**Supplementary Information**

**Breeding in the pandemic: short-term lockdown restrictions do not alter reproductive decisions and avian life-history traits in a European capital city**

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**Abstract**

Humans are transforming natural habitats into managed urban green areas and impervious surfaces with unprecedented pace. Yet the effects of human presence *per se* on animal life-history traits are rarely tested. This is particularly true in cities, where human presence is often indissociable from urbanisation itself. The onset of the SARS-CoV-2 outbreak, along with the resulting lockdown restrictions, offered a unique, “natural experiment” context to investigate wildlife responses to a sudden reduction of human activities. We analysed four years of avian breeding data collected in a European capital city to test whether lockdown measures altered nestbox occupancy and life-history traits in two urban adapters: great tits (*Parus major*) and blue tits (*Cyanistes caeruleus*). Lockdown measures, which modulated human presence, did not influence any of the life-history traits inferred. In contrast, tree cover, a distinct ecological attribute of the urban space, positively influenced clutch size, a key avian life-history and reproductive trait. This highlights the importance of habitat and food webs over human activity on animal reproduction in cities. We discuss our results in the light of other urban wildlife studies carried out during the pandemic, inviting the scientific community to carefully interpret all lockdown - associated shifts in biological traits.

**Table S1. Subset of GLMs and LMMs (ΔAICc < 2) with binomial and Gaussian distribution testing the association between lockdown restrictions and avian breeding occupancy and life – history traits.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Occupancy rate – binomial distribution – Lockdown categories** | | | | |
| **Species** | **Model subset** | **AICc** | **ΔAICc** | **AICc weight** |
| Great tit | (Intercept) + Lockdown status + Year | 1538.4 | 0.0 | 0.684 |
| n = 1636 | (Intercept) + Year | 1539.9 | 1.54 | 0.316 |
| 1 = 294; 0 = 1342 |  |  |  |  |
| Family: binomial |  |  |  |  |
| Blue tit | (Intercept) + Lockdown status | 1393.9 | 0.0 | 0.697 |
| n = 1636 | (Intercept) + Lockdownvstatus + Year | 1395.5 | 1.67 | 0.303 |
| 1 = 251; 0 = 1385  Family: binomial |  |  |  |  |
|  |  |  |  |  |
| **Laying date – Gaussian distribution – Lockdown categories** | | | | |
| **Species** | **Model subset** | **AICc** | **ΔAICc** | **AICc weight** |
| Great tit | (Intercept) + Year + Lockdown status + Lockdown status \* Year | 1795.1 | 0 | 1 |
| n = 290  Family: Gaussian |  |  |  |  |
|  |  |  |  |  |
| Blue tit | (Intercept) + Year + Lockdown status + Lockdown status \* Year | 1502.1 | 0 | 1 |
| n = 251  Family: Gaussian |  |  |  |  |
|  |  |  |  |  |
| **Clutch size – Gaussian distribution – Lockdown categories** | | | | |
| **Species** | **Model subset** | **AICc** | **ΔAICc** | **AICc weight** |
| Great tit | (Intercept) + Year | 974.3 | 0.0 | 0.538 |
| n = 278  Family: Gaussian | (Intercept) + Year + Lay date | 974.6 | 0.3 | 0.462 |
|  |  |  |  |  |
| Blue tit | (Intercept) + Lay date | 866.7 | 0 | 1 |
| n = 245  Family: Gaussian |  |  |  |  |
| **Incubation duration – Gaussian distribution - Lockdown categories** | | | | |
| **Species** | **Model subset** | **AICc** | **ΔAICc** | **AICc weight** |
| Great tit | (Intercept) +\_ Year + Lay date | 1226.4 | 0.0 | 0.534 |
| n = 245  Family: Gaussian | (Intercept) + Year + Lay date + Lockdown status | 1226.7 | 0.28 | 0.466 |
|  |  |  |  |  |
| Blue tit | (Intercept) + Year + Lay date | 1006.7 | 0.0 | 0.57 |
| n = 232  Family: Gaussian | (Intercept) + Year + Lay date + Lockdown status | 1007.3 | 0.57 | 0.43 |
|  |  |  |  |  |
|  |  |  |  |  |

**Table S1.** Subset of Generalised Linear Models and Linear Mixed Effects Models with binomial and Gaussian distribution partitioning variation in great tit and blue tit breeding occupancy and life-history traits (ΔAICc < 2). Data were collected for four years (from 2017 to 2020), models were run for great tits and blue tits separately. Model structures are described in section 2.4.1.

**Table S2. Subset of GLMs (ΔAICc < 2) with binomial and Gaussian distribution testing the association between tree cover (in %) and avian breeding occupancy and life-history traits.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Occupancy rate - % Tree cover** | | | | |
| **Species** | **Model subset** | **AICc** | **ΔAICc** | **AICc weight** |
| Great tit | (Intercept) + Tree cover + Year | 1537.9 | 0.0 | 0.73 |
| n = 1636 | (Intercept) + Year | 1539.9 | 1.99 | 0.27 |
| 1 = 294; 0 = 1342 |  |  |  |  |
| Family: binomial |  |  |  |  |
|  |  |  |  |  |
| Blue tit | (Intercept) | 1404.4 | 0.0 | 0.519 |
| n = 1636 | (Intercept) + Tree cover | 1405.8 | 1.40 | 0.258 |
| 1 = 251; 0 = 1385 | (Intercept) + Year | 1406.1 | 1.69 | 0.223 |
| Family: binomial |  |  |  |  |
|  |  |  |  |  |
| **Laying date - % Tree cover** | | | | |
| **Species** | **Model subset** | **AICc** | **ΔAICc** | **AICc weight** |
| Great tit | (Intercept) + Year | 1807.8 | 0.0 | 0.506 |
| n = 290 | (Intercept) + Year + Tree cover | 1807.8 | 0.05 | 0.494 |
| Family: Gaussian |  |  |  |  |
|  |  |  |  |  |
| Blue tit | (Intercept) + Year + Tree cover | 1511.5 | 0.0 | 1 |
| n = 251 |  |  |  |  |
| Family: Gaussian |  |  |  |  |
|  |  |  |  |  |
| **Clutch size - % Tree cover** | | | | |
| **Species** | **Model subset** | **AICc** | **ΔAICc** | **AICc weight** |
| Great tit | (Intercept) + Year + Tree cover + Lay date | 1010.3 | 0.0 | 0.334 |
| n = 278 | (Intercept) + Year + Tree cover + Lay date + Tree cover \* Year | 1010.5 | 0.17 | 0.307 |
| Family: Gaussian |  |  |  |  |
|  |  |  |  |  |
| Blue tit | (Intercept) + Tree cover + Lay date | 861.1 | 0.0 | 0.687 |
| n = 245 | (Intercept) + Year + Tree cover + Lay date | 862.7 | 1.57 | 0.313 |
| Family: Gaussian |  |  |  |  |
|  |  |  |  |  |
| **Incubation duration - % Tree cover** | | | | |
| **Species** | **Model subset** | **AICc** | **ΔAICc** | **AICc weight** |
| Great tit | (Intercept) + Year + Lay date | 1226.4 | 0.0 | 0.581 |
| n = 245 | (Intercept) + Year + Tree cover + Lay date | 1227.1 | 0.66 | 0.419 |
| Family: Gaussian |  |  |  |  |
|  |  |  |  |  |
| Blue tit | (Intercept) + Year + Lay date | 1006.7 | 0.0 | 1 |
| n = 232 |  |  |  |  |
| Family: Gaussian |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Table S2.** Subset of Generalised Linear Models with binomial and Gaussian distribution partitioning great tit and blue tit variation in breeding occupancy and life-history traits (ΔAICc < 2). Data were collected for four years (from 2017 to 2020), models were run for great tits and blue tits. Model structures are described in section 2.4.2.

**Table S3. Summary statistics of percentage tree cover in nestboxes occupied by great tits and blue tits from 2017 to 2020. For the entire dataset (n=409 nestboxes), the overall average tree cover (mean ± se) was 6.6% (± 0.64) and 49.1% (± 1.84) in LEA (n = 173) and LENA (n = 236) study sites, respectively.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Species** | **Year** | **n** | **Mean (± se)** |
| Great tit | 2017 | 53 | 36.1 (± 4.2) |
|  |  |  |  |
|  | 2018 | 84 | 31.8 (± 3.1) |
|  |  |  |  |
|  | 2019 | 81 | 32.7 (± 3.3) |
|  |  |  |  |
|  | 2020 | 73 | 38.4 (± 3.4) |
|  |  |  |  |
| Blue tit | 2017 | 71 | 30.3 (± 3.0) |
|  |  |  |  |
|  | 2018 | 67 | 30.3 (± 3.1) |
|  |  |  |  |
|  | 2019 | 51 | 30.6 (± 3.6) |
|  |  |  |  |
|  | 2020 | 62 | 27.7 (± 3.3) |
|  |  |  |  |

**Table S3.** Average tree cover in a 100m radius around each nestbox: “n” refers to the number of occupied nests within each year. Only first broods were included in the table. LEA stands for “Lockdown – Entrance Allowed”, LENA stands for “Lockdown – Entrance Not Allowed”

**Table S4. Z-tests for equality of proportions of occupied nestboxes in LEA and LENA study sites by year.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Year** | **NLEA** | **NLENA** | **χ2** | **DF** | **p-value** |
| Great tit | 2017 | 22 | 33 | 0.050 | 1 | 0.8 |
|  | 2018 | 31 | 53 | 0.997 | 1 | 0.3 |
|  | 2019 | 31 | 51 | 0.634 | 1 | 0.4 |
|  | 2020 | 26 | 47 | 1.309 | 1 | 0.2 |
|  |  |  |  |  |  |  |
| Blue tit | 2017 | 27 | 44 | 0.447 | 1 | 0.5 |
|  | 2018 | 22 | 45 | 2.494 | 1 | 0.1 |
|  | **2019** | 14 | 37 | **4.590** | **1** | **0.03** |
|  | **2020** | 18 | 44 | **4.648** | **1** | **0.03** |

**Table S4.** The total number of nestboxes available in LEA and LENA study sites was 173 and 236, respectively. NLEA and NLENA refers to the total number of nestboxes occupied within each lockdown status category.

**Table S5. No *year* effects in tree-cover variation among occupied nestboxes.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Great tit** | | | | | |
|  | **Df** | **Sum sq** | **Mean sq** | **F** | **p** |
| Year | 3 | 2111 | 703.8 | 0.824 | 0.481 |
| Residuals | 287 | 244992 | 853.6 |  |  |
|  |  |  |  |  |  |
| **Blue tit** | | | | | |
|  | **Df** | **Sum sq** | **Mean sq** | **F** | **p** |
| Year | 3 | 333 | 111.1 | 0.171 | 0.916 |
| Residuals | 247 | 160338 | 649.1 |  |  |