 3.14 g. By 10 August, she weighed 4.78 g, close to the mean for the 10 heaviest recorded that season. According to Pennycuick (eq. 50), she could have flown 1,413 km with no wind.

Like other small birds, hummingbirds should exploit favorable tailwinds. In fact, Willimont et al. (1988) found a positive correlation between wind velocity and the number of Ruby-throated Hummingbirds observed on days in which winds were northwesterly or westerly at Hawk Mountain, Pennsylvania ($P < 0.001$). It was not clear, however, whether there were actually more birds flying or whether those flying were more visible from the lookout. In some but not all past migrations, our impression was that increases in daily capture numbers were associated with cold-front passage, as if northwesterly winds had brought in new waves of migrants. There were, however, no significant barometric pressure changes that signified frontal movements during the 1988 Rufous migration at RMBL, and the rates of capture were essentially uniform from 13 to 27 July for adult males, 13 July to 15 August for adult females, and 22 July to 15 August for juveniles.

A 1,202 km flight of a Rufous Hummingbird (T12826) appears to have been possible. In our calculations (supplement available from Calder), we used arrival and departure masses, and rates of gain from Rufous southbound in the Sierras as well as our own records. These calculations suggest that T12826 would not have been ready to depart from Montana for 4–9 days after

TABLE 1. Hummingbird migratory recapture and recovery records.

Species	Bird	Banded	Recovery	Distance (km)	Elapsed time	Source
Rufous	T12826	Montana	Colorado	1,202	15 days	This study
Allen	X15053	California	Arizona	811	32 days	D. Bystrak pers. comm.
Ruby-throat	X29588	Oklahoma	Texas	760	32 days	Baumgartner 1986
Ruby-throat	X22259	Pennsylvania	Quebec	1,082	21 mo	D. Bystrak pers. comm.
Rufous	X02212	California	Oregon	1,039	21 mo	D. Bystrak pers. comm.

banding, and that she must have been in the RMBL vicinity for at least 2 days before capture. Subtracting from the 15 days out of sight, we have an ambiguous 6–9 days for the flight(s). With no wind, a hummingbird flying at an airspeed of 43 km/h (Greenewalt's [1960] maximum for the Ruby-throat) would travel 1,202 km in 28 h, or two 601-km legs in 14 h days apiece. The latter would leave 4–7 days for intermediate refueling. Whether the range of this migrant Rufous Hummingbird was 600 or 1,200 km depends on unknowns of tailwinds and success in access to feeding territories at refueling points.

Many migratory birds show site fidelity following an imprinting process in the first year of life (Able and Bingman 1987). Apparently, the geographical imprinting includes the entire route for hummingbirds (small brain size notwithstanding). During the 1987 and 1988 migrations, we found further evidence of route fidelity in the recapture of six individuals banded at RMBL in previous migrations. Four of these were juveniles when banded (for previous records, see Calder 1987).

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