**EIDC dataset 2:**  
Caterpillar masses from grass margins and hedgerows under streetlights, Oxfordshire, UK, 2018-2020

**The following document makes use of the methods included in the following study:** Street lighting has detrimental impacts on local insect populations

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**Field sites**

We compared moth caterpillar communities at lit and unlit sections of sites within a matched-pairs design in two types of habitats: hedgerows and grass margins (which each employed different sampling methods). Twenty-six pairs of sites were used, where a comparable linear section of both lit and unlit habitat was present. One additional site was a triplet (one unlit section, two sections lit with different street light types). All sites represented contiguous, linear strips of habitat, with lit and unlit sections separated by ≥60 m (median: 118 m, range 60-527 m).

Potential pairs were detected by overlaying spatial datasets of street lights covering the counties of Oxfordshire, Buckinghamshire, and Berkshire (southern England, UK) on satellite imagery to identify linear sections of habitat lit by at least one street light. Using Google Street View, ‘virtual site visits’ were then made to over 500 locations to identify whether contiguous and comparable habitat existed for lit and unlit transects. Of these, 153 locations were then visited in person to assess whether the matching criteria were met. This produced 26 pairs and one triplet where lit and unlit sections of habitat appeared identical, except for the presence of Artificial Light At Night (ALAN).

The street light treatments reflect the current lighting technologies used in the region. These were predominately LED and high-pressure sodium (HPS), with two low-pressure sodium (LPS) sites (14 HPS transects, 11 LED transects, and 2 LPS transects). According to the data provided by the relevant local authority, the lit transects had been illuminated by the same lighting treatment type for at least five years, so any differences in moth communities represent long-term impacts. The lit sections of all study sites remained fully lit for the entire night; all field sites were visited at least once between 02:00 – 04:00 to confirm that part-night lighting or dimming was not in operation. The lit sites were often illuminated by street lights on junctions or roundabouts in a rural setting, meaning the effects of ALAN were largely independent of urbanisation, which can have deleterious impacts on moth communities (Merckx & Van Dyck, 2019). To ensure that we could robustly disentangle the effects of ALAN from other elements of urbanisation, we conducted a GIS analysis which showed that the proportion of urbanisation at various spatial scales was not a useful predictor of caterpillar abundance. Light intensity was recorded using a lux meter (Andoer® HP-881C; resolution: 0.1 lux) at five evenly spaced points along each transect. This was done on cloudy nights or during the new moon. Readings were taken directly upwards at the height likely to be experienced by the caterpillars: 1.25 m for hedgerows and 0.25 m for grass margins. Lit hedgerow sites ranged from a transect average of 1.42 to 15.84 lux (mean: 5.7 lux), while lit grass transects varied between 0.18 and 7.14 lux (mean: 2.2 lux). Within each site type, the mean lux values of sodium and LED transects were not statistically different for either hedgerows (independent t-test: t(7.6)= -0.97, p= 0.34), or grass margins (t(13.9)= -0.2, p= 0.85). All unlit transects were estimated to be <0.01 lux on an overcast night (and all measured the minimum reading of 0.1 lux on the light metre).

An important caveat is that lux is based on human vision and, thus, potentially ecologically relevant spectral information can be omitted when using this unit of measurement (Longcore & Rich, 2004). Identical measurements of lux may not correspond to the same illumination as perceived by a caterpillar. Despite these shortcomings, lux is the SI unit for light intensity, and continues to be used by ecologists and urban planners alike due to its convenience.

Thirteen pairs of sites had comparable sections of hedgerow for beating and 15 had suitable strips of grass margin for sweep net sampling (two sites were used for both types of sampling).

**Spectra of the lighting treatments**

To assess the relative intensity of light across the visible spectrum of our field sites, we used an Ocean Optics USB2000+VIS-NIR-ES. We only have spectral data for grass margin sites (the spectrometer was only available to us for one month). The grass margin sites and hedgerow sites are taken from the same population (i.e. the region’s street light inventories) so we expect that the spectral composition of the LED and HPS lamps would be similar for both grassy margin and hedgerow sites. One metric of interpreting the spectral data is using the Correlated Colour Temperature (CCT) which converts the spectrum into a single value: lower values are warmer hues and higher values being cooler hues; for instance, natural noon daylight is 5000-6000 K.

High-pressure and low-pressure sodium lamps are inflexible in terms of their colour output, generating a characteristic yellow or orange glow. The CCT of HPS lamps is approximately 2200 K and LPS 1800 K

LEDs are flexible and can be any colour (commercial CCT white LEDs are typically vary from 2200 K to 6500 K, i.e., warm whites through to cold whites). The LEDs at our field sites were all white, though there was some variation in the temperature of these lights. We report relative values (the spectrometer had no available calibration). From spectra taken at our grass field sites, we estimate the CCT of the LED treatments to be 2700 K – 4000 K (i.e., warm white to neutral white).

**Site pairs matching criteria**

At each site, the lit and unlit transects were carefully paired to ensure that the habitat was comparable. Paired transects were geographically close (median: 118 m, range 60-527 m) so experienced similar climatic conditions. To minimise microclimatic differences arising from different aspects, lit and unlit transects were located along straight roads (a difference in angle of up to 25° was permissible). Hedgerow trees are important for local adult moth abundance, so the presence or absence of hedgerow trees (where a trunk clearly projected above the hedge) was recorded within 30 m of the transect midpoint, and sites where this differed were excluded (n=8). Transects were always within the same field so that the agricultural management (e.g., frequency of hedgerow management; pesticide usage) was consistent. Sites with an area of high-quality habitat located adjacent to one of the transects were excluded (n=2; one with an adjacent nature reserve, one with a stand of mature broadleaved woodland). For hedgerow sampling sites, the dominant woody plant species, hedgerow height, and width were controlled for.

At grass margin sampling sites, the vegetation height was recorded at the first sampling session to ensure the mean value (n=10, recorded at evenly spaced intervals along the transect) for lit and unlit transects did not differ by more than 10 cm, indicating the vegetation management (e.g., mowing grass verges around junctions) did not tend to be greater in one of the treatment types. Two sites did not meet this criterion so were excluded.

**Caterpillar sampling**

Two sampling methods were employed to compare the two feeding guilds of moth caterpillar communities at lit and unlit transects: hedgerow beating in spring for species feeding on deciduous woody trees and shrubs, and sweep net sampling in winter for species feeding nocturnally on grasses and low-growing herbaceous plants. Hedgerows were sampled during the day once in mid-May 2019 and once in mid-April in 2020. These dates correspond to the end and start, respectively, of the prime season for moth caterpillars feeding on the spring flush of foliage. These two specific periods were chosen so that any phenological artefacts on abundance arising from ALAN could be reduced. In the late spring sampling, caterpillars were the fourth or final instar, while in the early spring visit, caterpillars were first or second instar. This means we sampled at the beginning and at the end of the time this guild (spring flush feeders) spends as larvae. One site had been developed into housing between the two visits so was not sampled in 2020. Beating was conducted at three points along each transect, which were 14 m long. The dominant plant species of the hedgerow was recorded and was typically the same at a paired site (e.g., six *Crataegus*-dominated sampling points). Where this was not possible, the dominant species composition was kept constant within a pair (e.g., 2 unlit *Crataegus*-dominated points, one unlit *Acer campestre*, paired with 2 lit *Crataegus* and one lit *Acer campestre*). Beating used two methods: drainpipes for box-shaped hedges (8 sites) and a beating tray (5 sites). Three 2 m lengths of half drainpipe (width: 11.2 cm) were inserted at the base of the hedge lying next to each other perpendicular to the hedge direction (a modification of methods by (Maudsley et al., 2002; Staley et al., 2016)), while a traditional beating tray (Watkins & Doncaster; dimensions 110 cm x 86 cm) was used at sites where there was overhanging vegetation. In both cases, the vegetation was struck five times with a metal pole to dislodge caterpillars.

The second method was sweep netting grass margins for over-wintering noctuid caterpillars, which climb up grass stems to feed at night. Transects were established either on the road side (road verges) or the field side (agricultural margins), depending on where comparable habitat was available. Botanical surveys were conducted during June 2019 and Analyses of Similarities (ANOSIM) showed that for each site, the plant community of lit and unlit transects were indistinguishable. Caterpillar sampling took place on mild nights (forecasted minimum temperature ≥6°c) from December 2018 to April 2019 and was done at least one hour after sunset between 21:00 and 06:30. Transects were walked at a consistent pace while making brisk sweeps in a continuous figure-of-eight motion with a sweeping net (Watkins & Doncaster; diameter 50 cm; pentagon-shaped frame). The number of caterpillars recorded per transect was relatively low (mean: 6.9) so sites were visited several times over the season; most sites were sampled four times. At one site, new street lights were installed in the previously unlit section during the study period, so this site was only visited twice. Both transects in a pair were sampled an equal number of times so, while there was variation between sites, the statistical comparison between lit and unlit transects is unaffected by this variation in number of visits. Transects were marked with plastic markers on the first visit and were typically 14 m long but at some sites were longer if there was enough comparable habitat available across both sections of the pair (transect length was always kept the same between lit and unlit sections). Sampling of the lit and unlit sections was typically separated by around 10 minutes. The time of sampling (later converted to minutes past sunset) and the temperature (according to the external car thermometer) were recorded.

All caterpillars collected from the grass strips (n=826) and the late spring hedgerow sampling (n=1021) were retained (early spring caterpillars from 2020 were not kept due to the lack of laboratory access because of COVID-19 restrictions). Provisional identifications were assigned by the lead author using prior knowledge, existing literature (Porter, 2010), and [www.ukleps.org](http://www.ukleps.org). Hedgerow caterpillars were predominantly winter-flying geometrids (largely *Operophtera* spp.; as well as *Epirrata* spp., *Agriopis* spp., *Erannis defoliaria*, *Phigalia pilosaria*) and also summer-flying micro-moths (Tortricidae spp., *Acrobasis* sp., *Ypsolopha* sp.). These were grouped into 20 ‘taxonomic units’ (which including species, genera, family-level determinations, and “unknown”). Grass margin caterpillars were overwhelmingly over-wintering, grass-feeding noctuids (predominately, *Xestia xanthographa/X. sexstrigata;* also, *Mesapamea* spp., *Noctua pronuba*, *Phlogophora meticulosa*). Thirty-four day-flying Lepidoptera caterpillars were recorded (Nymphalidae and Zygaenidae). These were included in the analyses because day-flying species with nocturnal larval stages might still be adversely affected by ALAN (Boyes et al., 2021). Grass margins produced 16 taxonomic units (as defined above for the hedgerow guild).

All caterpillars were weighed using a digital analytical balance (resolution: 0.0001 g). The mean mass of caterpillars from grass margins was 98 mg (range: 0.07 mg to 2,240 mg) and the mean mass of hedgerow caterpillars was 43 mg (range: 0.2 mg to 866 mg).

**Quality control**

Matched pairs of lit and unlit sites were identified following detailed research with a specified set of criteria. All sites were sampled over the same nights to remove variations due to temperature.

Sampling took place using standardised methods as described above. All caterpillars were identified by D.H.B., using prior knowledge, and existing literature. Caterpillar samples were retained and kept at -20°C apart from the samples from spring 2020 which could not be retained due to Covid-19 restrictions preventing laboratory access. Data were collected using standardised recording forms and transcribed into a purpose-designed spreadsheet (Microsoft Excel) using dropdown menus and rules to ensure accurate data entry. Data entry took place within 24 hours of field visits. Calculations were automated using formulae in Excel.

Following data entry, records were double checked to ensure accidental typing errors were removed and to check for apparent outliers. Data were exported into their current format to facilitate statistical analysis.

**Details of data structure – main data**

The hedgerow count data are contained within Boyes\_et\_al\_2021\_hedgerows\_mass.csv   
The grass margin count data are contained within Boyes\_et\_al\_2021\_grass\_mass.csv.  
The following table details what data are contained within the different columns.

|  |  |
| --- | --- |
| **Column title** | **Description** |
| ‘Visit\_ID’ | ID number for visit (grass data only) |
| ‘Site\_ID’ | ID number for site |
| ‘Treatment’ | Lighting treatment:  - unlit control (unlit)  - LED streetlight (LED)  - High Pressure Sodium streetlight (HPS)  - Low Pressure Sodium streetlight (LPS) |
| ‘Sample\_number’ | Caterpillar sample reference code #1 |
| ‘Provisional\_ID’ | Provisional identification of caterpillar |
| ‘ID2’ | Identification of caterpillar at broader taxonomic resolution |
| ‘Caterpillar\_mass\_mg’ | Mass of caterpillar (mg) |
| ‘DaysSince’ | Days since start of sampling began (only for grass margins) |

**Data structure – field sites**

Information about the field sites is contained within Boyes\_et\_al\_2021\_field\_sites\_data.csv.

The following table details what data are contained within the different columns.

|  |  |
| --- | --- |
| **Column title** | **Description** |
| ‘Old\_Site\_ID’ | Site ID used at time of data collection |
| ‘SiteID\_Fig’ | Site ID used in Boyes et al., 2021. |
| ‘Sampling\_meth’ | Sampling method: Grass margin, Hedgerow, or both. |
| ‘Site\_Name’ | The sampling site name |
| ‘Light\_Type’ | The type of light installed in the lit section of the site. |
| ‘Lit\_transect\_centroid’ | The central OS Grid Reference for the lit section of transect |
| ‘Lit\_transect\_E’ | Eastings for the lit transect (centroid) |
| ‘Lit\_transect\_N’ | Northings for the lit transect (centroid) |
| ‘Lit\_transect\_lat’ | Latitude of the lit transect (centroid) |
| ‘Lit\_transect\_long’ | Longitude of the lit transect (centroid) |
| ‘Hedge\_mean\_illumination” | The mean light intensity measured in lux at 1.25 m from the ground (lux). |
| ‘Grass\_mean\_illumination’ | The mean light intensity measured in at grass height, 0.25 m from the ground (lux). |
| ‘Dist\_between\_trans’ | The distance between the lit and unlit transects, in meters, at each site. |
| ‘Unlit\_transect\_Centroid’ | The central OS Grid Reference for the unlit section of transect |
| ‘Unlit\_ transect\_ E’ | Eastings for the unlit transect |
| ‘Unlit\_ transect\_ N’ | Northings for the unlit transect |
| ‘Unlit\_ transect\_ Lat’ | Latitude of the unlit transect |
| ‘Unlit\_ transect\_Long’ | Longitude of the unlit transect |
| ‘Lit\_100\_urban’ | Lit area in square meters within 100 meters of transect centroid classified as urban on CEH 2017 landcover map. |
| ‘Lit\_250\_urban’ | Lit area in square meters within 250 meters of transect centroid classified as urban on CEH 2017 landcover map. |
| ‘Lit\_500\_urban’ | Lit area in square meters within 500 meters of transect centroid classified as urban on CEH 2017 landcover map. |
| ‘Unlit\_100\_urban‘ | Unlit area in square meters within 100 meters of transect centroid classified as urban on CEH 2017 landcover map. |
| ‘Unlit\_250\_urban’ | Unlit area in square meters within 250 meters of transect centroid classified as urban on CEH 2017 landcover map. |
| ‘Unlit\_500\_urban’ | Unlit area in square meters within 500 meters of transect centroid classified as urban on CEH 2017 landcover map. |
| ‘100m\_radius’ | Total area in square meters within 100-meter radius of transect centroid. |
| ‘250m\_radius’ | Total area in square meters within 250-meter radius of transect centroid. |
| ‘500m\_radius’ | Total area in square meters within 500-meter radius of transect centroid. |
| ‘Lit100s/urban’ | Proportion of lit area with 100-meter radius of transect centroid which is classified as urban |
| ‘Lit250s/urban’ | Proportion of lit area with 250-meter radius of transect centroid which is classified as urban |
| ‘Lit500s/urban’ | Proportion of lit area with 500-meter radius of transect centroid which is classified as urban |
| ‘Unlit100s/urban’ | Proportion of unlit area with 100-meter radius of transect centroid which is classified as urban |
| ‘Unlit250s/urban’ | Proportion of unlit area with 250-meter radius of transect centroid which is classified as urban |
| ‘Unlit500s/urban’ | Proportion of unlit area with 500-meter radius of transect centroid which is classified as urban |

**References:**

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