Supplementary Information

Manuscript „Reducing the fatal attraction of nocturnal insects using tailored and shielded road lights"

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Supplementary Table 1: Abundance (Individuals) per insect taxon and light treatment at the Experimental field site in Westhavelland from 2019-2022. Treatment numbers refer to treatments of the same years. 1: Conventional High 2019-2020 (n=14 samplings, LED 30.6 lx 3000K). 2: Conventional Low 2021 (n=15 samplings, LED 5.6 lx 3000K). 3: Tailored Low 2022 (n=16 samplings, LED 5.2 lx 3000K). Dark controls were sampled simultaneously to the lit treatments.

No. luminaires	12	12	12	12	12	12	
Taxa	**1. Conventional High**	**2. Conventional Low**	**3. Tailored High**	**1. Dark control**	**2. Dark control**	**3. Dark control**	**TOTAL**
Auchenorrhyncha	13	0	4	2	1	4	24
Blattodea	1	0	0	0	0	1	2
Brachycera	30	34	15	14	23	19	135
Coleoptera	292	125	53	193	159	119	941
Ephemeroptera	332	369	11	15	7	11	745
Heteroptera	173	33	8	3	4	5	226
Hymenoptera	55	21	27	20	10	16	149
Lepidoptera	182	109	51	14	30	8	394
Nematocera	2093	781	322	67	140	125	3528
Neuroptera	16	9	5	1	1	2	34
Odonata	0	0	0	0	1	0	1
Orthoptera	0	0	0	0	1	1	2
Psocoptera	7	1	6	17	3	12	46
Sternorrhyncha	29	641	19	18	8	37	752
Thysanoptera	39	2	42	62	6	59	210
Trichoptera	34	5	3	4	3	2	51
TOTAL	3296	2130	566	430	397	421	7240

Supplementary Table 2: Pairwise comparison of light treatments at the Experimental field site in Westhavelland from 2019-2022 (Tukey post hoc test of generalized linear model). Treatment numbers refer to treatments of the same years. 1: Conventional High 2019-2020 (n=14 samplings, LED 30.6 lx 3000K). 2: Conventional Low 2021 (n=15 samplings, LED 5.6 lx 3000K). 3: Tailored Low 2022 (n=16 samplings, LED 5.2 lx 3000K). Dark controls were sampled simultaneously to the lit treatments.

contrast	Estimate	SE	Df	t-ratio	p-value
1. Conventional High- 2. Conventional Low	0.072	0.316	1068	0.228	0.9999
1. Conventional High- 3. Shielded Low	1.324	0.290	1068	4.571	**<0.0001**
1. Conventional High- 1. Dark control	1.834	0.122	1068	14.975	**<0.0001**
1. Conventional High- 2. Dark control	1.435	0.330	1068	4.342	**0.0002**
1. Conventional High- 3. Dark control	1.608	0.302	1068	5.325	**<0.0001**
2. Conventional Low - 3. Tailored Low	1.252	0.305	1068	4.103	**0.0006**
2. Conventional Low - 1. Dark control	1.762	0.331	1068	5.317	**<0.0001**
2. Conventional Low - 2. Dark control	1.363	0.125	1068	10.911	**<0.0001**
2. Conventional Low - 3. Dark control	1.537	0.317	1068	4.854	**<0.0001**
3. Tailored Low - 1. Dark control	0.510	0.307	1068	1.664	0.5562
3. Tailored Low - 2. Dark control	0.111	0.320	1068	0.346	0.9993
3. Tailored Low - 3. Dark control	0.285	0.125	1068	2.274	0.2055
1. Dark control - 2. Dark control	-0.399	0.325	1068	-1.228	0.8233
1. Dark control - 3. Dark control	-0.225	0.296	1068	-0.761	0.9739
2. Dark control - 3. Dark control	0.174	0.310	1068	0.560	0.9935

Supplementary Table 3: Principal component analysis (PCA) at the Experimental field site in Westhavelland. Values depict loadings of individual insect taxa on Principal components 1-5. Loadings higher than 0.25 were considered important (bold numbers).

	PC1	PC2	PC3	PC4	PC5
% Variance	33.58	12.84	7.84	7.75	6.82
Auchenorrhyncha	-0.2356213	**-0.3198239**	0.07366546	0.17283232	-0.092528
Blattodea	-0.1640521	-0.1990486	**-0.3237697**	**0.42059662**	**-0.3026404**
Brachycera	-0.1447411	**0.33382626**	**0.3742818**	**0.25064754**	0.10752044
Coleoptera	**-0.2690216**	-0.1750551	0.24306165	-0.0293617	**0.361188**
Ephemeroptera	**-0.3500037**	**0.28650078**	0.06989279	0.1257441	-0.1226591
Heteroptera	**-0.3868926**	-0.0869555	0.01027054	0.06181093	0.01155648
Hymenoptera	-0.2349096	-0.1087259	-0.0965189	-0.3361367	-0.0053338
Lepidoptera	**-0.3731051**	0.07394211	-0.058808	-0.2079665	-0.0098119
Nematocera	**-0.4092176**	0.00825377	0.02285197	-0.0366636	-0.0091979
Neuroptera	-0.1939558	0.08611713	0.02469283	**-0.5608928**	0.05610538
Odonata	0.026496	0.06369693	-0.0050283	**0.36820042**	**0.71083202**
Orthoptera	0.06469994	-0.0864007	**0.51009815**	0.17111427	-0.4139557
Psocoptera	0.07502302	**-0.2893097**	**0.62796759**	-0.1315956	0.00512163
Sternorrhyncha	-0.0625816	**0.56953123**	0.04036873	0.08041811	-0.2410105
Thysanoptera	0.04606664	**-0.3928853**	-0.121507	0.02273054	-0.0673608
Trichoptera	**-0.3688297**	-0.1662645	-0.0268654	0.22039348	-0.00165

Supplementary Table 4: Permutational multivariate analysis of variance (PERMANOVA) at the Experimental field site in Westhavelland, showing differences in community composition between treatments (groups).

~ treatment	Df	Sumsq	R2	F	Pr(>F)
Westhavelland 2019-2022	5	4.3172	0.63297	22.764	0.001 ***

Supplementary Table 5: Pairwise comparison of distances of individual luminaires to group centroids within treatments (groups) at the Experimental field site in Westhavelland (Tukey post hoc test). Treatment numbers refer to treatments of the same years. 1: Conventional High 2019-2020 (n=14 samplings, LED 30.6 lx 3000K). 2: Conventional Low 2021 (n=15 samplings, LED 5.6 lx 3000K). 3: Tailored Low 2022 (n=16 samplings, LED 5.2 lx 3000K). Dark controls were sampled simultaneously to the lit treatments.

	difference in observed mean	lower end point Interval	upper end point interval	p-value adjusted
1. Conventional High-2. Conventional low	0,0059197	-0,0402532	0,05209262	0,99897304
3. Shielded low-2. Conventional low	0,05212431	0,00595139	0,09829723	**0,01796957**
2. Dark control-2. Conventional low	0,06517572	0,01900279	0,11134864	**0,0013467**
3. Dark control-2. Conventional low	0,07832065	0,03214772	0,12449357	**6,95e-05**
1. Dark control-2. Conventional low	0,09557455	0,04940162	0,14174747	**1,01e-06**
3. Shielded low-1. Conventional High	0,04620461	3,17e-05	0,09237754	**0,04974373**
2. Dark control-1. Conventional High	0,05925602	0,0130831	0,10542894	**0,0045947**
3. Dark control-1. Conventional High	0,07240095	0,02622803	0,11857387	**0,00027356**
1. Dark control-1. Conventional High	0,08965485	0,04348193	0,13582777	**4,45e-06**
2. Dark control-3. Shielded low	0,0130514	-0,0331215	0,05922433	0,96093045
3. Dark control-3. Shielded low	0,02619634	-0,0199766	0,07236926	0,55921912
1. Dark control-3. Shielded low	0,04345024	-0,0027227	0,08962316	0,07671436
3. Dark control-2. Dark control	0,01314493	-0,033028	0,05931785	0,95973424
1. Dark control-2. Dark control	0,03039883	-0,0157741	0,07657175	0,39215465
1. Dark control-3. Dark control	0,0172539	-0,028919	0,06342682	0,88094672

Supplementary Table 6: Abundance (Individuals) per insect taxon and light treatment at three municipal sites in Southern Germany in 2022. Alter Flugplatz n=9 samplings, 5 luminaires per treatment, transition from conventional (LED 4000K) luminaires to tailored and shielded luminaires (LED 4000K), Backofen Riedwiesen n=7 samplings, 5 luminaires per treatment transition from conventional (HPS 2000K cylinder) luminaires to tailored and shielded luminaires (LED 2700K), Heimbachaue n=7 samplings, 4 luminaires per treatment, transition from conventional (HPS 2000K bow-shaped) luminaires to tailored and shielded luminaires (LED 2700K).

Site	Alter Flugplatz		Backofen Riedwiesen		Heimbachaue		
Samplings	9		7		7		
No. Luminaires	5	5	5	5	4	4	
Taxa	Conventional	Tailored	Conventional	Tailored	Conventional	Tailored	TOTAL
Auchenorrhyncha	9	3	19	8	4	3	46
Blattodea	0	1	1	1	0	0	3
Brachycera	6	5	3	6	14	5	39
Coleoptera	138	80	58	24	23	6	329
Ephemeroptera	0	0	0	0	16	2	18
Heteroptera	32	13	34	18	12	5	114
Hymenoptera	132	42	69	32	37	7	319
Lepidoptera	14	9	13	6	20	9	71
Nematocera	66	24	82	32	144	117	465
Neuroptera	1	0	2	0	1	0	4
Psocoptera	9	6	5	3	2	3	28
Sternorrhyncha	8	3	14	3	62	11	101
Thysanoptera	0	1	0	0	0	0	1
Trichoptera	2	0	0	0	8	5	15
TOTAL	417	187	300	133	343	173	1553

Supplementary Table 7: Principal component analysis (PCA) Municipal Site Alter

Flugplatz. Values depict loadings of individual insect taxa on Principal components 1-4.

Loadings higher than 0.28 were considered important (bold numbers).

	PC1	PC2	PC3	PC4
% Variance	33.88	22.63	17.17	10.79
Auchenorrhyncha	0.24050021	**0.39399515**	0.27342009	-0.2121215
Blattodea	**-0.3107529**	**0.39202243**	-0.0079875	-0.2134744
Brachycera	0.24301752	-0.0549095	**0.52206907**	-0.0371794
Coleoptera	**0.35745541**	-0.1209738	-0.1694928	-0.1215668
Heteroptera	0.20000882	0.17886973	-0.2880691	**-0.4322331**
Hymenoptera	**0.28862556**	0.19569722	0.17024063	0.19012289
Lepidoptera	0.03759118	**0.51277394**	-0.194478	0.21776739
Nematocera	**0.3811234**	0.17485694	**-0.2813523**	-0.0299031
Neuroptera	**0.28027568**	0.26835256	**0.36612882**	-0.0693733
Psocoptera	**0.31029142**	-0.268166	0.00933669	**-0.4586825**
Sternorrhyncha	**0.28439092**	0.10646866	-0.0815506	**0.60073465**
Thysanoptera	**-0.3107529**	**0.39202243**	-0.0079875	-0.2134744
Trichoptera	0.19105812	0.02625703	**-0.5040788**	-0.0181004

Supplementary Table 8: Principal component analysis (PCA) Municipal Site Backofen Riedwiesen. Values depict loadings of individual insect taxa on Principal components 1-4. Loadings higher than 0.3 were considered important (bold numbers).

	PC1	PC2	PC3	PC4
% Variance	44.99	17.80	12.34	10.59
Auchenorrhyncha	**-0.3840247**	0.2162944	-0.0994781	-0.1637348
Blattodea	0.03309901	**-0.6105821**	0.23948746	0.17154773
Brachycera	0.04067656	0.17073111	**0.48278678**	**-0.7039311**
Coleoptera	**-0.3904951**	0.00829872	0.10297233	**0.30976987**
Heteroptera	-0.364239	0.26645463	0.21696604	0.06249668
Hymenoptera	**-0.3354182**	-0.2662175	-0.2042861	**-0.4510643**
Lepidoptera	-0.2777459	-0.2020255	**0.31520762**	-0.0741505
Nematocera	**-0.3783892**	-0.1629815	-0.0695112	0.16625742
Neuroptera	-0.228847	**-0.4964897**	-0.1881449	-0.2283531
Psocoptera	-0.2575337	0.25603234	**-0.5433436**	-0.0788156
Sternorrhyncha	**-0.3362995**	0.17287735	**0.40675309**	0.23113691

Supplementary Table 9: Principal component analysis (PCA) Municipal Site

Heimbachaue. Values depict loadings of individual insect taxa on Principal components 1-4.

Loadings higher than 0.29 were considered important (bold numbers).

	PC1	PC2	PC3	PC4
% Variance	43.67	22.86	18.08	9.29
Auchenorrhyncha	-0.2723873	-0.3755749	-0.0263781	**-0.4199659**
Brachycera	**-0.3204839**	0.28247124	0.08123023	**-0.359479**
Coleoptera	**-0.3070527**	0.21310789	-0.069098	**0.36493297**
Ephemeroptera	-0.2302752	**0.42212777**	**0.31645239**	0.02114359
Heteroptera	**-0.3639887**	-0.2712249	-0.0140519	0.21450567
Hymenoptera	**-0.3645556**	0.17310792	**-0.3042132**	-0.0853762
Lepidoptera	**-0.3786662**	-0.0242929	-0.1990551	**0.31222869**
Nematocera	-0.267004	**-0.3590159**	0.0712376	**-0.4417162**
Neuroptera	-0.0537008	0.14183897	**-0.6219865**	-0.227393
Psocoptera	0.19464541	0.07988313	**-0.5925921**	0.01731835
Sternorrhyncha	-0.2651799	**0.39820853**	0.10708702	-0.117901
Trichoptera	**-0.2909096**	**-0.3707629**	-0.0291216	**0.38596696**

Supplementary Table 10: Permutational multivariate analysis of variance

(PERMANOVA) at three Municipal Sites, showing differences in community composition

between treatments (groups).

~ treatment	Df	Sumsq	R2	F	Pr(>F)
Alter Flugplatz 2022	1	0.13000	0.38735	5.058	0.007 **
Backofen Riedwiesen 2022	1	0.11069	0.33609	4.0499	0.028 *
Heimbachaue 2022	1	0.13685	0.39048	3.8438	0.025 *

Supplementary Table 11: Comparison of distances of individual luminaires to group centroids within treatments (groups) for three Municipal Sites in Southern Germany (ANOVA).

Distances to centroid ~ treatment	Df	Sumsq	Mean Sq	F	Pr(>F)
Alter Flugplatz 2022	1	0.005879833	0.005879833	2.687716	0.1397561
Backofen Riedwiesen 2022	1	0.006552443	0.006552443	5.033116	0.05512696
Heimbachaue 2022	1	0.015639222	0.015639222	6.032961	0.04937285

Supplementary Table 12: Abundance (Individuals) per insect taxon and light treatment at Heimbachaue in 2022. Values refer to control experiments with conventional and tailored luminaires at the same CCT (2000K). n=5 samplings between July and October 2022, 4 luminaires per treatment, transition from conventional luminaires (HPS 2000K bow-shaped) to tailored and shielded luminaires (LED 2000K).

Order	Conventional HPS 2000K	Tailored LED 2000K	TOTAL
Auchenorrhyncha	8	2	10
Brachycera	10	0	10
Coleoptera	11	4	15
Ephemeroptera	4	0	4
Heteroptera	4	3	7
Hymenoptera	33	9	42
Lepidoptera	17	13	30
Nematocera	164	51	215
Psocoptera	3	3	6
Sternorrhyncha	16	5	21
Trichoptera	5	2	7
TOTAL	275	92	367

Factor Conventional to Tailored: 2.99

Supplementary Table 13: Effects of light treatments on insect abundance at Heimbachaue (generalized linear model). Results refer to control experiments with conventional and tailored luminaires at the same CCT (Conventional HPS 2000K bow-shaped vs. Tailored LED 2000K). n=5 samplings between July and October 2022, 4 luminaires per treatment, transition from conventional luminaires (HPS 2000K bow-shaped) to tailored and shielded luminaires (LED 2000K). Model structure: abundance ~ Luminaire + mean temperature + mean wind speed + (1|trap_number) + (1|starting_date), family=nbinom1)

Site	abundance ~	Estimate	SE	Z	P	
Heimbachaue	Conventional	6.3989	2.52115	2.538	0.011146	*
	Tailored	-1.0867	0.20716	-5.246	**1.56e-07**	***
	Temperature (°C)	-0.0092	0.13100	-0.070	0. 943891	
	Wind (m/s)	-1.2718	0.37240	-3.415	**0.000637**	***

Supplementary Table 14: Principal component analysis (PCA) Municipal Site Heimbachaue. Results refer to control experiments with conventional and tailored luminaires at the same CCT (Conventional HPS 2000K bow-shaped vs. Tailored LED 2000K). n=5 samplings between July and October 2022, 4 luminaires per treatment, transition from conventional luminaires (HPS 2000K bow-shaped) to tailored and shielded luminaires (LED 2000K). Values depict loadings of individual insect taxa on Principal components 1-4. Loadings higher than 0.30 were considered important (bold numbers).

	PC1	PC2	PC3	PC4
Auchenorrhyncha	**-0.36000835**	-0.14786840	0.21876540	**0.441738202**
Brachycera	**-0.39138819**	0.02677569	**-0.39111556**	-0.216960934
Coleoptera	-0.29158503	**-0.41999020**	-0.15004296	-0.162294911
Ephemeroptera	-0.29524787	0.18859199	**-0.54044850**	0.004851440
Heteroptera	-0.18336714	**0.33289843**	-0.04151374	**0.677916497**
Hymenoptera	-0.28788880	0.24647803	0.14587287	-0.310485809
Lepidoptera	-0.23309991	0.00981428	**0.57986172**	-0.075859296
Nematocera	**-0.45363421**	0.02550339	-0.05898345	0.086033033
Psocoptera	-0.05866727	**-0.57163427**	-0.06102385	-0.049794624
Sternorrhyncha	**-0.34697813**	-0.27407950	0.26815649	0.008075842
Trichoptera	-0.21108632	**0.43732649**	0.21498856	-0.399698494

Supplementary Table 15: Permutational multivariate analysis of variance (PERMANOVA) Municipal Site Heimbachaue. Results refer to control experiments with conventional and tailored luminaires at the same CCT (Conventional HPS 2000K bow-shaped vs. Tailored LED 2000K), showing differences in community composition between treatments (groups). n=5 samplings between July and October 2022, 4 luminaires per treatment, transition from conventional luminaires (HPS 2000K bow-shaped) to tailored and shielded luminaires (LED 2000K).

~ treatment	Df	Sumsq	R2	F	Pr(>F)
Heimbachaue 2022	1	0. 5234681	0.39048	6. 590974	0. 031*

Supplementary Table 16: Comparison of distances of individual luminaires to group centroids (ANOVA) within treatments (groups) at Heimbachaue. Results refer to control experiments with conventional and tailored luminaires at the same CCT (Conventional HPS 2000K bow-shaped vs. Tailored LED 2000K). n=5 samplings between July and October 2022, 4 luminaires per treatment, transition from conventional luminaires (HPS 2000K bow-shaped) to tailored and shielded luminaires (LED 2000K).

Distances to centroid ~ treatment	Df	Sumsq	Mean Sq	F	Pr(>F)
Heimbachaue 2022	1	0. 009531838	0.015639222	6. 310328	0.04577703*

Supplementary Table 17: Light Characteristics of light treatments at the Experimental field site in Westhavelland. Conventional Low 2021 (LED, 5.6 lx, 3000K), Tailored Low 2022 (LED, 5.2 lx, 3000K).

Parameter	unit	Conventional Low	Tailored Low
luminous flux	lm	691,2	310
dimming	%	16	52
power	W	8,224	19,552
light output	lm/W	84,05	15,86
Upper Light Output Ratio ULOR			
Imax >= 70°	cd/klm	357	33,5
Imax >= 80°	cd/klm	141	3,39
Imax >= 90°	cd/klm	0	0
Treshold Increment TI	%	7	0
Edge llluminance Ratio EIR		0,64	0,05
luminaire distance	m	20	20
luminairehight	m	4,85	4,85
street width	m	2,5	2,5
luminaire arm	m	0,4	0,4
luminaire tilt	°	0	10°
Em path	lx	5,6	5,18
Emin	lx	1,2	1,06
Uo		0,21	0,20
Edge area			
Emax,-2,5m	lx	2,6	0,09
Emin,-2,5m	lx	0,43	0,04
Emax,+2,5m	lx	2,1	0,13
Emin,+2,5m.	lx	1,2	0,1

Supplementary Table 18: Characterization of applied light treatments from 2019 to 2022 at the Experimental field site in Westhavelland.

Treatment	Year	Luminaire	Illuminant	No	Spectrum (K)	Mean lux (Em)	Min lux (Emin)	Sampling events
1. Conventional high	2019	Schreder Teceo	LED	12	3000	30.6	8.5	7
1. Conventional high	2020	Schreder Teceo	LED	12	3000	30.6	8.5	8
2. Conventional low	2021	Schreder Teceo	LED	12	3000	5.6	1.2	15
3. Tailored low	2022	Selux Tal + shield	LED	12	3000	5.2	1.2	16

Supplementary Table 19: Classification scale of protected areas in Baden-Württemberg according to sky brightness. Luminance obtained with an all-sky camera and processed with Sky Quality Camera software (see Material & Methods). Values were categorized in terms of zenith luminance.

Site	Sky brightness (mcd/ m^2)	Pollution class
Westhavelland	0.23 (Milky Way substracted)	Very low
Alter Flugplatz	2.4	extreme
Backofen Riedwiesen	1.6	very high
Heimbachaue	0.29	low

Supplementary Table 20: Classification of light treatments and sampling design at three municipal sites in Baden Württemberg, Southern Germany.

	Alter Flugplatz. Karlsruhe	Backofen Riedwiesen. Brühl	Heimbachaue. Betzweiler
Coordinates	49.02107968828992. 8.37779407517844	49.41185086276461. 8.519436152709618	48.363683514004585. 8.481609229369308
Habitat	Dry and sandy oligotrophic grasslands	Damp meadows, Wet floodplains	Wet Floodplain vegetation, Semi-arid grassland
Traffic usage	Cycle path. No motorized vehicles. pedestrians	Residential street <30km/h. Motorized vehicles + sidewalk	marketplace + parking lot. Slow Motorized vehicles
Pollution class	Extreme	Very high	Low
Light regime	Urban	Peri-urban	Rural
Luminaire Height (m)	4.5	3.5	3.5
No. luminaires per treatment	5	5	4
Sample events	9	7	7
Conventional treatment			
Luminaire	Trilux Lumega 700	Abele Geiger Trend	Hess Barcelona
Illuminant	LED	HPS	HPS
Mean Illuminance (lux)	9.5	3.1	5.1
CCT (K)	4000	2000	2000
Tailored and shielded treatment			
Luminaire	Selux Tal + shield	Selux Tal + shield	Selux Beta + shield
Illuminant	LED	LED	LED
Mean illuminance (lux)	9.2	3.1	5.2
CCT (K)	4000	2700	2700
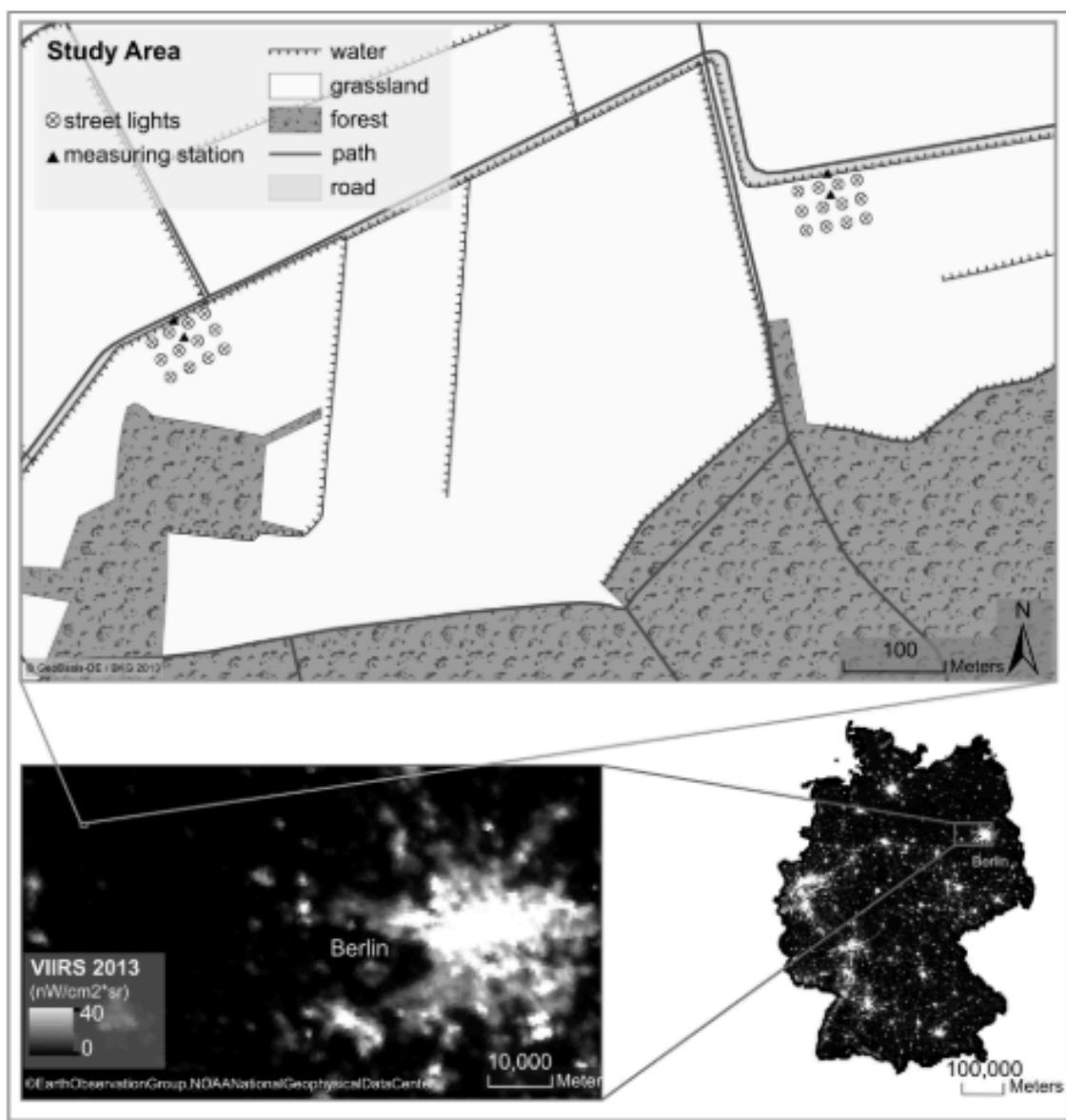
Supplementary Figure 1: Experimental field site Westhavelland derived from Holzhauer et al. 2015[1]. Western field: Lit treatments, n=12 luminaires, Eastern field: dark control treatment, n=12 luminaires.

Supplementary Figure 2: Undimmed Schreder Teceo luminaires (LED, 30.6 lux, CCT 3000K) installed from 2019-2020 on the western field of the Experimental site in Westhavelland. n=12 luminaires.

Supplementary Figure 3: Schreder Teceo LED luminaires equipped with flight interception traps on the western field of the Experimental site in Westhavelland. n=12 luminaires.

606539 Insektenfreundliche Beleuchtung
Gültekin Coskun | 02.09.2021
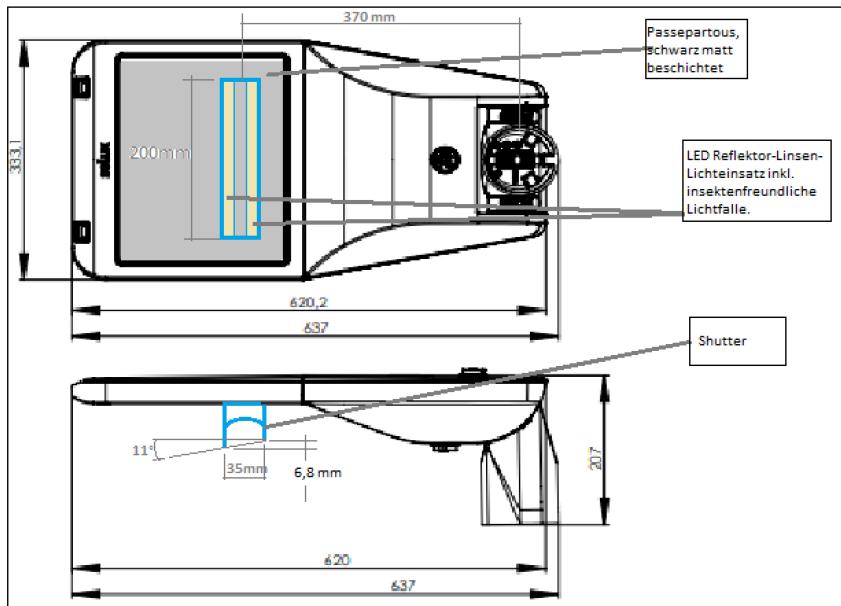
Supplementary Figure 4: Schematic drawing of the tailored and shielded SELUX prototype with external shield © Selux. Coskun Gültekin (top), application at the western field of the Experimental site in Westhavelland (bottom). n=12 luminaires.
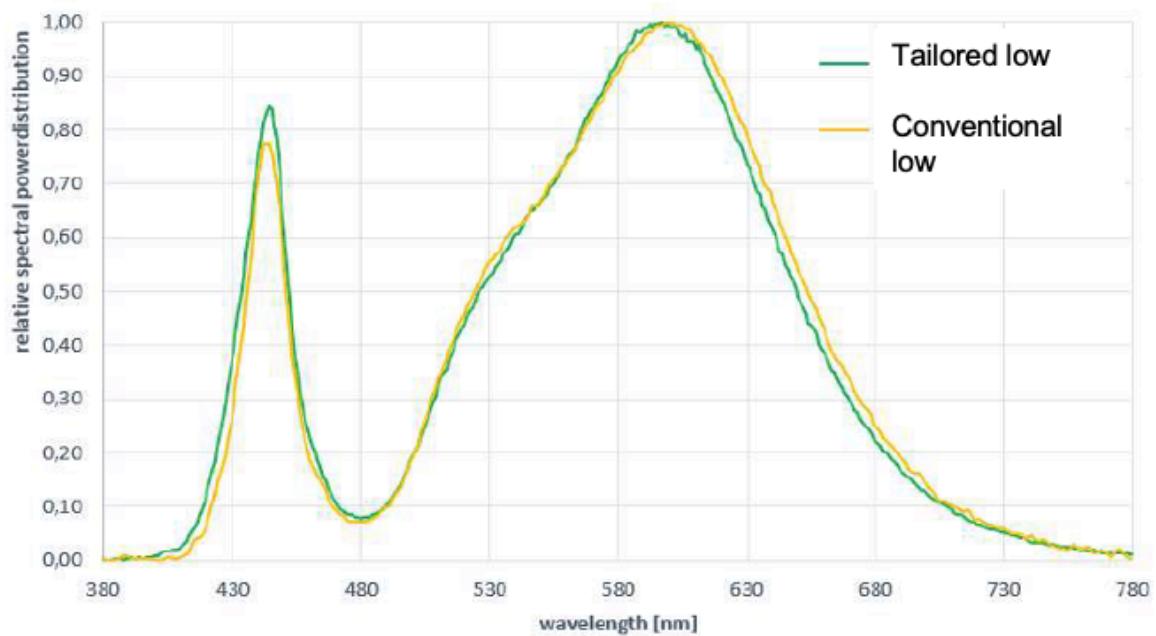
Supplementary Figure 5: Spectra of luminaires on the western field of the Experimental site in Westhavelland. Conventional low 2021: second treatment, Schreder Teceo luminaires (LED, E_m=5.6 lx, CCT 3000K). Tailored low 2022: third treatment, Selux Tal (LED, E_m=5,2 lx, CCT 3000K).

Supplementary Figure 6: Luminance measurements of luminaires at the Municipal Site Alter Flugplatz. Conventional luminaires (LED, E $_m$ = 9.5 lx, CCT 4000K) (left) and tailored and shielded luminaires (LED, E $_m$ = 9.2 lx, CCT 4000K) (right), n=9 samplings, 5 luminaires per treatment.
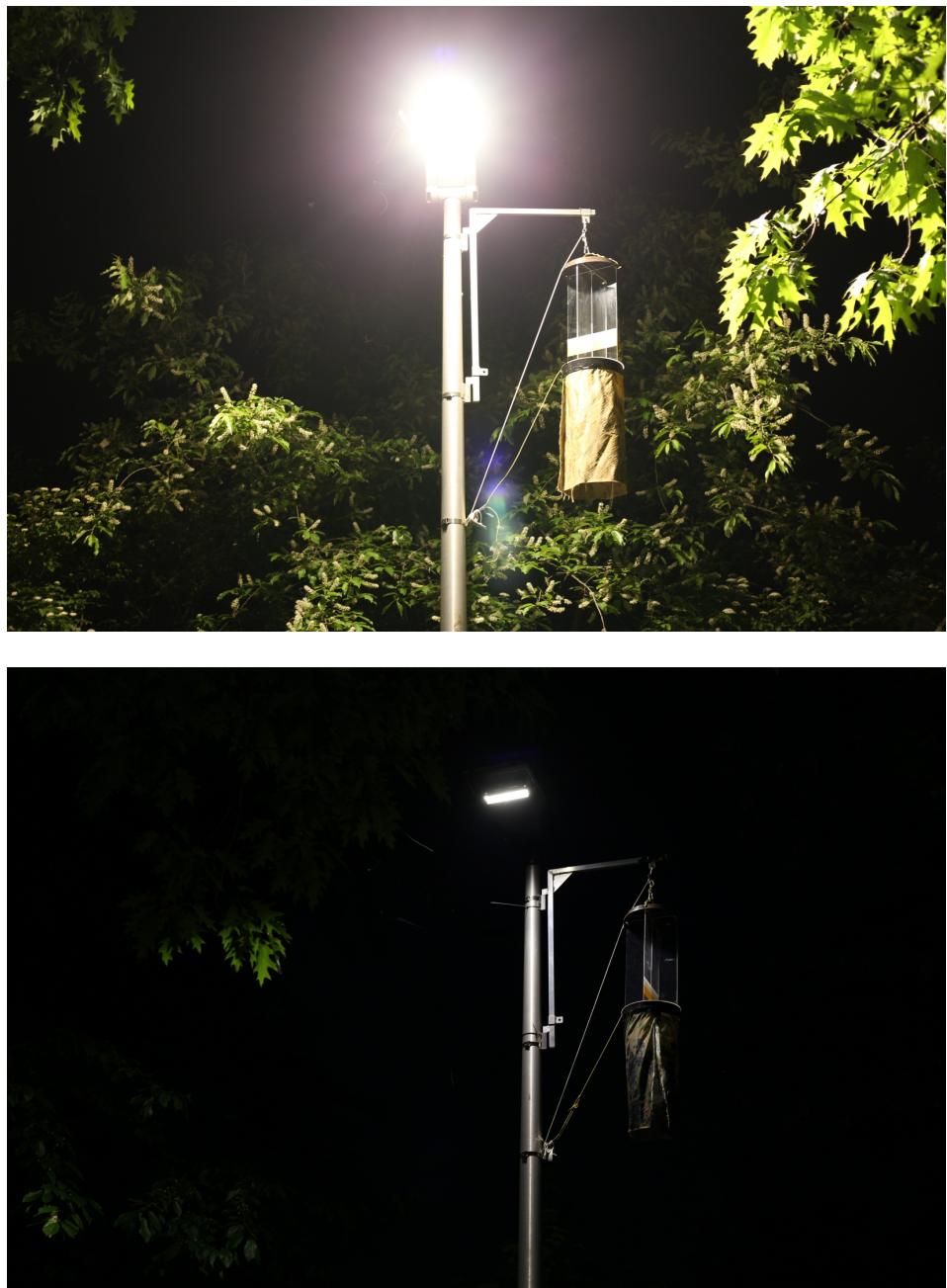
Supplementary Figure 7: Road lights at the Municipal Site Alter Flugplatz. Photos were taken at the same distance to luminaires. Conventional luminaires (LED, E_m = 9.5 lx, CCT 4000K) (top) and tailored and shielded luminaires (LED, E_m = 9.2 lx, CCT 4000K) (bottom). n=9 samplings, 5 luminaires per treatment.
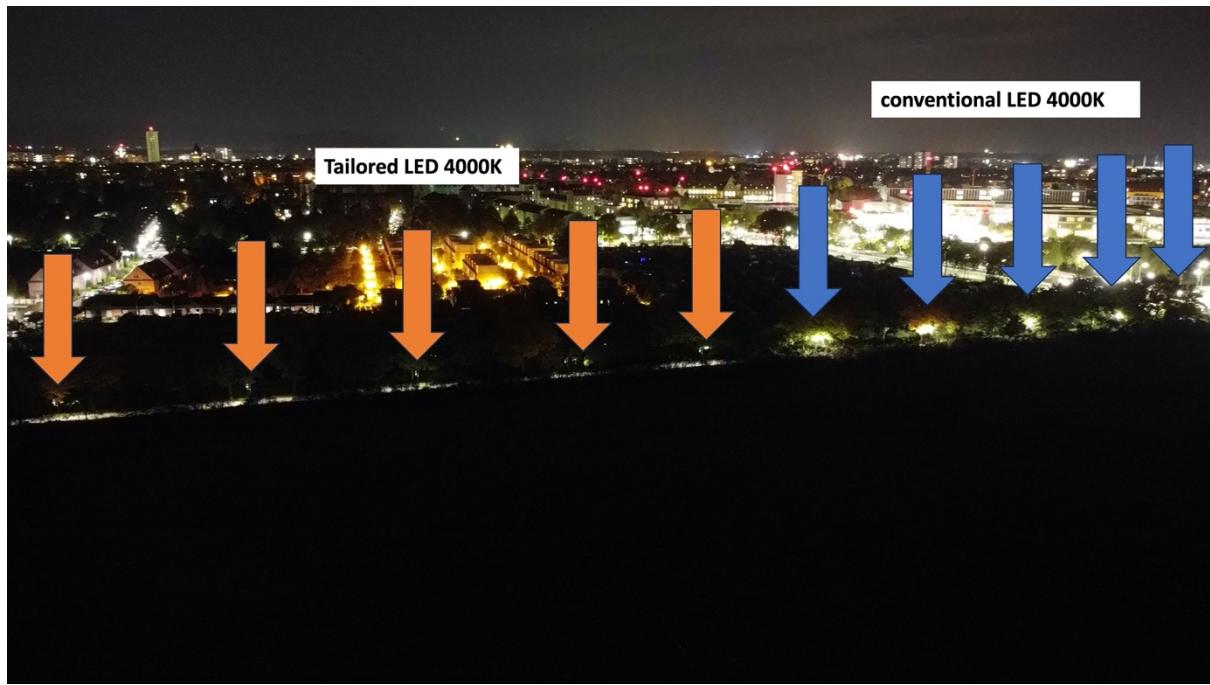
Supplementary Figure 8: Road lights at the Municipal Site Alter Flugplatz. Tailored and shielded luminaires (LED, E_m = 9.2 lx, CCT 4000K), n=5 (orange arrows). Conventional luminaires (LED, E_m = 9.5 lx, CCT 4000K), n=5 (blue arrows). Photos captured by drone from within the nature reserve.
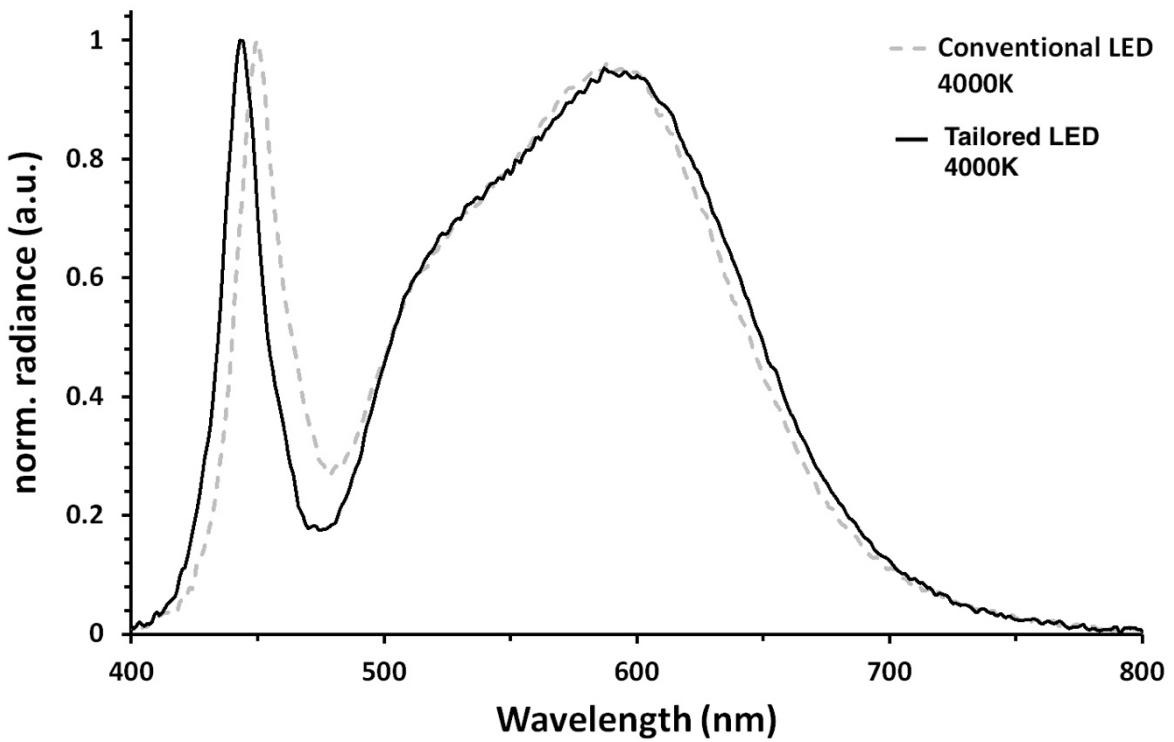
Supplementary Figure 9: Spectra of luminaires at the Municipal Site Alter Flugplatz.

Tailored and shielded luminaires (LED, E_m = 9.2 lx, CCT 4000K). Conventional luminaires (LED, E_m = 9.5 lx, CCT 4000K).
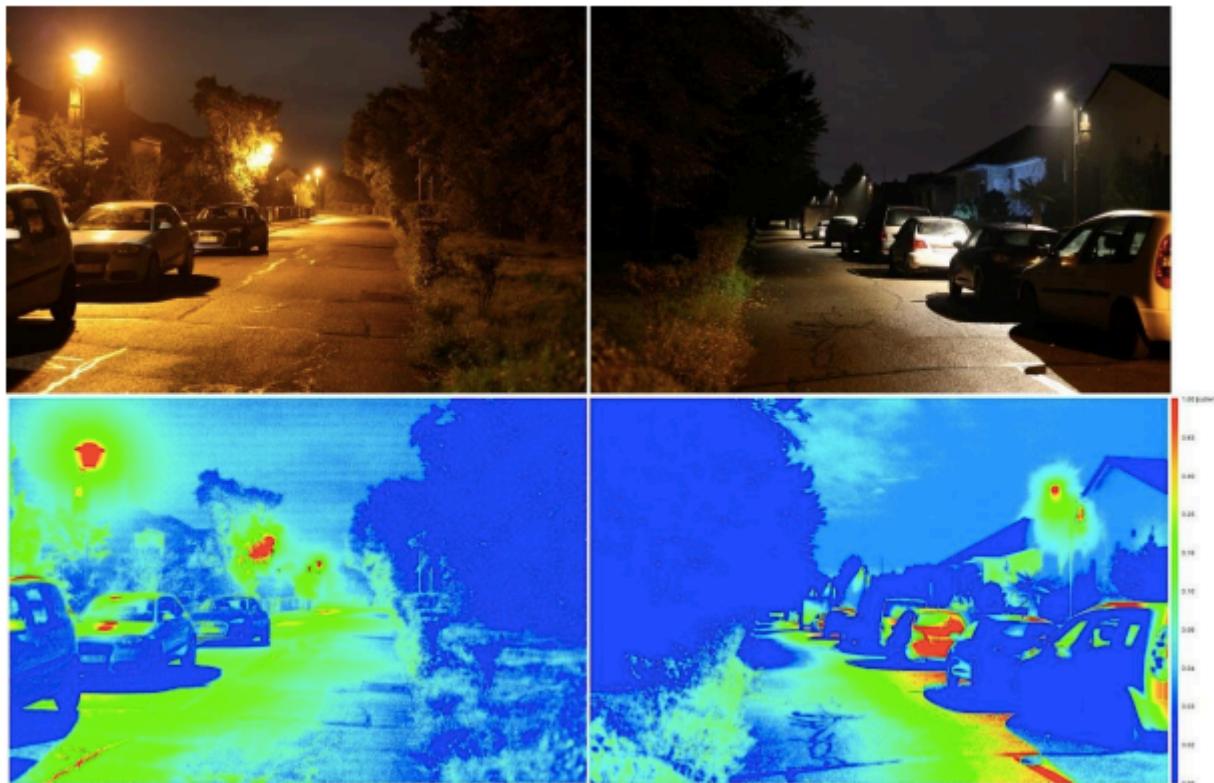
Supplementary Figure 10: Luminance measurements of luminaires at the Municipal Site Backofen Riedwiesen. Conventional luminaires (HPS cylinder, E $_m$ = 3.1 lx, CCT 2000K) (left) and tailored and shielded luminaires (LED, E $_m$ = 3.1 lx, CCT 2700K) (right). n=7 samplings, 5 luminaires per treatment.

Supplementary Figure 11: Road lights at the Municipal Site Backofen Riedwiesen. Photos were taken from the same distance to luminaires. Conventional luminaires (HPS cylinder, E_m = 3.1 lx, CCT 2000K) (top) and tailored and shielded LED luminaires (E_m = 3.1 lx, CCT 2700K) (bottom). n=7 samplings, 5 luminaires per treatment.
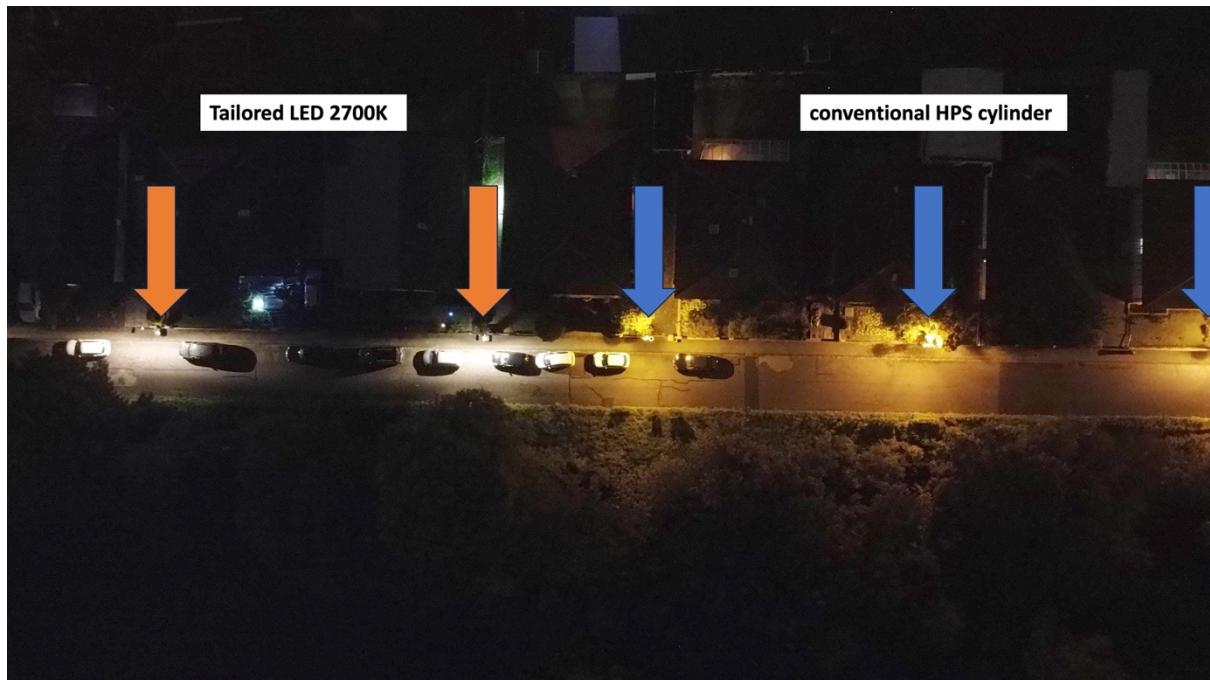
Supplementary Figure 12: Road lights at the Municipal Site Backofen Riedwiesen.

Tailored and shielded luminaires (LED, E $_m$ = 3.1 lx, CCT 2700K) n=5 (orange arrows).

Conventional luminaires (HPS cylinder, E $_m$ = 3.1 lx, CCT 2000K) n=5 (blue arrows). Photos

captured by drone.
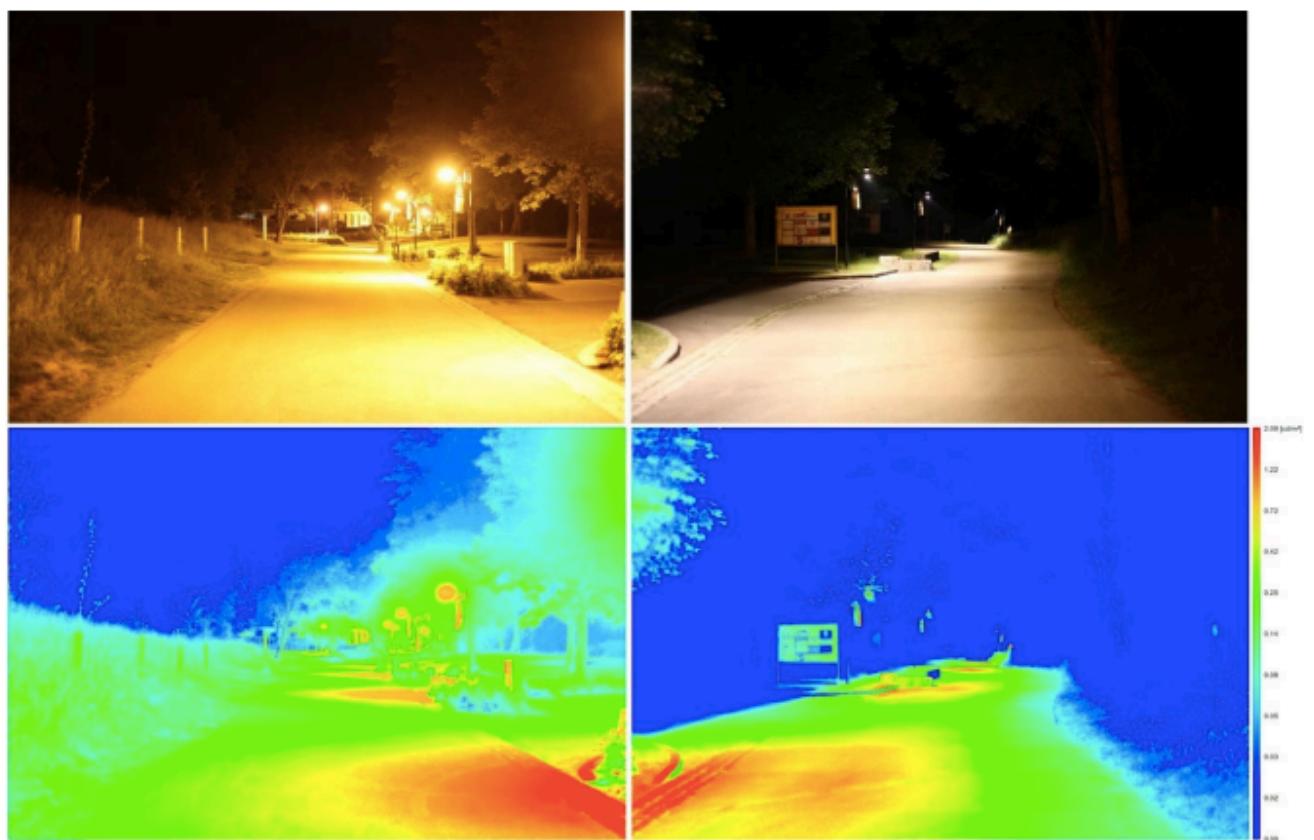
Supplementary Figure 13: Luminance measurements of luminaires at the Municipal Site Heimbachaue. Conventional luminaires (HPS bow-shaped, E $_m$ = 5.1 lx, CCT 2000K) (left) and tailored and shielded luminaires (LED, E $_m$ = 5.1 lx, CCT 2700K) (right). n=7 samplings, 4 luminaires per treatment.
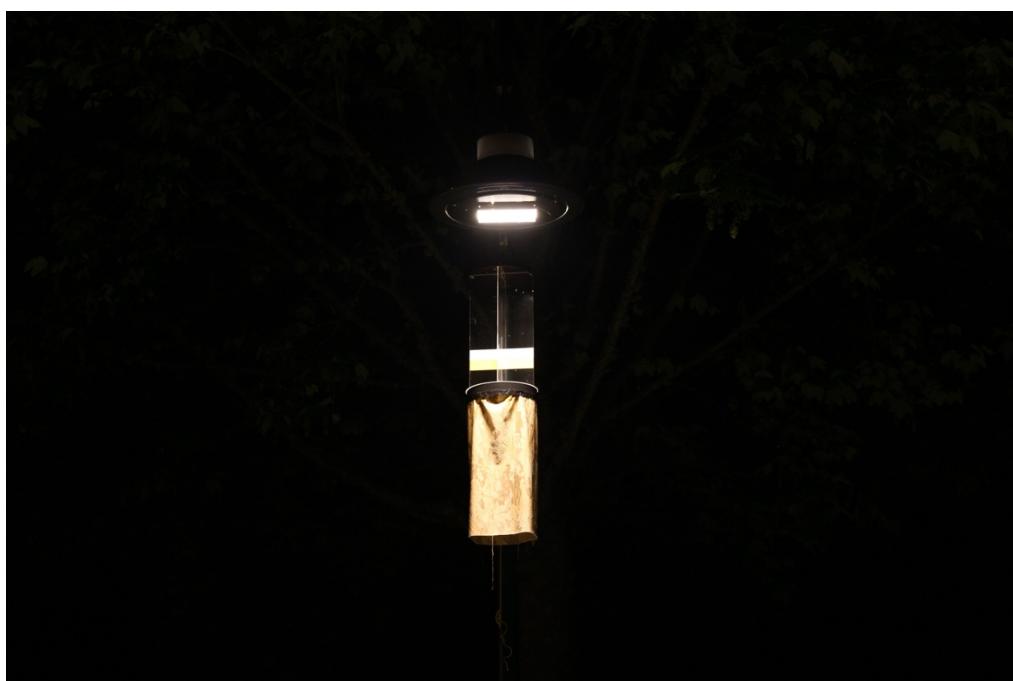
Supplementary Figure 14: Road lights at the Municipal Site Heimbachaue. Photos were taken from the same distance to luminaire. Conventional luminaires (HPS bow-shaped, E_m = 5.1 lx, CCT 2000K) (top) and tailored and shielded luminaires (LED, E_m = 5.1 lx, CCT 2700K) (bottom). n=7 samplings, 4 luminaires per treatment.
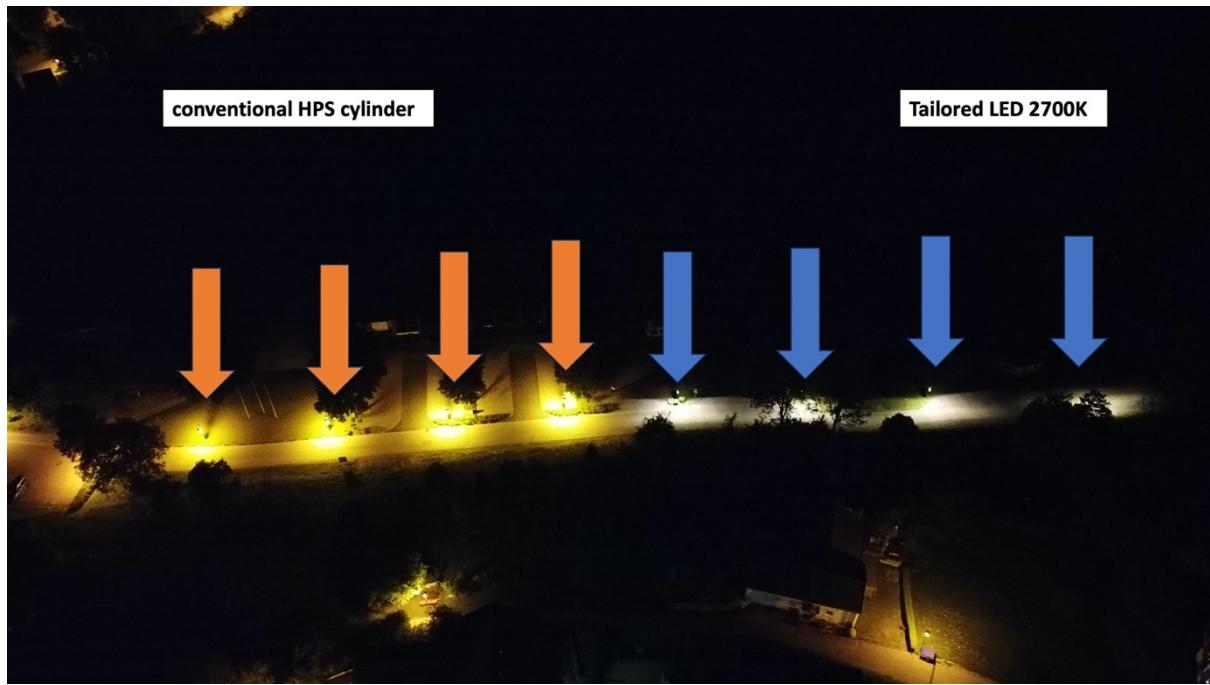
Supplementary Figure 15: Road lights at the Municipal Site Heimbachaue. Tailored and shielded luminaires (LED, E $_m$ = 5.1 lx, CCT 2700K) n=4 (blue arrows). Conventional luminaires (HPS bow-shaped, E $_m$ = 5.1 lx, 2000K) n=4 (orange arrows). Photos captured by drone.
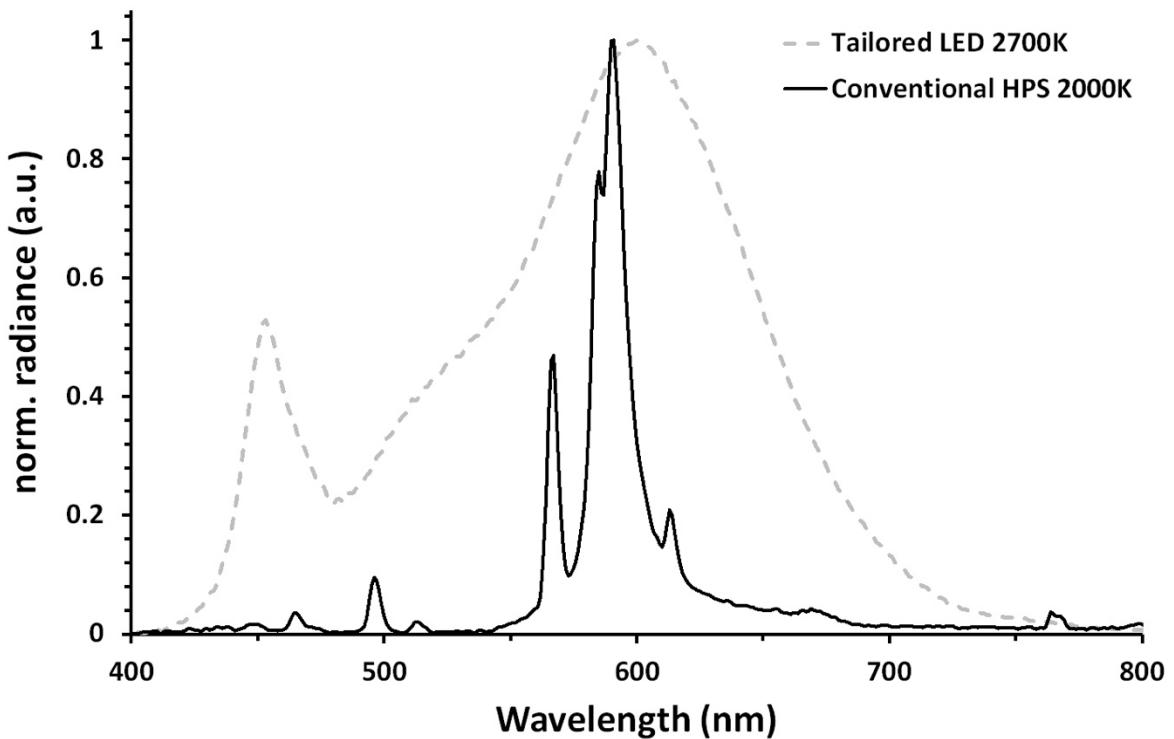
Supplementary Figure 16: Spectra of luminaires at the Municipal Site Heimbachaue.

Tailored and shielded luminaires (LED, E $_m$ = 5.1 lx, CCT 2700K). Conventional luminaires

(HPS bow-shaped, E $_m$ = 5.1 lx, 2000K).
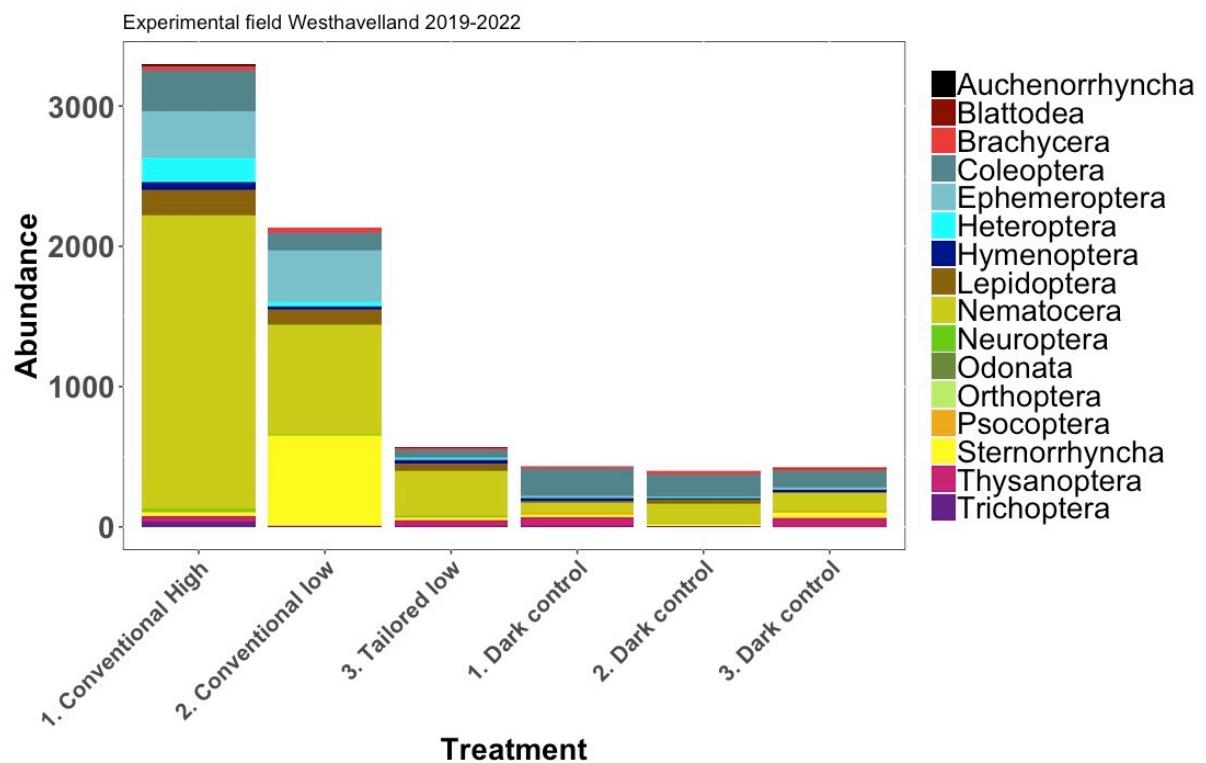
Supplementary Figure 17: Total insect abundance (individuals) in different treatments at the experimental field site in Westhavelland. Treatment numbers refer to treatments of the same years. 1: Conventional High 2019-2020 (n=14 samplings, LED 30.6 lx 3000K). 2: Conventional Low 2021 (n=15 samplings, LED 5.6 lx 3000K). 3: Tailored Low 2022 (n=16 samplings, LED 5.2 lx 3000K). Dark controls were sampled simultaneously to the lit treatments.
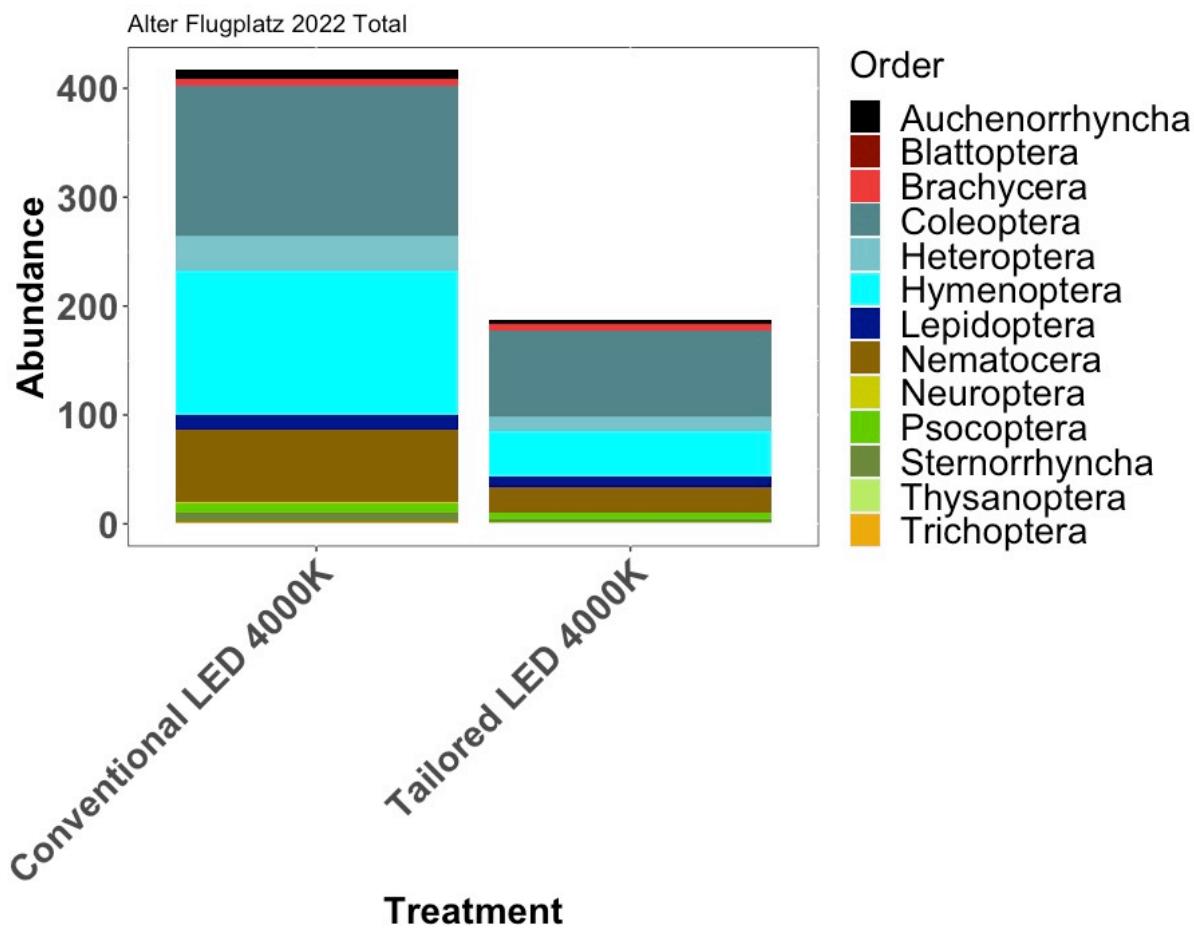
Supplementary Figure 18: Total insect abundance (individuals) in different light treatments at the municipal site Alter Flugplatz. n=9 samplings, 5 luminaires per treatment, transition from conventional (LED 4000K) luminaires to tailored and shielded luminaires (LED 4000K).
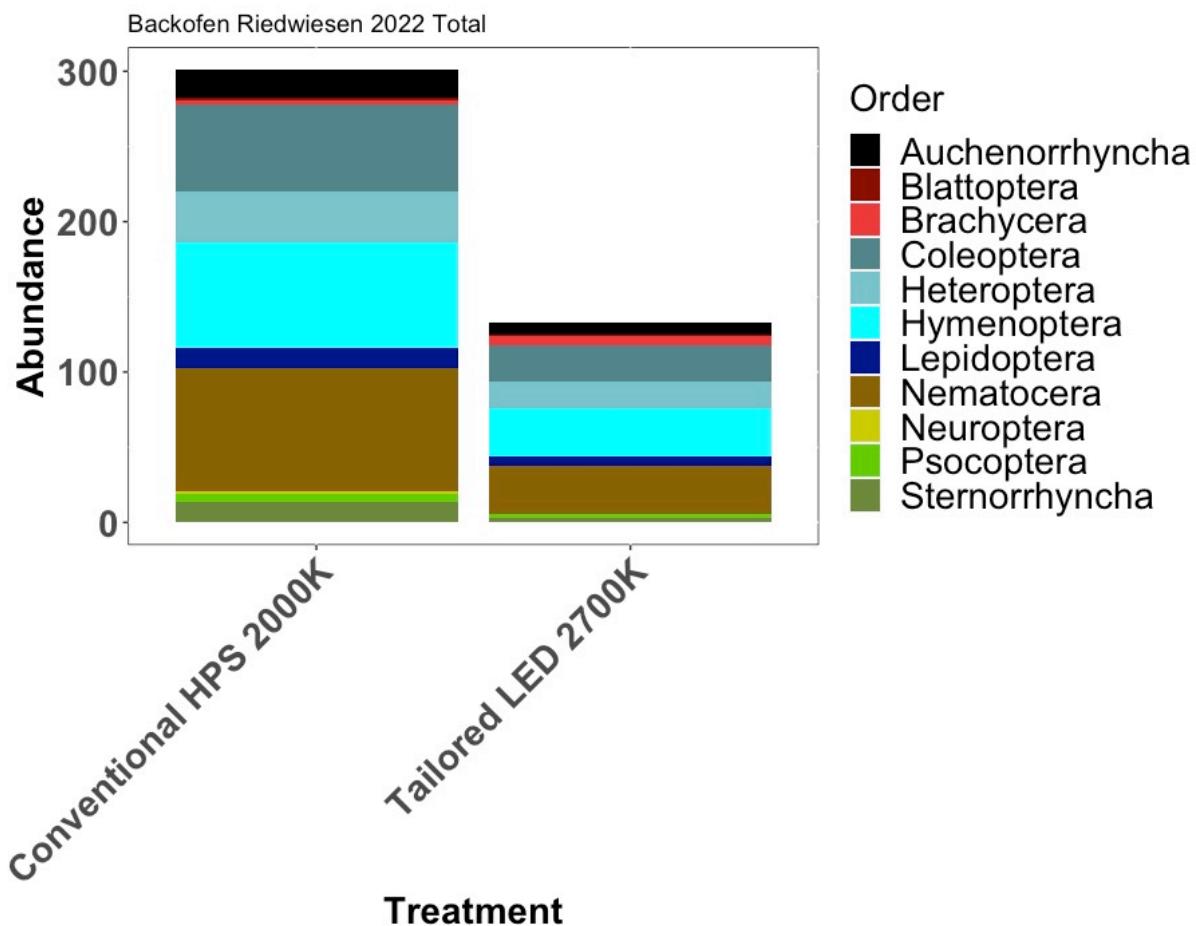
**Supplementary Figure 19: Total insect abundance (individuals) in different light treatments at the municipal site Backofen Riedwiesen.** n=7 samplings, 5 luminaires per treatment, transition from conventional (HPS 2000K cylinder) luminaires to tailored and shielded luminaires (LED 2700K).
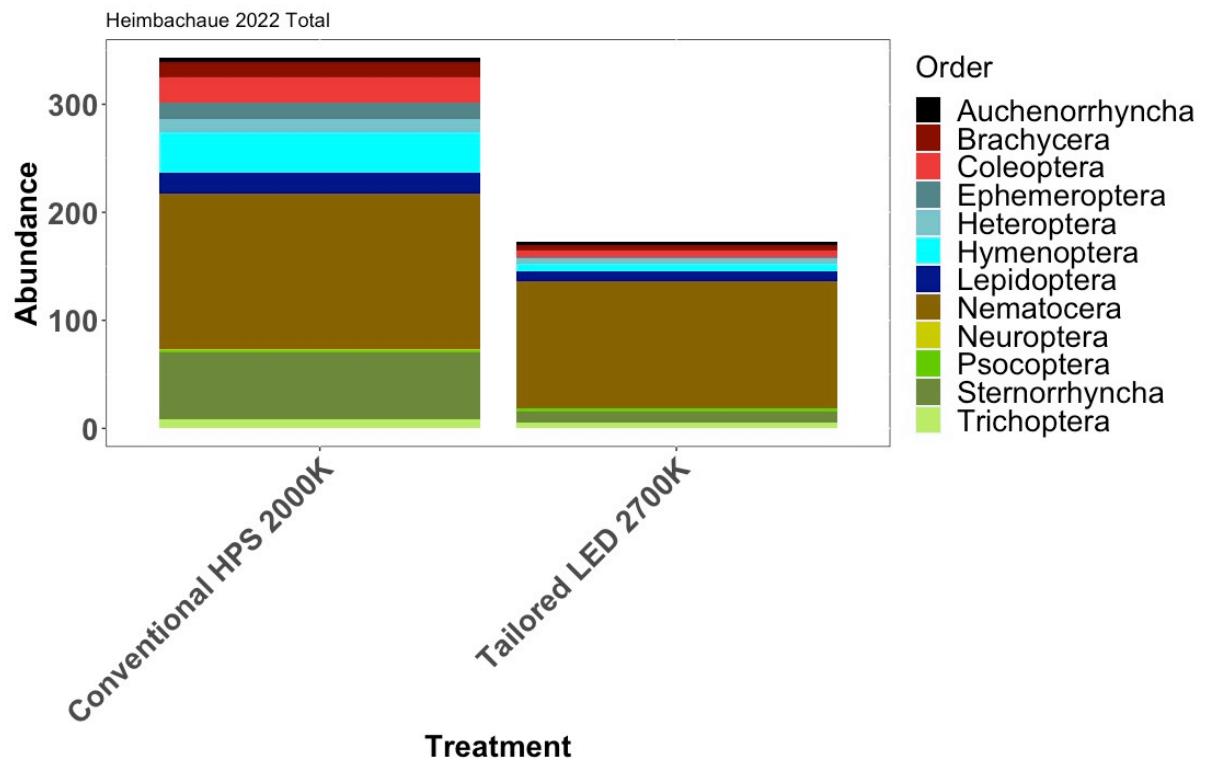
Supplementary Figure 20: Total insect abundance (individuals) in different light treatments at the municipal site Heimbachaue. n=7 samplings, 4 luminaires per treatment, transition from conventional (HPS 2000K bow-shaped) luminaires to tailored and shielded luminaires (LED 2700K).
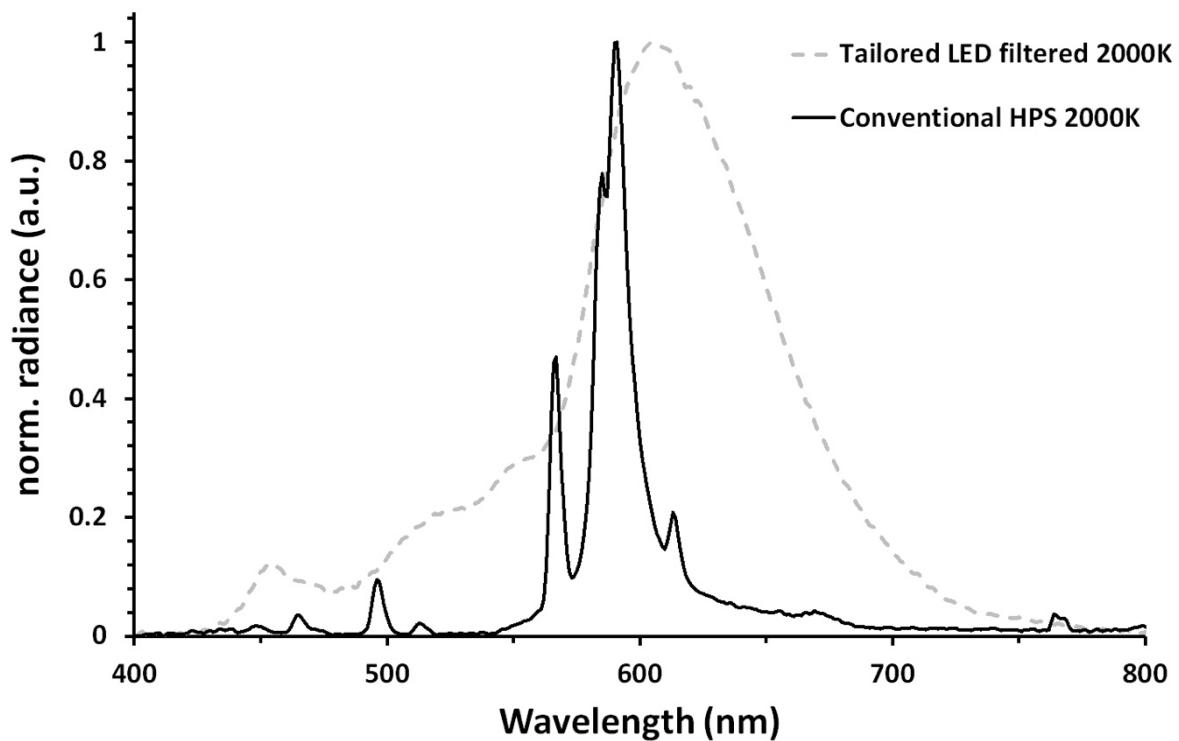
Supplementary Figure 21: Spectra of luminaires at the Municipal Site Heimbachaue in 5 additional control nights with conventional and tailored LED at the same CCT (2000K).
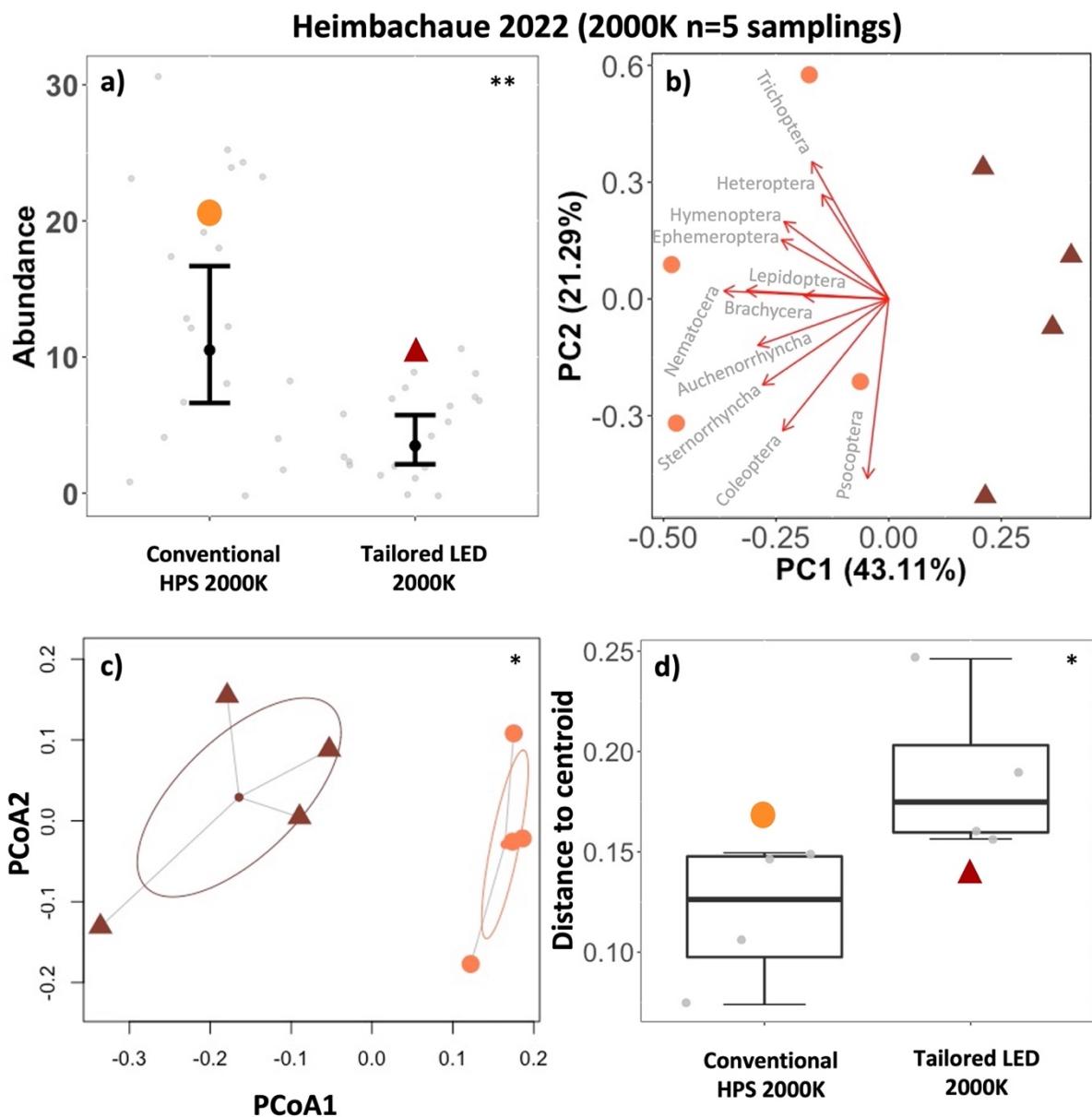
Supplementary Figure 22: Rural municipal site, Heimbachaue, Betzweiler. Control experiments with tailored and shielded LED with a CCT of 2000K instead of 2700K (Conventional HPS 2000K bow-shaped vs. Tailored LED 2000K) **a)** Total number of individuals per road light and night (Abundance) (grey points) in different treatments (symbols). n=5 samplings, 4 luminaires per treatment, transition from conventional luminaires (HPS 2000K) to tailored and shielded luminaires (LED 2000K). Predictions (black points) and 95% confidence intervals (error bars) based on a generalized linear regression model (p<0.001`***) (abundance ~ Luminaire + mean temperature + mean wind speed +

(1|trap_number) + (1|starting_date), family=nbinom1) **b)** PCA Principal component analysis of multiple luminaires (n=4) grouped by treatment (symbols). Arrows depict loadings of individual insect taxa **c)** PERMANOVA Permutational Multivariate Analysis of Variances (df=1, R^2= 0.323, F= 6.590, p= 0.035 *) of multiple luminaires grouped by treatment (symbols). Ellipses based on SD **d)** Within group dispersion (community dispersion) of luminaires in the same treatment (ANOVA p=0.045 *). Distances to centroids (grey points). Boxplots show median (thick line), interquartile range (IQR) (box), outliers (black points), 1.5 x IQR (whiskers).
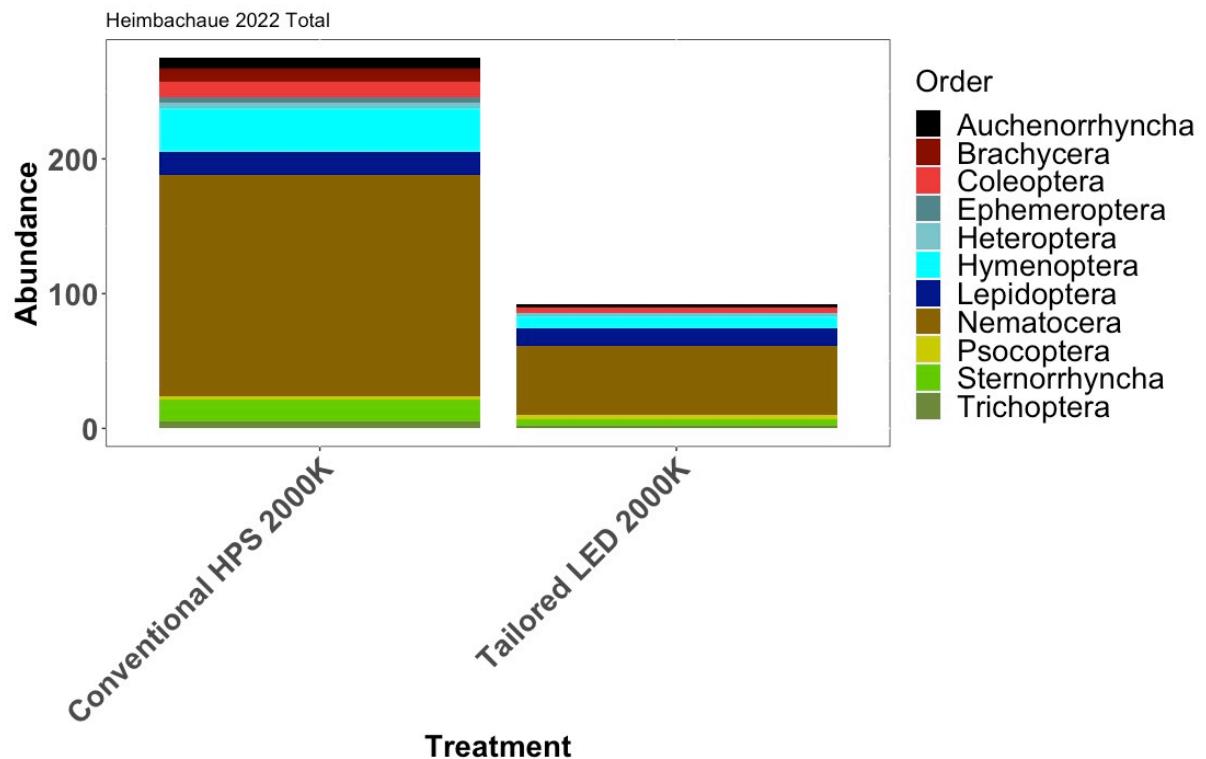
Supplementary Figure 23: Total insect abundances in additional control experiments at the municipal site Heimbachaue with the same colour temperature between treatments (Conventional HPS 2000K bow-shaped vs. Tailored LED 2000K). n=5 samplings, 4 luminaires per treatment, transition from conventional (HPS 2000K bow-shaped) luminaires to tailored and shielded luminaires (LED 2000K).
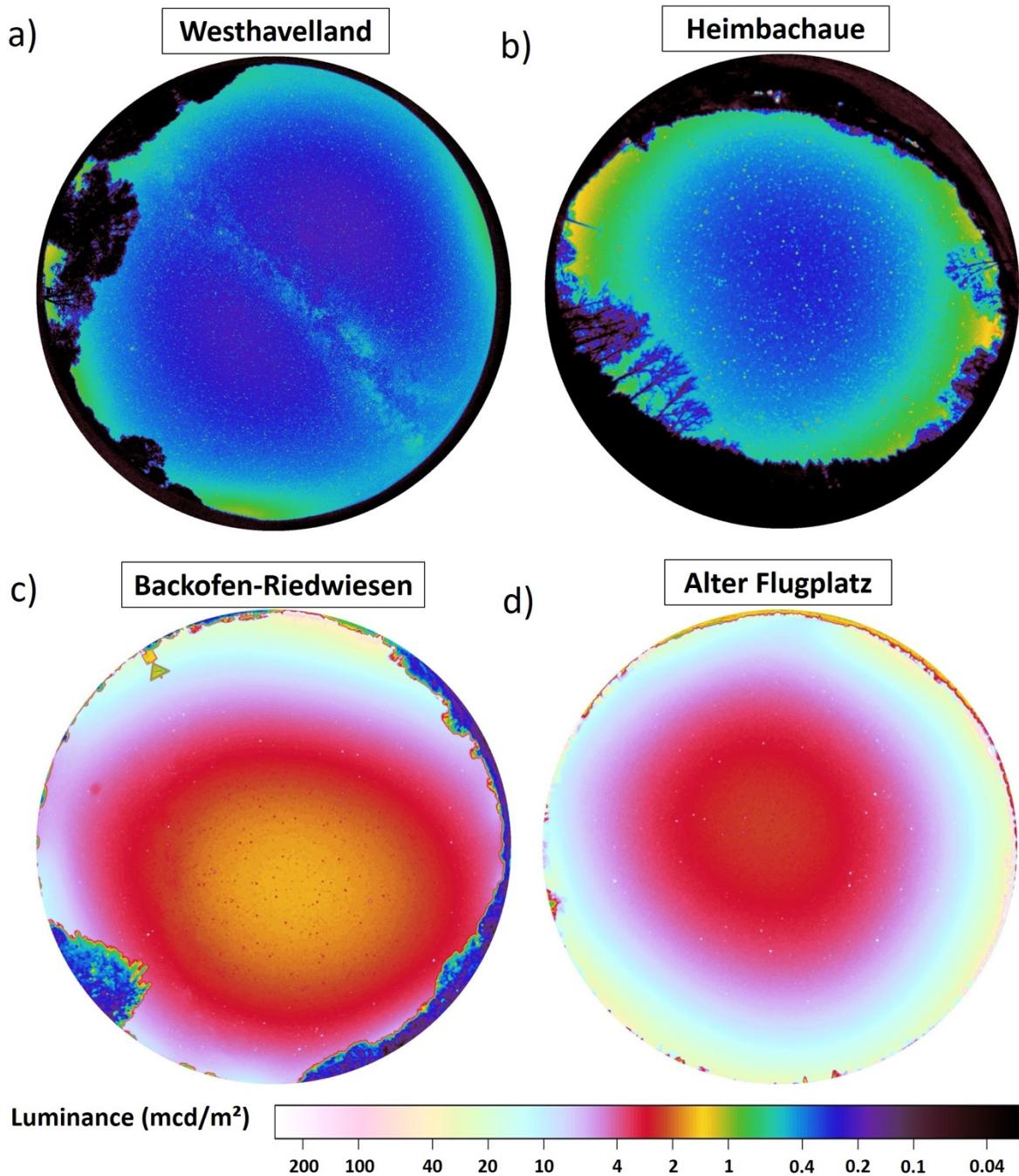
Supplementary Figure 24: The four images show luminance maps obtained with an all-sky camera and processed with Sky Quality Camera software (see methods). Values were categorized in terms of zenith luminance. **a)** Westhavelland with very low skyglow 0.23 mcd/m² (Milky Way subtracted), **b)** Heimbachaue with low skyglow 0.29 mcd/m², **c)** Backofen-Riedwiesen with very high skyglow 1.6 mcd/m² and **d)** Alter Flugplatz Karlsruhe with extreme skyglow 2.4 mcd/m². Photos © Andreas Jechow.

Supplementary References

1.   Holzhauer. S. I. J. *et al.* Out of the dark: Establishing a large-scale field experiment to assess the effects of artificial light at night on species and food webs. *Sustain.* **7**. 15593–15616 (2015).