**Electronic Supplementary Material 1: supplementary tables and figures**

*Article: Special delivery: scavengers direct seed dispersal towards ungulate carcasses. By Steyaert SMJG, Frank SC , Puliti S, Badia R, Arnberg MP, Beardsley J, Økelsrud A, Blaalid R*

ESM 1 Table 1: List of all vascular plants, mosses, and lichen species registered at the carcass site during a parallel study.

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| --- | --- | --- | --- | --- |
| **Woody plants** | **Graminoids** | **Herbs/Cryptogams** | **Mosses** | **Lichens** |
| *Betula nana* | *Avenella flexuosa* | *Solidago virgaurea* | *Marchantiophyta* sp. | *Cladonia arbuscula* |
| *Empetrum nigrum* | *Nardus stricta* | *Rubus chamaemorus* | *Ptilium ciliare* | *Cladodia rangiferina* |
| *Vaccinium myrtillus* | *Festuca ovina* | *Trientalis europea* | *Bryophyta* sp. | *Cladonia stellaris* |
| *Vaccinium vitis-idaea* | *Carex bigelowii* | *Hieracium* sp. | *Pleurozium schreberi* | *Cladonia uncialis* |
| *Vaccinium uliginosum* | *Carex brunnescens* | *Euphrasia* sp. | *Dicranum* sp. | *Cladonia* sp. |
| *Juniperus communis* | *Carex* sp. | *Pedicularis* sp. | *Sphagnum* sp. | *Cetraria* sp. |
| *Phyllodoce caerulea* | *Juncus trifidus* | *Huperzia selago* | *Polytrichum* sp. | *Flavocetraria cucullata* |
| *Salix herbacea* | *Juncus filiformis* |  | *Racomitrium* sp. | *Flavocetraria nivalis* |
| *Salix* sp. |  |  |  | *Stereocaulon* sp. |

ESM 1 Table 2. List of 45 candidate models predicting the occurrence of rodent feces and the number of bird and mesopredator feces around reindeer carcasses. Scat surveys were conducted at 75 1×1 m survey plots distributed over a reindeer mass die-off site at Hardangervidda, Norway, where an entire herd (N = 323) of wild tundra reindeer was killed by lightning on 26 August 2016. ‘Distance’ refers to distance to the nearest carcass in meters, and the distance measure (m) in parentheses following ‘carcass density’ represents its respective kernel search radius. Note that we always included an autocovariate, specific for each response variable to account for spatial autocorrelation.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Single effect candidate models*** | ***Interactive effect candidate models*** | | | ***Additive effect candidate models*** | | |
| Null model | Carcass density (1 m) | \* | Distance | Carcass density (1 m) | + | Distance |
| Distance | Carcass density (2 m) | \* | Distance | Carcass density (2 m) | + | Distance |
| Carcass density (1 m) | Carcass density (3 m) | \* | Distance | Carcass density (3 m) | + | Distance |
| Carcass density (2 m) | Carcass density (4 m) | \* | Distance | Carcass density (4 m) | + | Distance |
| Carcass density (3 m) | Carcass density (5 m) | \* | Distance | Carcass density (5 m) | + | Distance |
| Carcass density (4 m) | Carcass density (6 m) | \* | Distance | Carcass density (6 m) | + | Distance |
| Carcass density (5 m) | Carcass density (7 m) | \* | Distance | Carcass density (7 m) | + | Distance |
| Carcass density (6 m) | Carcass density (8 m) | \* | Distance | Carcass density (8 m) | + | Distance |
| Carcass density (7 m) | Carcass density (9 m) | \* | Distance | Carcass density (9 m) | + | Distance |
| Carcass density (8 m) | Carcass density (10 m) | \* | Distance | Carcass density (10 m) | + | Distance |
| Carcass density (9 m) | Carcass density (15 m) | \* | Distance | Carcass density (15 m) | + | Distance |
| Carcass density (10 m) | Carcass density (20 m) | \* | Distance | Carcass density (20 m) | + | Distance |
| Carcass density (15 m) | Carcass density (30 m) | \* | Distance | Carcass density (30 m) | + | Distance |
| Carcass density (20 m) |  |  |  |  |  |  |
| Carcass density (30 m) |  |  |  |  |  |  |
| Carcass density (40 m) |  |  |  |  |  |  |
| Carcass density (50 m) |  |  |  |  |  |  |
| Carcass density (100 m) |  |  |  |  |  |  |
| Carcass density (200 m) |  |  |  |  |  |  |

ESM 1 Table 3. Model selection results from assessing the number of mesopredator (upper panel) and bird (middle panel) scats, and the occurrence of rodent fecal pellet groups (bottom panel), in relation to reindeer carcass density and distance to the nearest carcass. Scats surveys were conducted at 75 1×1 m survey plots distributed over a reindeer mass die-off site (~240×100 m) at Hardangervidda, Norway, where nearly an entire herd (N = 323) of wild tundra reindeer was killed by lightning on 26 August 2016. The surveys were conducted early August 2017. ΔAICc = model rank differences of Akaike Information Criterion values corrected for small sample sizes, df = degrees of freedom. ‘Dist. to nearest carcass’ represents the Euclidean distance in meters to the nearest carcass, the selected kernel density search radius (m) follows the ‘Carcass density’ model term in parentheses. Note that all models included a response-specific autocovariate to control for spatial autocorrelation.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mesopredator** | | | | |
| *Model structure* | *df* | *AICc* | *ΔAICc* | *w* |
| Carcass density, 50 m | 3 | 83.4 | 0.00 | 0.223 |
| Carcass density, 40 m | 3 | 84.4 | 0.96 | 0.138 |
| Dist. to nearest carcass + carcass density (30 m) | 4 | 85.2 | 1.75 | 0.093 |
|  |  |  |  |  |
| **Bird** | | | | |
| *Model structure* | *df* | *AICc* | *ΔAICc* | *w* |
| Dist. to nearest carcass + carcass density (15 m) | 5 | 159.7 | 0.00 | 0.138 |
| Dist. to nearest carcass + carcass density (10 m) | 5 | 159.8 | 0.01 | 0.137 |
| Dist. to nearest carcass + carcass density (9 m) | 5 | 159.9 | 0.10 | 0.131 |
| Dist. to nearest carcass \* carcass density (8 m) | 5 | 160.1 | 0.37 | 0.114 |
| Dist. to nearest carcass + carcass density (7 m) | 4 | 161.0 | 1.21 | 0.075 |
| Dist. to nearest carcass \* carcass density (20 m) | 5 | 161.1 | 1.40 | 0.068 |
| Dist. to nearest carcass \* carcass density (7 m) | 5 | 161.3 | 1.51 | 0.065 |
| Dist. to nearest carcass + carcass density (8 m) | 4 | 161.5 | 1.75 | 0.057 |
|  |  |  |  |  |
| **Rodent** | | | | |
| *Model structure* | *df* | *AICc* | *ΔAICc* | *w* |
| Dist. to nearest carcass \* carcass density (5 m) | 5 | 85.7 | 0.00 | 0.101 |
| Carcass density, 50 m | 3 | 86.3 | 0.60 | 0.075 |
| Dist. to nearest carcass \* carcass density (6 m) | 5 | 86.5 | 0.85 | 0.066 |
| Carcass density, 100 m | 3 | 86.7 | 1.04 | 0.060 |
| Carcass density, 40 m | 3 | 86.7 | 1.04 | 0.060 |
| Dist. to nearest carcass \* carcass density (7 m) | 5 | 86.9 | 1.26 | 0.054 |
| Carcass density, 30 m | 3 | 87.1 | 1.45 | 0.049 |
| Carcass density, 200 m | 3 | 87.1 | 1.46 | 0.049 |
| Carcass density, 20 m | 3 | 87.4 | 1.76 | 0.042 |
| Carcass density, 15 m | 3 | 87.5 | 1.87 | 0.040 |

ESM 1 Table 4. Model results to assess the number of mesopredator (upper panel) and bird (middle panel) scats, and the occurrence of rodent fecal pellet groups (bottom panel), in relation to reindeer carcass density and distance to the nearest carcass. Scats surveys were conducted at 75 1×1 m survey plots distributed over a reindeer mass die-off site (~240×100 m) at Hardangervidda, Norway, where nearly an entire herd (N = 323) of wild tundra reindeer was killed by lightning on 26 August 2016. The surveys were conducted early August 2017. ΔAICc = model rank differences of Akaike Information Criterion values corrected for small sample sizes, df = degrees of freedom, ds = dispersion statistic. ‘Dist. to nearest carcass’ represents the Euclidean distance in meters to the nearest carcass, the selected kernel density search radius (m) follows the ‘Carcass density’ model term in parentheses. The response variable-specific autocovariate was included in all models to control for spatial autocorrelation.

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| --- | --- | --- | --- |
| **Mesopredator model (Poisson), ΔAICc = 0.00, df = 3, ds = 0.583** | | | |
| *Model term* | *β* | *se* | *p-value* |
| Intercept | -3.337 | 0.634 | <0.001 |
| Carcass density, 50 m | 56.835 | 14.267 | <0.001 |
| Autocovariate, 20m | -1.476 | 1.054 | 0.161 |
|  |  |  |  |
| **Bird model (Poisson), ΔAICc = 1.21, df = 4, ds = 1.147** | | | |
| *Model term* | *β* | *se* | *p-value* |
| Intercept | 0.0387 | 0.4663 | 0.934 |
| Dist. carcass | -0.1436 | 0.0490 | 0.003 |
| Carcass density, 7 m | 4.6527 | 1.4500 | 0.001 |
| Autocovariate, 20m | 0.2075 | 0.1264 | 0.101 |
|  |  |  |  |
| **Rodent model (Binomial), ΔAICc = 0.60, df = 3, ds = 1.110** | | | |
| *Model term* | *β* | *se* | *p-value* |
| Intercept | 0.271 | 0.905 | 0.764 |
| Carcass density, 50 m | -32.601 | 14.324 | 0.023 |
| Autocovariate, 20m | 1.365 | 1.182 | 0.248 |

ESM 1 Table 5. Crowberry seed load content in bird feces collected from cadaver decomposition islands of reindeer at our study site in Hardangervidda, Norway. For each sample (ID), we registered sample weight (air dried in g), the total number of crowberry seeds per sample (N seeds), the number of seeds that were assessed for viability using a tetrazolium test (N tested), the number of crowberry seeds that were considered as viable (N viable), and the proportion of viable crowberry seeds per sample (Prop. viable).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **ID** | **Weight (g)** | **N seeds** | **N tested** | **N viable** | **Prop. viable** |
| 1 | 0.60 | 39 | 14 | 5 | 0.357 |
| 2 | 1.76 | 118 | 13 | 8 | 0.615 |
| 3 | 2.14 | 55 | 10 | 2 | 0.200 |
| 4 | 0.43 | 52 | 7 | 6 | 0.857 |
| 5 | 0.70 | 139 | 12 | 5 | 0.417 |
| 6 | 0.66 | 217 | 16 | 9 | 0.563 |
| 7 | 1.97 | 68 | 14 | 9 | 0.643 |
| 8 | 0.26 | 323 | 8 | 4 | 0.500 |
| 9 | 0.31 | 32 | 9 | 5 | 0.556 |
| 10 | 1.30 | 206 | 10 | 6 | 0.600 |
| 11 | 0.77 | 32 | 7 | 1 | 0.143 |
| 12 | 0.88 | 112 | 11 | 2 | 0.182 |
| 13 | 0.43 | 40 | 6 | 0 | 0.000 |
| 14 | 0.58 | 100 | 9 | 4 | 0.444 |
| 15 | 0.58 | 36 | 16 | 4 | 0.250 |
| 16 | 0.48 | 31 | 5 | 5 | 1.000 |
| 17 | 0.49 | 31 | 10 | 1 | 0.100 |
| 18 | 0.53 | 25 | 8 | 4 | 0.500 |
| 19 | 1.08 | 42 | 15 | 6 | 0.400 |
| 20 | 0.25 | 14 | 6 | 1 | 0.167 |
| 21 | 2.75 | 56 | 8 | 0 | 0.000 |
| 22 | 0.38 | 43 | 12 | 2 | 0.167 |
| 23 | 1.17 | 159 | 18 | 6 | 0.333 |
| 24 | 1.08 | 307 | 20 | 5 | 0.250 |
| ***Total*** | ***21.58*** | ***2277*** | ***264*** | ***100*** | ***0.385*** |