

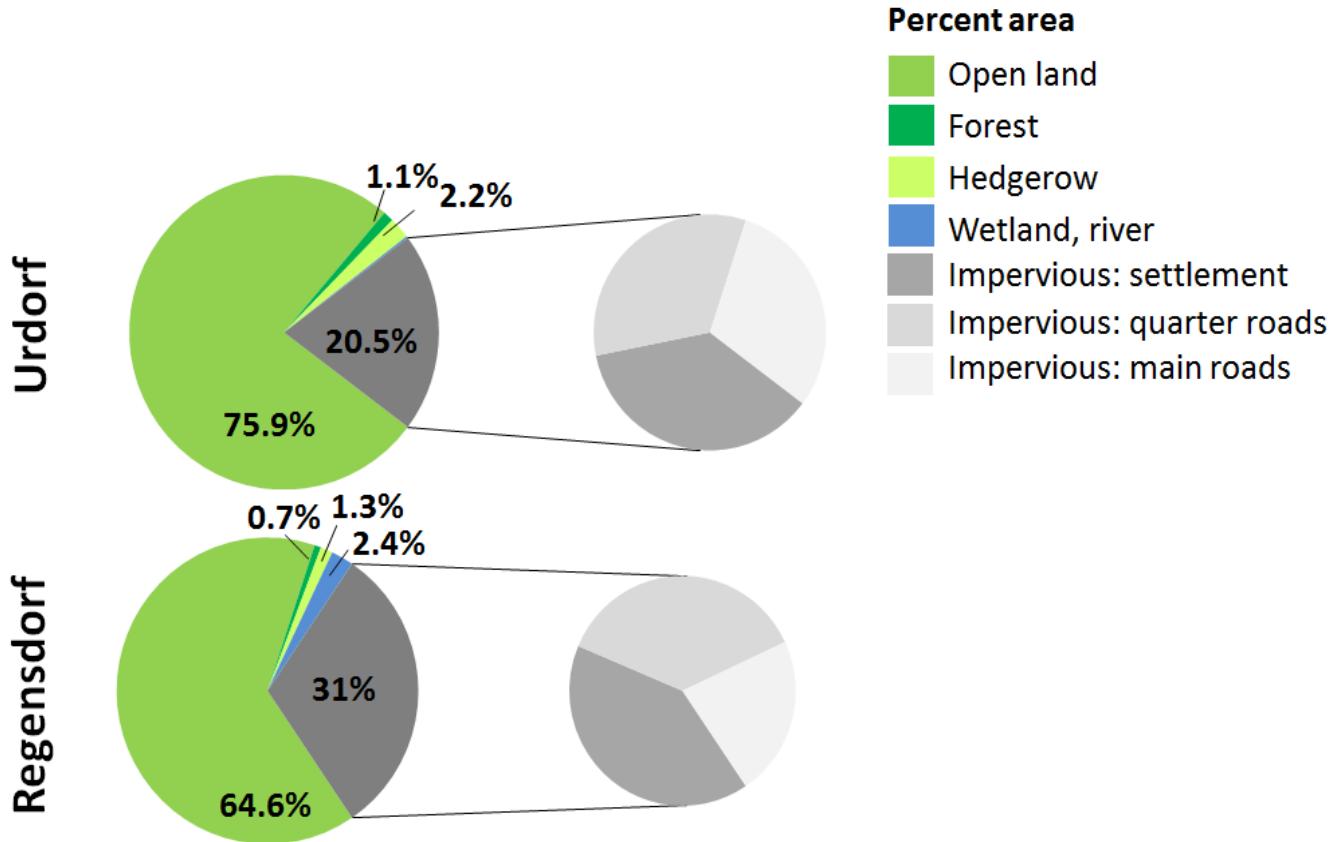
Appendix A

Fig. 1. Experimental set up in (A) Urdorf: 10 LED street lights of the type Schréder, Teceo 2, 4150 K and 5 batloggers; (B) Regensdorf: 10 street lights of the type Philips, Modalux-Speedstar BGP 322, 4000K and 5 batloggers. Location of street light poles (green dots) and batloggers (red cross). Image source: Google maps 2019; (C) surrounding land use (within 100 m of the investigated street lights).



dimmed light	3.5.- 5.5. 2017	full light	24.5.-25.5. 2017
	16.5.-19.5. 2017		15.6.-16.6. 2017
	30.5.-2.6. 2017		20.6.-23.6. 2017
	27.6.-28.6. 2017		4.7.-7.7. 2017
	17.7.-19.7. 2017		11.7.-14.7. 2017

(C)



Appendix B. Table 1. Final species verifications, taxonomic level of verification, guild assignment (according Frey-Ehrenbold, Bontadina, Arlettaz & Obrist 2013) and lowest Red List status (Bohnenstengel et al. 2014) deduced from the status of single species possibly contained in the Taxon (Contains1 - 5, LR1 - 5). Sequences only assigned to Chiroptera were not assigned to a guild.

Taxon	Taxon Level	Guild	RL	Contains1	RL1	Contains2	RL2	Contains3	RL3	Contains4	RL4	Contains5	RL5
Chiroptera spec.	order	-	LC_5										
<i>Eptesicus nilssonii</i>	species	LRE	VU_3										
<i>Eptesicus serotinus</i>	species	LRE	VU_3										
<i>Eptesicus spec.</i>	genus	LRE	VU_3	<i>Eptesicus serotinus</i>	VU_3	<i>Eptesicus nilssonii</i>	VU_3						
<i>Eptesicus/Hypsugo</i>	genus group	MRE	NT_4	<i>Eptesicus serotinus</i>	VU_3	<i>Eptesicus nilssonii</i>	VU_3	<i>Hypsugo savii</i>	NT_4				
<i>Eptesicus/Vespertilio/ Nyctalus</i>	genus group	LRE	NT_4	<i>Eptesicus serotinus</i>	VU_3	<i>Eptesicus nilssonii</i>	VU_3	<i>Nyctalus leisleri</i>	NT_4	<i>Nyctalus noctula</i>	NT_4	<i>Vespertilio murinus</i>	VU_3
<i>Hypsugo savii</i>	species	MRE	NT_4										
<i>Myotis bechsteinii</i>	species	SRE	VU_3										
<i>Myotis brandtii</i>	species	SRE	VU_3										
<i>Myotis brandtii/daubentonii</i>	species group	SRE	NT_4	<i>Myotis brandtii</i>	VU_3	<i>Myotis daubentonii</i>	NT_4						
<i>Myotis daubentonii</i>	species	SRE	NT_4										
<i>Myotis daubentonii/emarginatus</i>	species group	SRE	NT_4	<i>Myotis daubentonii</i>	NT_4	<i>Myotis emarginatus</i>	EN_2						
<i>Myotis</i>	species	SRE	LC_5	<i>Myotis</i>	NT_4	<i>Myotis</i>	LC_5						

<i>daubentonii/mystacinus</i>	group			<i>daubentonii</i>		<i>mystacinus</i>							
<i>Myotis emarginatus</i>	species	SRE	EN_2										
<i>Myotis emarginatus/brandtii</i>	species group	SRE	VU_3	<i>Myotis emarginatus</i>	EN_2	<i>Myotis brandtii</i>	VU_3						
<i>Myotis myotis</i>	species	SRE	VU_3										
<i>Myotis mystacinus</i>	species	SRE	LC_5										
<i>Myotis mystacinus/emarginatus</i>	species group	SRE	LC_5	<i>Myotis mystacinus</i>	LC_5	<i>Myotis emarginatus</i>	EN_2						
<i>Myotis spec.</i>	genus	SRE	VU_3										
<i>Nyctalus leisleri</i>	species	LRE	NT_4										
<i>Nyctalus leisleri/Vespertilio murinus</i>	genus group	LRE	NT_4	<i>Nyctalus leisleri</i>	NT_4	<i>Vespertilio murinus</i>	VU_3						
<i>Nyctalus noctula</i>	species	LRE	NT_4										
<i>Nyctalus spec.</i>	genus	LRE	NT_4	<i>Nyctalus leisleri</i>	NT_4	<i>Nyctalus noctula</i>	NT_4						
<i>Nyctalus/Vespertilio</i>	genus group	LRE	NT_4	<i>Nyctalus leisleri</i>	NT_4	<i>Nyctalus noctula</i>	NT_4	<i>Vespertilio murinus</i>	VU_3				
<i>Pipistrellus kuhlii</i>	species	MRE	LC_5										
<i>Pipistrellus nathusii</i>	species	MRE	LC_5										
<i>Pipistrellus nathusii/kuhlii</i>	species group	MRE	LC_5	<i>Pipistrellus kuhlii</i>	LC_5	<i>Pipistrellus nathusii</i>	LC_5						
<i>Pipistrellus pipistrellus</i>	species	MRE	LC_5										
<i>Pipistrellus pipistrellus/nathusii</i>	species group	MRE	LC_5	<i>Pipistrellus pipistrellus</i>	LC_5	<i>Pipistrellus nathusii</i>	LC_5						
<i>Pipistrellus pygmaeus</i>	species	MRE	NT_4										
<i>Pipistrellus</i>	species	MRE	LC_5	<i>Pipistrellus</i>	LC_5	<i>Pipistrellus</i>	NT_4						

<i>pygmaeus/pipistrellus</i>	group			<i>pipistrellus</i>		<i>pygmaeus</i>							
<i>Pipistrellus spec.</i>	genus	MRE	LC_5										
<i>Pipistrellus/Hypsugo</i>	genus	MRE	LC_5										
<i>Pipistrellus/Miniopterus</i>	genus	MRE	LC_5										
<i>Pipistrellus/Myotis</i>	genus	-	LC_5										
<i>Plecotus spec.</i>	genus	SRE	VU_3	<i>Plecotus auritus</i>	VU_3	<i>Plecotus austriacus</i>	CR_1	<i>Plecotus macrobullaris</i>	EN_2				
<i>Vespertilio murinus</i>	species	LRE	VU_3										

References:

- Bohnenstengel, T., Krättli, H., Obrist, M.K., Bontadina, F., Jaberg, C., Ruedi, M., & Moeschler, P. (2014). *Rote Liste Fledermäuse. Gefährdete Arten der Schweiz, Stand 2011*. Bern; Genève: Bundesamt für Umwelt; Centre de Coordination Ouest pour l'étude et la protection des chauves-souris.
- Frey-Ehrenbold, A., Bontadina, F., Arlettaz, R., & Obrist, M.K. (2013). Landscape connectivity, habitat structure and activity of bat guilds in farmland-dominated matrices. *Journal of Applied Ecology*, 50, 252-261.

Appendix C. Table 1. VIF of explanatory variables (fixed effects) for insect models. Light regime (full light, dimmed light), precipitation sum (sum of nightly precipitation), mean temperature (mean nightly temperature), site (Regensdorf, Urdorf).

(A) All insects

Explanatory variables	VIF
Light regime	1.16
Precipitation sum	1.12
Mean temperature	1.10
Site	1.02

(B) Coleoptera

Explanatory variables	VIF
Light regime	1.12
Precipitation sum	1.10
Mean temperature	1.08
Site	1.02

(C) Diptera

Explanatory variables	VIF
Light regime	1.29
Precipitation sum	1.20
Mean temperature	1.85
Site	1.02

(D) Heteroptera

Explanatory variables	VIF
Light regime	1.15
Precipitation sum	1.16
Mean temperature	1.09
Site	1.01

E) Hy

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era

Explanatory variables	VIF
Light regime	1.14
Precipitation sum	1.11
Mean temperature	1.09
Site	1.03

(F) Oth

ers

Explanatory variables	VIF
Light regime	1.22
Precipitation sum	1.19
Mean temperature	1.14
Site	1.00

Appendix C. Table 2. VIF of explanatory variables (fixed effects) for bat models. Light regime (full light, dimmed light), precipitation sum (sum of nightly precipitation), mean temperature (mean nightly temperature), insect biomass (sum of nightly insect dry biomass), site (Regensdorf, Urdorf). Guilds are (B – D) LRE: long-range echolocators, MR: mid-range echolocators, SRE: short-range echolocators; Red List categories (E - G: LC: least concern, VU: vulnerable, NT: near-threatened).

(A) All bats

Explanatory variables	VIF
Light regime	1.18
Precipitation sum	1.14
Mean temperature	1.2
Insect biomass	1.06
Site	1.1

(B) LRE

Explanatory variables	VIF
Light regime	1.19
Precipitation sum	1.26
Mean temperature	1.34
Insect biomass	1.09
Site	1.1

(C) MRE

Explanatory variables	VIF
Light regime	1.16
Precipitation sum	1.07
Mean temperature	1.09
Insect biomass	1.06
Site	1.1

(D) SRE

Explanatory variables	VIF
Light regime	1.28
Precipitation sum	1.25
Mean temperature	1.2
Insect biomass	1.14
Site	1.0

(E) LC

Explanatory variables	VIF
Light regime	1.1
Precipitation sum	1.1
Mean temperature	1.1
Insect biomass	1.0
Site	1.1

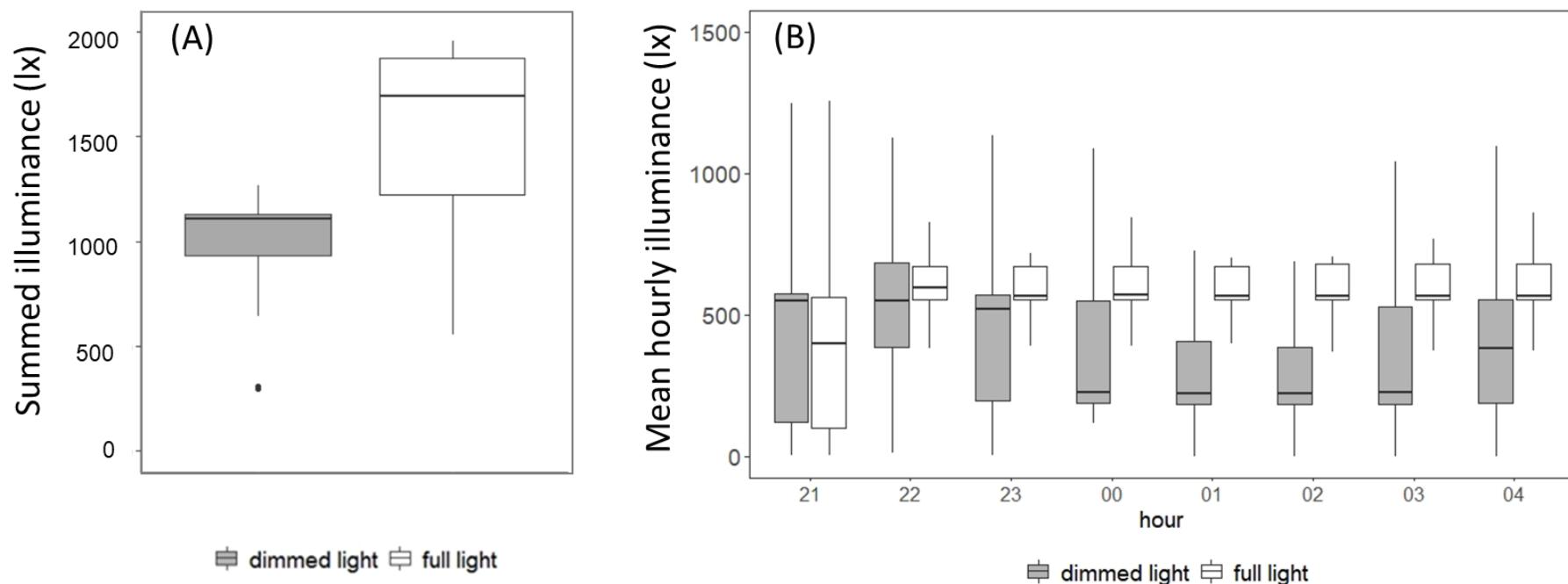
(F) VU

Explanatory variables	VIF
Light regime	1.3
Precipitation sum	1.2
Mean temperature	1.2
Insect biomass	1.1
Site	1.0

(G) NT

Explanatory variables	VIF
Light regime	1.2
Precipitation sum	1.2
Insect biomass	1.0
Mean temperature	1.2
Site	1.1

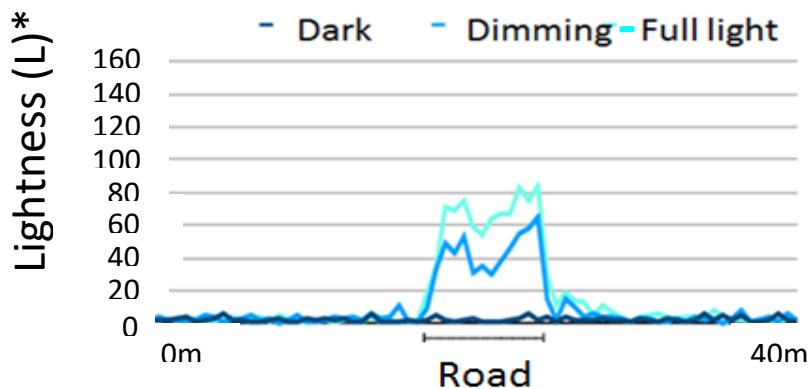
Appendix D. Fig. 1. Measured light levels (lx) at street lights. **(A)** Total (sum of illuminance) for full and dimmed street lights for all nights during the experiment pooled for both sites (Regensdorf, Urdorf). **(B)** Mean hourly illuminance values for full and dimmed street lights for all nights during the experiment for both sites.



Appendix E. Fig. 1. We illustrate the effect of LED street light dimming on the environment from drone flights for the experimental site in Urdorf.

The spatially explicit average lighting intensity under full (100%) and dimmed (70%) street lights was compared to turned-off street lights. To estimate the spatial distribution of street lights, the relative brightness of dimmed and full light conditions were assessed with a drone using a Sony NEX-7 camera with APS-C sensor (23.5x15.6 mm) . The large sensor area was needed to take night shots with a relatively shake-proof shutter speed. To be able to compare the RGB values of the images, we used solely the manual control of the camera exposure. All images were taken with

an empirically determined shutter speed of 1/60 and ISO 12800. The images were taken at heights between 50 and 70m with an image overlap of 70% to enable photogrammetric evaluation of different light intensities (full and dimmed light, no light). The high ISO value inevitably lead to high image noise, but visually poor image quality played only a minor role for the pursued quantitative evaluation. The image noise did not allow a full spatial estimation of illuminance, but near the street lights, almost no noise could be detected. However, some full-light images have partially saturated RGB values if the street lights were optimally aligned with the drone camera. The



* RGB, i.e., Lightness (L) = $(\min(R,G,B) + \max(R,G,B)) / 2$,
https://en.wikipedia.org/wiki/HSL_and_HS. The maximum value is 255 (white), i.e., the value at 80/255 = 31%

measured 35% difference between full and dimmed light can only be relatively compared.

Appendix F. Table 1. Number of caught insects under dimmed and full street light conditions at two experimental sites (Regensdorf, Urdorf)

Location	Light regime	Sample size	Number of caught insects								
			All insects	Order				Other orders			
				Coleoptera	Diptera	Heteroptera	Hymenoptera	Lepidoptera	Neuropterida	Trichoptera	Ephemeroptera
Regensdorf	dimmed	16	1281	532	359	95	107	18	16	5	1
Regensdorf	full	16	2685	1018	565	607	417	46	111	13	56
Total		32	3966	1550	924	702	524	64	127	18	57
Urdorf	dimmed	16	911	318	363	98	110	5	7	4	6
Urdorf	full	16	1970	557	351	369	581	23	7	18	64
Total		32	2881	875	714	467	691	28	14	22	70
Total	dimmed	32	2192	850	722	193	217	23	23	9	7
Total	full	32	4655	1575	916	976	998	69	118	31	120
Total		64	6847	2425	1638	1169	1215	92	141	40	127

Appendix F. Table 2. Number of bat passes recorded under dimmed and full street light conditions in Regensdorf and Urdorf. Bat guilds (LRE: long-range echolocators, MRE: mid-range echolocators, SRE: short-range echolocators), Red List categories (LC: least concern, NT: near threatened, VU: vulnerable, EN: endangered, DD: not distinguishable)

Location	Light regime	Sample size	Number of bat passes															
			All bats		Guilds			Red List categories					Taxa (genus)					
			LRE	MRE	SRE	LC	NT	VU	EN	DD	<i>Pipistrellus</i>	<i>Myotis</i>	<i>Nyctalus</i>	<i>Eptesicus</i>	<i>Hypsugo</i>	<i>Plecotus</i>	<i>Vespertillo</i>	
Regensdorf	dimmed	16	8617	142	8433	42	8431	125	61	0	0	8433	40	71	70	0	2	1
Regensdorf	full	16	29365	123	29120	122	29099	139	123	0	4	29099	109	73	54	16	13	1
Total		32	37982	265	37553	164	37530	264	184	0	4	37532	149	144	124	16	15	2
Urdorf	dimmed	16	5428	115	5252	61	5151	208	68	1	0	5240	61	53	64	10	0	1
Urdorf	full	16	8385	106	8147	132	8025	226	131	1	2	8103	130	50	74	26	1	0
Total		32	13813	221	13399	193	13176	434	199	2	2	13343	191	103	138	36	1	1
Total	dimmed	32	14045	257	13685	103	13582	333	129	1	0	13673	101	124	134	10	2	2
Total	full	32	37750	229	37267	254	37124	365	254	1	6	37202	239	123	128	42	14	1
Total		64	51795	486	50952	357	50706	698	383	2	6	50875	340	247	262	52	16	3
Total Guilds			51795															
Total Red List							51795											
Total Taxa																		51795

Appendix G. Table 1. Macrolepidopterans collected during the experiment in Regensdorf, det. Ladislaus RESER, Nature Museum Lucerne, Switzerland.

Order	Family	Genus	Species	Author	Sum
Lepidoptera	Arctiidae	<i>Spilosoma</i>	<i>lubricipeda</i>	Linnaeus, 1758	4
Lepidoptera	Noctuidae	<i>Mythimna</i>	<i>albipuncta</i>	Denis & Schiffermüller, 1775	3
Lepidoptera	Arctiidae	<i>Eilema</i>	<i>caniola</i>	Hübner, 1808	3
Lepidoptera	Noctuidae	<i>Mythimna</i>	<i>pallens</i>	Linnaeus, 1758	2
Lepidoptera	Noctuidae	<i>Zanclognatha</i>	<i>tarsipennalis</i>	Treitschke, 1835	2
Lepidoptera	Geometridae	<i>Campaea</i>	<i>margaritata</i>	Linnaeus, 1767	2
Lepidoptera	Geometridae	<i>Macaria</i>	<i>liturata</i>	Clerck, 1759	2
Lepidoptera	Pyralidae	<i>Cydalima</i>	<i>perspectalis</i>	Herrich-Schäffer, 1847	1
Lepidoptera	Pantheidae	<i>Colocasia</i>	<i>coryli</i>	Linnaeus, 1758	1
Lepidoptera	Nolidae	<i>Pseudoips</i>	<i>prasinana</i>	Linnaeus, 1758	1
Lepidoptera	Noctuidae	<i>Agrotis</i>	<i>segetum</i>	Denis & Schiffermüller, 1775	1
Lepidoptera	Noctuidae	<i>Apamea</i>	<i>ophiogramma</i>	Esper, 1794	1
Lepidoptera	Noctuidae	<i>Calophasia</i>	<i>lunula</i>	Hufnagel, 1766	1
Lepidoptera	Noctuidae	<i>Elaphria</i>	<i>venustula</i>	Hübner, 1790	1
Lepidoptera	Noctuidae	<i>Lacanobia</i>	<i>oleracea</i>	Linnaeus, 1758	1
Lepidoptera	Noctuidae	<i>Noctua</i>	<i>pronuba</i>	Linnaeus, 1758	1
Lepidoptera	Noctuidae	<i>Ochropleura</i>	<i>plecta</i>	Linnaeus, 1761	1
Lepidoptera	Noctuidae	<i>Platyperigea</i>	<i>kadenii</i>	Freyer, 1836	1
Lepidoptera	Noctuidae	<i>Xylena</i>	<i>vetusta</i>	Hübner, 1813	1
Lepidoptera	Geometridae	<i>Ematurga</i>	<i>atomaria</i>	Linnaeus, 1758	1
Lepidoptera	Geometridae	<i>Opisthograptis</i>	<i>luteolata</i>	Linnaeus, 1758	1
Lepidoptera	Geometridae	<i>Rhinoprora</i>	<i>rectangulata</i>	Linnaeus, 1758	1
Lepidoptera	Geometridae	<i>Scopula</i>	<i>marginepunctata</i>	Goeze, 1781	1
Lepidoptera	Cossidae	<i>Phragmataecia</i>	<i>castaneae</i>	Hübner, 1790	1
Lepidoptera	Arctiidae	<i>Eilema</i>	<i>depressa</i>	Esper, 1787	1
Lepidoptera	Arctiidae	<i>Eilema</i>	<i>lurideola</i>	Zincken, 1817	1

Appendix G. Table 2. Macrolepidopterans collected during the experiment in Urdorf, det.

Ladislaus RESER, Nature Museum Lucerne, Switzerland. The total of the collected

specimens is 15.

Order	Family	Genus	Species	Taxonomic reference	Sum
Lepidoptera	Geometridae	<i>Cepphis</i>	<i>advenaria</i>	Hübner, 1790	5
Lepidoptera	Cossidae	<i>Zeuzera</i>	<i>pyrina</i>	Linnaeus, 1761	3
Lepidoptera	Arctiidae	<i>Lithosia</i>	<i>quadra</i>	Linnaeus, 1758	1
Lepidoptera	Arctiidae	<i>Spilosoma</i>	<i>lubricipeda</i>	Linnaeus, 1758	1
Lepidoptera	Geometridae	<i>Epirrhoe</i>	<i>alternata</i>	Müller, 1764	1
Lepidoptera	Noctuidae	<i>Agrotis</i>	<i>exclamationis</i>	Linnaeus, 1758	1
Lepidoptera	Noctuidae	<i>Diachrysia</i>	<i>chrysitis</i>	Linnaeus, 1758	1
Lepidoptera	Noctuidae	<i>Hoplodrina</i>	<i>ambigua</i>	Denis & Schiffermüller, 1775	1
Lepidoptera	Noctuidae	<i>Hoplodrina</i>	<i>octogenaria</i>	Goeze, 1781	1

Appendix H. Table 1. Parameter estimates of negative binomial regression models for insect abundance for both sites, Urdorf and Regensdorf. sum Ix (sum of the nightly amount of light); mean temperature (mean nightly temperature); sum precipitation (nightly precipitation sum); R^2 (random): contribution of random effects in reducing overall model variability; R^2 (fixed and random factors); Akaike information criterion (AIC) for random effects and AIC of the full model. Statistical levels of significance: *** < 0.001 , ** < 0.01 , * < 0.05 , . < 0.1 . VIF less than 1.5 indicated low multicollinearity in the data (Zuur, Ieno & Elphick 2010).

Systematic/ ecological unit	Explanatory variables				Model performance			
	Sum Ix	Mean temperature	Sum precipitation	Site	R^2 (random)	R^2 (total)	AIC (random effects)	AIC (full model)
all insects	0.5 (*)	2.7 (***)	-1.0 (**)	-0.5 (***)	0.5	0.7	3829.5	3689.0
Coleoptera	-0.5	3.0 (***)	-1.4 (**)	-0.3 (*)	0.4	0.6	2846.7	2754.9
Diptera	0.7 (**)	1.7 (***)	-0.4	-0.0	0.2	0.3	2523.3	2438.9
Heteroptera	1.0 (*)	7.3 (***)	-2.3 (**)	-0.0	0.6	0.7	1864.1	1792.6
Hymenoptera	3.89 (***)	2.6 (.)	-1.2	-1.5 (***)	0.3	0.7	1816.8	1782.1
Other	0.7	3.3 (***)	-1.3	-1.0 (***)	0.2	0.4	1147.1	1082.8

Appendix H. Table 2. Results of negative binomial regression models for bat activity; sites (Regensdorf, Urdorf); sum lx (sum of the mean nightly amount of light; mean temp (mean nightly temperature); sum prec (mean nightly precipitation sum); sum biomass (sum of the nightly caught insect biomass). Guilds: LRE: long-range echolocators, MR: mid-range echolocators, SRE (short-range echolocators); Red List categories: LC (species of least concern), VU (vulnerable), NT (near-threatened); R^2 (random): contribution of random in reducing overall model variability; R^2 (fixed and random factors); Akaike information criterion (AIC) for random effects and AIC of the full model. Statistical levels of significance: *** < 0.001 ** < 0.01, * < 0.05, . < 0.1

VIF less than 1.7 indicated low multicollinearity in the data (Zuur, Ieno & Elphick 2010).

Systematic/ ecological unit	Explanatory variables					Model performance			
	Sum lx	Mean temperature	Sum precipitation	Sum biomass	Site	R^2 (random)	R^2 (total)	AIC (random effects)	AIC (total)
all bats									
LRE	0.9 (.)	0.2	-1.1	-1.4	-0.5 (*)	0.02	0.45	633.8	636.9
MRE	0.2	2.7 (***)	-1.0	0.7	-1.2 (***)	0.2	0.9	3252.9	2947.8
SRE	0.3	1.0 (*)	-1.1 (.)	0.5	-1.2 (***)	0.2	0.8	5698.9	5632.4
LC	0.3	2.7 (***)	.0.9	0.7	-1.2 (***)	0.3	0.9	3252.8	2941.8
VU	0.06	0.4	-0.3	-0.06	0.0	0.2	0.7	606.9	611.5
NT	0.2	1.2 (*)	-1.1 (.)	0.5	-1.2 (***)	0.04	0.43	850.5	831.4