Materials and Methods

Field data and reproductive effort

Upon arrival in the breeding grounds (year \(x\)), we captured redstarts, sampled a tail feather (3rd retrix), and marked them with a unique combination of color leg bands. In the same season, the number of young fledged by each male was determined by the young present 1-2 days before the fledging date (8-9 days after hatching) and re-confirmed by the number of young that left the nest 1-2 days after fledging. All males that failed to fledged young lost their nests due to predation and provided little or no parental care (only females incubate clutches): the mean number of nestling-feeding days among males that failed to fledge young was only 2.4 d (±1 s.d., \(n = 9\)) compared with males that fledged young 11 d (±1.2, \(n = 12\)), and 55% of nests that failed to fledge young were depredated during the egg stage. In addition, none of the males that failed to fledge young were observed molting during the nesting period. The following breeding season (year \(x+1\)), the 3rd retrix from returning males was collected for \(\delta D\) analysis to estimate molting latitude in year \(x\).
Isotope analysis

Stable-hydrogen isotope ratios ($^{2}H/^{1}H = R$) are expressed in δ notation (‰) where $\delta = \left[\frac{R_{\text{sample}}}{R_{\text{standard}}} - 1\right] \times 1000$ and $R_{\text{standard}}$ is the hydrogen isotope ratio of the international standard of Vienna standard mean ocean water (V-SMOW). Feathers were cleaned of surface oils using a 2:1 chloroform:methanol solution, and left to air dry and equilibrate with local atmosphere for 72 h. We cut approximately 0.1-0.15 mg from the distal and proximal ends of each tail feather, loaded them separately into silver capsules and heated them at 100°C for 24 h to remove potential surface water. The capsules were then loaded into a reduction furnace (Finnegan TC/EA) at 1450°C and introduced on-line to an isotope-ratio mass spectrometer (Finnegan MAT Delta Plus XL). Two in-house standards were run for every five unknowns indicating reproducibility to within ± 3 ‰ ($n = 15$).

Molting latitude

δD values from adult feathers grown in the region of our study site fall between -85 and -75 ‰ (S1) and δD values from redstart nestling feathers grown at our study site (-83 ± 3 ‰, $n = 7$) also fall within this range. Given our measurement error, we conservatively estimated individuals with δD values = -88 to -72 ‰ to have grown their feathers at or near our study site on the breeding grounds.

Color analysis

We measured plumage reflectance across the entire bird-visible spectrum (320-700 nm) using a probe (maintained at 2 mm from, and at a right angle to, the feather surface) encased in a rubber sheath attached by fibre optic cables to a Deuterium-halogen light
source and an Ocean Optics S2000 spectrometer. Feathers were mounted on black velvet to minimize reflectance from the background. We calibrated each measurement with a reference standard (Spectralon®), so that reflectance spectra could be calculated as the percentage of incident light that was reflected at each wavelength. Five measurements (3 mm² area) were taken randomly from the orange-red patch at the leading edge of the feather vane (≥ 3 mm between measurements). We calculated total reflectance (RT) as an index of the brightness of the color (where higher values are paler colors), and both red- (C R) and UV-chromas (C UV) as indices of spectral purity, or saturation, in the red (575-700 nm) and UV (320-400 nm) regions of the reflectance spectrum, respectively. Neither RT nor CUV were correlated with δD (P > 0.40), and none of the three color variables were correlated with each other (P > 0.10).

Results
To examine whether δD and red chroma values might be invariant from year to year within individuals, rather than condition and situation dependent, we looked at correlations between consecutive years within individuals. Our results suggest that these traits vary considerably from year-to-year: δD in year x-1 versus year x: \( r^2 = 0.001, P = 0.94, n = 6 \); red chroma in year x-1 versus year x: \( r^2 = 0.11, P = 0.52, n = 6 \). We added 12 individuals (of unknown breeding origin in year x-1) for the color analysis and found an even weaker correlation in red chroma between year x-1 and year x: \( r^2 = 0.003, P = 0.81, n = 18 \).
References