Oikos

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Appendix A1

Table A1. The species collected in the dung pats from both within and outside territorial sites.

The size range and the sampling day are also provided for both treatment and the control.

	Species	Size range (mm)	Sampling day
Coprophagpus beetles	*Geotrupes* sp.	12–18	3,7
	Onthophagus yubarinus	6–8	3,7
	Aphodius elegans .	8–11	3,7
	.	–	
	Aphodius sp. 1	8–11	3,7
	Onthophagus tabidus	6–8	3,7
	Aphodius sp. 2	3–4	3,7
	Aphodius sp. 3	2–2.5	3,7
Maggots		7–16	7
Predators	*Philonthus rubripennis*	13–20	3,7,20
	Paedcrus fuscipes	5–7	3,7,20
	Camponotus herculeanus	4–6	3,7,20

Table A2. Results of data normality test and associated Student t-test (or Wilcoxon rank test) showing the difference in number of maggots, coprophagous beetles, predator beetles and dry dung weight between within and outside territorial sites in each sampling time. WS and PN denote the results of the Shapiro–Wilk normality test; W, T and p denote the results of Wilcoxon or *t* test. n = 10 for each treatment in each sampling time.

Sample time		No. of maggots*				No. of coprophagous beetles				No. of predator beetles				Dry dung weight			
		WS	PN	W	p	WS	PN	T	p	WS	PN	T	p	WS	PN	T	p
Day 3	within					0.932	0.467	0.197	0.847	0.95	0.669	2.033	0.057	0.910	0.278	1.387	**0.0183**
	outside					0.960	0.782			0.921	0.365			0.961	0.802		
Day 7	within	0.811	0.0271	68	0.218	0.934	0.524	2.642	**0.017**	0.908	0.302	0.0744	0.942	0.960	0.802	0.330	0.745
	outside	0.942	0.598			9.937	0.554			0.968	0.880			0.844	0.0643		
Day 20	within					0.919	0.386	0.077	0.939	0.918	0.374	27.5*	0.087	0.962	0.821	1.000	0.332
	outside					0.917	0.364			0.781	0.0122			0.928	0.462		
Day 80	within													0.971	0.905	4.260	**0.001**
	outside													0.904	0.275		

* As the data on number of maggots and the number of predatory beetles in the third sampling are not normally distributed, a Wilcoxon rank test was used to test the difference in the variables between within- and outside- territorial sites, and therefore W value is shown here. Student t-test was used for the other variables.

Table A3. Results of data normality test and the Student t-test (or Wilcoxon rank test) showing the difference in soil nutrient between within and outside ant territories. WS and PN denote the results of the Shapiro–Wilk normality test; W, T and p denote the results of Wilcoxon or *t*-test. n = 10 for each treatment in each sampling time.

Treat	Total nitrogen				Total phosphorus				Soluble nitrogen*				Soluble phosphorous*			
	W	PN	T	p	W	PN	T	p	W	PN	T	p	W	PN	W	p
Within	0.919	0.347	3.548	**0.003**	0.945	0.605	1.430	0.171	0.862	0.081	2.363	**0.033**	0.922	0.375	60.5	0.449
Outside	0.955	0.731			0.913	0.306			0.975	0.933			0.820	**0.026**		

*Since soluble nitrogen of within territory and soluble phosphorus of outside territories are not normally distributed (Shapiro–Wilk test), Wilcoxon rank tests were used to test for the difference in the variables. Student t-test was used for total N and total P.

Table A4. Results of data normality test and the Student t test showing the difference in aboveground plant biomass between within and outside ant territories. WS and PN denote the results of the Shapiro–Wilk normality test; W, T and p denote the results of Wilcoxon or *t*-test. n = 10 for each treatment in each sampling time.

Treat	Grasses				Sedges				Forbs				Total			
	W	PN	T	p	W	PN	T	p	W	PN	T	p	W	PN	T	p
Within	0.959	0.794	1.040	0.315	0.928	0.461	1.442	0.0609	0.951	0.705	1.709	0.111	0.941	0.588	5.146	**0.0003**
Outside	0.954	0.738			0.957	0.762			0.962	0.801			0.970	0.885		

Table A5. Results of F-tests for linear regressions between dry dung weight and total nitrogen (TN), total phosphorus (TP), soluble nitrogen (SN) and soluble phosphorus (SP).

	DF	F	p	R^2
TN	1,18	4.778	**0.042**	0.166
TP	1,18	2.955	0.103	0.093
SN	1,18	0.494	0.491	0.027
SP	1,18	1.548	0.229	0.028

Table A6. Results of prior assumption test and GLMs showing the differences in number of ants (NA), number of *Onthophagus tabidus* (NOT), number of *Onthophagus yubarinus* (NOY), number of *Onthophagus tabidus* attacked (NOTA), and number of *Onthophagus yubarinus* attacked (NOYA) among different distances from anthills. *goodfit* function with "*MinChisq*" method in '*vcd*' package (Meyer et al. 2006) showed that number of ants, number of beetles entering to the dung and being attacked are Poisson distributed, and therefore generalized linear models with Poisson error distribution were employed to test the difference among different distances from anthills. The significant differences are denoted by different letters in the right column.

	Distance	Distribution		F (DF)	p	Tukey HSD
		χ^2	p			
NA	25	146.60	0.692	14.792 (2,11)	<0.001	a
	50	92.02	0.480			a,b
	100	26.079	0.718			b
NOT	25	0.987	0.964	14.263 (2,12)	<0.001	a
	50	8.95	0.256			b
	100	5.575	0.850			b
NOY	25	6.65	>0.99	16.137 (2,12)	<0.001	a
	50	4.242	>0.99			b
	100	11.41	>0.99			b
NOTA	25	2.029	0.363	18.6 (2,15)	<0.001	a
	50	4.101	0.5			b
	100	3.313	0.069			c
NOYA	25	0.0190	0.891	3.889 (2,15)	<0.001	a
	50	0.952	0.329			b
	100	3.313	0.069			b

Meyer, D. et al. 2006. vcd: visualizing categorical data. R package ver. 1.0-6.

Figure A1. Variation in the number of ants (mean ± SE) at the distances of 25, 50 and 100 cm from anthills (n = 5 for all). The values with different letters above the columns are significantly different from each other at $p < 0.05$, as determined by generalized linear model (with Poisson error distribution) followed by Tukey's test. See appendix Table A6 for statistical details.

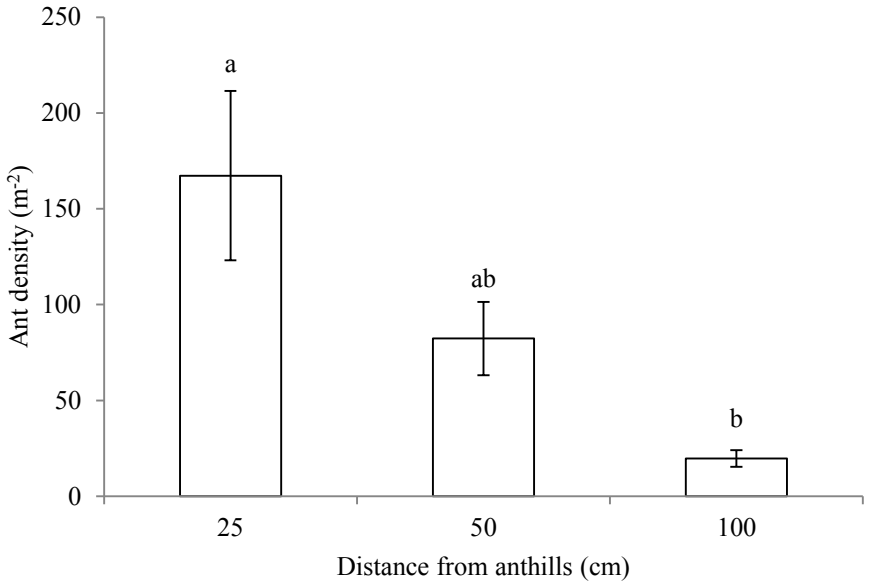

Figure A2. The number (mean ± SE) of the largest body-sized species *Onthophagus tabidus* (a) and the most abundant species *Onthophagus yubarinus* (b) entering dung pats within 10 minutes at three distances from anthills (n = 6 for all). The values with different letters above the columns are significantly different from each other at $p < 0.05$, as determined by generalized linear model (with Poisson error distribution) followed by Tukey's test. See appendix Table A6 for statistical details.

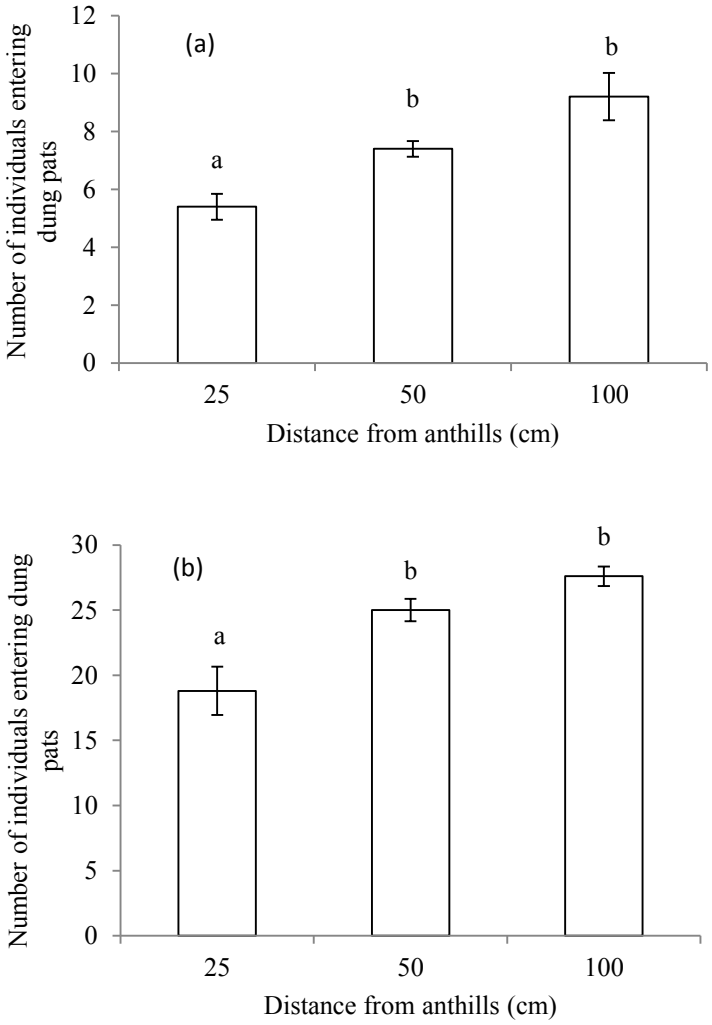

Figure A3. The frequency (mean ± se) of being attacked by ants in the largest body-size species *Onthophagus tabidus* (a) and the most abundant species *Onthophagus yubarinus* (b) entering dung pats at the distances of 25, 50 and 100 cm from anthills (n = 6 for all). There was almost no attack (<0.5 time per 10 min) observed for both species at the distance of 100 cm from anthills. The values with different letters above the columns are significantly different from each other at $p < 0.05$, as determined by generalized linear model (with Poisson error distribution), followed by Tukey's test. See appendix Table A6 for statistical details. An attack event is defined as a single ant or more usually an aggregate of ants defend their territory by directly hitting intruders with their bodies or spraying chemical chemical repellent (e.g. acid formic) until the beetle retreats.