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Crop & Pasture Science

Supplementary Material

Beneficial invertebrates of dairy pastures in south-eastern Australia

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Table S1. Analysis of bulk paddock samples and individual site samples undertaken by Nutrient Advantage®, a NATA accredited laboratory. Methods follow those described in GE Rayment & DJ Lyons (2011) Soil Chemical Methods - Australasia, CSIRO Publishing. Melbourne, Australia.

Soil measurement	Units	Sample analysed
Electrical Conductivity using a Saturated Extract approximation (ECSE)	dS/m	Site
Phosphorus (Colwell)	mg/kg	Bulk
Phosphorus (Olsen)	mg/kg	Bulk
Potassium (Colwell) (available Potassium)	mg/kg	Bulk
Potassium (Amm. Acetate)	mg/kg	Bulk
Ammonium Nitrogen	mg/kg	Bulk
Nitrate Nitrogen	mg/kg	Bulk
Chloride	mg/kg	Bulk
Sulphur (KCI)	mg/kg	Bulk
Copper	mg/kg	Bulk
Iron	mg/kg	Bulk
Manganese	mg/kg	Bulk
Aluminium	mg/kg	Bulk
Zinc (DTPA)	mg/kg	Bulk
Boron (Hot CaCl2)	mg/kg	Bulk
Calcium, Magnesium, Potassium, Sodium (Ammonium Acetate)	$cmol_c/kg$	Bulk
Cation Exchange Capacity	$cmol_c/kg$	Bulk
Calcium/Magnesium ratio	ratio	Bulk
Exchangeable Sodium Percentage	%	Bulk
Aluminium % of Cations	%	Bulk
pH (1:5 water), pH (1:5 CaCl2)	ratio	Site
Electrical Conductivity (1:5 water)	dS/m	Site

Colour & Texture (Hand bolus)	categorical	Bulk
Organic Carbon	%	Site
Organic Matter	%	Bulk
%Coarse Sand, %Fine Sand, %Silt, %Clay (Hydrometer and wet sieve)	%	Site
Calculated soil texture (based on % fractions of sand, silt and clay)	categorical	Site

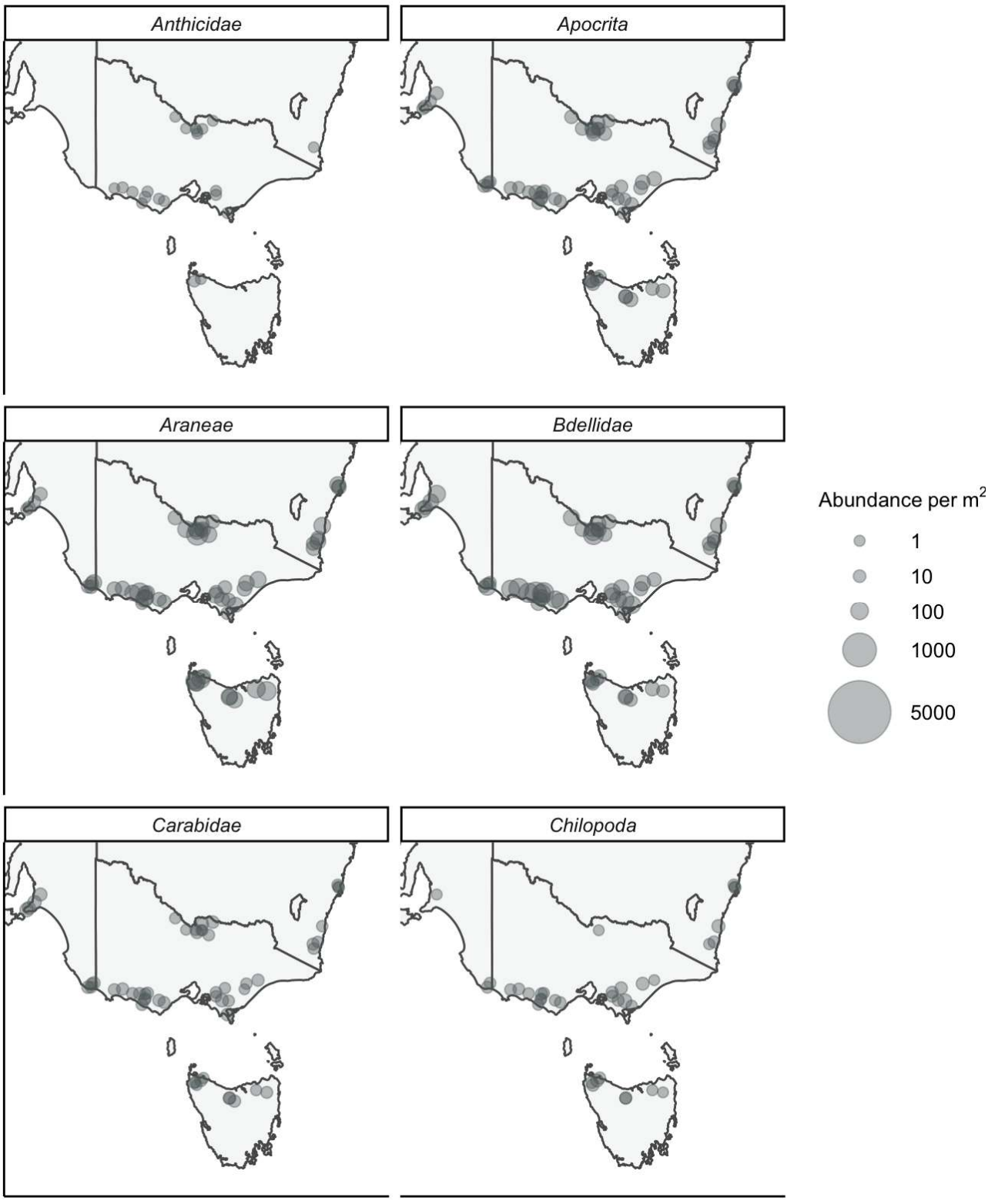
Table S2. List of invertebrate taxa where the functional role within dairy pasture systems could not be confidently assigned due to poor taxonomic resolution of these individuals and/or poor knowledge of their ecological function in pastures.

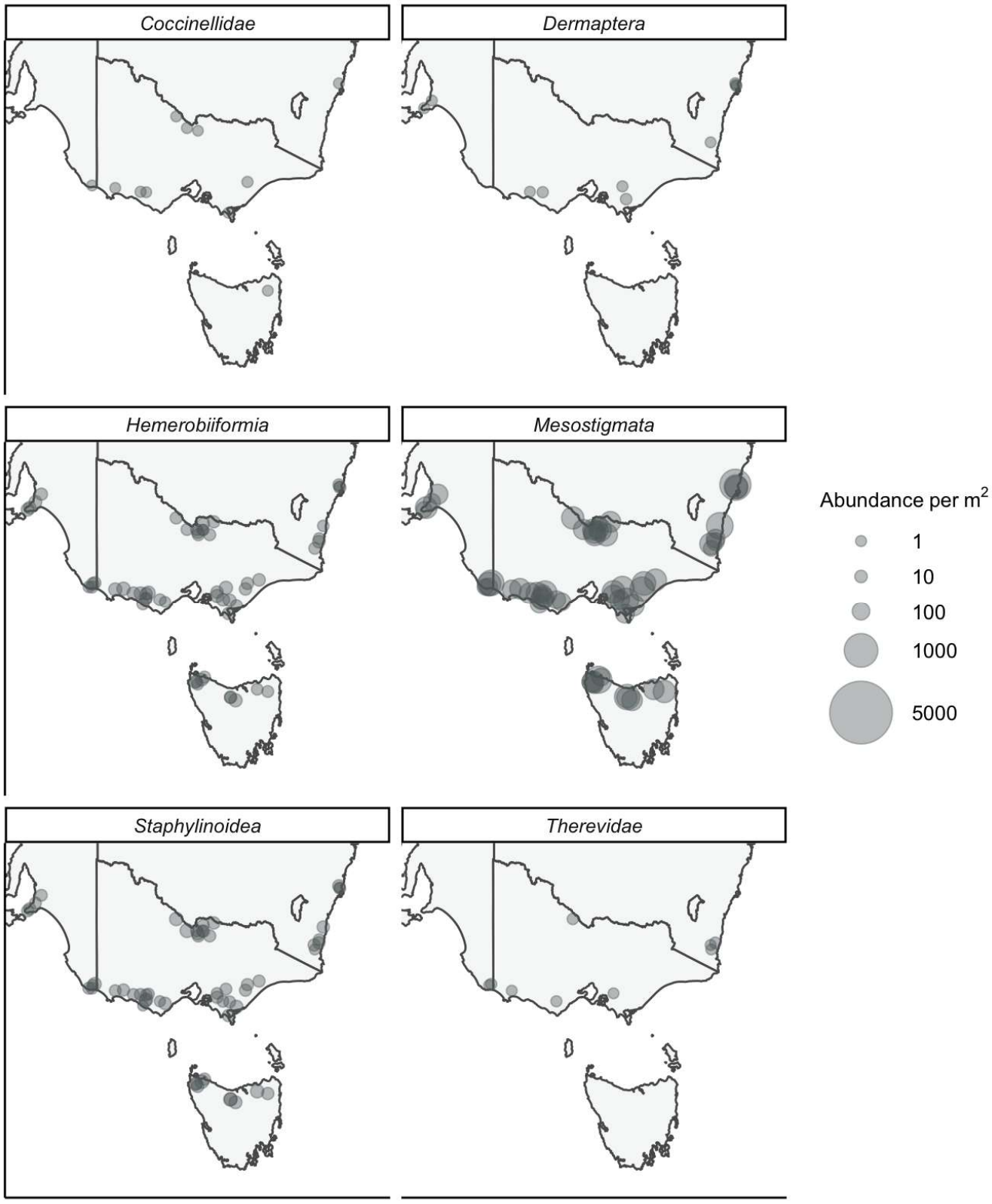
Taxa	**Scientific name**	**Lowest taxonomic classification**
Christmas beetle	Anoplognathus	Tribe
Dipluran	Diplura	Order
Other beetles	Coleoptera	Order
Other flies	Diptera	Order
Other Hemiptera	Hemiptera	Order
Other Heteroptera	Heteroptera	Sub Order
Other mites	Acari	Sub Class
Other Rutelinae	Rutelinae	Sub Family
Other Scarabaeidae	Scarabaeidae	Family
Phyllotocus beetle	*Phyllotocus* spp.	Genus

Table S3. Pest invertebrate taxa identified, and their average abundance (per m^2), within seven dairy regions of south-eastern Australia. FSA = Fleurieu Peninsula, ESA = eastern South Australia, GIP = Gippsland, NSW = south coast New South Wales, NVC = northern Victoria, SWVC = south west Victoria, TAS = Tasmania.

Common name	Scientific name	Region						
		FSA	ESA	GIP	NSW	NVC	SWVC	TAS
Blackheaded cockchafer	*Acrossidius tasmaniae*	16.09	6.41	7.75	0.00	0.07	1.74	7.00
Redheaded cockchafer	*Adoryphorus coulonii*	0.00	0.16	14.5	0.00	0.00	2.38	3.81
Root aphid colony	Aphidoidea	13.75	5.94	35.06	3.36	0.13	13.37	35.81
Auchenorrhyncha	Auchenorrhyncha	9.97	18.15	46.13	32.32	39.61	32.96	44.78
Balaustium mite	*Balaustium medicagoense*	0.07	3.03	1.49	118.08	2.37	0.51	0.44
Bryobia mite	*Bryobia* spp.	0.48	0.14	43.34	14.16	2.84	0.15	5.01
Vineyard snail	*Cernuella virgata*	0.78	5.62	0.00	0.31	0.00	0.00	0.00
Coccoidea	Coccoidea	20.79	33.45	30.68	11.63	2.71	13.07	15.12
Pointed snail	*Cochlicella acuta*	0.00	0.78	0.00	0.00	0.00	0.06	0.00
Other weevils	Curculionoidea	31.24	74.45	16.24	48.11	25.51	10.75	28.67
Argentine scarab	*Cyclocephala signaticollis*	0.00	0.00	0.00	2.50	0.00	0.00	0.00
Grey field slug	*Deroceras reticulatum*	0.90	2.64	1.35	0.49	0.32	1.60	3.21
True wireworm	Elateridae	4.06	2.34	29.55	12.4	6.69	18.07	20.56
European earwig	*Forficula auricularia*	3.13	0.00	0.06	0.00	0.07	0.06	0.06
Other slugs	Gastropoda (slugs)	0.14	0.16	0.56	0.00	0.00	1.41	1.58
Other snails	Gastropoda (snails)	29.34	58.61	16.24	2.70	0.20	44.37	44.17
Redlegged earth mite	*Halotydeus destructor*	1167.99	1314.43	212.42	14.68	457.92	339.15	0.61
African black beetle	*Heteronychus arator*	1.56	0.00	3.69	9.14	0.59	0.12	0.00

Other Lepidoptera	Lepidoptera	9.31	8.01	12.27	15.71	5.68	18.38	21.49
Argentine stem weevil	*Listronotus bonariensis*	0.00	0.00	0.39	0.00	1.05	0.82	0.72
Mandalotus weevil	*Mandalotus* spp.	0.00	0.00	0.00	0.00	0.06	0.00	0.17
Other Melolonthinae	Melolonthinae	26.09	58.13	2.75	0.08	0.07	1.86	1.94
Black keeled slug	*Milax gagates*	0.63	4.11	0.25	0.07	0.20	2.62	2.00
Black field earwig	*Nala lividipes*	0.16	0.00	0.19	0.08	0.26	0.32	0.00
Armyworm	Noctuidae	0.31	0.16	0.92	7.93	0.06	0.47	0.18
Portuguese millipede	*Ommatoiulus moreletii*	1.09	0.63	0.06	0.00	0.07	0.35	0.06
Other Orthoptera	Orthoptera	0.16	0.00	1.83	0.39	0.06	0.28	0.92
Blue oat mite	*Penthaleus* spp.	366.03	245.03	231.69	285.45	231.14	279.4	41.97
Small pointed snail	*Prietocella barbara*	31.73	210.46	2.89	2.54	0.03	11.76	19.93
Mealy bug colony	Pseudococcidae	0.47	2.66	14.31	2.73	1.32	2.03	62.63
Bird cherry oat aphid	*Rhopalosiphum padi*	395.69	1568.28	502.34	509.82	909.33	351.78	587
Yellowheaded cockchafer	*Sericesthis* spp.	20.94	0.16	1.25	2.19	1.32	0.00	1.50
Lucerne flea	*Sminthurus viridis*	169.97	1632.43	1333.9	438.27	740.68	1082.01	3507.49
Spotted vegetable weevil	*Steriphus diversipes*	0.00	0.69	0.00	0.34	0.00	0.00	0.00
Black field cricket	*Teleogryllus commodus*	0.00	0.41	0.19	0.00	0.03	0.24	0.08
False wireworm	Tenebrionidae	5.81	1.56	3.15	1.44	4.48	2.88	1.85
Spider mite	Tetranychidae	0.00	0.00	0.11	0.41	0.23	0.00	0.00
White Italian snail	*Theba pisana*	0.00	4.06	0.00	0.00	0.00	0.06	0.00
Spotted alfalfa aphid	*Therioaphis trifolii*	0.00	1.10	47.03	26.23	55.9	2.61	31.57
Pest thrip	Thysanoptera	12.86	79.54	64.38	56.48	35.63	54.90	34.24


Anthicidae
Apocrita
Araneae
Bdellidae
Carabidae
Chilopoda
Abundance per m2
1
10
100
1000
5000


Coccinellidae
Dermaptera
Hemerobiiformia
Mesostigmata
Staphylinoidea
Therevidae
Abundance per m2
1
10
100
1000
5000

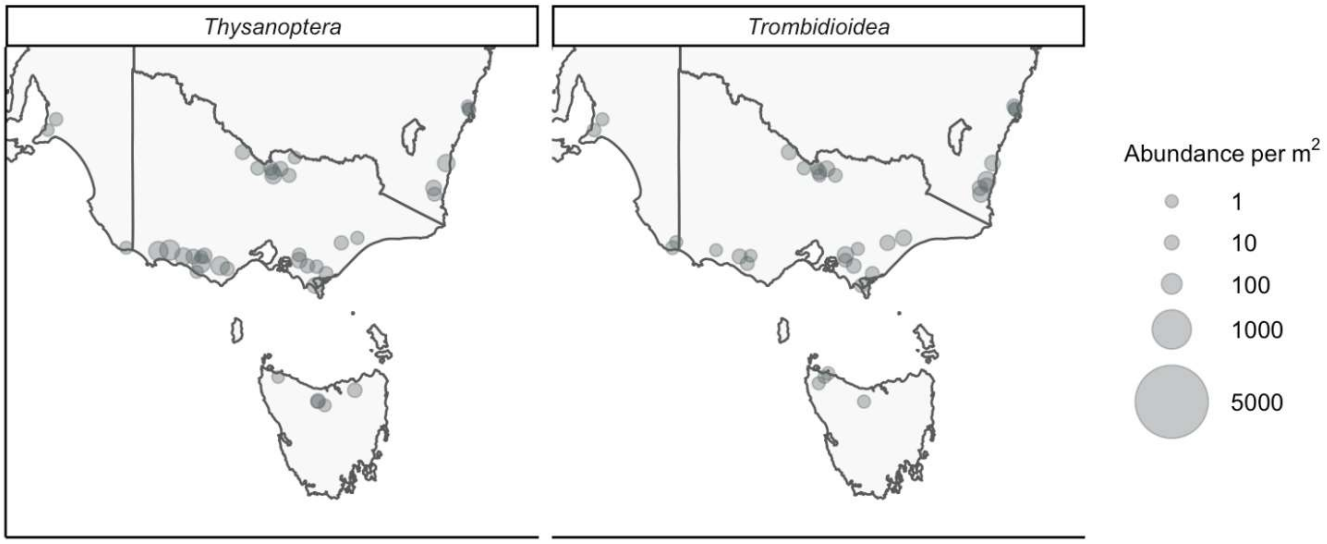
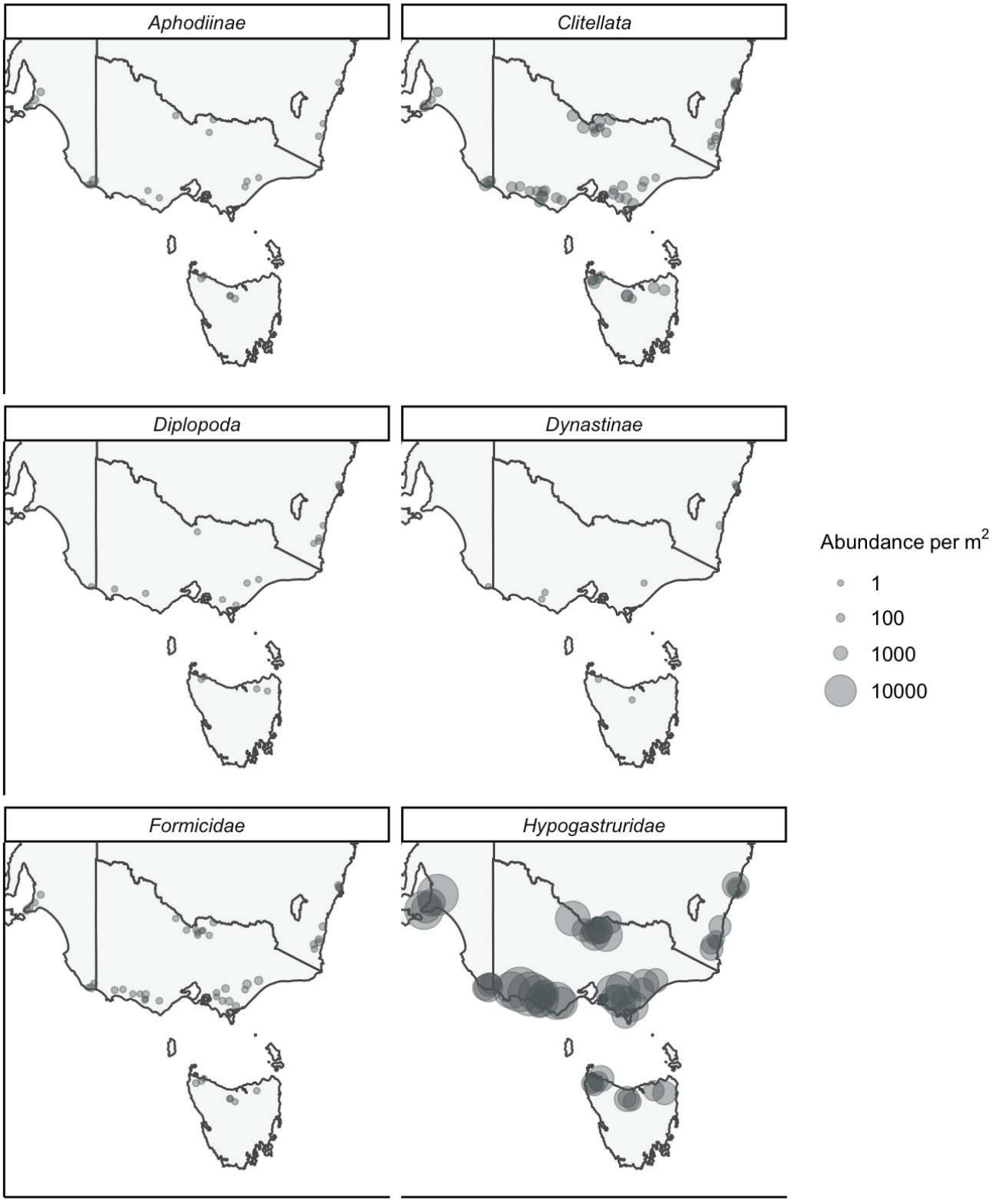


Figure S1. Distribution maps for natural enemy taxa from above- and below-ground samples. The size of the circles represents the average abundance of each taxon (calculated by summing the above- and below-ground abundances) at each paddock where they were found in our survey.


Aphodiinae
Clitellata
Diplopoda
Dynastinae
Formicidae
Hypogastruridae
Abundance per m2
1
100
1000
10000

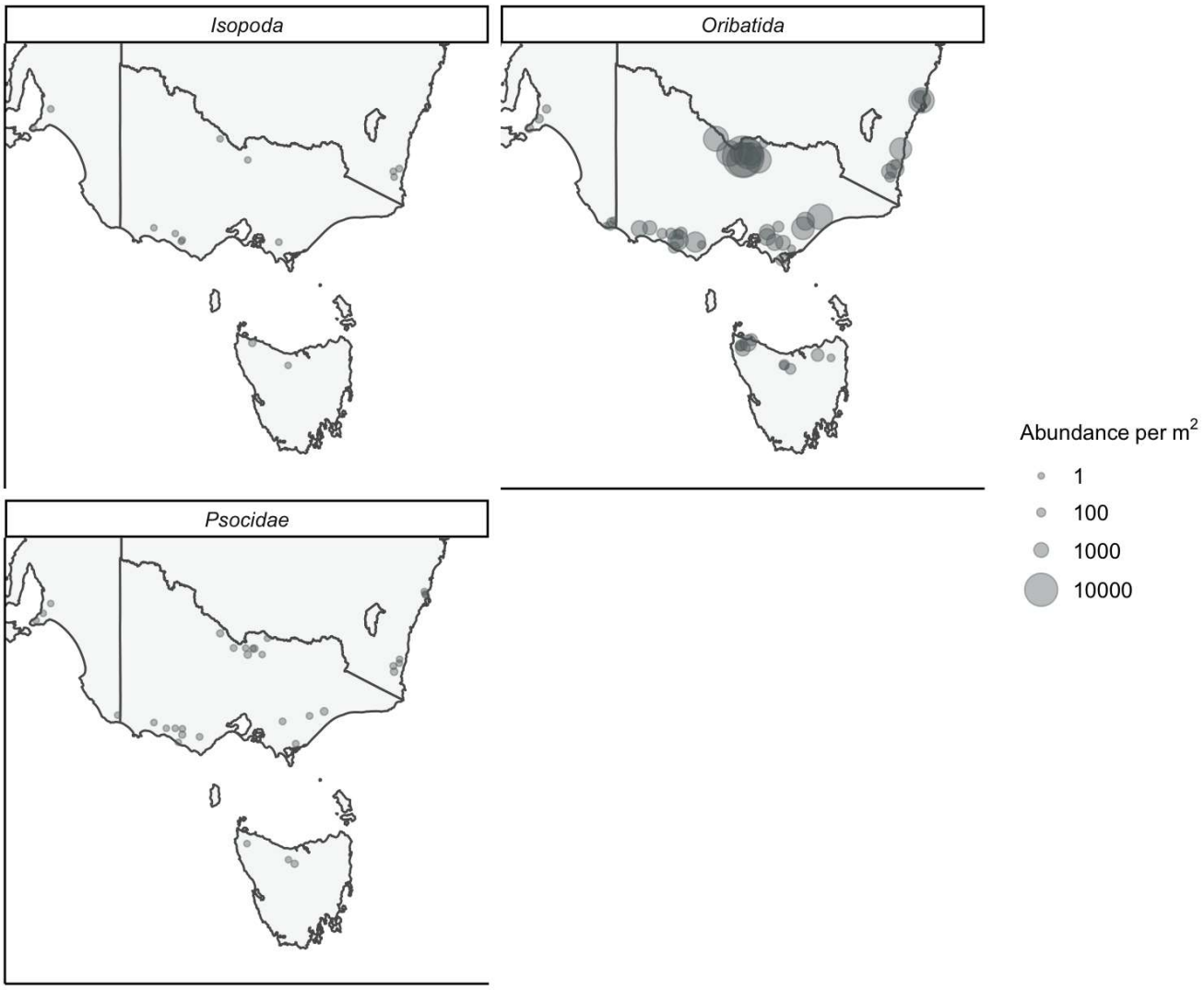


Figure S2. Distribution maps for other beneficial taxa from above- and below-ground samples. The size of the circles represents the average abundance of each taxon (calculated by summing the above- and below-ground abundances) at each paddock where they were found in our survey.

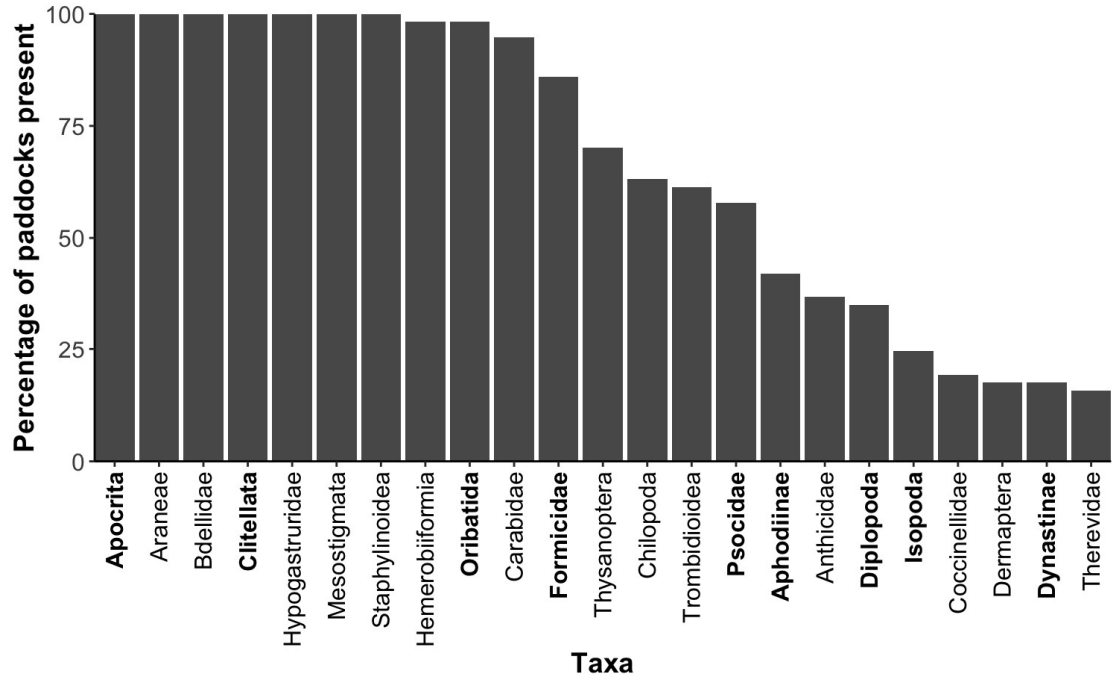


Figure S3. Percentage of paddocks where each natural enemy (plain text) and other beneficial (bold text) taxon was found to be present during our survey.

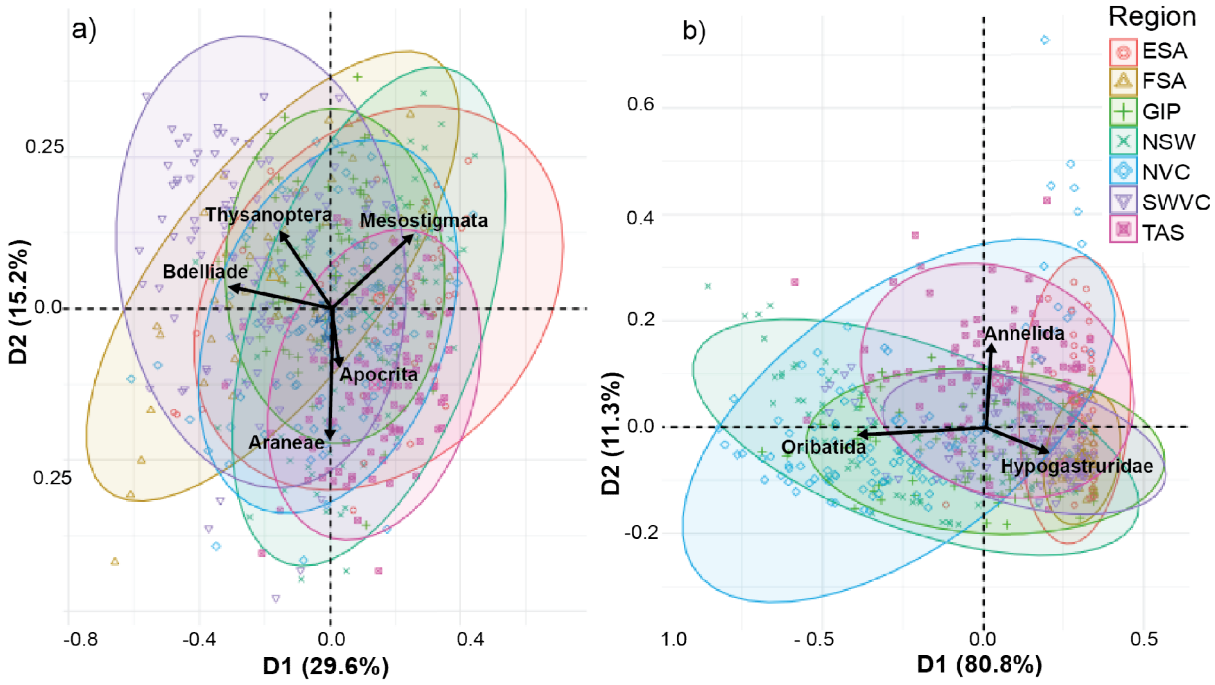


Figure S4. PCA biplot for the abundance of (a) natural enemies and (b) other beneficials. Each dot represents an individual sampling site; the closer two dots are in space, the more similar the natural

enemy or other beneficial taxa are. The colour of the dots indicates the corresponding region. Arrows show vectors based on the taxa with the greatest loadings on the two leading dimensions identified by the PCA. The angles between each arrow represent the correlation between taxa abundances at different sites (*i.e.,* angles of 0°, 90° and 180° between arrows would indicate correlations of 1, 0 and -1, respectively).

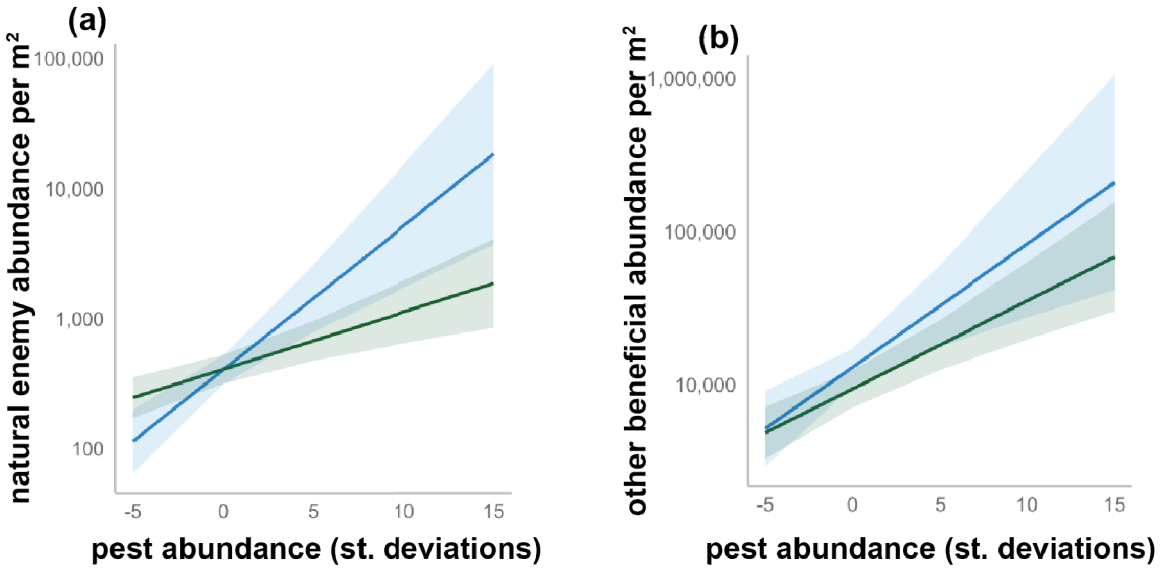


Figure S5. The predicted association of pest abundance with the abundances of (a) natural enemies and (b) other beneficials in spring (green colour) and autumn (blue colour) from mixed models that accounted for the effects of region and repeated measurements of sites over time. Note that pests are on a standardized scale (*i.e.,* 0 is the mean).

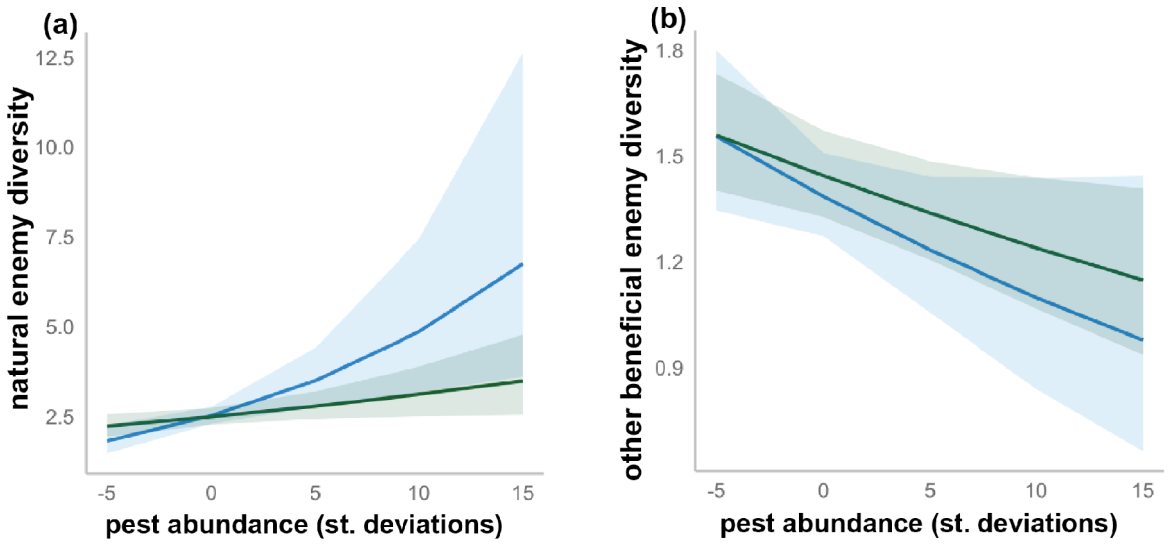


Figure S6. The predicted association of pest abundance with the diversity of (a) natural enemies and (b) other beneficials in spring (green) and autumn (blue). Lines are based on the marginal effects predicted from mixed models that accounted for the effects of region and repeated measurements of sites over time. Note that pests are on a standardized scale (*i.e.,* 0 is the mean).

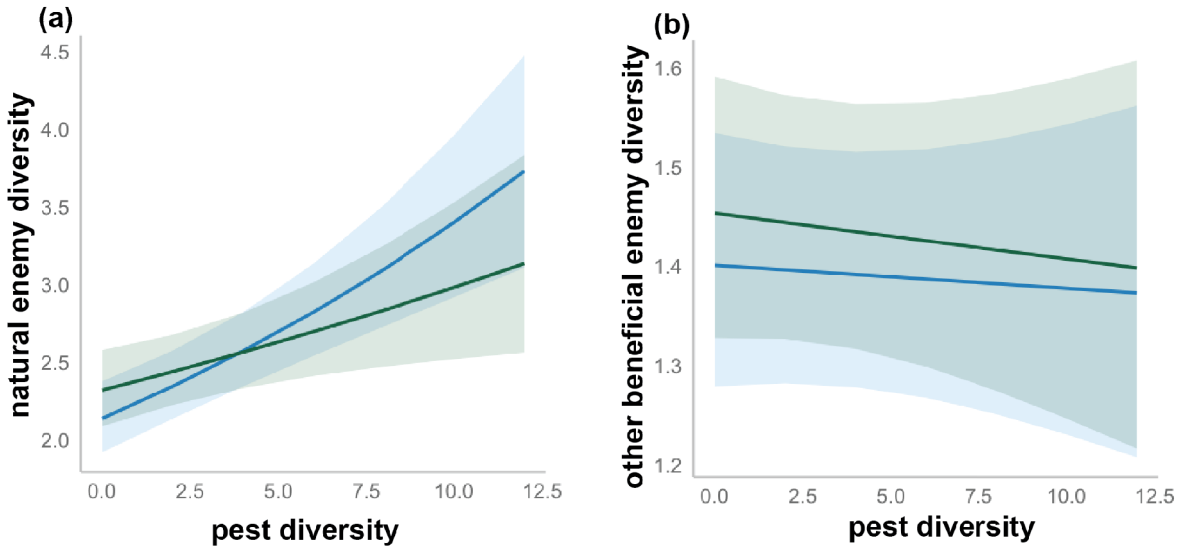


Figure S7. The predicted association between the pest diversity with the diversity of (a) natural enemies and (b) other beneficials in spring (green) and autumn (blue). Lines are based on the marginal effects predicted from mixed models that accounted for the effects of region and repeated measurements of sites over time.