GSA Data Repository 2017213

Rojas, et al., 2017, Global biogeography of Albian ammonoids: A network-based approach: Geology, doi:10.1130/G38944.1.

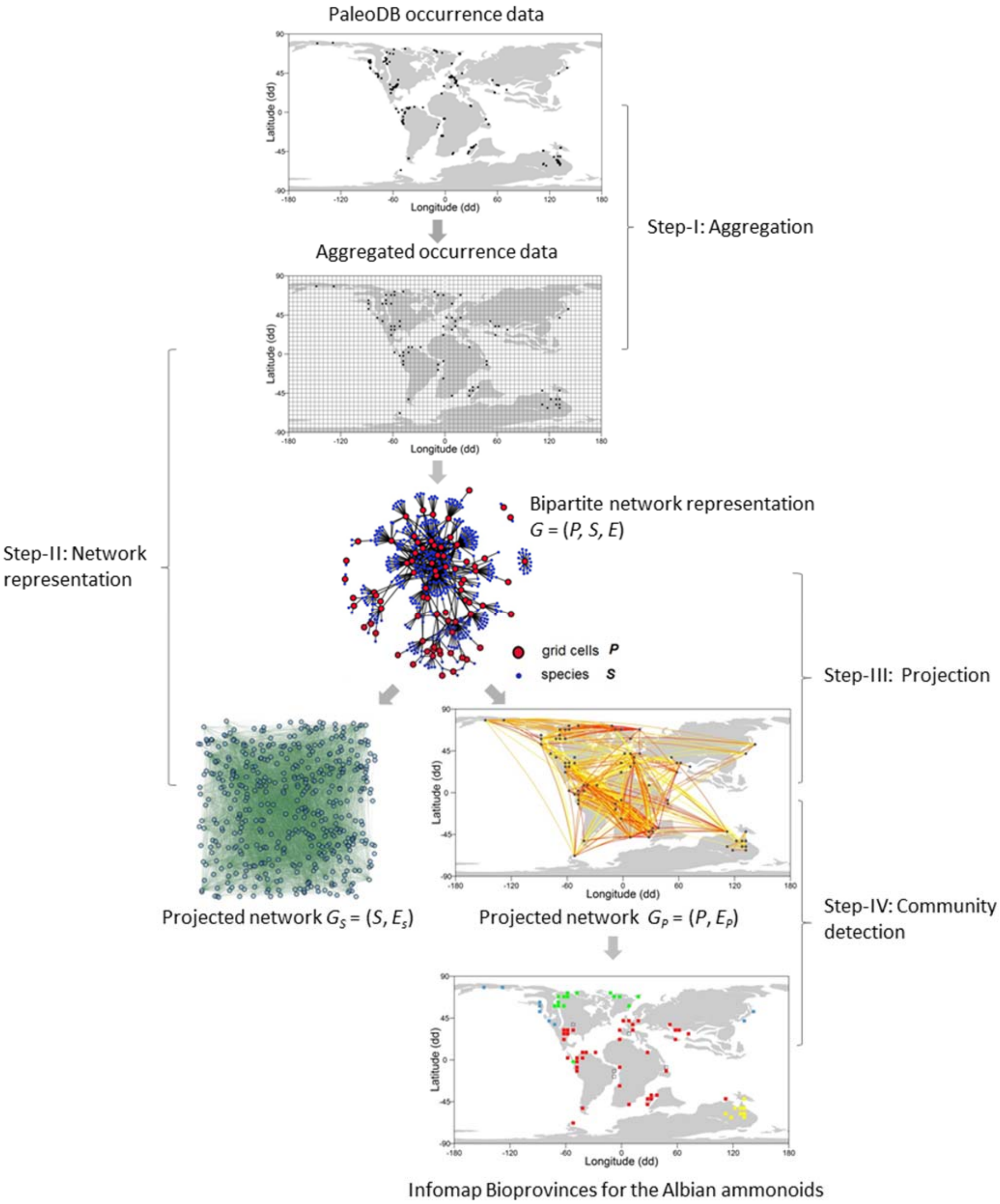

Figure DR1. Workflow diagram indicating the procedures implemented in the analysis of the global records of Albian ammonoids.

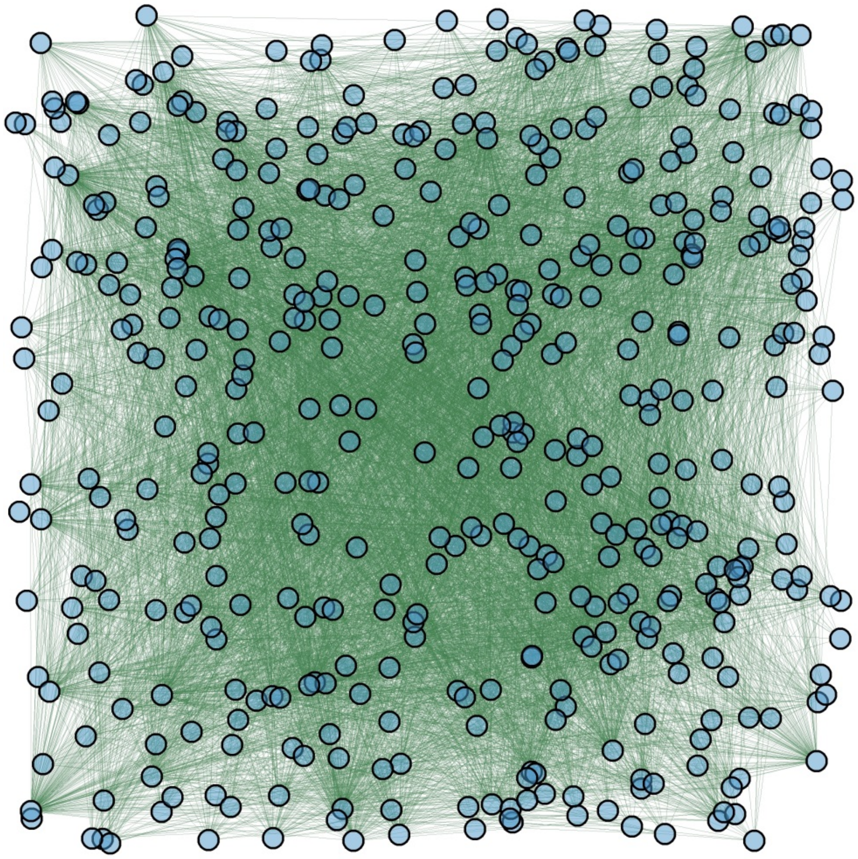

Figure DR2. Projected network G_S. It is a projection from the bipartite network *G* onto the node subset *S*. Dots represent species and lines represent the connections between them. Normalized centrality scores for individual species are summarized in Table DR5.

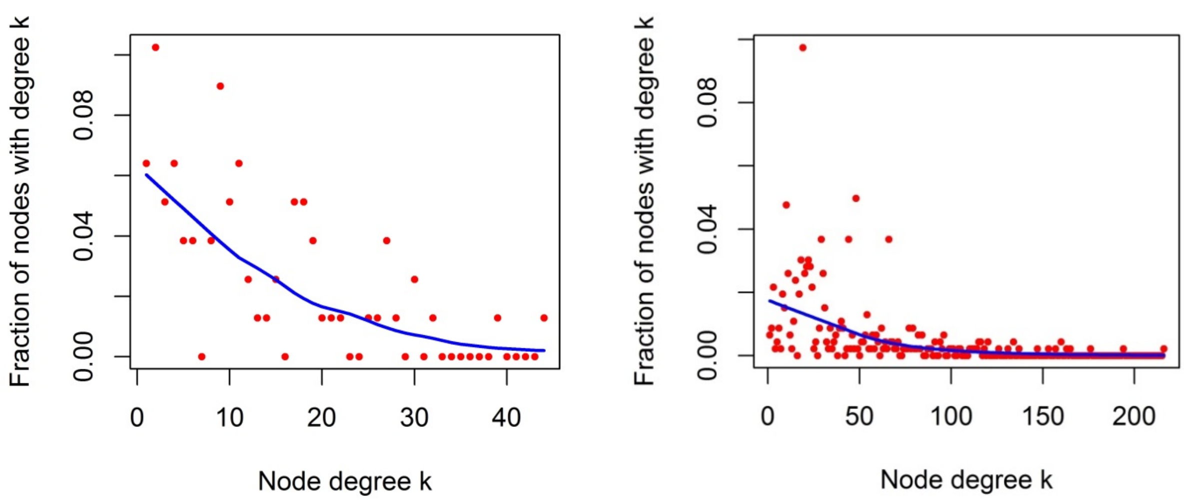

Figure DR3. Node degree distribution for the projected networks G_P (left) and G_S (right)

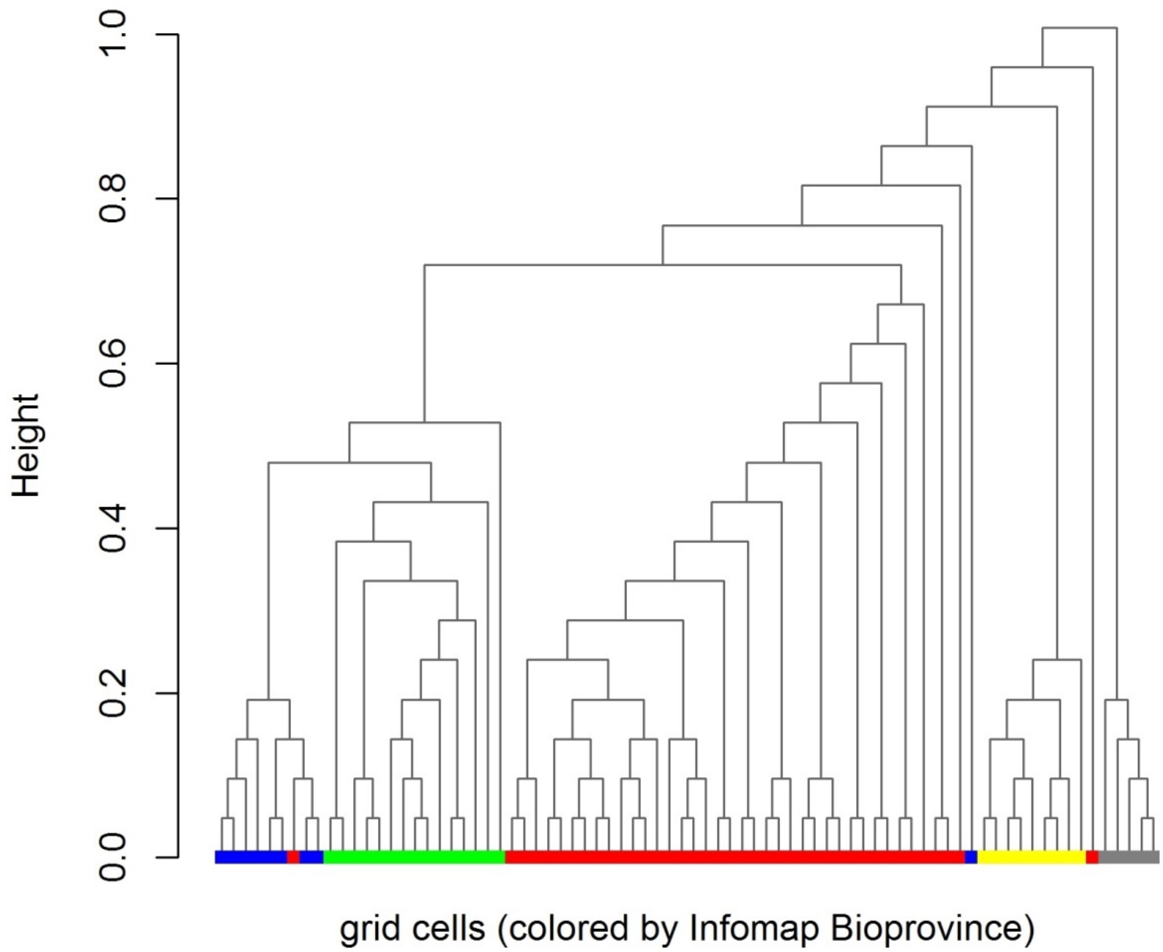

Figure DR4. Ammonoid occurrence data per grid cell (i.e., incidence matrix *B*) clustered using the unweighted pair-group arithmetic average method (UPGMA). Distances between grid cells were calculated using Bray–Curtis dissimilarity. For easier comparison of the cluster topology with the Infomap bioprovinces, the height of the tree nodes were adjusted so that the tree will have a distance of 1 unit between each parent/child nodes. The height range was also adjusted to 1. This analysis was performed using the *vegan* package for R software (version 2.3-4, Oksanen et al., 2016).

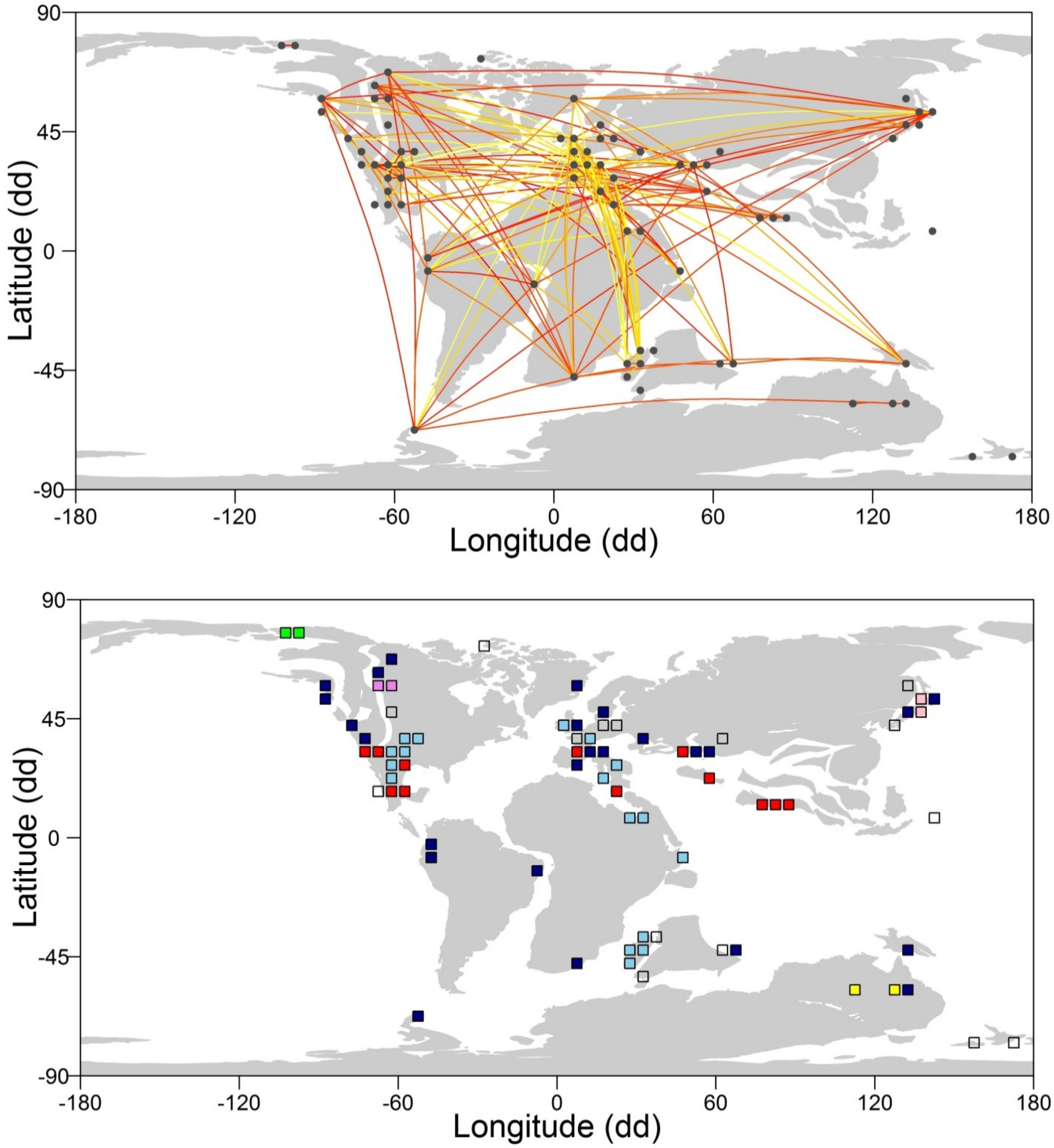

Figure DR5. Top: Projected network $G_{P\text{-}benthos}$ derived from Albian benthic marine invertebrate records in the PaleoDB. Links are colored indicating their connection strength (*CS*). Bottom: Infomap bioprovinces. Black unfilled squares are isolated nodes.

Infomap Bioprovince	IB1	IB2	IB3	IB4	IB5	IB6	IB7
Anthozoa	1	36	91	—	—	—	—
Asteroidea	1	14	—	—	100	—	—
Bivalvia	24	26	1	100	—	—	100
Calcarea	—	—	—	—	—	—	—
Crinoidea	7	—	—	—	—	—	—
Demospongea	—	—	—	—	—	—	—
Echinoidea	9	2	—	—	—	—	—
Gastropoda	—	—	—	—	—	—	—
Hexactinellida	—	—	—	—	—	—	—
Holothuroidea	—	—	0	—	—	—	—
Lingulata	1	6	—	—	—	—	—
Malacostraca	7	7	2	—	—	75	—
Ophiuroidea	—	0	0	—	—	25	—
Rhynchonellata	51	8	5	—	—	—	—

Figure DR6. Taxonomic composition of the Infomap bioprovinces delineated in the projected network $G_{P\text{-}benthos}$.

Table DR1. Incidence matrix (B) representing the connections between species (S) and grid cells (P) for the Albian ammonoid data gathered from the PaleoDB

Algorithm	Number of comunities*	Comunities size	Q†	NMI§
InfoMap (IM)	4	40, 15, 9, 9	0.24	N.A.#
Label Propagation (LP)	4	40, 12,12, 9	0.24	0.94
Walktrap (WT)	3	40, 24, 9	0.26	0.92
Multilevel (ML)	4	25, 22, 17, 9	0.31	0.78
Fastgreedy (FG)	4	25, 23, 16, 9	0.30	0.78
Leading Eigenvector (LE)	5	26, 19, 14, 9, 2	0.28	0.70
Edge Betweenness (EB)	9	23, 9, 7, 7, 5, 3, 2, 2, 2	0.18	0.65

*Isolate nodes have not been taken into account since they provide no meaningful information on the overall network structure.

†Q = Modularity.

§NMI = Normalized Mutual Information score.

#N.A. = not applicable.

Table DR2. Comparison of the estimated community structures in the projected network derived from Albian ammonoid records in the PaleoDB (G_P).

Table DR3. Incidence matrix (B) representing the connections between species (S) and grid cells (P) for the Albian marine invertebrate data gathered from the PaleoDB

Network	Ammonoids (G_P)	Benthos ($G_{P\text{-}benthos}$)
Number of nodes	78	77
Number of links	433	176
Density	0.14	0.06
Modularity (Q)	0.23	0.37
Infomap comunities (size ≥ 2 nodes)	4	7
Disconected nodes	5	15

Table DR4. Comparison of the projected networks derived from Albian ammonoid (G_P) and benthic marine invertebrate records ($G_{P\text{-benthos}}$) in the PaleoDB.

Species	DEC	EVC	BTC
Desmoceras (Desmoceras) latidorsatum	215	0.93	0.62
Phylloceras velledae	193	1.00	0.21
Hysteroceras orbignyi	175	0.93	0.17
Hysteroceras subbinum	164	0.65	0.17
Anagaudryceras sacya	162	0.41	0.83
Douvilleiceras mammillatum	159	0.50	0.72
Anisoceras perarmatum	159	0.77	0.26
Anisoceras armatum	156	0.79	0.18
Dipoloceras (Dipoloceras) cristatum	152	0.70	0.35
Beudanticeras beudanti	146	0.61	0.52
Lechites (Lechites) gaudini	136	0.76	0.15
Douvilleiceras orbignyi	133	0.55	0.18
Puzosia quenstedti	133	0.56	0.18
Phylloceras (Hypophylloceras) seresitense	130	0.69	0.06
Hamites venetzianus	125	0.46	0.15
Tetragonites rectangularis	119	0.43	0.39
Hysteroceras carinatum	119	0.52	0.06
Hysteroceras binum	117	0.52	0.07
Protanisoceras blancheti	115	0.44	0.29
Hamites virgulatus	115	0.31	0.15
Tetragonites timotheanus	114	0.49	0.25
Stoliczkaia (Stoliczkaia) notha	114	0.69	0.04
Hysteroceras varicosum	113	0.55	0.03
Dipoloceras (Dipoloceras) bouchardianum	112	0.54	0.03
Goodhallites goodhalli	111	0.48	1.00
Neophlycticeras (Neophlycticeras) brottianum	110	0.58	0.05
Hysteroceras choffati	109	0.39	0.09
Tetragonites subtimotheanus	104	0.32	0.31
Puzosia (Puzosia) mayoriana	103	0.57	0.05
Salaziceras (Salaziceras) salazacense	100	0.37	0.04
Scaphites hugardianus	99	0.50	0.04
Leymeriella (Neoleymeriella) regularis	98	0.54	0.08
Stoliczkaia (Stoliczkaia) dispar	95	0.43	0.06
Leymeriella (Leymeriella) tardefurcata	95	0.53	0.03
Leymeriella (Neoleymeriella) pseudoregularis	95	0.53	0.03
Mortoniceras (Subschloenbachia) perinflatum	94	0.45	0.08
Mortoniceras (Mortoniceras) arietiforme	93	0.28	0.16
Ostlingoceras (Ostlingoceras) puzosianum	93	0.50	0.02
Mariella (Mariella) bergeri	90	0.47	0.03
Hamites subvirgulatus	90	0.53	0.01

Species	DEC	EVC	BTC
Sciponoceras baculoide	88	0.39	0.05
Mortoniceras (Subschloenbachia) rostratum	87	0.30	0.21
Douvilleiceras monile	86	0.22	0.21
Mortoniceras (Mortoniceras) inflatum	83	0.32	0.08
Eogaudryceras (Eogaudryceras) shimizui	83	0.34	0.04
Mariella (Mariella) miliaris	83	0.34	0.04
Mortoniceras (Mortoniceras) pricei	82	0.34	0.11
Dipoloceras (Rhytidoceras) elegans	81	0.26	0.18
Mortoniceras (Deiradoceras) devonense	81	0.35	0.04
Neophlycticeras (Neophlycticeras) blancheti	81	0.44	0.03
Stoliczkaia (Stoliczkaia) clavigera	80	0.37	0.02
Idiohamites tuberculatus	79	0.30	0.05
Lyelliceras lyelli	78	0.26	0.19
Kossmatella (Kossmatella) romana	78	0.29	0.04
Pervinquieria stoliczkai	78	0.32	0.02
Labeceras plasticum	78	0.35	0.02
Pseudhelicoceras robertianum	77	0.43	0.02
Phyllopachyceras baborense	76	0.28	0.03
Cantabrigites cantabrigense	76	0.43	0.00
Mortoniceras (Mortoniceras) fallax	76	0.43	0.00
Neophlycticeras (Neophlycticeras) rhodanense	76	0.43	0.00
Myloceras joffrei	75	0.26	0.04
Ptychoceras laeve	74	0.19	0.41
Anahoplites planus	73	0.28	0.05
Lechites (Lechites) moreti	70	0.26	0.15
Neophlycticeras (Protissotia) itierianum	70	0.33	0.03
Mortoniceras (Mortoniceras) pachys	69	0.30	0.09
Beudanticeras (Uhligella) rebouli	68	0.25	0.12
Pervinquieria bassleri	67	0.20	0.02
Neokentroceras costatum	67	0.23	0.01
Brewericeras hulenense	66	0.04	0.11
Oxytropidoceras (Venezoliceras) madagascariense	66	0.24	0.03
Discohoplites subfalcatus	65	0.26	0.01
Anisoceras pseudoelegans	65	0.26	0.01
Cenisella bonnetiana	65	0.26	0.01
Diadochoceras nodosocostatum	65	0.26	0.01
Dipoloceras (Dipoloceroides) delaruei	65	0.26	0.01
Dipoloceras (Dipoloceroides) subdelaruei	65	0.26	0.01
Discohoplites simplex	65	0.26	0.01
Gaudryceras (Gaudryceras) cassisianum	65	0.26	0.01

Table DR5. Centrality scores for the nodes in the projected network G_S (Fig. DR2). Degree Centrality (DEC) ranks higher a node that has a high number of connections to other nodes. This metric identifies highly connected species (i.e., important nodes in the network) and is related to the extent of their geographic distribution as well as the number of different taxa recorded per grid cell; Betweenness Centrality (BTC) ranks higher a node that connects along shortest paths with many other nodes. This metric is used to classified species as peripheral, intermediate or central in the network (Ma, et. al., 2016); Eigenvector Centrality (EVC) ranks higher a node if it connects to highly connected nodes. Those nodes not necessarily have a high number of connections but are connected to important nodes in the network. Note that only ranked higher nodes are included in the table.

REFERENCES CITED IN THE APPENDIX

Ma, B., Wang, H., Dsouza, M., Lou, J., He, Y., Dai, Z., Brookes, P.C., Xu, J., and Gilbert, J.A., 2016, Geographic patterns of co-occurrence network topological features for soil microbiota at continental scale in eastern China: The ISME Journal, v. 10, no. 8, p. 1891–1901, doi: 10.1038/ismej.2015.261.

Oksanen, J., Blanchet, F. G., Kindt, R., Legendre, P., Michin, P. R., O'Hara, R. B., Simpson, G. L., Solymos, P., Stevens, M. H. H., and Wagner, H., 2016, vegan: Community Ecology Package.

R Core Team, 2016, R: A Language and Environment for Statistical Computing: Vienna, R Foundation for Statistical Computing.