SUPPORTING INFORMATION

For "Bats and birds increase crop yield in tropical agroforestry landscapes"

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Table S1 - *Study site and tree characteristics*

We measured all study trees at the beginning of our study (June 2010) and 6 months later in February 2011. An overview of the mean study tree sizes (a, b), distance to the closest primary forest (c), mean shade cover (d) and the dominant legume shade tree species (e: B = *Gliricidia* sp.; A = *Erythrina* sp.; mean height of 8 m; N = 2148) for each study site are shown in the table. The cacao tree diameter (dbh) was measured below the first branching of the cacao trees (mean height = 85 cm, N = 120). Tree size parameters a and b do not change the results of the final models from Table S6 if added as additional covariable.

	a	b	c	d	e
Study site ID	**mean tree height (cm)**	**mean tree dbh (cm)**	**distance to next primary forest (m)**	**mean shade cover (%)**	**dominant shade tree species**
1	246.63	5.70	0	0.66	B
2	315.81	8.73	200	0.74	B
3	311.25	7.40	480	0.50	A
4	308.94	10.51	1100	0.03	B
5	380.81	12.15	3000	0.06	B
6	260.69	6.20	2300	0.65	B
7	304.19	8.64	450	0.46	A
8	285.69	8.00	380	0.20	B
9	265.50	7.50	1200	0.50	A
10	322.25	8.45	800	0.63	B
11	271.06	7.62	3000	0.21	B
12	244.31	6.59	2700	0.53	B
13	268.44	6.74	1800	0.20	A
14	300.94	7.67	1800	0.28	B
15	297.56	7.51	0	0.02	B

Table S2 - *Detailed information on the research assistant team*

In total, 46 local assistants regularly assisted the first author (B.M.) in the field. B.M. was present in the field during the whole period of the study. All major parts of the field work were within her responsibility, and coordinated by her. In the field, there were basically two types of field work: physical work (construction; maintenance; transportation) and scientific work (preparation, collection and processing of data). The first type was conducted by a large number of local field assistants and workers, including the cacao plantation owners themselves. Scientific work was exclusively planned and supervised by the first author. B.M. did preliminary investigations for all datasets and trained scientific head assistants as long as necessary in each case (2-8 weeks). All head assistants were either well experienced scientific field work assistants (with minimum 6 years of experience in other biological research projects; e.g. SFB552/"STORMA" by the DFG), or biology master students from the Tadulako University in Palu. After weeks of training, coordination and supervision by B.M., they collected data in the field (e.g. leaf measurements; counting of fruits; weighing seeds) in groups of at least two persons per task. During the whole period of field work, all tasks were supervised by the first author and regular trainings occurred to test the accuracy of the measurements in the field and the technical devices used in our study. The head assistants did not change during the study. Except three persons assisting for a shorter period, the field work team consisted of the same persons during the whole experiment.

field work	**Short description of tasks and field work**
Manual	All tasks supervised and coordinated by the first author and scientific-assistants: Construction and maintenance of treatments; Daily opening and closing of exclosure cages; Pruning and mowing in treatments; Transportation of field equipment and other logistic tasks; Assisting in data collection
Scientific	Data measurements (after previous training periods): Head assistants helped with coordination of local workers, and were responsible in one major data project each (fruit development data and leaf herbivory data); Master students assisted during insect surveys (all identifications confirmed by B.M.), and helped with entry of first data. Bird mist netting was done in cooperation with a scientific bird expert (Dadang Dwi Putra).

Table S3 - *Insectivorous bird species*

Most common excluded insectivorous bird species were determined by repeated mist netting surveys on our 15 study sites (monthly mist netting per site in September 2010 and between February and June 2011; total of 7 mist netting runs per site). Short method description: We used 8 mist nets per study site (each net 6 x 3 m in size with 6mm mesh size) and situated them along a continuous net line (48 m) in the middle of the study site. From 06h00 until 17h00, nets were checked every 60 minutes (every 30 minutes only under cold weather conditions). All captured birds were identified, banded with uniquely numbered metal rings and measured following the Level 1 standard of the revised field method manual published by Bairlein et al. (1995)[1]. The ten most common bird species are listed according to the total number of individuals captured (excluding re-captures) and with their habitat affiliations and distribution (endemic v. widespread species). In total, we observed 71 bird species belonging to 37 families within the 15 studied cacao agroforestry systems.

Species name	**Habitat affiliation**	**Endemic/Widespread**	**Total number**
Zosterops chloris	GEN	W	626
Dicaeum celebicum	GEN	E	167
Dicaeum aureolimbatum	GEN	E	61
Zosterops atrifrons	GEN	W	48
Nectarinia jugularis	OL	W	25
Halcyon chloris	OL	W	20
Scissirostrum dubium	GEN	E	19
Aplonis minor	GEN	W	13
Nectarinia aspasia	GEN	W	9
Dicaeum nehrkoni	FO	E	9

*Habitat affiliation: GEN (generalistic); OL (open land) and FO (forest) habitat.

[1] Bairlein, F., Jenni, L., Kaiser, A., Karlsson, L., Noordwijk, A., Peach, W. and Walinder, G. (1995). European-African songbird migration network: manual of field methods. *Vogelwarte Helgoland, Wilhelmshaven*.

Table S4 - *Insectivorous bat species*

List of the insectivorous bat species captured in a mist netting study of Graf (2010)[2]. The study was conducted in the Kulawi valley, situated at the western border of the Lore Lindu National Park in Central Sulawesi (approximately 23 km apart from our study area in Napu valley). Insectivorous bat species (Microchiroptera) were captured along a habitat gradient (natural forests, selectively logged forests and agroforestry systems) and belonged to 4 families and 7 species.

Family	**Species**
Rhinolophidae	*Rhinolophus borneensis* (Peters, 1861)
Rhinolophidae	*Rhinolophus euryotis* (Temminck, 1835)
Hipposideridae	*Hipposideros cervinus* (Gould, 1863)
Verspertilionidae	*Myotis ater* (Peters, 1866)
Verspertilionidae	*Myotis horsfieldii* (Temminck, 1840)
Verspertilionidae	*Myotis muricola* (Gray, 1864)
Megadermatidae	*Megaderma spasma* (Linnaeus, 1758)

[2] Graf, S. (2010). Diversity and habitat use of understorey bats in forest and agroforestry systems at the margin of Lore Lindu National Park (Central Sulawesi, Indonesia). Diploma thesis, University of Vienna.

Table S5 – *Arthropod responses to bird/bat exclosures*

Results from final linear mixed effect (lme) models (with treatment) fit by REML (Restricted Maximum Likelihood) and Post Hoc tests (Tukey´s Test) for the total number of each investigated arthropod group (log transformed) both on (A) woody tree parts and on the (B) tree foliage. The table results from the summary statistics of the final lme model (value and Standard Error SE) and the Tukey´s Post Hoc test of significance (*P*-value, upper and lower bound of Confidence Interval CI) for both tree positions.

				A) **WOODY TREE PARTS**			B) **TREE FOLIAGE**		
Group	Exclosure	final model		Tukey´s Test			Tukey´s Test		
name	treatment	value	SE	p	CI_upper	CI_lower	p	CI_upper	CI_lower
Lepidoptera larvae	Control	1.039	0.307	–	0	0	–	0	0
	Day ex.	0.779	0.386	0.110	1.687	-0.128	**0.013**	0.960	0.088
	Night ex.	0.792	0.386	0.103	1.699	-0.115	0.935	0.524	-0.348
	Full ex.	0.322	0.386	0.740	1.229	-0.585	**0.026**	0.917	0.045
Coleoptera	Control	2.208	0.249	–	0	0	–	0	0
	Day ex.	0.567	0.320	0.186	1.319	-0.185	**0.0001**	1.322	0.431
	Night ex.	0.146	0.320	0.941	0.898	-0.606	0.100	0.435	-0.456
	Full ex.	0.794	0.320	**0.036**	1.546	0.041	**0.0009**	1.126	0.234
Formicidae (adult wingless ants)	Control	4.470	0.293	–	0	0	–	0	0
	Day ex.	0.119	0.384	0.980	0.783	-1.022	0.160	1.698	-0.204
	Night ex.	0.393	0.384	0.608	1.296	1.296	**0.044**	1.921	0.020
	Full ex.	0.555	0.384	0.336	1.458	1.458	**0.002**	2.335	0.434
Arachnida	Control	3.478	0.155	–	0	0	–	0	0
	Day ex.	0.676	0.193	**0.001**	1.129	0.226	**0.011**	1.083	0.114
	Night ex.	0.484	0.193	**0.033**	0.937	0.937	0.061	0.952	-0.017
	Full ex.	0.692	0.193	**0.001**	1.145	0.239	0.079	0.930	-0.039
Aphididae	Control	0.775	0.392	–	0	0	–	0	0
	Day ex.	0.984	0.554	0.193	2.303	-0.336	0.725	2.302	-1.072
	Night ex.	0.228	0.554	0.957	1.091	-1.548	0.975	1.927	-1.447
	Full ex.	2.626	0.554	**0.0001**	3.945	1.306	**0.0001**	4.895	1.521
Orthoptera	Control	0.365	0.138	–	0	0	–	0	0
	Day ex.	0.205	0.195	0.596	0.668	-0.258	0.387	0.879	-0.235
	Night ex.	0.974	0.195	**0.001**	1.437	0.511	**0.0002**	1.494	0.381
	Full ex.	0.316	0.195	0.254	0.779	-0.146	0.999	0.563	-0.551
Blattodea	Control	0.713	0.209	–	0	0	–	0	0
	Day ex.	0.465	0.283	0.202	1.096	-0.167	0.818	0.397	-0.212
	Night ex.	2.095	0.283	**0.001**	2.726	1.463	**0.0006**	0.790	0.180
	Full ex.	0.070	0.283	0.988	0.702	-0.561	1.000	0.305	-0.305

Table S6 – *Cacao fruit development and leaf herbivory*

Results from final linear mixed effect (lme) models (withtreatment) fitted by REML (Restricted Maximum Likelihood) and Post Hoc tests (Tukey´s Test) for different stages of the cacao harvesting process (yield in kg/treatment; N of harvested fruits; N of small fruits; log transformed N of cacao flowers) and the percentage of leaf damage due to herbivores. The table shows results from the summary statistics of the final lme model (value and Standard Error SE) and the Tukey´s Post Hoc test of significance (*P*-value, upper and lower bound of Confidence Interval CI).

		final model		Tukey´s Test		
Variable	Exclosure treatment	value	SE	p	CI_upper	CI_lower
Cacao yield	Control	1.940	0.198	–	0	0
	Day ex.	-0.459	0.213	0.081	0.042	-0.959
	Night ex.	-0.536	0.213	**0.032**	-0.035	-1.037
	Full ex.	-0.677	0.213	**0.004**	-0.177	-1.178
Fruits (harv.)	Control	92.000	9.275	–	0	0
	Day ex.	-27.267	10.869	**0.033**	-1.736	-52.792
	Night ex.	-28.533	10.869	**0.024**	-3.003	-54.059
	Full ex.	-40.800	10.869	**0.001**	-15.270	-66.325
Fruits (small)	Control	1185.000	175.640	–	0	0
	Day ex.	-306.867	204.891	0.307	174.415	-788.281
	Night ex.	-578.067	204.891	**0.013**	-96.785	-1059.481
	Full ex.	-514.133	204.891	**0.033**	-32.851	-995.548
Flowers (log)	Control	8.521	0.160	–	0	0
	Day ex.	-0.405	0.153	**0.012**	-0.046	-0.765
	Night ex.	-0.234	0.153	0.355	0.216	-0.503
	Full ex.	-0.143	0.153	0.136	0.126	-0.593
Leaf Damage (%)	Control	407.112	39.175	–	0	0
	Day ex.	11.880	55.402	0.993	142.021	-118.257
	Night ex.	0.976	55.402	0.993	131.118	-129.161
	Full ex.	11.703	55.402	1.000	141.845	-118.434

Table S7 – *Yield vs. pest insect abundances*

Relationship between total cacao yield (dry weight of harvest outcome) and the total number of herbivore arthropods resulting from linear mixed effect models (lme). Significant relationships in bold.

Herbivore group	lme model	
	F-value (1,44)	p-value
Lepidoptera larvae	0.037	0.848
Coleoptera	0.512	0.478
Aphids	7.459	**0.009**
Orthoptera	0.572	0.454

Figure S1 – *Cacao fruit development, leaf herbivory and fruit pests*

Effects of the experimental exclosures (Day, Night and Full exclosure of birds and bats) on (a) the number of small cacao fruits, (b) number of cacao flowers (LOG), (c) the total leaf loss area (in cm^2) and the percentages of the notorious cacao fruit pests (d) cocoa pod borer (*Conopomorpha cramerella*), (e) mirid damage (*Helopeltis sulawesii*) and (f) early fruit abortion (cherrele wilt). Each exclosure treatment effect is shown relative to the unmanipulated control treatment (dashed line at zero level). The mean value of each parameter is displayed in black (± 95% confidence intervals) and original data on study site-level (15 circles per treatment) are displayed as grey filled circles. This allows a direct visual interpretation of treatment effects on (a) – (f). Asterisk symbols represent statistical significance for p-values below 0.05 (*).