# Supplementary Information

# Forest structure determines nest box use by Central European boreal owls

Richard Ševčík, Bohuslav Kloubec, Jan Riegert, Jiří Šindelář, Marek Kouba & Markéta Zárybnická

**Table S1.** The abundance of small mammals in snap traps in the Ore Mountains and the Trebon Basin in 2015–2017. The number of individuals, trapping index (i.e., the number of individuals per 100 trap-nights, mean ± SD), and the total proportion of particular species are shown.

| | | 2015 | | 2016 | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Study area | Species | No. of inds. | Trapping index | No. of inds. | Trapping index | No. of inds. | Trapping index | Total number | % |
| Ore Mts. | *Apodemus* mice | 11 | 1.53 ± 1.11 | 0 | 0.00 | 30 | 4.17 ± 4.01 | 41 | 54.0 |
| | *Microtus* voles | 1 | 0.14 ± 0.34 | 0 | 0.00 | 1 | 0.14 ± 0.34 | 2 | 2.6 |
| | *Myodes* voles | 4 | 0.56 ± 0.68 | 1 | 0.14 ± 0.34 | 26 | 3.61 ± 6.53 | 31 | 40.8 |
| | *Sorex* shrews | 2 | 0.28 ± 0.68 | 0 | 0.00 | 0 | 0.00 | 2 | 2.6 |
| | Total | 18 | 2.50 ± 1.18 | 1 | 0.14 ± 0.34 | 57 | 7.92 ± 9.45 | 76 | 100.0 |
| Trebon Basin | *Apodemus* mice | 10 | 1.39 ± 1.88 | 2 | 0.28 ± 0.43 | 2 | 0.28 ± 0.43 | 14 | 53.9 |
| | *Microtus* voles | 1 | 0.14 ± 0.34 | 0 | 0.00 | 0 | 0.00 | 1 | 3.8 |
| | *Myodes* voles | 2 | 0.28 ± 0.68 | 4 | 0.56 ± 1.01 | 4 | 0.56 ± 0.86 | 10 | 38.5 |
| | *Sorex* shrews | 1 | 0.14 ± 0.34 | 0 | 0.00 | 0 | 0.00 | 1 | 3.8 |
| | Total | 14 | 1.94 ± 1.64 | 6 | 0.83 ± 1.39 | 6 | 0.83 ± 1.05 | 26 | 100.0 |

**Table S2.** The results of GLMM analysis (*lmer* function). The effect of the study area, year, and their interaction on the abundance of small mammals.

| Model | AIC | df | Chi | % of explained variability | P |
|---|---|---|---|---|---|
| *Apodemus* mice | | | | | |
| null model | 165.78 | 35 | | | |
| null model + area | 164.83 | 34 | 2.95 | 1.85 | 0.086 |
| null model + year | 163.58 | 33 | 3.25 | 3.71 | 0.071 |
| null model + year*area | 156.13 | 32 | 13.45 | 12.30 | 0.004 |
| *Myodes* voles | | | | | |
| null model | 181.94 | 35 | | | |
| null model + area | 182.83 | 34 | 1.11 | 0.63 | 0.292 |
| null model + year | 182.82 | 33 | 2.01 | 1.77 | 0.156 |
| null model + year*area | 184.53 | 32 | 4.29 | 4.21 | 0.232 |
| *Microtus* voles | | | | | |
| null model | 2.16 | 35 | | | |
| null model + area | 3.79 | 34 | 0.37 | 8.57 | 0.546 |
| null model + year | 3.91 | 33 | 1.89 | 36.95 | 0.170 |
| null model + year*area | 8.73 | 32 | 1.18 | 47.18 | 0.758 |
| *Sorex* shrews | | | | | |
| null model | 22.18 | 35 | | | |
| null model + area | 23.97 | 34 | 0.21 | 1.32 | 0.644 |
| null model + year | 22.19 | 33 | 3.78 | 24.70 | 0.052 |
| null model + year*area | 27.46 | 32 | 0.72 | 29.16 | 0.868 |

**Table S3.** Partial relationships of *Apodemus* mouse abundance between the study areas (Ore Mts., Trebon Basin) and years (2015–2017) using a post-hoc test (function *lsmeans* in lsmeans package).

| Area | Year | Contrast | Estimate | df | t-ratio | P |
|---|---|---|---|---|---|---|
| Ore Mts. | | 2015 – 2016 | 1.53 | 20.0 | 1.54 | 1.000 |
| Ore Mts. | | 2015 – 2017 | -2.64 | 20.0 | -2.66 | 0.134 |
| Ore Mts. | | 2016 – 2017 | -4.17 | 20.0 | -4.21 | 0.004 |
| Trebon Basin | | 2015 – 2016 | 1.11 | 20.0 | 1.12 | 1.000 |
| Trebon Basin | | 2015 – 2017 | 1.11 | 20.0 | 1.12 | 1.000 |
| Trebon Basin | | 2016 – 2017 | 0.00 | 20.0 | 0.00 | 1.000 |
| | 2015 | Ore Mts. – Trebon Basin | 0.14 | 28.4 | 0.13 | 1.000 |
| | 2016 | Ore Mts. – Trebon Basin | -0.28 | 28.4 | -0.26 | 1.000 |
| | 2017 | Ore Mts. – Trebon Basin | 3.89 | 28.4 | 3.58 | 0.011 |

**Table S4.** The number of sampling points, the number of sampling points with owl vocalisation, the vocal occupancy rate (i.e., the number of vocalising individuals per the number of sampling points), and the density of vocalising individuals related to the study area (Ore Mts., Trebon Basin), year (2015–2017), and period (April, May).

| | | | Ore Mts. | | | | Trebon Basin | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Species | Month | No. of sampling points | No. of sampling points with vocalisation | Vocal occupancy rate | Density per 10 km$^2$ | No. of sampling points | No. of sampling points with vocalisation | Vocal occupancy rate | Density per 10 km$^2$ |
| 2015 | Boreal owl | April | 34 | 20 | 0.59 | 1.87 | 31 | 16 | 0.52 | 1.64 |
| | | May | 26 | 13 | 0.50 | 1.59 | 31 | 18 | 0.58 | 1.85 |
| | Tawny owl | April | 34 | 14 | 0.41 | 1.31 | 31 | 15 | 0.48 | 1.54 |
| | | May | 26 | 10 | 0.38 | 1.22 | 31 | 15 | 0.48 | 1.54 |
| | Eagle owl | April | 34 | 0 | 0.00 | 0.00 | 31 | 2 | 0.06 | 0.21 |
| | | May | 26 | 0 | 0.00 | 0.00 | 31 | 1 | 0.03 | 0.10 |
| | Pygmy owl | April | 34 | 3 | 0.09 | 0.28 | 31 | 6 | 0.19 | 0.62 |
| | | May | 26 | 2 | 0.08 | 0.24 | 31 | 11 | 0.35 | 1.13 |
| | Long-eared owl | April | 34 | 3 | 0.09 | 0.28 | 31 | 1 | 0.03 | 0.10 |
| | | May | 26 | 3 | 0.12 | 0.37 | 31 | 0 | 0.00 | 0.00 |
| | Mean ± SD | | 30.0 ± 4.2 | 6.8 ± 6.9 | 0.23 ± 0.22 | 0.72 ± 0.70 | 31.0 ± 0.0 | 8.5 ± 7.2 | 0.27 ± 0.23 | 0.87 ± 0.74 |
| 2016 | Boreal owl | April | 36 | 17 | 0.47 | 1.50 | 31 | 7 | 0.23 | 0.72 |
| | | May | 35 | 6 | 0.17 | 0.55 | 21 | 4 | 0.19 | 0.61 |
| | Tawny owl | April | 36 | 17 | 0.47 | 1.50 | 31 | 15 | 0.48 | 1.54 |
| | | May | 35 | 14 | 0.40 | 1.27 | 21 | 8 | 0.38 | 1.21 |
| | Eagle owl | April | 36 | 1 | 0.03 | 0.09 | 31 | 0 | 0.00 | 0.00 |
| | | May | 35 | 0 | 0.00 | 0.00 | 21 | 0 | 0.00 | 0.00 |
| | Pygmy owl | April | 36 | 2 | 0.06 | 0.18 | 31 | 9 | 0.29 | 0.92 |
| | | May | 35 | 2 | 0.06 | 0.18 | 21 | 1 | 0.05 | 0.15 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Long-eared owl | April | 36 | 3 | 0.08 | 0.27 | 31 | 2 | 0.06 | 0.21 |
| | | May | 35 | 3 | 0.09 | 0.27 | 21 | 0 | 0.00 | 0.00 |
| | Mean ± SD | | 35.5 ± 0.5 | 6.5 ± 6.8 | 0.18 ± 0.19 | 0.58 ± 0.60 | 26.0 ± 5.3 | 4.6 ± 5.0 | 0.17 ± 0.17 | 0.54 ± 0.55 |
| 2017 | Boreal owl | April | 36 | 18 | 0.50 | 1.59 | 32 | 11 | 0.34 | 1.09 |
| | | May | 36 | 14 | 0.39 | 1.24 | 32 | 11 | 0.34 | 1.09 |
| | Tawny owl | April | 36 | 11 | 0.31 | 0.97 | 32 | 18 | 0.56 | 1.79 |
| | | May | 36 | 9 | 0.25 | 0.80 | 32 | 14 | 0.44 | 1.39 |
| | Eagle owl | April | 36 | 0 | 0.00 | 0.00 | 32 | 1 | 0.03 | 0.10 |
| | | May | 36 | 0 | 0.00 | 0.00 | 32 | 1 | 0.03 | 0.10 |
| | Pygmy owl | April | 36 | 1 | 0.03 | 0.09 | 32 | 9 | 0.28 | 0.90 |
| | | May | 36 | 2 | 0.06 | 0.18 | 32 | 5 | 0.16 | 0.50 |
| | Long-eared owl | April | 36 | 5 | 0.14 | 0.44 | 32 | 3 | 0.09 | 0.30 |
| | | May | 36 | 3 | 0.08 | 0.27 | 32 | 2 | 0.06 | 0.20 |
| | Mean ± SD | | 36.0 ± 0.0 | 6.3 ± 6.4 | 0.18 ± 0.18 | 0.56 ± 0.56 | 32.0 ± 0.0 | 7.5 ± 6.0 | 0.23 ± 0.19 | 0.75 ± 0.59 |

**Table S5.** The number of boxes, the number of boxes occupied by animal taxa (boreal owls, common goldeneyes, pine martens, passerine birds, bats, and insects), and the nest box occupancy rate (the number of occupied nest boxes per available nest boxes) related to the study area (Ore Mts., Trebon Basin), year (2015–2017), and period (spring: April-May, autumn: September-October).

| | | | Ore Mts. | | | Trebon Basin | | |
|---|---|---|---|---|---|---|---|---|
| Year | Species | Period | Number of boxes | Number of occupied boxes | Nest box occupancy rate | Number of boxes | Number of occupied boxes | Nest box occupancy rate |
| 2015 | Boreal owl | Spring | 230 | 23 | 0.10 | 245 | 3 | 0.01 |
| | Passeriformes | Spring | 230 | 11 | 0.05 | 245 | 20 | 0.08 |
| | Insect | Spring | 230 | 0 | 0.00 | 245 | 0 | 0.00 |
| | Pine marten | Spring | 230 | 3 | 0.01 | 245 | 0 | 0.00 |
| | Goldeneye | Spring | 230 | 0 | 0.00 | 245 | 0 | 0.00 |
| | Bats | Spring | 230 | 0 | 0.00 | 245 | 0 | 0.00 |
| | | Mean ± SD | 230.0 ± 0.0 | 6.2 ± 9.3 | 0.03 ± 0.04 | 245.0 ± 0.0 | 3.8 ± 8.0 | 0.02 ± 0.03 |
| 2016 | Boreal owl | Spring | 246 | 23 | 0.09 | 242 | 2 | < 0.01 |
| | Passeriformes | Spring | 246 | 74 | 0.30 | 242 | 17 | 0.07 |
| | Insect | Spring | 246 | 0 | 0.00 | 242 | 2 | < 0.01 |
| | Pine marten | Spring | 246 | 2 | < 0.01 | 242 | 1 | < 0.01 |
| | Goldeneye | Spring | 246 | 0 | 0.00 | 242 | 0 | 0.00 |
| | Bats | Spring | 246 | 0 | 0.00 | 242 | 0 | 0.00 |
| | | Mean ± SD | 246.0 ± 0.0 | 16.5 ± 29.6 | 0.07 ± 0.12 | 242.0 ± 0.0 | 3.7 ± 6.6 | 0.02 ± 0.03 |
| | Boreal owl | Autumn | 246 | 0 | 0.00 | 56 | 0 | 0.00 |
| | Passeriformes | Autumn | 246 | 19 | 0.08 | 56 | 0 | 0.00 |
| | Insect | Autumn | 246 | 1 | < 0.01 | 56 | 29 | 0.52 |
| | Pine marten | Autumn | 246 | 0 | 0.00 | 56 | 0 | 0.00 |
| | Goldeneye | Autumn | 246 | 0 | 0.00 | 56 | 0 | 0.00 |
| | Bats | Autumn | 246 | 0 | 0.00 | 56 | 0 | 0.00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Mean ± SD | 246.0 ± 0.0 | 3.3 ± 7.7 | 0.01 ± 0.03 | 56.0 ± 0.0 | 4.8 ± 11.8 | 0.09 ± 0.21 |
| 2017 | Boreal owl | Spring | 246 | 18 | 0.07 | 237 | 0 | 0.00 |
| | Passeriformes | Spring | 246 | 49 | 0.20 | 237 | 19 | 0.08 |
| | Insect | Spring | 246 | 0 | 0.00 | 237 | 26 | 0.11 |
| | Pine marten | Spring | 246 | 0 | 0.00 | 237 | 0 | 0.00 |
| | Goldeneye | Spring | 246 | 0 | 0.00 | 237 | 1 | < 0.01 |
| | Bats | Spring | 246 | 0 | 0.00 | 237 | 0 | 0.00 |
| | | Mean ± SD | 246.0 ± 0.0 | 11.2 ± 19.9 | 0.05 ± 0.08 | 237.0 ± 0.0 | 7.7 ± 11.7 | 0.03 ± 0.05 |
| | Boreal owl | Autumn | 246 | 1 | < 0.01 | 200 | 0 | 0.00 |
| | Passeriformes | Autumn | 246 | 15 | 0.06 | 200 | 38 | 0.19 |
| | Insect | Autumn | 246 | 0 | 0.00 | 200 | 87 | 0.44 |
| | Pine marten | Autumn | 246 | 0 | 0.00 | 200 | 0 | 0.00 |
| | Goldeneye | Autumn | 246 | 0 | 0.00 | 200 | 0 | 0.00 |
| | Bats | Autumn | 246 | 0 | 0.00 | 200 | 3 | 0.02 |
| | | Mean ± SD | 246.0 ± 0.0 | 2.7 ± 6.1 | 0.01 ± 0.02 | 200.0 ± 0.0 | 21.3 ± 35.5 | 0.11 ± 0.18 |