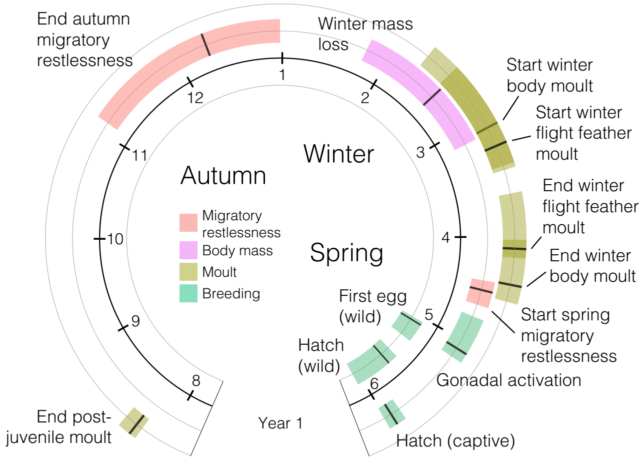

Figure 1. Annual Cycle Events in First-Year Captive and Wild Pied Flycatchers

Boxplots (central bars indicate median, boxes show interquartile range) show the timing of annual cycle events for 1981 and 2002 cohorts combined, as well as reproductive events in wild birds (inside circle).

See also Figures S1 and S2.

Based on extensive documentation of climate-induced advances in spring phenology [2, 5, 6, 10, 15, 25, 29], we expected earlier spring timing (end of winter moults, start of migratory restlessness, reproductive activation) in the 2002 cohort compared to 1981. Because flycatchers are protandric and there is a high fitness prime on early male [30] but not necessarily female phenology [18], we expected particularly evident advances in males. In contrast, for autumn, phenological trends and underlying selection pressures are inconsistent for migratory songbirds [31, 32]. We therefore considered advances and delays in autumn phenology (end of post-juvenile body moult and migratory restlessness) to be equally possible, and we did not expect consistent differences between the sexes. Likewise, we had no directional expectation for changes in winter timing (body mass drop, start of winter moults) in either sex. To test these hypotheses, we derived seasonal timing indices by averaging the times of events for each individual. We also examined timing traits individually.

Captive flycatchers showed some evidence of delayed autumn timing. The autumn index averaged later in 2002 by 10 days (95% CI −1.6 to 22; $\chi^2_1 = 2.9$; p = 0.087; Figures 2A and 3). This delay was more pronounced in males, although the cohort × sex interaction did not reach statistical significance ($\chi^2_1 = 2.1$; p = 0.15; males: 18 days, 95% CI 2.4 to 34; females: 1.2 days, 95% CI −16 to 18). The observed delay was associated with autumn migratory restlessness, which was variable but ended 17 days later in 2002 (95% CI −7.1 to 42; Figures 3 and S3). In contrast, the end of post-juvenile moult, which occurs before migration, was only slightly delayed in 2002 (2 days, 95% CI −1.3 to 5.4) and strongly depended on hatch date (0.89 d d^{-1}, 95% CI 0.54 to 1.3).

In winter, the sign of phenology changes reversed. The winter timing index averaged 7.7 days earlier in 2002, but the effect was not statistically significant (95% CI −23 to 7.8; $\chi^2_1 = 1.0$; p = 0.31; Figures 2B and 3). The observed difference was largely attributable to winter moults, which started 8–9 days earlier in 2002 (body moult: −9.1 days, 95% CI −23 to 5; flight feather moult: −8.1 days, 95% CI −24 to 7.7; Figures 3 and S3). In contrast, there was no advance in the timing of body mass drop (0.38 days, 95% CI −19 to 20), which occurs before moult. Winter and autumn timing indices were not correlated (r = 0.18).

Captive flycatchers significantly advanced spring phenology in 2002 relative to 1981 (Figures 2C and 3). The spring timing index averaged 9.3 days earlier in 2002 (95% CI −16 to −2.9; $\chi^2_1 = 7.3$; p = 0.007) and across cohorts males were protandric by 6.4 days (95% CI −13 to −0.18, $\chi^2_1 = 4$; p = 0.045). The spring advance was particularly evident in winter flight feather moult, which terminated 14 days earlier in 2002 (95% CI −26 to −1.8; Figures 3 and S3). End of winter body moult and start of spring migratory restlessness both occurred 4 days earlier in 2002 (body moult: −4.4 days, 95% CI −13 to 4.5; restlessness: −3.8 days, 95% CI −11 to 3.6). The timing of gonadal activation advanced clearly in males (−7.8 days, 95% CI −15 to −0.16) but not in females (0.34 days, 95% CI −7.3 to 8). There was a correlation between spring and winter timing indices (r = 0.87) but not between spring and autumn (r = 0.16).

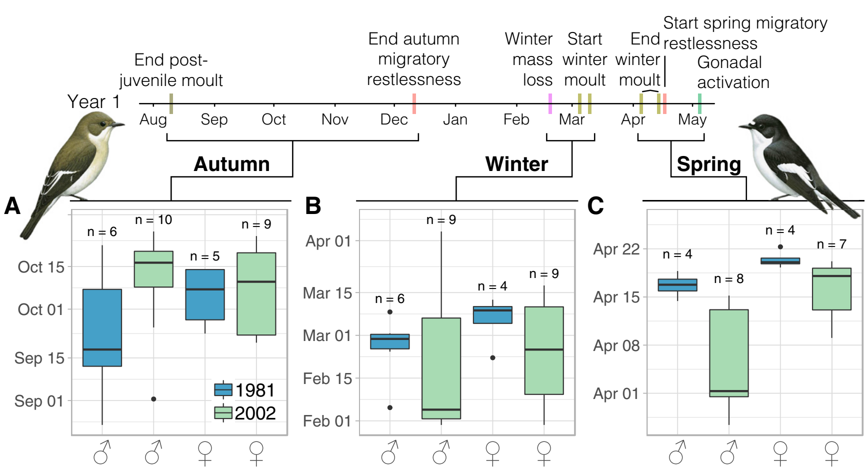

Figure 2. Changes in Captive Flycatchers

(A–C) Comparison between the 1981 (blue) and 2002 (green) cohorts in annual cycle timing (A, autumn; B, winter; C, spring). The top timeline shows the median time of each event during the year (pooled across study cohorts). Below are timing indices calculated by averaging across seasonal traits for each individual. Boxplots show the median as a line, the interquartile range as a box, and data within 1.5 times the interquartile range as whiskers; further points are shown as dots. The illustrations are reproduced with permission from *Handbook of Birds of the World* [33].

See also Figures S1–S3.