

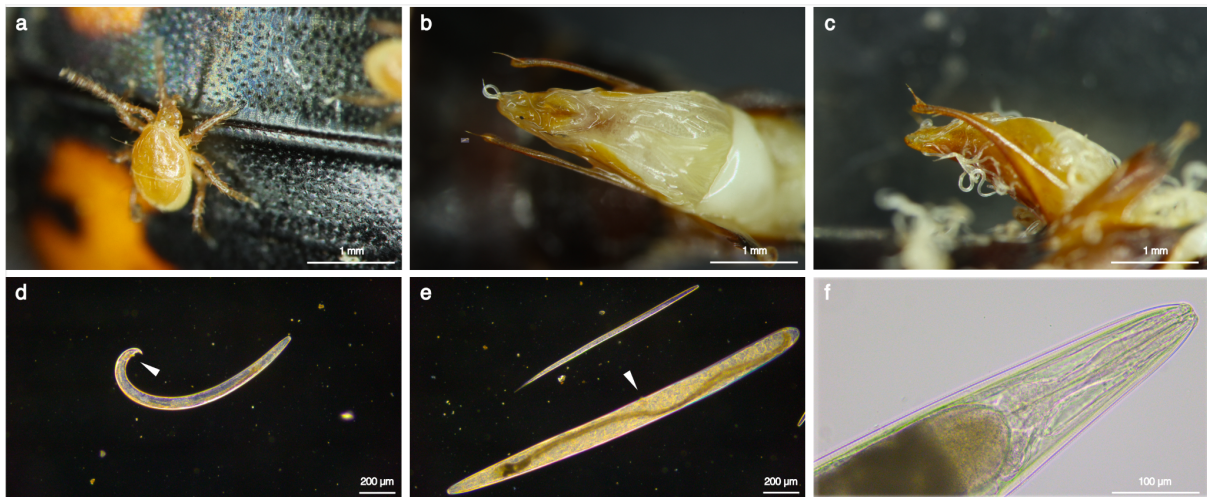
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*Corresponding author: Syuan-Jyun Sun

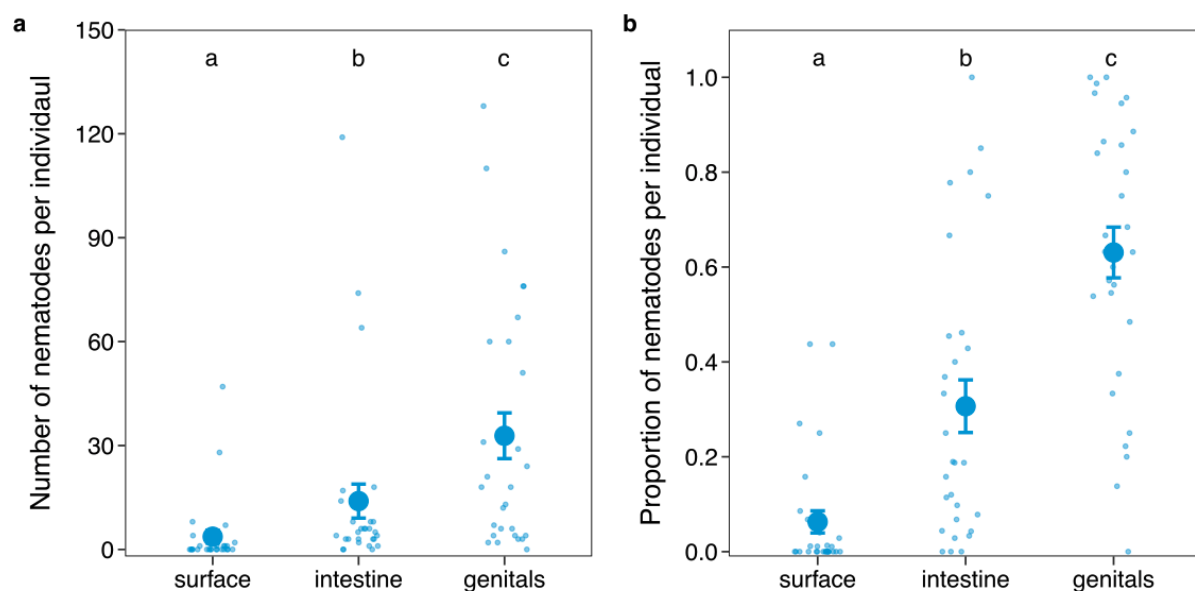
Supplementary Methods

DNA extraction for carrion microbiome analysis

Total DNA from swab microbial samples was extracted using the QIAamp PowerFecal Pro DNA Kit following the manufacturer's protocol. Briefly, 800 µL of Solution CD1 was added to each PowerBead Pro Tube containing the sample. Samples were homogenized via bead beating (10 min vortex at maximum speed), followed by centrifugation at 15,000 × g for 1 min to pellet debris. The supernatant was transferred to a clean microcentrifuge tube, mixed with 200 µL of Solution CD2, vortexed, and centrifuged again. Up to 700 µL of the resulting supernatant was combined with 600 µL of Solution CD3, vortexed, and loaded onto the provided spin column for silica-based binding of DNA. Wash steps with Solution EA and Solution C5 were performed according to the manufacturer's instructions. DNA was eluted in 50-100 µL of Solution C6 and stored at -20°C for downstream applications. The QIAamp protocol's use of mechanical and chemical lysis ensures effective recovery of DNA from diverse bacteria and removal of PCR inhibitors. Negative extraction controls (blank swabs and buffer-only tubes) were processed alongside samples to monitor contamination. All steps were performed under sterile conditions to minimize exogenous microbial DNA contamination.

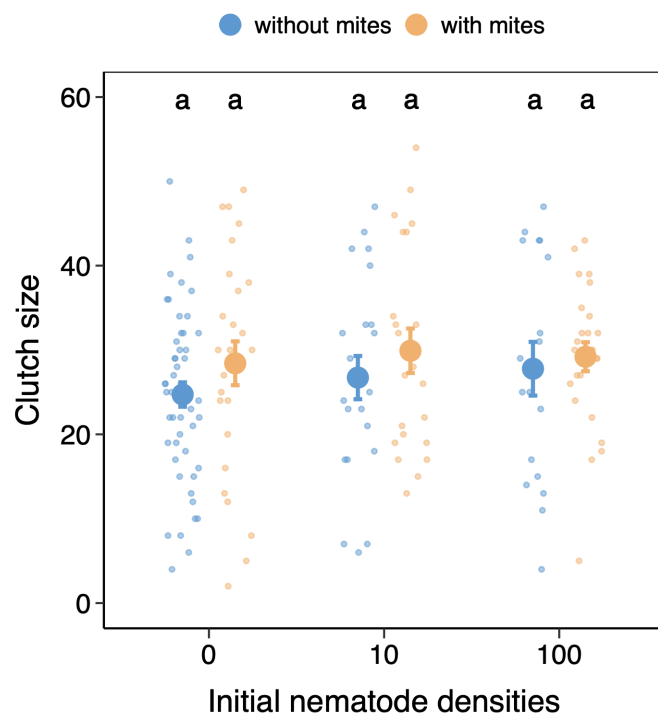


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50 Supplementary Fig 1. The relationship between host burying beetles and their phoretic mites
51 and nematodes. (a) During transportation by the host beetle, the mite deutonymphs attach
52 externally to the beetle surface, whereas (b,c) the nematodes are transported internally as
53 dauers, predominantly occupying the hind gut and the genital (b, dorsal; c, lateral). Upon
54 arrival at a carcass, both mites and nematodes disembark, further moult into (d) adult male
55 characterised by its copulatory spicule (arrowhead) and (e) female (the lower nematode in
56 (e)) to mate and reproduce (arrowhead showing its vulva). (f) Anterior region of the head of a
57 female nematode showcases the bacterial feeding structure. Photo credit: Syuan-Jyun Sun
58 and Yu-Hsuan Lee.



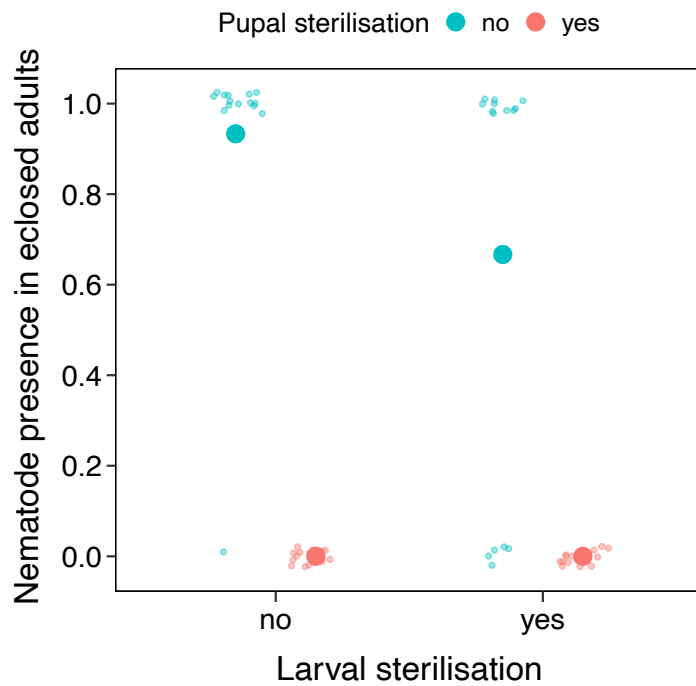
Supplementary Fig 2. Nematode distribution on laboratory-reared burying beetles. (a) Mean $\pm$ SE number of nematodes and (b) their proportions on different body parts of each burying beetle individual (as pointed). Different letters on each panel indicate statistical differences of pairwise comparisons between body parts.

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Supplementary Fig 3. Clutch size of burying beetles breeding under different combinations of nematode and mite treatments. Letters indicate statistical differences between treatments on pairwise comparisons. Each point represents a different brood. Mean $\pm$ SE was as indicated.



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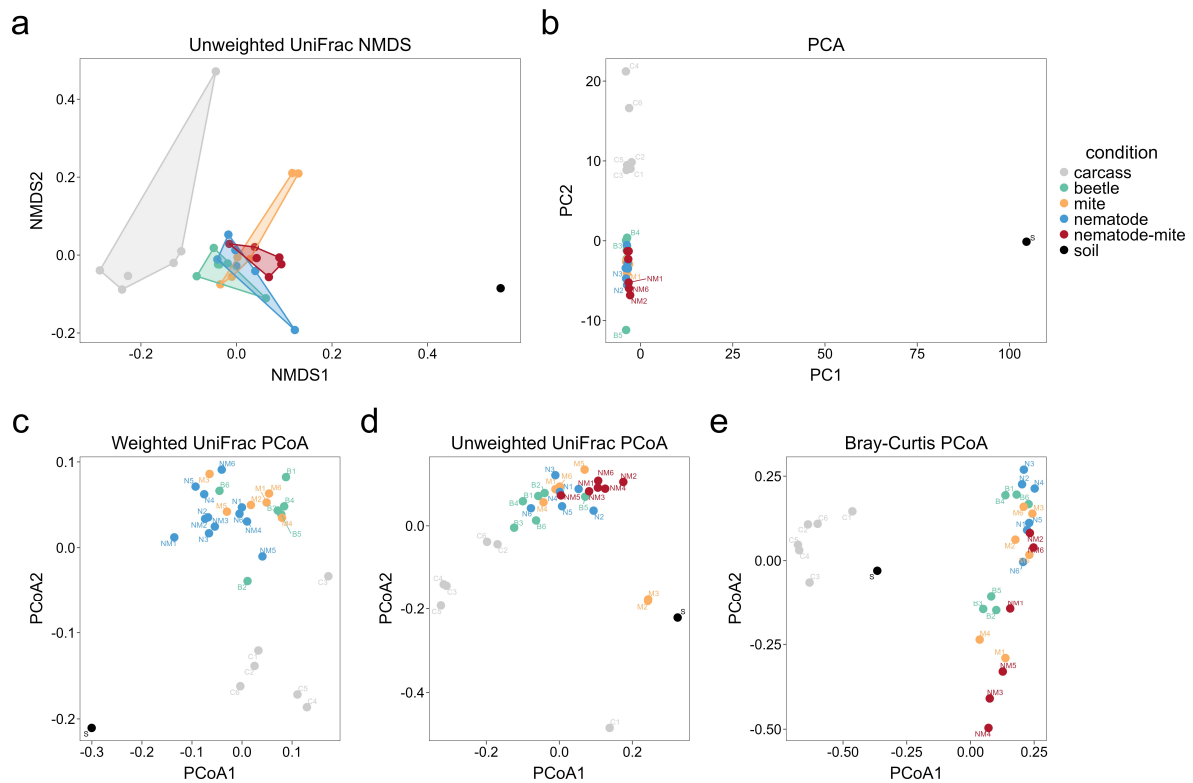
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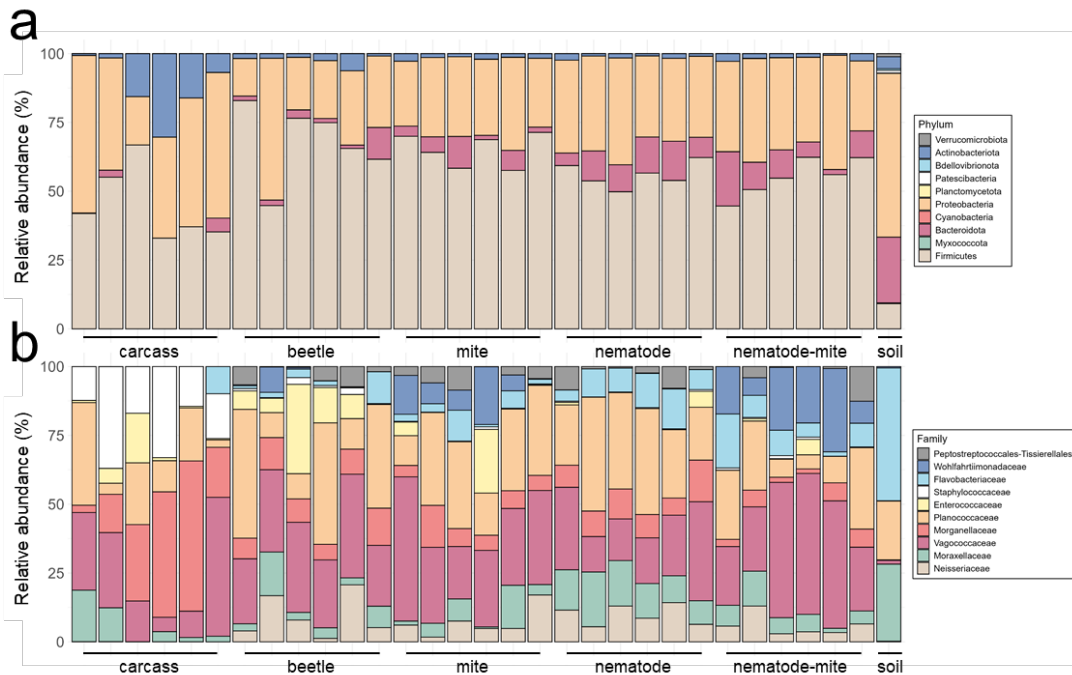
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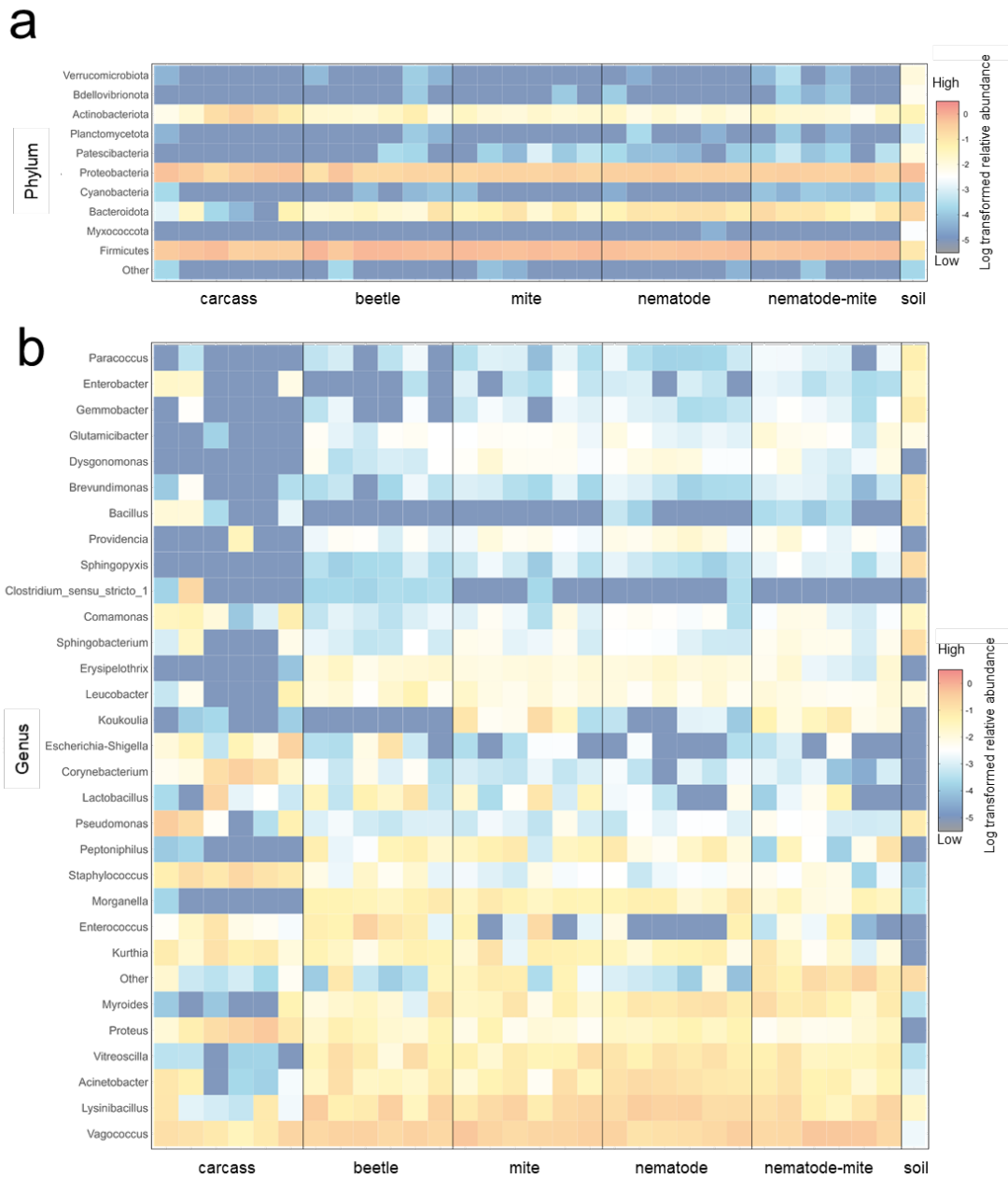
Supplementary Fig 4. Effects of larval and pupal sterilisation on nematode presence in eclosed beetles. Each point represents an individual beetle, scored for nematode presence (1 = present, 0 = absent). Mean values per treatment are shown as larger circles.



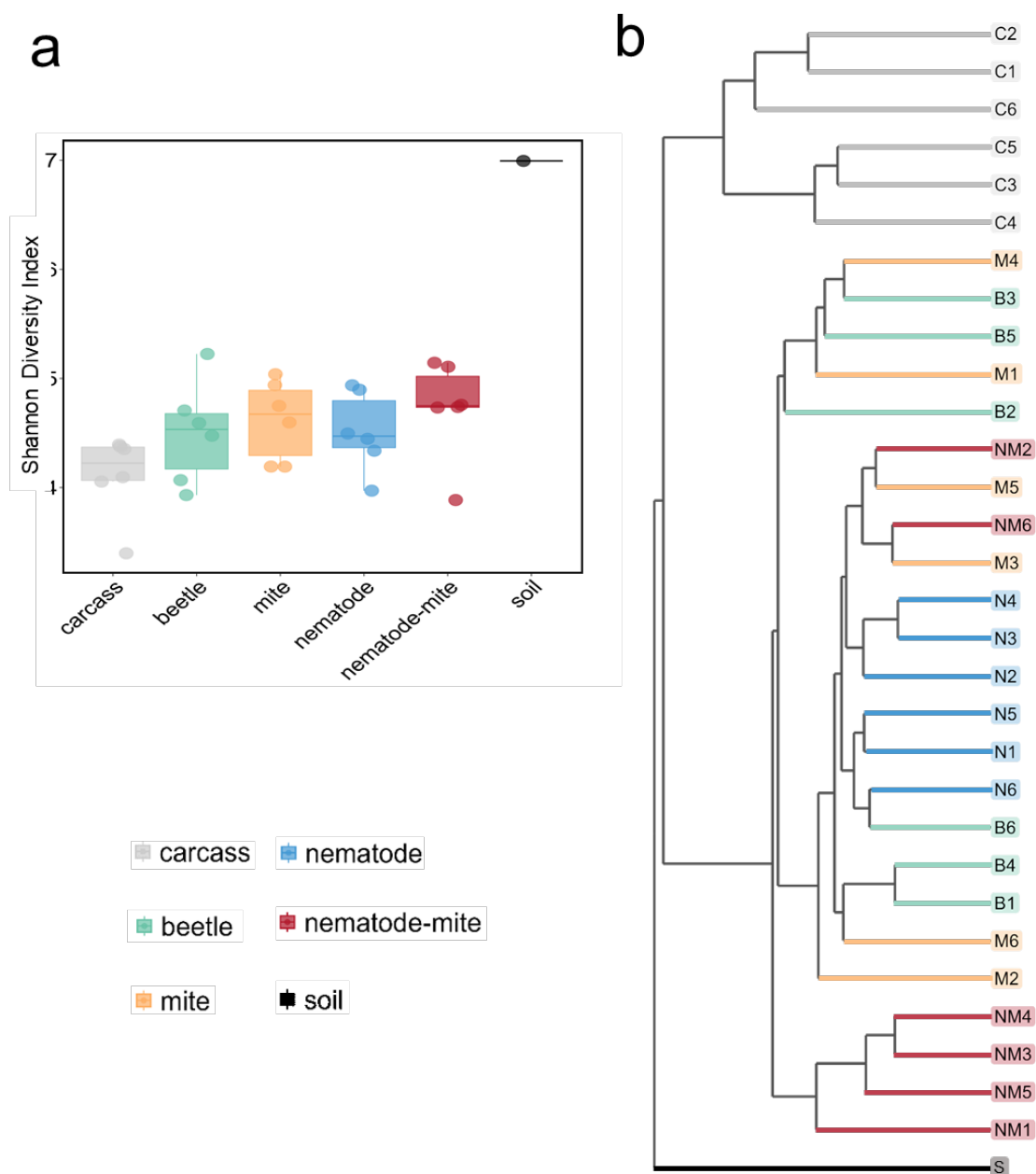
Supplementary Fig 5. Beta diversity analyses of bacterial communities across treatments. (a) NMDS plot based on unweighted UniFrac distances showing differences in community membership. (b) Principal Component Analysis (PCA) illustrating variation in bacterial community composition. (c) PCoA plot based on weighted UniFrac distances reflecting differences in community structure considering taxa abundance. (d) PCoA plot based on unweighted UniFrac distances highlighting differences in community membership. (e) PCoA plot based on Bray-Curtis dissimilarity representing compositional differences incorporating abundance data. Carcass: carcass only; beetle: carcass with beetle; mite: carcass with beetle and 10 mite deutonymphs; nematode: carcass with beetle and 10 J2 nematodes; nematode-mite: carcass with beetle, 10 mite deutonymphs and 10 J2 nematodes; soil: soil only.



Supplementary Fig 6. Relative abundance of microbial taxa at three taxonomic levels across different treatments (carcass: carcass only; beetle: carcass with beetle; mite: carcass with beetle and 10 mite deutonymphs; nematode: carcass with beetle and 10 J2 nematodes; nematode-mite: carcass with beetle, 10 mite deutonymphs and 10 J2 nematodes; soil: soil only). (a) Phylum-level composition showing the top 10 phyla; (b) Family-level composition showing the top 10 families.



Supplementary Fig 7. Heatmaps showing the log-transformed relative abundance of microbial taxa across samples grouped by different treatments (carcass: carcass only; beetle: carcass with beetle; mite: carcass with beetle and 10 mite deutonymphs; nematode: carcass with beetle and 10 J2 nematodes; nematode-mite: carcass with beetle, 10 mite deutonymphs and 10 J2 nematodes; soil: soil only). (a) Phylum-level heatmap displaying the top 10 abundant phyla; (b) Genus-level heatmap displaying the top 30 abundant genera. Colour intensity reflects relative abundance, with a continuous gradient.



Supplementary Fig 8. Additional analyses of bacterial communities. (a) Shannon diversity index comparing bacterial alpha diversity across treatments. (b) UPGMA clustering dendrogram illustrating similarities among bacterial communities from different samples.

Table S1. Results from the models for analysing the effects of nematodes and mites on the reproductive success of beetles.

Explanatory variables	X²	d.f.	P-value
Brood size			
initial nematode density	1.26	2	0.533
mite treatment	0.07	1	0.784
body size	2.63	1	0.105
carcass mass	0.92	1	0.337
Brood mass			
initial nematode density	4.53	2	0.104
mite treatment	5.87	1	0.015
body size	4.90	1	0.027
carcass mass	0.16	1	0.687
Average larval mass			
initial nematode density	11.07	2	0.004
mite treatment	11.42	1	0.001
body size	3.14	1	0.076
carcass mass	14.36	1	<0.001
brood size	278.37	1	<0.001
initial nematode density x mite treatment	6.18	2	0.046

Table S2. Results from the models for analysing the effects of nematodes and mites on the reproductive success of nematodes and mites.

Explanatory variables	X²	d.f.	P-value
Number of nematodes on females			
initial nematode density	0.25	1	0.615
mite treatment	4.47	1	0.035
body size	0.56	1	0.456
carcass mass	0.01	1	0.932
Number of mites on females			
initial nematode density	8.43	2	0.015
body size	3.80	1	0.051
carcass mass	0.80	1	0.372

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128 Table S3. Results of PERMANOVA (Adonis) testing for differences in community
129 composition across all groups.

Source	Df	Sums of Sqs	R ²	F	Model P Value
condition	4	3.5764	0.480	5.77	0.001
residuals	25	3.8696	0.519		
total	29	7.4461	1.000		

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132 Table S4. Pairwise PERMANOVA results comparing differences in community composition
 133 among sample groups. Significant differences (P Adjust < 0.05) are bolded.

Comparison		Df	F model	R ²	P value	P adjust
beetle	carcass	1	7.91	0.442	0.005	0.008
beetle	mite	1	1.03	0.094	0.386	0.386
beetle	nematode	1	1.64	0.141	0.097	0.108
beetle	nematode-mite	1	3.53	0.261	0.005	0.008
carcass	mite	1	8.58	0.462	0.002	0.006
carcass	nematode	1	11.4	0.534	0.005	0.008
carcass	nematode-mite	1	9.94	0.499	0.001	0.006
mite	nematode	1	1.76	0.150	0.066	0.082
mite	nematode-mite	1	2.04	0.169	0.048	0.068
nematode	nematode-mite	1	4.70	0.320	0.002	0.006

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137 Table S5. Overall ANOSIM test for differences in community composition across all groups.

Comparison	R	P Value	N perm
All groups	0.4602	0.001	999

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Table S6. Pairwise ANOSIM results testing differences in community composition between sample groups. Significant differences ($P < 0.05$) indicate distinct community structures between the groups.

Comparison		R	P value	P adjust	N perm
beetle	carcass	0.989	0.001	0.01	999
	mite	0.039	0.316	0.316	999
	nematode	0.157	0.07	0.077	999
	nematode-mite	0.537	0.006	0.01	999
carcass	mite	0.994	0.006	0.01	999
	nematode	1.000	0.003	0.01	999
	nematode-mite	1.000	0.004	0.01	999
mite	nematode	0.180	0.034	0.048	999
	nematode-mite	0.213	0.057	0.071	999
nematode	nematode-mite	0.537	0.005	0.01	999

158	Supplementary Movies
159	Video S1
160	Towers waving behaviour of the nematode <i>Rhomborhabditis regina</i> dauers in the carrion
161	nest of <i>Nicrophorus nepalensis</i>
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163	Video S2
164	Genital colonisation by the nematodes <i>Rhomborhabditis regina</i> in a male <i>Nicrophorus</i>
165	<i>nepalensis</i>
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