**Supplementary Material**

Artificial grass in parks as a potential new threat for urban bird communities

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Table S1. Summary of the environmental characterization of the surveyed point-count areas (obtained in the survey point count, except park area), according to the grass type. Numeric variables are accounted as their average value its standard error and the range (minimum – maximum values). Categoric variables as noted as the occurrence proportion of each level: Presence of shrubs <1m (level 1 = absence, level 2 = presence); Presence of shrubs >1m (level 1 = absence, level 2 = presence); Presence of exotic vegetation; Presence of vegetation with fruit (level 1 = absence, level 2 = presence); Presence of supplementary food (level 1 = absence, level 2 = presence); Presence of sources of water (level 1 = absence, level 2 = fountains, level 3 = ponds, level 4 = fountains and ponds); Presence of children's play areas (level 1 = absence, level 2 = presence).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Average ± SD | Range | Level 1 | Level 2 | Level 3 | Level 4 |
| Artificial grass (n=21) |  |  |  |  |  |  |
| Park area (ha) | 0.5±0.5 | 0.05-2.3 | - | - | - | - |
| Distance to outskirts (m) | 181.3±200.4 | 0-844 | - | - | - | - |
| Arboreal species richness | 4.3±1.6 | 2-8 | - | - | - | - |
| Arboreal species abundance | 19.4±9.6 | 6-46 | - | - | - | - |
| Presence of shrubs <1m | - | - | 0.57 | 0.43 | - | - |
| Presence of shrubs >1m | - | - | 0.52 | 0.48 | - | - |
| Presence of exotic vegetation | - | - | 0.14 | 0.86 | - | - |
| Presence of vegetation with fruit | - | - | 0.52 | 0.48 | - | - |
| Presence of supplementary food | - | - | 0.33 | 0.67 | - | - |
| Presence of sources of water | - | - | 0.43 | 0.48 | 0.05 | 0.05 |
| Presence of children's play areas | - | - | 0.10 | 0.90 | - | - |
| Natural grass (n=24) |  |  |  |  |  |  |
| Park area (ha) | 1.4±1.3 | 0.1-5.7 | - | - | - | - |
| Distance to outskirts (m) | 160.4±180.2 | 0-627 | - | - | - | - |
| Arboreal species richness | 6.3±2.9 | 2-12 | - | - | - | - |
| Arboreal species abundance | 26.3±10.9 | 10-46 | - | - | - | - |
| Presence of shrubs <1m | - | - | 0.33 | 0.67 | - | - |
| Presence of shrubs >1m | - | - | 0.46 | 0.54 | - | - |
| Presence of exotic vegetation | - | - | 0.04 | 0.96 | - | - |
| Presence of vegetals with fruit | - | - | 0.46 | 0.54 | - | - |
| Presence of supplementary food | - | - | 0.75 | 0.25 | - | - |
| Presence of sources of water | - | - | 0.54 | 0.17 | 0.13 | 0.17 |
| Presence of children's play areas | - | - | 0.25 | 0.75 | - | - |

Table S2. Summary of the frequency and mean abundance (± SD) of each species in artificial | natural grass parks. The classification in groups (Ground, Other, or Both) used in later statistical analyses is also shown.

|  |  |  |  |
| --- | --- | --- | --- |
| **Species** | **Group** | **Frequency** | **Abundance** |
| *Accipiter nisus* | Other | 0|0.04 | 0±0|0.04±0.2 |
| *Aegithalos caudatus* | Other | 0|0.04 | 0±0|0.08±0.41 |
| *Anas platyrhynchos* | Other | 0|0.04 | 0±0|0.83±4.08 |
| *Carduelis spinus* | Both | 0.05|0 | 0.05±0.22|0±0 |
| *Certhia brachydactyla* | Other | 0|0.17 | 0±0|0.29±0.75 |
| *Chloris chloris* | Ground | 0.05|0 | 0.05±0.22|0±0 |
| *Columba livia* | Ground | 0.24|0.29 | 0.95±2.31|1.13±2.77 |
| *Columba palumbus* | Ground | 0|0.04 | 0±0|0.08±0.41 |
| *Erithacus rubecula* | Ground | 0.05|0.67 | 0.05±0.22|1.38±1.41 |
| *Fringilla coelebs* | Ground | 0.05|0.13 | 0.1±0.44|0.13±0.34 |
| *Gallinula chloropus* | Other | 0|0.04 | 0±0|0.04±0.2 |
| *Motacilla alba* | Ground | 0.43|0.63 | 0.52±0.68|1.58±1.72 |
| *Motacilla cinerea* | Ground | 0|0.04 | 0±0|0.08±0.41 |
| *Myopsitta monachus* | Both | 0.05|0.17 | 0.05±0.22|1.75±5.33 |
| *Parus major* | Both | 0.1|0.17 | 0.19±0.6|0.54±1.28 |
| *Passer domesticus* | Ground | 0.86|0.83 | 5.71±5.24|7.42±6.16 |
| *Passer montanus* | Ground | 0|0.04 | 0±0|0.04±0.2 |
| *Periparus ater* | Other | 0|0.04 | 0±0|0.04±0.2 |
| *Phoenicurus ochruros* | Ground | 0.43|0.58 | 0.62±0.92|2±2.86 |
| *Phylloscopus collybita* | Both | 0.24|0.67 | 1.19±2.86|2.71±4.03 |
| *Pica pica* | Both | 0.1|0.42 | 0.14±0.48|0.83±1.24 |
| *Psittacula krameri* | Both | 0|0.04 | 0±0|0.04±0.2 |
| *Pycnonotus jocosus* | Other | 0|0.13 | 0±0|0.58±1.64 |
| *Serinus serinus* | Ground | 0|0.13 | 0±0|0.29±0.91 |
| *Streptopelia decaocto* | Ground | 0.48|0.75 | 1.48±2.18|3.5±3.83 |
| *Sturnus unicolor* | Ground | 0.48|0.54 | 1.24±1.64|1.08±1.28 |
| *Sturnus vulgaris* | Ground | 0.05|0 | 0.1±0.44|0±0 |
| *Sylvia atricapilla* | Other | 0.19|0.21 | 0.29±0.72|0.54±1.14 |
| *Sylvia melanocephala* | Other | 0.05|0.29 | 0.05±0.22|0.71±1.16 |
| *Turdus merula* | Ground | 0.14|0.67 | 0.19±0.51|1.75±1.94 |
| *Upupa epops* | Ground | 0|0.04 | 0±0|0.04±0.2 |

Table S3. GLMM results for alpha diversity measurements (species richness, S; Shannon diversity, H; Pielou’s evenness, J; abundance, A) of all the birds together, using park area, grass type and their interaction as fixed variables, and town locality as random variable. We include the degrees of freedom (df), marginal R squared (R2m), conditional R squared (R2c), the estimate for each fixed variable and its standard error (SE), the z value and its corresponding P value, the variance explained by the random effects and its standard deviation.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| α diversity measure | | df | R2m | R2c | Variables | Estimate | SE | z value | P | Variance | SD |
| S |  | 41 | 0.425 | 0.430 |  |  |  |  |  |  |  |
|  | Random effects |  |  |  | Locality |  |  |  |  | 0.001 | 0.040 |
|  | Fixed effects |  |  |  | Intercept | 1.335 | 0.114 | 11.759 | <0.001 |  |  |
|  |  |  |  |  | Park area | 0.104 | 0.054 | 1.917 | 0.055 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.559 | 0.146 | 3.837 | <0.001 |  |  |
| H |  | 36 | 0.298 | 0.298 |  |  |  |  |  |  |  |
|  | Random effects |  |  |  | Locality |  |  |  |  | <0.001 | <0.001 |
|  | Fixed effects |  |  |  | Intercept | 1.157 | 0.103 | 11.284 | <0.001 |  |  |
|  |  |  |  |  | Park area | 0.096 | 0.060 | 1.580 | 0.114 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.397 | 0.139 | 2.845 | 0.004 |  |  |
| J |  | 37 | 0.002 | 0.002 |  |  |  |  |  |  |  |
|  | Random effects |  |  |  | Locality |  |  |  |  | <0.001 | <0.001 |
|  | Fixed effects |  |  |  | Intercept | 1.468 | 0.659 | 2.229 | 0.026 |  |  |
|  |  |  |  |  | Park area | 0.032 | 0.412 | 0.078 | 0.938 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.122 | 0.913 | 0.134 | 0.893 |  |  |
| A |  | 40 | 0.415 | 0.884 |  |  |  |  |  |  |  |
|  | Random effects |  |  |  | Locality |  |  |  |  | 0.162 | 0.402 |
|  | Fixed effects |  |  |  | Intercept | 2.709 | 0.134 | 20.192 | <0.001 |  |  |
|  |  |  |  |  | Park area | -0.237 | 0.148 | -1.608 | 0.108 |  |  |
|  |  |  |  |  | Grass | 0.336 | 0.125 | 2.693 | 0.007 |  |  |
|  |  |  |  |  | Park area:Grass (Natural) | 0.339 | 0.155 | 2.525 | 0.012 |  |  |

Table S4. GLMM results for alpha diversity measurements (species richness, S; Shannon diversity, H; Pielou’s evenness, J; abundance, A) of the ground foraging species, using park area, grass type and their interaction as fixed variables, and town locality as random variable. We include the degrees of freedom (df), marginal R squared (R2m), conditional R squared (R2c), the estimate for each fixed variable and its standard error (SE), the z value and its corresponding P value, the variance explained by the random effects and its standard deviation.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| α diversity measure | | df | R2m | R2c | Variables | Estimate | SE | z value | P | Variance | SD |
| S |  |  |  |  |  |  |  |  |  |  |  |
|  | Random effects | 41 | 0.301 | 0.432 | Locality |  |  |  |  | 0.042 | 0.204 |
|  | Fixed effects |  |  |  | Intercept | 1.262 | 0.136 | 9.278 | <0.001 |  |  |
|  |  |  |  |  | Park area | 0.101 | 0.033 | 1.530 | 0.126 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.481 | 0.160 | 3.001 | 0.002 |  |  |
| H |  | 35 | 0.205 | 0.284 |  |  |  |  |  |  |  |
|  | Random effects |  |  |  | Locality |  |  |  |  | 0.016 | 0.126 |
|  | Fixed effects |  |  |  | Intercept | 1.154 | 0.112 | 10.273 | <0.001 |  |  |
|  |  |  |  |  | Park area | 0.061 | 0.061 | 1.062 | 0.288 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.327 | 0.139 | 2.342 | 0.019 |  |  |
| J |  | 36 | 0.006 | 0.006 |  |  |  |  |  |  |  |
|  | Random effects |  |  |  | Locality |  |  |  |  | <0.001 | <0.001 |
|  | Fixed effects |  |  |  | Intercept | 1.384 | 0.667 | 2.076 | 2.076 |  |  |
|  |  |  |  |  | Park area | 0.051 | 0.421 | 0.122 | 0.122 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.212 | 0.917 | 0.232 | 0.232 |  |  |
| A |  | 40 | 0.233 | 0.911 |  |  |  |  |  |  |  |
|  | Random effects |  |  |  | Locality |  |  |  |  | 0.338 | 0.581 |
|  | Fixed effects |  |  |  | Intercept | 2.615 | 0.169 | 15.478 | <0.001 |  |  |
|  |  |  |  |  | Park area | -0.273 | 0.153 | -1.789 | 0.074 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.272 | 0.129 | 2.118 | 0.034 |  |  |
|  |  |  |  |  | Park area: Grass (Natural) | 0.408 | 0.162 | 2.527 | 0.012 |  |  |

Table S5. GLMM results for alpha diversity measurements (species richness, S; Shannon diversity, H; Pielou’s evenness, J; abundance, A) of the group defined as other species, using park area, grass type and their interaction as fixed variables, and town locality as random variable. We include the degrees of freedom (df), marginal R squared (R2m), conditional R squared (R2c), the estimate for each fixed variable and its standard error (SE), the z value and its corresponding P value, the variance explained by the random effects and its standard deviation.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| α diversity measure | | df | R2m | R2c | Variables | Estimate | SE | z value | P | Variance | SD |
| S |  | 41 | 0.381 | 0.381 |  |  |  |  |  |  |  |
|  | Random effects |  |  |  | Locality |  |  |  |  | <0.001 | <0.001 |
|  | Fixed effects |  |  |  | Intercept | -0.369 | 0.254 | -1.456 | 0.145 |  |  |
|  |  |  |  |  | Park area | 0.195 | 0.083 | 2.357 | 0.018 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.953 | 0.302 | 3.158 | 0.002 |  |  |
| H |  |  |  |  |  |  |  |  |  |  |  |
|  | Random effects | 18 | 0.131 | 0.131 | Locality |  |  |  |  | <0.001 | <0.001 |
|  | Fixed effects |  |  |  | Intercept | 0.716 | 0.191 | 3.739 | <0.001 |  |  |
|  |  |  |  |  | Park area | 0.093 | 0.051 | 1.820 | 0.069 |  |  |
|  |  |  |  |  | Grass (Natural) | -0.037 | 0.199 | -0.184 | 0.854 |  |  |
| J |  |  |  |  |  |  |  |  |  |  |  |
|  | Random effects | 19 | 0.002 | 0.002 | Locality |  |  |  |  | <0.001 | <0.001 |
|  | Fixed effects |  |  |  | Intercept | 1.802 | 1.683 | 1.071 | 0.284 |  |  |
|  |  |  |  |  | Park area | -0.063 | 0.436 | -0.145 | 0.885 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.058 | 0.757 | 0.033 | 0.974 |  |  |
| A |  |  |  |  |  |  |  |  |  |  |  |
|  | Random effects | 41 | 0.573 | 0.881 | Locality |  |  |  |  | 0.325 | 0.5698 |
|  | Fixed effects |  |  |  | Intercept | 0.509 | 0.241 | 2.121 | 0.034 |  |  |
|  |  |  |  |  | Park area | 0.377 | 0.099 | 3.800 | <0.001 |  |  |
|  |  |  |  |  | Grass (Natural) | 0.982 | 0.221 | 4.451 | <0.001 |  |  |

Table S6. GLM results for beta diversity measurements (total beta diversity and its partition into turnover and nestedness) of the three established bird groups, using grass type as predictor variable. We include the degrees of freedom (df), R squared (R2), the estimate for grass type and its standard error (SE), the z value and its corresponding P value.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| β diversity measure | | df | R2 | Variables | Estimate | SE | z value | P |
| All species | |  |  |  |  |  |  |  |
| βtotal | | 485 | 0.002 | Intercept | 0.890 | 0.152 | 5.860 | <0.001 |
|  |  |  |  | Grass (Natural) | -0.216 | 0.198 | -1.089 | 0.276 |
| βturnover | | 485 | 0.008 | Intercept | -0.212 | 0.139 | -1.525 | 0.127 |
|  |  |  |  | Grass (Natural) | 0.371 | 0.184 | 2.018 | 0.044 |
| βnestedness | | 485 | 0.032 | Intercept | -1.037 | 0.157 | -6.608 | <0.001 |
|  | |  |  | Grass (Natural) | -0.930 | 0.2415 | -3.851 | <0.001 |
| Ground species | |  |  |  |  |  |  |  |
| βtotal | | 465 | 0.001 | Intercept | 0.733 | 0.154 | 4.728 | <0.001 |
|  |  |  |  | Grass (Natural) | -0.153 | 0.199 | -0.767 | 0.443 |
| βturnover | | 465 | 0.011 | Intercept | -0.537 | 0.150 | -3.568 | <0.001 |
|  |  |  |  | Grass (Natural) | 0.434 | 0.193 | 2.251 | 0.024 |
| βnestedness | | 465 | 0.028 | Intercept | -0.817 | 0.157 | -5.193 | <0.001 |
|  |  |  |  | Grass (Natural) | -0.792 | 0.226 | -3.514 | <0.001 |
| Other species | |  |  |  |  |  |  |  |
| βtotal | | 307 | <0.001 | Intercept | 1.515 | 0.381 | 4.318 | <0.001 |
|  |  |  |  | Grass (Natural) | -0.064 | 0.385 | -0.165 | 0.869 |
| βturnover | | 307 | 0.001 | Intercept | 0.945 | 0.300 | 3.145 | 0.002 |
|  |  |  |  | Grass (Natural) | -0.191 | 0.329 | -0.581 | 0.562 |
| βnestedness | | 307 | 0.001 | Intercept | -2.199 | 0.449 | -4.889 | <0.001 |
|  |  |  |  | Grass (Natural) | 0.301 | 0.487 | 0.618 | 0.536 |