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Global synthesis of effects of plant species diversity on trophic groups and interactions

Nian-Feng Wan[1,2,11], Xiang-Rong Zheng[3,11], Li-Wan Fu[3], Lars Pødenphant Kiær[4], Zhijie Zhang[5], Rebecca Chaplin-Kramer[6,7], Matteo Dainese[8], Jiaqi Tan[9], Shi-Yun Qiu[2], Yue-Qing Hu[3], Wei-Dong Tian[3], Ming Nie[2], Rui-Ting Ju[2], Jian-Yu Deng[10], Jie-Xian Jiang[1]✉, You-Ming Cai[1]✉ and Bo Li[2]✉

[1]Eco-environmental Protection Research Institute, Shanghai Academy of Agricultural Sciences, Shanghai Key Laboratory of Protected Horticultural Technology, Shanghai Engineering Research Centre of Low-carbon Agriculture, Shanghai, China. [2]Ministry of Education Key Laboratory for Biodiversity Science and Ecological Engineering, Coastal Ecosystems Research Station of the Yangtze River Estuary, Institute of Biodiversity Science, School of Life Sciences, Fudan University, Shanghai, China. [3]State Key Laboratory of Genetic Engineering, Institute of Biostatistics, School of Life Sciences, Fudan University, Shanghai, China. [4]Department of Plant and Environmental Sciences, University of Copenhagen, Copenhagen, Denmark. [5]Department of Biology, University of Konstanz, Konstanz, Germany. [6]Natural Capital Project, Woods Institute for the Environment, Stanford University, Stanford, CA, USA. [7]Institute on the Environment, University of Minnesota, Minneapolis, MN, USA. [8]Institute for Alpine Environment, EURAC Research, Bolzano, Italy. [9]Department of Biological Sciences, University of Pittsburgh, Pittsburgh, PA, USA. [10]Department of Plant Protection, School of Agriculture and Food Science, Zhejiang Agriculture and Forestry University, Hangzhou, China. [11]These authors contributed equally: Nian-Feng Wan, Xiang-Rong Zheng. ✉e-mail: jiangjiexian@163.com; cym59059@163.com; bool@fudan.edu.cn

Supplementary information

Supplementary Table 1. Overview of the 351 papers used in the meta-analysis of the effects of increased plant species diversity on predators, parasitoids, herbivores and plants. For each paper, the table indicates whether it provides information on abundance (N), diversity (D), and impact (I, indicating herbivore damage, predation and parasitism, respectively) of the herbivores, predators and parasitoids, as well as information on plant growth (G), reproductive output (R) and quality (Q). The trophic cascade column indicates whether a bi- or tri-trophic interaction was studied, and if yes which one.

No.	Study	Herbivore			Predator			Parasitoid			Plant			Trophic interaction	Plant life form	Ecosystem type	Replications for each study
		N	D	I	N	D	I	N	D	I	G	R	Q				
1	Abdala-Roberts et al. (2016)	√							√	√				Parasitoid → herbivore	Woody plant	Forest	3
2	Abdala-Roberts et al. (2015)	√		√	√									Predator → herbivore	Woody plant	Forest	4
3	Abou-Elela et al. (2012)										√			No trophic interaction	Herbaceous plant	Agroecosystem	3
4	Adati et al. (2011)	√								√				Parasitoid → herbivore	Herbaceous plant	Agroecosystem	3
5	Adhikari and Reddy (2017)	√		√							√			Herbivore → plant	Herbaceous plant	Agroecosystem	6
6	Agegnehu et al. (2008)										√	√		No trophic interaction	Herbaceous plant	Agroecosystem	4
7	Alalouni et al. (2014)			√										No trophic interaction	Woody plant	Forest	3
8	Alghali (1993)	√		√								√		Herbivore → plant	Herbaceous plant	Agroecosystem	3
9	Allan et al. (2011)										√			No trophic interaction	Herbaceous plant	Grassland	4
10	Altieri and Gliessman (1983)	√		√							√			Herbivore → plant	Herbaceous plant	Agroecosystem	3
11	Altieri and Schmidt (1986)	√		√								√		Herbivore → plant	Woody plant	Agroecosystem	3
12	Amini et al. (2013)											√	√	No trophic interaction	Herbaceous plant	Agroecosystem	3
13	Amoako and Kidega. (1983)			√										No trophic interaction	Herbaceous plant	Agroecosystem	4
14	Amoako-Atta and Omolo (1983)			√							√			Herbivore → plant	Herbaceous plant	Agroecosystem	4
15	Andow (1990)	√					√				√			Predator → herbivore → plant	Herbaceous plant	Agroecosystem	5
16	Andow and Risch (1985)	√			√		√							Predator → herbivore	Herbaceous plant	Agroecosystem	4

17	Andow and Risch (1987)							√			No trophic interaction	Herbaceous plant	Agroecosystem	4
18	Andow et al. (1986)	√							√		Herbivore → plant	Herbaceous plant	Agroecosystem	4
19	Anja et al. (2012)								√		No trophic interaction	Herbaceous plant	Grassland	4
20	Armstrong and Mckinlay (1997)			√							No trophic interaction	Herbaceous plant	Agroecosystem	4
21	Bach (1980a)	√		√					√	√	Predator → herbivore→ plant	Herbaceous plant	Agroecosystem	3
22	Bach (1980b)	√		√						√	Predator → herbivore→ plant	Herbaceous plant	Agroecosystem	2
23	Bach (1981)	√							√		Herbivore → plant	Herbaceous plant	Agroecosystem	4
24	Bach and Tabashnik (1990)	√					√	√			Parasitoid → herbivore	Herbaceous plant	Agroecosystem	2
25	Bachmann et al. (2017)							√			No trophic interaction	Herbaceous plant	Grassland	4
26	Badenes-Pérez et al. (2017)	√		√				√			Predator / Parasitoid → herbivore	Herbaceous plant	Agroecosystem	4
27	Balmer et al. (2014)		√			√		√		√	Predator/Parasitoid→herbivore→plant	Herbaceous plant	Agroecosystem	3
28	Balzan et al. (2014)			√							No trophic interaction	Herbaceous plant	Agroecosystem	5
29	Banks (2000)	√									No trophic interaction	Herbaceous plant	Grassland	3
30	Bennett and Gratton (2013)				√						No trophic interaction	Herbaceous plant	Agroecosystem	6
31	Berndt et al. (2015)						√				No trophic interaction	Woody plant	Agroecosystem	5
32	Bessler et al. (2009)								√		No trophic interaction	Herbaceous plant	Grassland	4
33	Bickerton and Hamilton (2012)					√					No trophic interaction	Herbaceous plant	Agroecosystem	4
34	Björkman et al. (2007)	√									No trophic interaction	Herbaceous plant	Agroecosystem	4
35	Björkman et al. (2010)			√		√					No trophic interaction	Herbaceous plant	Agroecosystem	4
36	Blaauw et al. (2017)	√									No trophic interaction	Herbaceous plant	Agroecosystem	4
37	Blubaugh et al. (2016)			√							No trophic interaction	Herbaceous plant	Agroecosystem	5
38	Booij et al. (1997)			√	√						No trophic interaction	Herbaceous plant	Agroecosystem	4
39	Bottenberg et al. (1998)	√	√	√			√	√		√	Predator / Parasitoid → herbivore→plant	Herbaceous plant	Agroecosystem	4
40	Brennan (2013)								√		No trophic interaction	Herbaceous plant	Agroecosystem	5
41	Brennan (2016)								√		No trophic interaction	Herbaceous plant	Agroecosystem	3

42	Brezzi et al. (2017)			√										No trophic interaction	Woody plant	Forest	4
43	Broad et al. (2008)	√								√				Parasitoid → herbivore	Herbaceous plant	Agroecosystem	6
44	Brown (2012)	√		√	√							√		Predator → herbivore → plant	Woody plant	Agroecosystem	5
45	Brown and Mathews (2007)			√						√				Parasitoid → herbivore	Woody plant	Agroecosystem	3
46	Brown and Mathews (2008)			√										No trophic interaction	Woody plant	Agroecosystem	2
47	Brown and Schmitt (2001)				√									No trophic interaction	Woody plant	Agroecosystem	4
48	Brown et al. (2003)				√									No trophic interaction	Woody plant	Agroecosystem	4
49	Brown et al. (2010)			√				√						Parasitoid → herbivore	Woody plant	Agroecosystem	4
50	Buchanan and Hooks (2018)	√			√						√			Predator → herbivore → plant	Herbaceous plant	Agroecosystem	4
51	Bugg and Dutcher (1993)	√			√									Predator→ herbivore	Woody plant	Agroecosystem	4
52	Bugg et al. (1991)	√			√									Predator → herbivore	Herbaceous plant	Agroecosystem	3
53	Cai et al. (2007)		√			√			√					Predator / Parasitoid → herbivore	Herbaceous plant	Agroecosystem	3
54	Campos-Navarrete et al. (2015a)	√			√									Predator → herbivore	Woody plant	Forest	4
55	Campos-Navarrete et al. (2015b)	√			√	√								Predator → herbivore	Woody plant	Forest	4
56	Cárcamo and Spence (1994)				√									No trophic interaction	Herbaceous plant	Agroecosystem	2
57	Carmona and Landis (1999)				√									No trophic interaction	Herbaceous plant	Agroecosystem	4
58	Carr et al. (1995)											√		No trophic interaction	Herbaceous plant	Agroecosystem	4
59	Castagneyrol et al. (2017)			√			√				√			Predator → herbivore → plant	Woody plant	Forest	8
60	Castagneyrol et al. (2019)			√							√			Herbivore → plant	Woody plant	Forest	2
61	Castagneyrol et al. (2014)			√										No trophic interaction	Woody plant	Forest	2
62	Castle (2006)	√												No trophic interaction	Woody plant	Agroecosystem	4
63	Chen et al. (1994)	√						√		√				Parasitoid → herbivore	Woody plant	Agroecosystem	5
64	Chen et al. (2011)				√									No trophic interaction	Woody plant	Agroecosystem	3
65	Clark and Francis (1985a)										√	√		No trophic interaction	Herbaceous plant	Agroecosystem	4
66	Clark and Francis (1985b)										√	√	√	No trophic interaction	Herbaceous plant	Agroecosystem	2
67	Coll and Bottrell (1994)	√									√			Herbivore → plant	Herbaceous plant	Agroecosystem	4

68	Costello (1994)			√					√			Herbivore → plant	Herbaceous plant	Agroecosystem	4
69	Costello and Altieri (1995)	√						√				Parasitoid → herbivore	Herbaceous plant	Agroecosystem	4
70	Costello and Daane (1998)				√							No trophic interaction	Woody plant	Agroecosystem	5
71	Cowles et al. (2016)								√			No trophic interaction	Herbaceous plant	Grassland	4
72	Daßler et al. (2008)								√		√	No trophic interaction	Herbaceous plant	Grassland	4
73	Dassou et al. (2015)			√	√							Predator → herbivore	Herbaceous plant	Agroecosystem	4
74	Degooyer et al. (1999)	√							√			Herbivore → plant	Herbaceous plant	Agroecosystem	4
75	Dehaan et al. (2010)								√			No trophic interaction	Herbaceous plant	Grassland	4
76	Deloach and Peters (1972)	√		√	√							Predator → herbivore	Woody plant	Agroecosystem	4
77	Dempster (1969)	√			√			√		√		Predator → herbivore → plant	Herbaceous plant	Agroecosystem	2
78	Depalo et al. (2017)			√				√				Parasitoid → herbivore	Herbaceous plant	Agroecosystem	4
79	Ditner et al. (2013)					√						No trophic interaction	Herbaceous plant	Agroecosystem	7
80	Dybzinski et al. (2008)								√			No trophic interaction	Herbaceous plant	Grassland	4
81	Easterbrook and Tooley (2010)	√		√								No trophic interaction	Herbaceous plant	Agroecosystem	4
82	Ebeling et al. (2013)	√										No trophic interaction	Herbaceous plant	Grassland	4
83	Ebeling et al. (2017)	√	√						√			Herbivore → plant	Herbaceous plant	Grassland	4
84	Ebeling et al. (2012)					√						No trophic interaction	Herbaceous plant	Grassland	4
85	Ebeling et al. (2014)	√	√									No trophic interaction	Herbaceous plant	Grassland	4
86	Eisenhauer et al. (2010a)								√			No trophic interaction	Herbaceous plant	Grassland	4
87	Eisenhauer et al. (2017)								√			No trophic interaction	Herbaceous plant	Grassland	4
88	Eisenhauer et al. (2009a)								√			No trophic interaction	Herbaceous plant	Grassland	4
89	Eisenhauer et al. (2011)	√	√		√	√						Predator → herbivore	Herbaceous plant	Grassland	4
90	Eisenhauer et al. (2009b)								√			No trophic interaction	Herbaceous plant	Grassland	4
91	Eisenhauer et al. (2010b)								√			No trophic interaction	Herbaceous plant	Grassland	4
92	Ekesi et al. (1999)									√		No trophic interaction	Herbaceous plant	Agroecosystem	4
93	Englishloeb et al. (2015)						√	√				No trophic interaction	Woody plant	Agroecosystem	4

94	Esquivel-Gómez et al. (2017)				√	√							No trophic interaction	Woody plant	Forest	4
95	Fernandes et al. (2012)	√											No trophic interaction	Woody plant	Agroecosystem	4
96	Fernandes et al. (2013)	√											No trophic interaction	Herbaceous plant	Agroecosystem	4
97	Fischer et al. (2015)									√			No trophic interaction	Herbaceous plant	Grassland	4
98	Flombaum and Sala (2008)									√			No trophic interaction	Herbaceous plant	Grassland	3
99	Forehand et al. (2006)	√					√		√				Predator / Parasitoid → herbivore	Herbaceous plant	Agroecosystem	6
100	Fornara and Tilman (2009)									√			No trophic interaction	Herbaceous plant	Grassland	4
101	Gao et al. (2008)	√			√			√					Predator / Parasitoid → herbivore	Woody plant	Agroecosystem	3
102	Garcia and Altieri (1992)	√											No trophic interaction	Herbaceous plant	Agroecosystem	3
103	Gethi and Khaemba (1991)	√											No trophic interaction	Herbaceous plant	Agroecosystem	5
104	Gold et al. (1989)			√						√	√		Herbivore → plant	Woody plant	Agroecosystem	4
105	Gordon et al. (2017)	√											No trophic interaction	Herbaceous plant	Agroecosystem	3
106	Grez (1997)				√						√		No trophic interaction	Herbaceous plant	Agroecosystem	3
107	Grossman and Cavender-Bares (2019)			√									No trophic interaction	Woody plant	Forest	3
108	Grossman et al. (2017)									√			No trophic interaction	Woody plant	Forest	3
109	Gubsch et al. (2011)										√		No trophic interaction	Herbaceous plant	Grassland	4
110	Guyot et al. (2016)			√									No trophic interaction	Woody plant	Forest	4
111	Haddad et al. (2010)	√	√		√	√							Predator → herbivore	Herbaceous plant	Grassland	4
112	Haddad et al. (2011)	√			√			√					Predator / Parasitoid → herbivore	Herbaceous plant	Grassland	4
113	Hagler et al. (2018)	√			√								Predator → herbivore	Herbaceous plant	Agroecosystem	4
114	Hahn et al. (2017)			√						√			Herbivore → plant	Woody plant	Forest	4
115	Hanna et al. (2003)	√			√				√			√	Predator / Parasitoid → herbivore→ plant	Woody plant	Agroecosystem	3
116	Hanspetersen et al. (2010)				√			√					No trophic interaction	Herbaceous plant	Agroecosystem	4
117	Harvey and Eubanks (2005)	√											No trophic interaction	Herbaceous plant	Agroecosystem	10
118	Hector et al. (2011)									√			No trophic interaction	Herbaceous plant	Grassland	4

119	Helenius (1989)	√											No trophic interaction	Herbaceous plant	Agroecosystem	5
120	Hertzog et al. (2017)						√						No trophic interaction	Herbaceous plant	Grassland	4
121	Hertzog et al. (2016)	√	√		√	√							Predator → herbivore	Herbaceous plant	Grassland	4
122	Hickman and Wratten (1996)	√			√								Predator → herbivore	Herbaceous plant	Agroecosystem	3
123	Hilje and Stansly (2008)	√									√		Herbivore → plant	Herbaceous plant	Agroecosystem	4
124	Hinds and Hooks (2013)	√			√								Predator → herbivore	Herbaceous plant	Agroecosystem	4
125	Hogg et al. (2011)	√											No trophic interaction	Herbaceous plant	Agroecosystem	9
126	Hooks and Johnson (2004)	√			√						√		Predator → herbivore → plant	Herbaceous plant	Agroecosystem	4
127	Hooks and Johnson (2015)	√								√	√	√	Herbivore → plant	Herbaceous plant	Agroecosystem	4
128	Hooks and Johnson (2002).	√			√						√		Predator → herbivore → plant	Herbaceous plant	Agroecosystem	4
129	Hooks et al. (1998)	√			√					√			Predator → herbivore → plant	Herbaceous plant	Agroecosystem	4
130	Hooks et al. (2013)	√											No trophic interaction	Herbaceous plant	Agroecosystem	4
131	Horgan et al. (2017)	√			√			√	√	√	√		Predator / Parasitoid → herbivore →plant	Herbaceous plant	Agroecosystem	5
132	Horn (1981)	√			√								Predator → herbivore	Herbaceous plant	Agroecosystem	4
133	Horn (1987)	√						√					Parasitoid → herbivore	Herbaceous plant	Agroecosystem	4
134	Horton and Capinera (1987)	√		√									No trophic interaction	Herbaceous plant	Agroecosystem	5
135	Hossain et al. (2001)	√			√								Predator → herbivore	Herbaceous plant	Agroecosystem	7
136	Huang et al. (2018)									√			No trophic interaction	Woody plant	Forest	4
137	Hummel et al. (2010)			√							√	√	Herbivore → plant	Herbaceous plant	Agroecosystem	4
138	Hurej and Twardowski (2006)				√								No trophic interaction	Herbaceous plant	Agroecosystem	4
139	Irvin et al. (2006)								√				No trophic interaction	Woody plant	Agroecosystem	3
140	Jackson and Sisson (1998)			√									No trophic interaction	Herbaceous plant	Agroecosystem	4
141	Jactel et al. (2006)	√			√					√			Predator → herbivore → plant	Woody plant	Forest	4
142	Kemp and Barrett (1989)	√			√					√	√		Predator → herbivore → plant	Herbaceous plant	Agroecosystem	3
143	Kenny and Chapman (1988)	√									√		Herbivore → plant	Herbaceous plant	Agroecosystem	5

144	Khalsa et al. (2014)								√	No trophic interaction	Herbaceous plant	Grassland	4
145	Khalsa et al. (2012)								√	No trophic interaction	Herbaceous plant	Grassland	4
146	Khan et al. (2006)		√				√	√		Herbivore → plant	Herbaceous plant	Agroecosystem	6
147	Kloen and Altieri (1990)	√		√			√			Predator →Herbivore → plant	Herbaceous plant	Agroecosystem	3
148	Knops et al. (2007)								√	No trophic interaction	Herbaceous plant	Grassland	4
149	Koricheva et al. (2000)	√		√						Predator → herbivore	Herbaceous plant	Grassland	4
150	Kumar (2017)	√						√		Herbivore → plant	Herbaceous plant	Agroecosystem	3
151	Kyamanywa et al. (2011)	√		√						Predator → herbivore	Herbaceous plant	Agroecosystem	6
152	Lagerlof and Wallin (1993)	√		√						Predator → herbivore	Herbaceous plant	Agroecosystem	4
153	Lai et al. (2011)	√						√		Herbivore → plant	Herbaceous plant	Agroecosystem	3
154	Lambert et al. (1987)		√							No trophic interaction	Herbaceous plant	Agroecosystem	4
155	Lamp (1991)	√	√				√			Herbivore → plant	Herbaceous plant	Agroecosystem	4
156	Landl and Glauninger (2013)	√								No trophic interaction	Herbaceous plant	Agroecosystem	12
157	Langer (2015)	√				√				Parasitoid → herbivore	Herbaceous plant	Agroecosystem	3
158	Latheef and Ortiz (1984)	√	√							No trophic interaction	Herbaceous plant	Agroecosystem	3
159	Lawrence and Bach (1989)	√								No trophic interaction	Herbaceous plant	Agroecosystem	8
160	Lee and Heimpel (2005)					√				No trophic interaction	Herbaceous plant	Agroecosystem	4
161	Lemes et al. (2014)	√								No trophic interaction	Woody plant	Forest	22
162	Leslie et al. (2017)			√			√			No trophic interaction	Herbaceous plant	Agroecosystem	4
163	Letourneau (1986)	√								No trophic interaction	Herbaceous plant	Agroecosystem	4
164	Letourneau (1987)			√	√	√				No trophic interaction	Herbaceous plant	Agroecosystem	3
165	Letourneau (1990a)	√		√	√	√				Predator / Parasitoid→ herbivore	Herbaceous plant	Agroecosystem	5
166	Letourneau (1990b)	√		√						Predator → herbivore	Herbaceous plant	Agroecosystem	4
167	Letourneau and Altieri (1983)	√		√				√		Predator → herbivore → plant	Herbaceous plant	Agroecosystem	5
168	Li et al. (2018)	√								No trophic interaction	Woody plant	Agroecosystem	3
169	Li et al. (2001a)						√			No trophic interaction	Herbaceous plant	Agroecosystem	3

170	Li et al. (2001b)								√		No trophic interaction	Herbaceous plant	Agroecosystem	3
171	Lin et al. (2003)	√		√							Predator → herbivore	Woody plant	Agroecosystem	3
172	Lin et al. (2011)	√									No trophic interaction	Herbaceous plant	Agroecosystem	5
173	Lipowsky et al. (2011)							√			No trophic interaction	Herbaceous plant	Grassland	4
174	Litsinger et al. (1991)	√		√					√		Predator → herbivore → plant	Herbaceous plant	Agroecosystem	4
175	Loranger et al. (2014)		√								No trophic interaction	Herbaceous plant	Grassland	4
176	Lu et al. (2019)		√								No trophic interaction	Herbaceous plant	Agroecosystem	3
177	Luigi et al. (2007)								√		No trophic interaction	Herbaceous plant	Agroecosystem	3
178	Lundgren and Fergen (2010)	√	√		√						Predator → herbivore	Herbaceous plant	Agroecosystem	8
179	Lundgren and Fergen (2011)					√					No trophic interaction	Herbaceous plant	Agroecosystem	8
180	Luther et al. (1996)	√	√								No trophic interaction	Herbaceous plant	Agroecosystem	3
181	Ma et al. (2007)	√					√				Parasitoid → herbivore	Herbaceous plant	Agroecosystem	3
182	Ma et al. (2010)	√		√							Predator→ herbivore	Woody plant	Agroecosystem	3
183	Manandhar et al. (2009)	√							√		Herbivore → plant	Herbaceous plant	Agroecosystem	4
184	Manandhar et al. (2017)	√	√	√					√		Predator → herbivore → plant	Herbaceous plant	Agroecosystem	4
185	Manandhar and Wright (2015)		√				√		√		Parasitoid → herbivore → plant	Herbaceous plant	Agroecosystem	4
186	Manandhar and Wright (2016)						√				No trophic interaction	Herbaceous plant	Agroecosystem	4
187	Mardfar et al. (2013)							√	√		No trophic interaction	Herbaceous plant	Agroecosystem	3
188	Marquard et al. (2009a)							√			No trophic interaction	Herbaceous plant	Grassland	4
189	Marquard et al. (2009b)							√			No trophic interaction	Herbaceous plant	Grassland	4
190	Martin et al. (1990)							√		√	No trophic interaction	Woody plant	Agroecosystem	4
191	Mason and Leihner (1988)							√	√		No trophic interaction	Woody plant	Agroecosystem	4
192	Mason et al. (1986a)								√		No trophic interaction	Woody plant	Agroecosystem	4
193	Mason et al. (1986c)									√	No trophic interaction	Herbaceous plant	Agroecosystem	4
194	Mason et al. (1986b)							√			No trophic interaction	Woody plant	Agroecosystem	4
195	Mathews et al. (2017)	√	√								No trophic interaction	Herbaceous plant	Agroecosystem	4

196	Matteson (1982)	√	√							√		Herbivore → plant	Herbaceous plant	Agroecosystem	6
197	Meagher and Meyer (1990)		√									No trophic interaction	Woody plant	Agroecosystem	6
198	Menalled et al. (1999)							√				No trophic interaction	Herbaceous plant	Agroecosystem	3
199	Meyer et al. (2017)		√									No trophic interaction	Herbaceous plant	Grassland	4
200	Meyling et al. (2013)	√		√				√				Predator / Parasitoid → herbivore	Herbaceous plant	Agroecosystem	3
201	Midega and Khan (2003)			√	√							No trophic interaction	Herbaceous plant	Agroecosystem	4
202	Midega et al. (2004)					√		√				No trophic interaction	Herbaceous plant	Agroecosystem	4
203	Moreira et al. (2012)	√		√					√		√	Predator→ herbivore → plant	Woody plant	Forest	4
204	Mucheru-Muna et al. (2010)									√		No trophic interaction	Herbaceous plant	Agroecosystem	5
205	Muiruri et al. (2019)	√							√		√	Herbivore → plant	Woody plant	Forest	2
206	Mutiga et al. (2010)	√								√		Herbivore → plant	Herbaceous plant	Agroecosystem	3
207	Nakahira et al. (2012)	√										No trophic interaction	Herbaceous plant	Agroecosystem	6
208	Nampala et al. (2010)			√								No trophic interaction	Herbaceous plant	Agroecosystem	3
209	Nemec et al. (2014)			√								No trophic interaction	Herbaceous plant	Grassland	6
210	Nestmann et al. (2011)								√			No trophic interaction	Herbaceous plant	Grassland	4
211	Ning et al. (2017)									√		No trophic interaction	Herbaceous plant	Agroecosystem	3
212	Nitschke et al. (2017)	√	√					√	√	√		Predator → herbivore → plant	Herbaceous plant	Grassland	4
213	Nitschke et al. (2010)								√			No trophic interaction	Herbaceous plant	Grassland	4
214	Nitschke et al. (2015)								√			No trophic interaction	Herbaceous plant	Grassland	4
215	Noman et al. (2013)									√		No trophic interaction	Herbaceous plant	Agroecosystem	3
216	Nwilene et al. (2011)		√									No trophic interaction	Herbaceous plant	Agroecosystem	9
217	Nyasani et al. (2012)	√	√	√			√			√		Predator / Parasitoid → herbivore →plant	Herbaceous plant	Agroecosystem	4
218	OBrien et al. (2017)	√		√								Predator → herbivore	Woody plant	Forest	4
219	Ogenga-Latigo et al. (1992a)		√									No trophic interaction	Herbaceous plant	Agroecosystem	2
220	Ogenga-Latigo et al. (1992b)		√									No trophic interaction	Herbaceous plant	Agroecosystem	2

221	Ogol et al. (1998)				√	√			√			No trophic interaction	Herbaceous plant	Agroecosystem	5
222	Oor and Odebiyi (2001)	√		√							√	Herbivore → plant	Herbaceous plant	Agroecosystem	3
223	Oram et al. (2018)									√		No trophic interaction	Herbaceous plant	Grassland	4
224	Parajulee and Slosser (1999)	√			√						√	Predator → herbivore → plant	Woody plant	Agroecosystem	3
225	Parajulee et al. (1997)	√			√							Predator → herbivore	Woody plant	Agroecosystem	3
226	Pascual-Villalobos et al. (2006)			√	√							Predator → herbivore	Herbaceous plant	Agroecosystem	3
227	Pavuk and Stinner (1991)	√										No trophic interaction	Herbaceous plant	Agroecosystem	4
228	Pease and Zalom (2010)	√		√	√				√			Predator / Parasitoid → herbivore	Woody plant	Agroecosystem	8
229	Pellissier and Jabbour (2018)	√					√					Parasitoid → herbivore	Herbaceous plant	Agroecosystem	5
230	Perfecto and Sediles (1992)	√			√							Predator → herbivore	Herbaceous plant	Agroecosystem	3
231	Petermann et al. (2010)	√	√				√	√		√		Parasitoid→ herbivore→ plant	Herbaceous plant	Grassland	4
232	Pfiffner et al. (2009)					√			√			No trophic interaction	Herbaceous plant	Agroecosystem	2
233	Phoofolo et al. (2010)				√							No trophic interaction	Herbaceous plant	Agroecosystem	3
234	Piotto et al. (2010)									√		No trophic interaction	Woody plant	Forest	4
235	Piper (1996)	√										No trophic interaction	Herbaceous plant	Agroecosystem	3
236	Power (1987)	√										No trophic interaction	Herbaceous plant	Agroecosystem	3
237	Pretzsch and Schütze (2009)									√		No trophic interaction	Woody plant	Forest	4
238	Ramalho et al. (2012)	√		√	√						√	Predator → herbivore→ plant	Herbaceous plant	Agroecosystem	4
239	Ramalho et al. (2015)	√		√	√						√	Predator → herbivore → plant	Woody plant	Agroecosystem	4
240	Rämert (2010)			√	√							No trophic interaction	Herbaceous plant	Agroecosystem	4
241	Ramert (2012)			√							√	Herbivore → plant	Herbaceous plant	Agroecosystem	4
242	Rämert and Ekbom (1996)			√	√							Predator → herbivore	Herbaceous plant	Agroecosystem	5
243	Ratnadass et al. (2015)	√		√								No trophic interaction	Herbaceous plant	Agroecosystem	4
244	Rea et al. (2015)	√		√								No trophic interaction	Herbaceous plant	Agroecosystem	8
245	Reddy and Willey (1981)										√	No trophic interaction	Herbaceous plant	Agroecosystem	4
246	Reich et al. (2004)									√		No trophic interaction	Herbaceous plant	Grassland	4

247	Ribeiro and Gontijo (2017)	√		√		√	√				Predator / Parasitoid→ herbivore	Herbaceous plant	Agroecosystem	3
248	Risch (1979)	√									No trophic interaction	Herbaceous plant	Agroecosystem	3
249	Risch (1981)	√									No trophic interaction	Herbaceous plant	Agroecosystem	2
250	Roda et al. (1997)	√									No trophic interaction	Herbaceous plant	Agroecosystem	4
251	Rosado-Sánchez et al. (2018a)							√		√	No trophic interaction	Woody plant	Forest	4
252	Rosado-Sánchez et al. (2018b)		√					√		√	Herbivore → plant	Woody plant	Forest	4
253	Roscher et al. (2011)							√			No trophic interaction	Herbaceous plant	Grassland	4
254	Roscher et al. (2013)							√	√		No trophic interaction	Herbaceous plant	Grassland	4
255	Roscher et al. (2018)							√		√	No trophic interaction	Herbaceous plant	Grassland	4
256	Roscher et al. (2016)							√			No trophic interaction	Herbaceous plant	Grassland	4
257	Rusinamhodzi et al. (2006)								√		No trophic interaction	Herbaceous/woody plants	Agroecosystem	4
258	Ryan et al. (1980)	√									No trophic interaction	Herbaceous plant	Agroecosystem	4
259	Saeed et al. (2013)	√									No trophic interaction	Herbaceous plant	Agroecosystem	3
260	Santalla et al. (1994)							√	√		No trophic interaction	Herbaceous plant	Agroecosystem	2
261	Santalla et al. (1995)							√	√	√	No trophic interaction	Herbaceous plant	Agroecosystem	2
262	Sarker et al. (2009)								√		No trophic interaction	Herbaceous plant	Agroecosystem	3
263	Schader et al. (2005)								√		No trophic interaction	Woody plant	Agroecosystem	4
264	Schellhorn and Sork (1997)	√		√				√			Predator → herbivore → plant	Herbaceous plant	Agroecosystem	4
265	Scherber et al. (2006a)		√								No trophic interaction	Herbaceous plant	Grassland	4
266	Scherber et al. (2006b)		√								No trophic interaction	Herbaceous plant	Grassland	4
267	Schmidt (2015)							√			Herbivore → plant	Woody plant	Forest	6
268	Schmidtke et al. (2010)							√			No trophic interaction	Herbaceous plant	Grassland	4
269	Schmitz et al. (2013)							√			No trophic interaction	Herbaceous plant	Grassland	4
270	Scholte (2015)								√		No trophic interaction	Herbaceous plant	Agroecosystem	3
271	Schuldt et al. (2010)		√								No trophic interaction	Woody plant	Forest	4
272	Schuldt et al. (2014)				√						No trophic interaction	Woody plant	Forest	4

273	Schuldt et al. (2015)			√								No trophic interaction	Woody plant	Forest	4
274	Schuldt et al. (2019)		√			√		√				No trophic interaction	Woody plant	Forest	4
274	Schuldt et al. (2019)		√			√		√				No trophic interaction	Herbaceous plant	Grassland	4
275	Seabloom et al. (2017)									√		No trophic interaction	Herbaceous plant	Grassland	4
276	Seagraves and Yeargan (2006)				√							No trophic interaction	Herbaceous plant	Agroecosystem	4
277	Sekamatte et al. (2003)			√							√	Herbivore → plant	Herbaceous plant	Agroecosystem	5
278	Sherawat et al. (2012)	√			√						√	Predator → herbivore→ plant	Herbaceous plant	Agroecosystem	5
279	Shi et al. (2014)	√	√		√	√						Predator → herbivore	Herbaceous plant	Agroecosystem	4
280	Showler and Greenberg (2003)	√		√	√		√			√	√	Predator / Parasitoid→ herbivore→ plant	Woody plant	Agroecosystem	6
281	Sibhatu et al. (2015)									√		No trophic interaction	Herbaceous plant	Agroecosystem	3
282	Siemann et al. (1998)		√			√		√				No trophic interaction	Herbaceous plant	Grassland	4
283	Sigsgaard (1999)	√										No trophic interaction	Herbaceous plant	Agroecosystem	4
284	Silva et al. (2010)					√						No trophic interaction	Woody plant	Agroecosystem	3
285	Singh et al. (2017)	√			√							Predator → herbivore	Herbaceous plant	Agroecosystem	9
286	Sirrine et al. (2008)										√	No trophic interaction	Woody plant	Agroecosystem	4
287	Skelton and Barrett (2005)	√			√					√		Predator→ herbivore→ plant	Herbaceous plant	Agroecosystem	3
288	Skovgård and Päts (1996)	√							√			Parasitoid → herbivore	Herbaceous plant	Agroecosystem	3
289	Smith et al. (2000a)	√										No trophic interaction	Herbaceous plant	Agroecosystem	3
290	Smith and Mcsorley (2000)	√					√					Parasitoid → herbivore	Herbaceous plant	Agroecosystem	4
291	Smith et al. (2000b)	√			√							Predator → herbivore	Herbaceous plant	Agroecosystem	4
292	Smith (1976)	√									√	Herbivore → plant	Herbaceous plant	Agroecosystem	2
293	Smith (1969)	√			√							Predator → herbivore	Herbaceous plant	Agroecosystem	4
294	Soundararajan and Chitra (2012)	√		√	√							Predator → herbivore	Herbaceous plant	Agroecosystem	4
295	Staab et al. (2014)					√						No trophic interaction	Woody plant	Forest	4
296	Staudacher et al. (2013)	√		√						√		Herbivore → plant	Herbaceous plant	Agroecosystem	7

297	Steinauer et al. (2016)									√		No trophic interaction	Herbaceous plant	Grassland	4
298	Stephens et al. (1998)						√					No trophic interaction	Woody plant	Agroecosystem	8
299	Straub et al. (2013)	√		√	√					√		Predator →Herbivore → plant	Herbaceous plant	Agroecosystem	3
300	Straub et al. (2014)	√		√								No trophic interaction	Herbaceous plant	Agroecosystem	12
301	Sujayanand et al. (2015)	√		√		√					√	Predator → herbivore→ plant	Herbaceous plant	Agroecosystem	3
302	Sun et al. (2017)									√		No trophic interaction	Woody plant	Forest	4
303	Symstad et al. (2000)		√					√				No trophic interaction	Herbaceous plant	Grassland	4
304	Tahvanainen and Root (1972)	√					√		√	√		Parasitoid → herbivore → plant	Herbaceous plant	Agroecosystem	2
305	Tajmiri et al. (2017)	√		√	√	√						Predator → herbivore	Herbaceous plant	Agroecosystem	3
306	Theunissen et al. (1995)			√								No trophic interaction	Herbaceous plant	Agroecosystem	4
307	Theunissen and Ouden (1980)	√		√								No trophic interaction	Herbaceous plant	Agroecosystem	3
308	Tillman et al. (2004)	√		√	√						√	Predator → herbivore→ plant	Woody plant	Agroecosystem	4
309	Tillman (2006)	√										No trophic interaction	Woody plant	Agroecosystem	3
310	Tillman and Mullinix (2004)	√		√	√				√			Predator / Parasitoid → herbivore	Woody plant	Agroecosystem	3
311	Tillman et al. (2001)									√		No trophic interaction	Herbaceous plant	Grassland	4
312	Tillman et al. (1996)									√		No trophic interaction	Herbaceous plant	Grassland	4
313	Toko et al. (1996)	√										No trophic interaction	Woody plant	Agroecosystem	4
314	Tomaseto et al. (2019)	√										No trophic interaction	Woody plant	Agroecosystem	3
315	Tonhasca (2011)						√					No trophic interaction	Herbaceous plant	Agroecosystem	4
316	Tonhasca-Jr and Stinner (1991)	√										No trophic interaction	Woody plant	Agroecosystem	4
317	Trdan et al. (2005)	√		√								No trophic interaction	Herbaceous plant	Agroecosystem	3
318	Tukahirwa and Coaker (1982)	√		√							√	Herbivore → plant	Herbaceous plant	Agroecosystem	4
319	Tulli et al. (2013)	√			√							Predator → herbivore	Herbaceous plant	Agroecosystem	4
320	Uvah and Coaker (1984)	√		√	√							Predator → herbivore	Herbaceous plant	Agroecosystem	3
321	van Moorsel et al. (2017)									√		No trophic interaction	Herbaceous plant	Grassland	4
322	van Moorsel et al. (2018)									√		No trophic interaction	Herbaceous plant	Grassland	6

323	van Ruijven and Berendse (2003)							√			No trophic interaction	Herbaceous plant	Grassland	6
324	Verdelli et al. (2012)							√	√		No trophic interaction	Herbaceous plant	Agroecosystem	4
325	Wagg et al. (2017)							√			No trophic interaction	Herbaceous plant	Grassland	4
326	Wan et al. (2015)	√		√							Predator → herbivore	Woody plant	Agroecosystem	3
327	Wan et al. (2019)	√									No trophic interaction	Woody plant	Agroecosystem	3
328	Wan et al. (2014a)	√		√							Predator → herbivore	Woody plant	Agroecosystem	3
329	Wan et al. (2014b)			√	√						Predator → herbivore	Woody plant	Agroecosystem	3
330	Wan et al. (2018)	√		√							Predator → herbivore	Woody plant	Agroecosystem	3
331	Wan et al. (2016)	√									No trophic interaction	Woody plant	Agroecosystem	3
332	Wang et al. (2011)	√		√					√		Predator → herbivore→ plant	Herbaceous plant	Agroecosystem	3
333	Waterworth (1994)								√		No trophic interaction	Woody plant	Agroecosystem	5
334	Weigelt et al. (2009)							√			No trophic interaction	Herbaceous plant	Grassland	4
335	Weiss et al. (1994)	√							√		Herbivore → plant	Herbaceous plant	Agroecosystem	5
336	Weisser et al. (2017)							√		√	No trophic interaction	Herbaceous plant	Grassland	4
337	Welti et al. (2017)	√		√			√	√			Predator / Parasitoid → herbivore→plant	Herbaceous plant	Grassland	4
338	Werling et al. (2012)			√		√					No trophic interaction	Herbaceous plant	Agroecosystem	5
339	Wilson et al. (2010)							√			No trophic interaction	Woody plant	Forest	3
340	Woltz et al. (2012)			√							No trophic interaction	Herbaceous plant	Agroecosystem	4
341	Xie et al. (2012)	√		√			√				Predator / Parasitoid → herbivore	Herbaceous plant	Agroecosystem	3
342	Xu et al. (2011)		√								No trophic interaction	Herbaceous plant	Agroecosystem	3
343	Yang et al. (2018)					√					No trophic interaction	Woody plant	Forest	4
344	Yao et al. (2012)	√									No trophic interaction	Herbaceous plant	Agroecosystem	3
345	Zeng et al. (2017)		√					√	√		No trophic interaction	Woody plant	Forest	4
346	Zhang et al. (2017)	√									No trophic interaction	Woody plant	Forest	4
347	Zhang et al. (2007)								√		No trophic interaction	Herbaceous plant	Agroecosystem	4

348	Zhang et al. (2017)	√	√	√		Predator / Parasitoid → herbivore	Woody plant	Agroecosystem	3
349	Zhou et al. (2013a)	√	√	√	√	Predator / Parasitoid→ herbivore→ plant	Herbaceous plant	Agroecosystem	3
350	Zhou et al. (2013b)	√			√	Herbivore → plant	Herbaceous plant	Agroecosystem	4
351	Zhu et al. (2015)	√	√			Predator → herbivore	Herbaceous plant	Grassland	3

Supplementary Table 2. Overview of the meta-regression models used to test our research questions. For each model, the table gives the predictor variables included, the Akaike information criterion (AIC), the reference model (model 1) for the log-likelihood ratio test, and the statistics of the log-likelihood ratio tests (log-likelihoods [L-L], X^2, degrees of freedom compared to the reference model [d.f.] and the corresponding P-value) based on model comparisons. Model 1 was nested within Model 1.1—1.4; and Model 2 was nested within Model 2.1-2.4. Details on the comparison between Model 1 and Model 2 are provided in Supplementary Methods. The response variable in all models was the effect size of the responses of predators, parasitoids, herbivores and plants to the different comparison groups. There were 2914 effect sizes from 351 papers. Trophic group included predators, parasitoids, herbivores and plants. Ecosystem type included agroecosystems, forests and grasslands. Plant life form comprised herbaceous and woody plants. Biome type was divided into tropical and temperate biomes. Trophic group response category included predator abundance, predator diversity, predation, parasitoid abundance, parasitoid diversity, parasitism, herbivore abundance, herbivore diversity, herbivore damage, and the growth, reproduction and quality of plants.

Model	Question	Predictor variables	AIC	Ref.	L—L	X^2	d.f.	*n*	*P*-value
1	1	Trophic group	13415	-	-6702	-	-	2914	-
1.1	2	Trophic group × ecosystem type	13154	1	-6564	277.4769	8	2914	2.5381×10^{-55}
1.2	2	Trophic group × plant life form	13390	1	-6686	33.2191	4	2914	1.0772×10^{-6}
1.3	2	Trophic group × biome type	13333	1	-6657	90.5556	4	2914	1.0034×10^{-18}
1.4	1	Trophic group × $\log_2$ (added plant species over control)	13302	1	-6645	115.1857	1	2914	7.1662×10^{-27}
2	1	Trophic group response category	13279	1	-6626	152.6005	8	2914	5.6212×10^{-29}
2.1	2	Trophic group response category × ecosystem type	13034	2	-6481	290.3348	23	2914	4.0837×10^{-48}
2.2	2	Trophic group response category × plant life form	13241	2	-6595	61.3552	12	2914	1.2766×10^{-8}
2.3	2	Trophic group response category × biome type	13194	2	-6572	109.1011	12	2914	9.0099×10^{-18}
2.4	1	Trophic group response category ×log2 (added plant species over control)	13206	2	-6589	75.0215	1	2914	4.6562×10^{-18}

Supplementary Table 3. Results of publication bias assessment based on the residuals from the various models. The results include the test-statistics and P-values of the regression tests. Trophic group included predators, parasitoids, herbivores and plants. Ecosystem type included agroecosystems, forests and grasslands. Plant life form comprised herbaceous and woody plants. Biome type was divided into tropical and temperate biomes. Trophic group response category includes predator abundance, predator diversity, predation, parasitoid abundance, parasitoid diversity, parasitism, herbivore abundance, herbivore diversity, herbivore damage, and the growth, reproduction and quality of plants.

Model	Predictor variables	*n*	Regression test value	*P*-value
1	Trophic group	2914	0.4894	0.6246
1.1	Trophic group × ecosystem type	2914	0.6356	0.5250
1.2	Trophic group × plant life form	2914	0.4184	0.6757
1.3	Trophic group × biome type	2914	0.0332	0.9735
1.4	Trophic group × $\log_2$ (added plant species over control)	2914	-0.4897	0.6244
2	Trophic group response category	2914	0.4860	0.6270
2.1	Trophic group response category × ecosystem type	2914	0.3433	0.7314
2.2	Trophic group response category × plant life form	2914	0.5507	0.5818
2.3	Trophic group response category × biome type	2914	0.4497	0.6529
2.4	Trophic group response category ×$\log_2$ (added plant species over control)	2914	-0.3149	0.7528

Supplementary Table 4. Results of the meta-regression analysis for the four trophic groups and their response categories (as presented also in Fig. 2a). In addition to the estimated mean effect sizes, test-statistics (*t*-value), and the associated *P*-values, the number of studies (#Studies) and observations (#Obs) available for each predictor category are also presented.

Category	#Obs	#Studies	Effect size	*t*-value	*P*-value
Total predator response	709	128	0.7658	10.7642	0.0000
Total parasitoid response	160	57	0.8016	8.3821	0.0000
Total herbivore response	1004	218	-0.9963	-14.9740	0.0000
Total plant response	1041	163	0.6832	14.4656	0.0000
Predator abundance response	524	108	0.6941	8.7337	0.0000
Predator diversity response	138	21	0.8035	4.6628	0.0000
Predation response	47	14	1.4575	4.4502	0.0000
Parasitoid abundance response	58	25	0.8412	5.5771	0.0000
Parasitoid diversity response	25	6	2.0013	5.9806	0.0000
Parasitism response	77	37	0.3882	3.9103	0.0001
Herbivore abundance response	617	172	-1.0868	-15.4267	0.0000
Herbivore diversity response	57	12	0.9556	7.1694	0.0000
Herbivore damage response	330	81	-1.1920	-8.2389	0.0000
Plant growth response	629	103	0.9702	14.6716	0.0000
Plant quality response	114	17	0.1746	2.2793	0.0226
Plant reproduction response	298	78	0.3484	4.0945	0.0000

Supplementary Table 5. Results of the meta-regression analysis for the four trophic groups and their response categories for different ecosystems (agroecosystems, grasslands and forests) (as presented also in Fig. 2b). In addition to the estimated mean effect sizes, test-statistics (*t*-value), and the associated *P*-values, the number of studies (#Studies) and observations (#Obs) available for each predictor category are also presented.

Category	#Studies	#Obs	Effect size	*t*-value	*P*-value
Agroecosystem-Predator	104	533	0.7377	11.1120	0.0000
Agroecosystem-Parasitoid	49	124	0.5081	6.2265	0.0000
Agroecosystem-Herbivore	177	732	-1.3648	-20.6466	0.0000
Agroecosystem-Plant	98	541	0.3365	5.5884	0.0000
Grassland-Predator	13	64	1.0894	6.5970	0.0000
Grassland-Parasitoid	7	29	2.0684	5.0032	0.0000
Grassland-Herbivore	19	133	0.6487	4.0185	0.0001
Grassland-Plant	49	391	1.2260	14.6417	0.0000
Forest-Predator	12	112	-0.0518	-0.1466	0.8834
Forest-Parasitoid	2	7	1.7774	2.8230	0.0048
Forest-Herbivore	23	139	-0.1956	-0.9692	0.3325
Forest-Plant	16	109	0.5247	4.6268	0.0000
Agroecosystem-Predator abundance	93	457	0.7253	9.1985	0.0000
Agroecosystem-Predator diversity	10	51	0.7625	5.9792	0.0000
Agroecosystem-Predation	11	25	0.6902	4.1815	0.0000
Agroecosystem-Parasitoid abundance	22	47	0.6554	5.0789	0.0000
Agroecosystem-Parasitoid diversity	1	4	1.9160	2.9840	0.0028
Agroecosystem-Parasitism	35	73	0.3545	3.4713	0.0005
Agroecosystem-Herbivore abundance	150	498	-1.1468	-16.4129	0.0000
Agroecosystem-Herbivore diversity	2	10	0.2724	1.1061	0.2687
Agroecosystem-Herbivore damage	63	224	-2.0734	-13.0873	0.0000
Agroecosystem-Plant growth	42	227	0.3966	3.6273	0.0003
Agroecosystem-Plant quality	7	57	0.1683	1.5912	0.1116
Agroecosystem-Plant reproduction	74	257	0.3547	3.9416	0.0001
Grassland-Predator abundance	8	27	1.1019	2.5273	0.0115
Grassland-Predator diversity	7	28	0.7381	4.6850	0.0000
Grassland-Predation	1	9	2.5662	5.3871	0.0000
Grassland-Parasitoid abundance	3	11	2.7718	2.2293	0.0258
Grassland-Parasitoid diversity	4	15	1.9959	3.8621	0.0001
Grassland-Parasitism	1	3	1.3204	2.6621	0.0078
Grassland-Herbivore abundance	12	64	-0.2469	-1.3172	0.1878
Grassland-Herbivore diversity	9	41	1.0695	6.4541	0.0000
Grassland-Herbivore damage	5	28	2.0515	4.3985	0.0000
Grassland-Plant growth	45	307	1.4553	15.8847	0.0000
Grassland-Plant quality	6	44	0.3787	1.8834	0.0597
Grassland -Plant reproduction	3	40	0.3856	1.4940	0.1352
Forest-Predator abundance	7	40	-0.4657	-1.0760	0.2819
Forest-Predator diversity	5	59	-0.3066	-0.6174	0.5370
Forest-Predation	2	13	3.7468	2.3683	0.0179
Forest-Parasitoid abundance	/	/	/	/	/
Forest-Parasitoid diversity	2	6	2.1357	3.1846	0.0014
Forest-Parasitism	1	1	0.0184	0.0225	0.9820

Forest-Herbivore abundance	10	55	-1.8181	-3.7965	0.0001
Forest-Herbivore diversity	2	6	2.7197	3.8566	0.0001
Forest-Herbivore damage	13	78	0.2660	1.4710	0.1413
Forest-Plant growth	16	95	0.6675	5.2210	0.0000
Forest-Plant quality	4	13	-0.1325	-0.5670	0.5707
Forest-Plant reproduction	1	1	-2.1727	-2.1207	0.0339

Supplementary Table 6. Results of the meta-regression analysis for the four trophic groups and their response categories for two plant life forms (herbaceous plants and woody plants) (as presented also in Fig. 2c). In addition to the estimated mean effect sizes, test-statistics (*t*-value), and the associated *P*-values, the number of studies (#Studies) and observations (#Obs) available for each predictor category are also presented.

Category	#Studies	#Obs	Effect size	*t*-value	*P*-value
Herbaceous plant-Predator	94	427	0.8530	10.6891	0.0000
Herbaceous plant-Parasitoid	45	125	0.7226	6.5963	0.0000
Herbaceous plant-Herbivore	162	732	-1.1435	-15.0542	0.0000
Herbaceous plant-Plant	133	852	0.7606	13.6591	0.0000
Woody plant-Predator	35	282	0.5376	3.9282	0.0001
Woody plant-Parasitoid	13	35	1.0288	5.4826	0.0000
Woody plant-Herbivore	57	272	-0.5645	-4.3283	0.0000
Woody plant-Plant	32	189	0.3971	4.8824	0.0000
Herbaceous plant-Predator abundance	79	326	0.8464	7.6436	0.0000
Herbaceous plant-Predator diversity	15	67	0.7372	7.3061	0.0000
Herbaceous plant-Predation	12	34	1.0171	5.5593	0.0000
Herbaceous plant-Parasitoid abundance	17	40	0.7341	4.2495	0.0000
Herbaceous plant-Parasitoid diversity	5	19	1.9803	4.8938	0.0000
Herbaceous plant-Parasitism	31	66	0.3511	3.1282	0.0018
Herbaceous plant-Herbivore abundance	133	475	-1.1346	-14.6576	0.0000
Herbaceous plant-Herbivore diversity	11	51	0.8011	6.7085	0.0000
Herbaceous plant-Herbivore damage	55	206	-1.8264	-9.2744	0.0000
Herbaceous plant-Plant growth	83	523	1.0551	13.6863	0.0000
Herbaceous plant-Plant quality	12	80	0.2324	2.1810	0.0292
Herbaceous plant-Plant reproduction	65	249	0.3708	3.9714	0.0001
Woody plant-Predator abundance	29	198	0.5054	4.5280	0.0000
Woody plant-Predator diversity	7	71	0.0832	0.1991	0.8422
Woody plant-Predation	2	13	3.7468	2.3683	0.0179
Woody plant-Parasitoid abundance	8	18	1.2489	3.1602	0.0016
Woody plant-Parasitoid diversity	2	6	2.1357	3.1846	0.0014
Woody plant-Parasitism	6	11	0.6941	2.6533	0.0080
Woody plant-Herbivore abundance	39	142	-0.9201	-5.5584	0.0000
Woody plant-Herbivore diversity	2	6	2.7197	3.8566	0.0001
Woody plant-Herbivore damage	26	124	-0.2626	-1.3645	0.1724
Woody plant-Plant growth	20	106	0.5996	5.1781	0.0000
Woody plant-Plant quality	6	34	0.1016	0.7459	0.4557
Woody plant-Plant reproduction	14	49	0.2411	1.1479	0.2510

Supplementary Table 7. Results of the meta-regression analysis for the four trophic groups and their response categories for two biomes (tropical and temperate biomes) (as presented also in Fig. 2d). In addition to the estimated mean effect sizes, test-statistics (*t*-value), and the associated *P*-values, the number of studies (#Studies) and observations (#Obs) available for each predictor category are also presented.

Category	#Studies	#Obs	Effect size	*t*-value	*P*-value
Tropical biome - Predator	25	96	0.2471	2.4514	0.0142
Tropical biome - Parasitoid	14	39	0.2941	2.1798	0.0293
Tropical biome - Herbivore	53	288	-1.5239	-12.9746	0.0000
Tropical biome - Plant	38	275	0.1389	1.5783	0.1145
Temperate biome - Predator	103	613	0.8564	10.0424	0.0000
Temperate biome - Parasitoid	43	121	1.0228	8.2026	0.0000
Temperate biome - Herbivore	165	716	-0.7709	-9.8158	0.0000
Temperate biome - Plant	125	766	0.8803	16.1906	0.0000
Tropical biome - Predator abundance	24	85	0.1785	1.7274	0.0841
Tropical biome - Predator diversity	3	6	1.1749	3.2776	0.0010
Tropical biome - Predation	2	5	0.1426	0.3063	0.7594
Tropical biome - Parasitoid abundance	6	11	0.5724	2.1275	0.0334
Tropical biome - Parasitoid diversity	1	1	0.1246	0.1522	0.8791
Tropical biome - Parasitism	13	27	0.2357	1.3794	0.1678
Tropical biome - Herbivore abundance	42	178	-1.0490	-8.8274	0.0000
Tropical biome - Herbivore diversity	1	1	1.0103	1.2842	0.1991
Tropical biome - Herbivore damage	22	109	-2.6673	-10.3508	0.0000
Tropical biome - Plant growth	15	105	0.1942	1.0434	0.2968
Tropical biome - Plant quality	15	41	0.0435	0.3652	0.7149
Tropical biome - Plant reproduction	31	129	0.1585	1.1544	0.2483
Temperate biome - Predator abundance	84	439	0.8024	8.1599	0.0000
Temperate biome - Predator diversity	18	132	0.7780	4.1507	0.0000
Temperate biome - Predation	12	42	1.6998	4.5381	0.0000
Temperate biome - Parasitoid abundance	19	47	1.0666	4.9821	0.0000
Temperate biome - Parasitoid diversity	5	24	2.1023	6.2241	0.0000
Temperate biome - Parasitism	24	50	0.5065	3.9834	0.0001
Temperate biome - Herbivore abundance	130	439	-1.1134	-12.6978	0.0000
Temperate biome - Herbivore diversity	15	56	0.9693	6.9762	0.0000
Temperate biome - Herbivore damage	59	221	-0.5248	-3.2716	0.0011
Temperate biome - Plant growth	88	524	1.0983	16.1757	0.0000
Temperate biome - Plant quality	12	73	0.3009	2.4900	0.0128
Temperate biome - Plant reproduction	47	169	0.4831	4.3758	0.0000

Supplementary Table 8. Results of the meta-regression analysis for predator/parasitoid performance (predator abundance, predation, parasitoid abundance and parasitism), herbivore performance (herbivore abundance and herbivore damage) and plant performance (plant growth, quality and reproduction) and their response categories in pairwise correlation analysis (as presented also in Fig. 3). In addition to the estimated mean effect sizes, test-statistics (*t*-value), and the associated *P*-values, the number of studies (#Studies) and observations (#Obs) available for each predictor category are also presented.

Ecosystem	Category	#Obs	#Studies	Effect size	*t*-value	*P*-value
Terrestrial ecosystem	Predator performance (Predator performance vs. herbivore performance)	315	88	0.8957	13.2168	0.0000
Terrestrial ecosystem	Parasitoid performance (Parasitoid performance vs. herbivore performance)	102	37	0.9178	8.9220	0.0000
Terrestrial ecosystem	Predator and parasitoid performance (Predator and parasitoid performance vs. herbivore performance)	417	104	0.9083	15.8370	0.0000
Terrestrial ecosystem	Herbivore performance (Predator performance vs. herbivore performance)	315	88	-1.1832	-16.9569	0.0000
Terrestrial ecosystem	Herbivore performance (Parasitoid performance vs. herbivore performance)	102	37	-1.2463	-8.9769	0.0000
Terrestrial ecosystem	Herbivore performance (Predator and parasitoid performance vs. herbivore performance)	417	104	-1.1940	-19.2129	0.0000
Terrestrial ecosystem	Herbivore performance (Herbivore performance vs. plant performance)	294	75	-1.0951	-15.0027	0.0000
Terrestrial ecosystem-	Plant performance (Herbivore performance vs. herbivore performance)	294	75	0.7641	11.0308	0.0000
Agroecosystem	Predator and parasitoid performance (Predator and parasitoid performance vs. herbivore performance)	361	87	0.8196	14.9802	0.0000
Agroecosystem	Herbivore performance (Predator and parasitoid performance vs. herbivore performance)	361	87	-1.1468	-19.5878	0.0000
Agroecosystem	Herbivore performance (Herbivore performance vs. plant performance)	241	63	-1.2687	-16.4049	0.0000
Agroecosystem	Plant performance (Herbivore performance vs. plant performance)	241	63	0.9018	11.4624	0.0000
Grassland	Predator and parasitoid performance (Predator and parasitoid performance vs. herbivore performance)	30	9	2.3626	6.0439	0.0000
Grassland	Herbivore performance (Predator and parasitoid performance vs. herbivore performance)	30	9	-1.7679	-3.7725	0.0002
Grassland	Herbivore performance (Herbivore performance vs. plant performance)	12	4	0.3082	0.8897	0.3736
Grassland	Plant performance (Herbivore performance vs. plant performance)	12	4	-0.1060	11.4624	0.7449
Forest	Predator and parasitoid performance (Predator and parasitoid performance vs. herbivore performance)	26	8	0.7586	1.6901	0.0910
Forest	Herbivore performance (Predator and parasitoid performance vs. herbivore performance)	26	8	-0.9594	-3.1877	0.0014
Forest	Herbivore performance (Herbivore performance vs. plant performance)	41	8	-0.2306	-1.4894	0.1364
Forest	Plant performance (Herbivore performance vs. plant performance)	41	8	0.3159	2.2080	0.0272

Supplementary Table 9. Results of the meta-regression analysis for predator/parasitoid performance (predator abundance, predation, parasitoid abundance and parasitism), herbivore performance (herbivore abundance and herbivore damage) and plant performance (plant growth, quality and reproduction) and their response categories in path analysis (as presented also in Fig. 4). In addition to the estimated mean effect sizes, test-statistics (*t*-value), and the associated *P*-values, the number of studies (#Studies) and observations (#Obs) available for each predictor category are also presented.

Ecosystem	Category	#Obs	#Studies	Effect size	*t*-value	*P*-value
Terrestrial ecosystem	Predator and parasitoid performance (Predator and parasitoid performance vs. herbivore performance vs. plant)	136	39	0.9582	10.8925	0.0000
Terrestrial ecosystem	Herbivore performance (Predator and parasitoid performance vs. herbivore performance vs. plant)	136	39	-0.8976	-11.8735	0.0000
Terrestrial ecosystem	Plant performance (Predator and parasitoid performance vs. herbivore performance vs. plant)	136	39	0.7373	8.1154	0.0000
Agroecosystem	Predator and parasitoid performance (Predator and parasitoid performance vs. herbivore performance vs. plant)	119	33	0.9582	10.8925	0.0000
Agroecosystem	Herbivore performance (Predator and parasitoid performance vs. herbivore performance vs. plant)	119	33	-0.8976	-11.8735	0.0000
Agroecosystem	Plant performance (Predator and parasitoid performance vs. herbivore performance vs. plant)	119	33	0.7373	8.1154	0.0000

Supplementary Table 10. Results of the association analyses of response categories for the two pairs of trophic groups—predator (abundance and predation) and parasitoid (abundance and parasitism) performance vs. herbivore (abundance and damage) performance, and herbivore (abundance and damage) performance vs. plant (growth, reproduction and quality) performance for the different ecosystems, plant life forms and biomes. The predictor and response columns specify the trophic group pairs and the moderator category. The slope estimate represents the strength of the relationship. Besides the test-statistics (*t*-value) and *P*-values, the number of studies (#Studies) and observations (#Obs) for the predictor-response pair are also presented.

Predictor	Response	#Studies	#Obs	Slope Estimate	*t*-value	*P*-value
Predator performance-Terrestrial ecosystem	Herbivore performance	88	315	-0.1907	-2.6497	0.0085
Predator and parasitoid performance-Terrestrial ecosystem	Herbivore performance	104	417	-0.1992	-3.3650	0.0008
Parasitoid performance-Terrestrial ecosystem	Herbivore performance	37	102	-0.2400	-2.5352	0.0128
Predator and parasitoid performance- Agroecosystem	Herbivore performance	87	361	-0.1327	-1.9719	0.0494
Predator and parasitoid performance -Grassland	Herbivore performance	9	30	-0.6079	-4.4164	0.0001
Predator and parasitoid performance –Forest	Herbivore performance	8	26	-0.4950	-2.3163	0.0294
Predator and parasitoid performance - Herbaceous plant	Herbivore performance	77	296	-0.2807	-5.3179	0.0000
Predator and parasitoid performance - Woody plant	Herbivore performance	27	121	0.0378	0.2084	0.8352
Predator and parasitoid performance - Tropical biome	Herbivore performance	25	117	-0.3150	-3.5891	0.0000
Predator and parasitoid performance - Temperate	Herbivore performance	79	300	-0.1511	-2.0173	0.0446
Herbivore performance - Terrestrial ecosystem	Plant performance	75	294	-0.0507	-1.1982	0.2318
Herbivore performance - Agroecosystem	Plant performance	63	241	-0.0032	-0.0677	0.9461
Herbivore performance - Grassland	Plant performance	4	12	-0.1576	-0.9340	0.3723
Herbivore performance - Forest	Plant performance	8	41	0.1146	0.7637	0.4496
Herbivore performance - Herbaceous plant	Plant performance	59	202	-0.0350	-0.6088	0.5433
Herbivore performance - Woody plant	Plant performance	16	92	-0.0719	-1.3622	0.1765
Herbivore performance - Tropical biome	Plant performance	22	100	0.0356	0.3994	0.6904
Herbivore performance - Temperate	Plant performance	53	194	-0.0947	-2.1084	0.0363

Supplementary Table 11. Results of the path analyses for the effects of the increased plant species diversity on the tri-trophic interactions of predator (abundance and predation) and parasitoid (abundance and parasitism) performance, herbivore (abundance and damage) performance, and plant (growth, reproduction and quality) performance in terrestrial ecosystems and agroecosystems. The predictor and response columns specify the trophic group pairs and the moderator category. The estimate represents the strength of the relationship. The std. estimate denotes the standardized estimate coefficients for the fitted path-analytic models. The number of studies (#Studies) and observations (#Obs) for the predictor-response pair are also presented.

Ecosystem	Predictor	Response	#Studies	#Obs	Estimate	Std. Estimate	*P*-value
All terrestrial ecosystems	Increased plant species diversity	Predator and parasitoid performance	39	136	0.3471	0.1213	0.0646
	Predator and parasitoid performance	Herbivore performance	39	136	-0.1953	-0.2235	0.0017
	Increased plant species diversity	Herbivore performance	39	136	0.1168	0.0467	0.4007
	Herbivore performance	Plant performance	39	136	-0.0453	-0.0500	0.4254
	Increased plant species diversity	Plant performance	39	136	-0.0026	-0.0012	0.9851
Agroecosystems	Increased plant species diversity	Predator and parasitoid performance	39	136	0.2718	0.0893	0.1946
	Predator and parasitoid performance	Herbivore performance	39	136	-0.2998	-0.3209	0.0001
	Increased plant species diversity	Herbivore performance	39	136	0.0564	0.0198	0.7401
	Herbivore performance	Plant performance	39	136	-0.0466	-0.0502	0.4896
	Increased plant species diversity	Plant performance	39	136	0.2466	0.0936	0.2272

Supplementary Methods

Further description of study selection

In agroecosystems, some plant species diversity studies on intercropping or diversification of the vegetation cover were combined with tests of crop rotation. In those cases, we considered only the spatial (within-year) component, not the temporal component caused by (between-year) crop rotation. If the number of replicates was not given in a certain cited study, we referred to other similar literature to find out the number of replicate. Among the 351 studies, only one study (e.g. Smith, 1969)[1] did not provide the actual number of replicates, and so we downloaded the Ph. D thesis of the original authors (Smith JG) and found that four replicates were used. For studies that included more than one location, we considered these experimental observations separately in each location and used the longitudes and latitudes of all locations in Fig.1, respectively. Among the 351 studies, there were 5 observational studies of plant species diversity where the authors used the average values of different locations having the same lower plant species diversity as the control group, and the average values of different locations with the same higher plant species diversity as the treatment group. When the means of observed plant performance indicators (e.g., plant biomass in seven studies, plant shoot length in one study), or the indicators for herbivores (e.g., herbivore richness in one study, herbivory rate in one study, herbivore abundance in three studies), parasitoids (e.g., parasitoid species richness in one study) and predators (e.g., predator abundance in one study, predator species richness in three studies) were not presented in the study, we extracted these values directly from the figures (e.g. if a linear or a non-linear relationship between plant species richness and one of these indicators were shown in a figure in the paper, we extracted the values from the fitting equations).

When the treatment group was paired with the control group, we excluded multiple comparisons within a single study, and we selected different comparison data (observations with lowest plant diversity were considered as control group while the others as the treatment group). Generally, in experimental studies (where the number of plant species could be manipulated) just a single plant species represented the control group, while in observational studies the control group could sometime include more than one plant species. Although 47 studies were carried out at the Jena Experiment, 16 at the Cedar Creek Experiment and 6 at the BEF Experiment, respectively, these were independent from each other in their study objective and represented about 20% of all studies included in this meta-analysis. Specifically, among 351 plant species diversity papers, 19.66 % of them come from randomized biodiversity experiments (i.e., 13.39%, 4.56% and 1.71% of 315 papers come from Jena Experiment, Cedar Creek Experiment and BEF Experiment, respectively).

Further description of predictor variables

As predictor variables, we used five categorical variables and one continuous variable. **(1) Trophic group:** A categorical variable that indicates whether the organisms whose responses were studied were predators (i.e. carnivores of arthropod herbivores), parasitoids (i.e. parasitic wasps and parasitic flies), herbivores or plants (i.e. crops, trees, grass, native plants, weeds and/or their mixture). Here, insect pests (e.g., *Bemisia tabaci*, *Myzus persicae*) that damage crops were considered as herbivores. **(2) Response category:** We classified the response variables into multiple categories nested within each trophic group. The predator group included the response categories abundance of predators, diversity of predators, and predation rate. The parasitoid group included abundance and diversity of parasitoids, and parasitism rate. The herbivore group included abundance and diversity of herbivores, and herbivory damage. The plant life form included growth, quality and reproduction of the plants. Diversity measures included species richness and Shannon index values. Arthropods (predators, parasitoids, herbivores) were sampled with sweep nets, pitfall traps or pan traps around the focal plants, collected directly on the plant or plant parts (leaves, flower stalks, stems, tillers), and combined samples from counting directly the visible arthropods on a plant and from counting arthropods that dropped into trays below the plants after shaking or beating the plants. Herbivore damage was assessed as percentage or number of plants infested by herbivores, or as loss of plant yield or biomass due to herbivores. Parasitism rate was assessed as the percentage of herbivores parasitized by parasitoids. Predation rate was assessed as the percentage of preyed herbivores. Plant growth was assessed as growth rate, and as plant size characteristics, such as plant width, height, biomass, leaf area, leaf thickness and number of leaves. Here, we put plant productivity (i.e., plant biomass) into plant growth. Only three studies related to plant productivity (e.g., shoot biomass ($g•m^{-2}$), aboveground biomass ($g•m^{-2}$)) were included in this paper. Plant reproduction was assessed as the yield of fruits, grains, pods, vegetative reproductive plant parts and seeds per area, and as reproductive traits measured on individual plants, such as flower or pod production and grain number per spike. Plant quality was assessed as the content of oil (e.g. canola), energy, protein, fat, sugar, chlorophyll or various nutrients (e.g., N, P K). **(3) Ecosystem Type:** We categorized the ecosystems into agroecosystems (crop ecosystem, ornamental plant plantation systems and orchards), grasslands and forests. **(4) Plant life form**: A categorical variable indicating whether the focal plants on which arthropods (predators, parasitoids and herbivores) were sampled, or for which growth, reproduction and quality were assessed are herbaceous or woody (Liao *et al*. 2008)[2]. If there were both herbaceous and woody species in the control plots, we categorized the plot according to the life form of the plant species on which the data were collected. **(5) Biome type:** A categorical variable indicating whether the study was performed in the tropical or temperate zones. The North Temperate Zone is from the Tropic of Cancer (23.5^o N) to the Arctic Circle (66.5^o N), and the South Temperate Zone is from the Tropic of Capricorn (23.5^o S) to the Antarctic Circle (66.5^o S). The Tropic Zone are from 0-23.5^o N and from 0-23.5^o S. **(6) Number of added plant species**: A continuous variable indicating the number of species by which plant species richness was increased over the control group (i.e. the number of species added by manipulated plant diversity in experimental designs, such as interplanting, intercropping, cover vegetation) or by non-manipulated plant diversity in observational studies that compared plant diversity across sites. Among the 351 studies cited in this paper, 5 were observational studies and 346 experimental studies.

The meta-regression models for model comparison and parameter estimation

We used the R package metafor (version 2.0) for meta-regression analysis. Standardized Mean Difference (SMD) was used as the effect size measures (argument “measure” set to “SMD” in the function “escalc()”). We used the unbiased sampling variance estimate to evaluate the sampling variances of the SMDs (argument “vtype” set to “UB” in the function “escalc()”). To test the significance of the interaction effects between the trophic group (herbivores, predators, parasitoids and plants) and the various moderators (i.e. ecosystem types, plant life forms, biome types and the number of added plant species), the likelihood ratio test compared the null model, following the equation:

$$\mathrm{y_{ij}} = \text{trophic functional group} + \mathrm{s_i} + \mathrm{e_{ij}} + \epsilon_{\mathrm{ij}},$$

with a full model, as follows:

$$\mathrm{y_{ij}} = \text{trophic functional group} + \text{trophic functional group} \times \text{moderator} + \mathrm{s_i} + \mathrm{e_{ij}} + \epsilon_{\mathrm{ij}},$$

Here, y_{ij} is the j^{th} effect size from the i^{th} study, s_i is the random effect term representing the i^{th} study effect, and e_{ij} is the random effect term for the within-study effect for the j^{th} effect size from the i^{th} study. Finally, ϵ_{ij} is the error term with variance equal to the SMD’s sampling variance estimate.

To test for the significance of trophic groups, the null model above was compared with a full model, as follows:

$$y_{ij} = \text{trophic functional group} + \text{trophic functional group response category} + s_i + e_{ij} + \epsilon_{ij},$$

Note that the trophic group response categories are nested within trophic groups. For example, the three predator response categories (predator abundance, predator diversity, and predation) are nested within the predator group. Similar nested structures apply to the trophic groups of parasitoids, herbivores and plants. Thus, by design, the individual trophic group effect was confounded by its associated response categories' effects. The effect parameters for the four trophic groups and the twelve trophic group response categories were therefore not all estimable within the full model. Since the goal was to assess whether the full model provides a better fit than the null model, predator abundance, parasitism, herbivore damage, and plant reproduction (selected automatically by the "metafor" R package) were not estimated in the full model. However, as the full model still retained the effects for the four trophic groups, the null model remained nested within the full model, ensuring the applicability of the likelihood-ratio-test (LRT). The effects for the four removed response categories were estimated later using an alternatively-parametrized model without the four trophic group effects (see below).

To test the significance of the interaction effects between trophic group response category (predator abundance, predator diversity, predation, parasitoid abundance, parasitoid diversity, parasitism, herbivore abundance, herbivore diversity, herbivore damage, and the growth, reproduction and quality of plants) and the various moderators, the likelihood ratio test compared the null model, following the equation:

$$y_{ij} = \text{trophic functional group response category} + s_i + e_{ij} + \epsilon_{ij},$$

with a full model, as follows:

$$y_{ij} = \text{trophic functional group response category} + \text{trophic functional group response category} \times \text{moderator} + s_i + e_{ij} + \epsilon_{ij}.$$

To test the effects and confidence intervals for each trophic group, trophic group response category, and their interactions with the moderators, we used the following models:

$$y_{ij} = \text{trophic functional group} + s_i + e_{ij} + \epsilon_{ij},$$

$$y_{ij} = \text{trophic functional group} \times \text{moderator} + s_i + e_{ij} + \epsilon_{ij},$$

$$y_{ij} = \text{trophic functional group response category} + s_i + e_{ij} + \epsilon_{ij},$$

$$y_{ij} = \text{trophic functional group response category} \times \text{moderator} + s_i + e_{ij} + \epsilon_{ij}.$$

Note that compared to the earlier models with interaction terms, the updated models did not contain a main effect term for trophic group or trophic group response category. This re-parameterization ensured that the main-effect and interaction terms, necessary to address our research objectives, were estimable.

Transformation of herbivore effects sizes

The signs of the herbivore effects sizes were switched prior to meta-regression modeling. Afterwards, the parameter estimates and the associated confidence intervals for herbivore-related terms (i.e., herbivore abundance, herbivore diversity, herbivory damage, and the interactions of these terms with other moderators) were then switched back to the original scale for correct interpretation.

It is important to note that the study level random effect s_i represents an additive effect for the trophic group and response categories. Under this scenario, the assumption of an additive study effect would be inappropriate, because the study effect is applied in an additive manner simultaneously to all trophic groups and response categories. The assumption of an additive study effect would thus only hold if all of the trophic group effects point in the same direction, but not when the herbivore effect is expected to be negative, while the other effects are expected to be positive. By changing the sign of the herbivore effect sizes, the assumption of the additive study effect was more likely to be fulfilled.

Meta-regressions for pair-wise association analysis between trophic groups

To examine the relationships between different trophic levels, the following models were used:

$$\text{response SMD} = \text{intercept} + \beta \cdot \text{predictor SMD} + s_i + e_{ij} + \epsilon_{ij},$$

$$\text{response SMD} = \text{moderator} + \beta \cdot \text{predictor SMD} \times \text{moderator} + s_i + e_{ij} + \epsilon_{ij},$$

In these models, ϵ_{ij} is the error term with variance equal to the response SMD's sampling variance estimate. The above models can be used to examine the association between the predictor SMD and the response SMD. For example, we can use the above model to analyze how changes in predator and/or parasitoid performance can affect herbivore performance, and how the association can change for different moderator categories by setting the predictor SMD and the response SMD as the predator and/or parasitoid performance (abundances of predators and parasitoids, predation and parasitism) and herbivore performance (abundance and damage), respectively. In the first model, the slope term β represents the change in response SMD as the predictor SMD changes. The significance of the slope term was tested using the LRT, comparing the model to the intercept-only model. In the second model, the moderator main effect term provides different effect estimates for different categories of the moderator, while the interaction term provides different slope estimates for the predictor within different moderator categories.

Meta-analytic path analysis using piecewiseSEM

The R package 'piecewiseSEM' was used to conduct the path analysis. Unfortunately, the 'metafor' packages cannot be integrated 'piecewiseSEM'. Therefore, we implemented a meta-analytic path-analysis in piecewiseSEM using the approach documented on the metafor support website (http://www.metaforproject.org/doku.php/tips:rma_vs_lm_lme_lmer). Briefly, a special feature of meta-regression is that the variances of the error term are assumed to be known. Special treatment is thus required to ensure that mixed-effect models can account for the known variances in model estimation. The use of the "lme()" function in the R package "nlme" can reasonably emulate the results of metafor by setting the arguments "control" to "lmeControl(sigma = 1) and "weights" to "varFixed(~ vi)", where "vi" is the estimated sampling variances. As piecewiseSEM supports the function lme(), we used lme() instead of metafor for meta-regression model fitting in the path analyses. Below, we provided the models used as input for piecewiseSEM:

a) *Diversity – predator and/or parasitoid performance – herbivore performance*

$$\begin{aligned}1.\ &\text{predator and/or parasitoid performance SMD}\\ &\quad= \text{intercept} + \beta \cdot \log_2(\text{number of added plant species over control}) + s_i + e_{ij} + \epsilon_{ij},\end{aligned}$$

$$2.\ \text{herbivore performance SMD} = \text{intercept} + \beta_1 \cdot \text{predator and/or parasitoid performance SMD} + \beta_2 \cdot \log_2(\text{number of added plant species over control}) + s_i + e_{ij} + \epsilon_{ij}.$$

b) *Diversity – herbivore performance – plant performance*

$$\begin{aligned}1.\ &\text{herbivore performance SMD}\\ &\quad= \text{intercept} + \beta \cdot \log_2(\text{number of added plant species over control}) + s_i + e_{ij} + \epsilon_{ij},\end{aligned}$$

$$2.\ \text{plant performance SMD} = \text{intercept} + \beta_1 \cdot \text{herbivore performance SMD} + \beta_2 \cdot \log_2(\text{number of added plant species over control}) + s_i + e_{ij} + \epsilon_{ij}.$$

c) *Diversity – predator and parasitoid performance – herbivore performance – plant performance*

$$1.\ \text{predator and parasitoid performance SMD} = \text{intercept} + \beta \cdot \log_2(\text{number of added plant species over control}) + s_i + e_{ij} + \epsilon_{ij},$$

$$2.\ \text{herbivore performance SMD} = \text{intercept} + \beta_1 \cdot \text{predator and parasitoid performance SMD} +$$

$$\beta_2 \cdot \log_2(\text{number of added plant species over control}) + s_i + e_{ij} + \epsilon_{ij},$$

$$3.\ \text{plant performance SMD} = \text{intercept} + \beta_1 \cdot \text{herbivore performance SMD} +$$

$$\beta_2 \cdot \log_2(\text{number of added plant species over control}) + s_i + e_{ij} + \epsilon_{ij}.$$

Meta-regression on several subsets of the data

To explore our data in more detail, we also used meta-regression on several subsets of the data. First, to test the effect of the number of plant species added by manipulated/non-manipulated plant diversity, we analyzed each trophic group (predators, parasitoids, herbivores, plants) separately using $\log_2$-transformed number of plant species added as a moderator term. To test the effect of different ecosystems on each trophic group, we also analyzed each trophic group separately using the type of ecosystem as a moderator term. In these subset analyses, we used the intercept-only models as reference models for LRTs.

Additional information on pairwise analysis

The studies that included the match/pairwise values of predator/parasitoid performance vs. herbivore performance and herbivore performance vs. plant performance in agroecosystems, grasslands or forests, were used to conduct the pairwise analysis. We explored whether predator/parasitoid performance was negatively associated with herbivore performance by fitting a meta-regression model using the SMD of herbivore performance as the response, and the SMD of predator/parasitoid performance as the moderator variable. As in the above meta-regression models, random effect terms were introduced to account for between-study, within-study and random sampling effects. We further explored the association between predator and/or parasitoid performance and herbivore performance across different ecosystems, plant life forms and biomes. This was achieved by adding an interaction term between the SMD of predator and/or parasitoid performance and individually ecosystem types, plant life form types and biome types in the model, and estimating the model parameters for the interaction terms. Additionally, these were pair-wise correlations between two trophic groups that responded similarly to the increased plant species diversity, and therefore, plant diversity was not integrated into this model.

Additional information on path analysis

To jointly analyze the effect of increased plant species diversity, predator and parasitoid performance, herbivore performance and plant performance in all ecosystems or in agroecosystems, a full model (as depicted in the network shown in Figs. 4a and 4b) was fitted. Only 3 studies were found for grassland and forest systems, respectively. Consequently, the effect of these two ecosystems on the trophic interactions was not tested. The goodness-of-fit for path analysis models were assessed using the d-separation test, a test based on the Fisher's C statistic and its associated p-value. For the goodness-of-fit test, a p-value larger than our pre-determined significance level of 0.05 is desired, as a p-value smaller than 0.05 suggests that the fitted model has significant lack-of-fit. All the 39 studies (136 observations) included in this model derived from experimental studies. In each study, the three pairwise comparisons (predator and parasitoid performance vs. herbivore performance vs. plant performance) were tested at the same location. Additionally, we used the study identity as a random effect in the model. In this way, we reduced the possible effects derived from confounding variables.

Effects of different ecosystems, plant life forms and biomes on responses of four trophic groups

The differences in response to plant diversity among the four trophic groups significantly depended on the type of ecosystem (X^2 =277.477, d.f. = 8, P <0.001; Supplementary Table 2). In line with the overall effect on terrestrial ecosystems, increased plant species diversity in agroecosystems had positive effects on predators, parasitoids and plants (predator: t_{532} = 11.112, P< 0.001; parasitoid: t_{123}= 6.227, P < 0.001; plant: t_{540} = 5.588, P< 0.001), and a negative effect on herbivores (t_{731} = -20.647, P< 0.001). Increased plant species diversity in grasslands had positive effects on all of the four trophic groups (predator: t_{63} = 6.597, P < 0.001; parasitoid: t_{28}= 5.003, P < 0.001; herbivore: t_{132}= 4.019, P < 0.001; plant: t_{390}= 14.642, P < 0.001). In forests, the responses of parasitoids and plants to increased plant diversity were both significantly positive while the responses of predators and herbivores were negative but not significant (predator: t_{111} = -0.147, P=0.883; parasitoid: t_{6}= 2.823, P=0.005; herbivore: t_{138}= -0.969, P =0.333; plant: t_{108}= 4.627, P < 0.001). Overall, the effects of the different ecosystem types significantly depended on the trophic group response categories (X^2 =290.335, d.f. = 23, P<

0.001; Supplementary Table 2 and Extended Data Fig. 1), and the results for these different subsets are shown in Extended Data Fig. 1 and Supplementary Table 5.

The differences among the four trophic groups in their response to increased plant species diversity depended on the life form of the focal plants (X^2 = 33.219, d.f. = 4, P < 0.001; Supplementary Table 2). For herbaceous plants, plant diversity had positive effects on predators and parasitoids (predator: t_{426} = 10.689, P < 0.001; parasitoid: t_{124} = 6.596, P < 0.001), negative effects on herbivores (t_{731} = -15.054, P < 0.001), and positive effect on plants (t_{851} =13.659, P < 0.001). When the focal plants were in woody-dominated ecosystems, plant diversity had positive effects on predators (t_{281} = 3.928, P< 0.001), parasitoids (t_{34} = 5.483, P < 0.001) and plants (t_{188} = 4.882, P < 0.001) but negative effects on herbivores (t_{271} = -4.328, P < 0.001) (Fig. 2c; Supplementary Table 6). Overall, the effects of plant life form significantly depend on the trophic group response category (X^2 = 61.355, d.f. = 12, P< 0.001; Supplementary Table 2), and the results for these different subset are shown in Extended Data Fig. 2 and Supplementary Table 6.

The differences in response to plant diversity among the four trophic groups significantly depended on the biome type (X^2 = 90.556, d.f. = 4, P <0.001; Supplementary Table 2). In tropical biomes, the responses of the three trophic groups to plant diversity were significant (predator: t_{95} = 2.451, P=0.014; parasitoid: t_{38} = 2.180, P =0.029; herbivore: t_{287} = -12.975, P< 0.001; plant: t_{274} = 1.578, P=0.115). In temperate biomes, all trophic responses were significant (predator: t_{612} = 10.042, P< 0.001; parasitoid: t_{120} = 8.203, P < 0.001; herbivore: t_{715} = -9.816, P< 0.001; plant: t_{765} = 16.191, P< 0.001) (Fig 2d; Supplementary Table 7). Overall, the effect of biome type depended significantly on the trophic group response categories (X^2 = 109.101, d.f. = 12, P < 0.001; Supplementary Table 2), and the results for these different subsets are shown in Supplementary Table 7 and Extended Data Fig. 3.

Publication bias assessment

The regression test on the raw effect sizes suggested a non-significant publication bias from 2914 observations in 351 cited studies in this meta-analysis paper (regression test value = 0.489, P =0.625). Nagakawa and Santos (2012)[3] argued that since meta-regressions are performed to adjust for various sources of heterogeneity, it is more appropriate to perform publication bias assessment separately for each model using the regression model residuals (as opposed to the raw effect sizes). The regression tests on model residuals also suggested that all models had no significant publication bias (Supplementary Table 3). Even so, to better assess the robustness of our results given the publication bias, we did sensitivity analyses using the trim-and-fill method on the residuals for the dataset. The trim-and-fill analysis suggested that there was one non-significant number of missing studies due to publication bias from 2914 observations in 351 cited studies (P = 0.3042). Additionally, the fail-safe number for the full dataset of 351 cited articles was 101836, much larger than the ad-hoc threshold 14580 (14580=5n + 10, where n is the number of observations in the analyses (n = 2914 in our meta-analysis)). In other words, one would have to add 101836 missing studies with an average effect size of zero to make the combined effect size statistically insignificant. Meanwhile, the trim-and-fill analysis indicated that there was a significant sensitivity bias (P = 0.0013) in the 136 observations of 39 studies used in the path analysis. The major reason is probably the insufficient sample size. Thus, more studies are needed to better explore the tri-trophic interactions of predators, herbivores and plants.

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