Mitochondrial genome evolution and tRNA truncation in Acariformes mites: new evidence from eriophyoid mites

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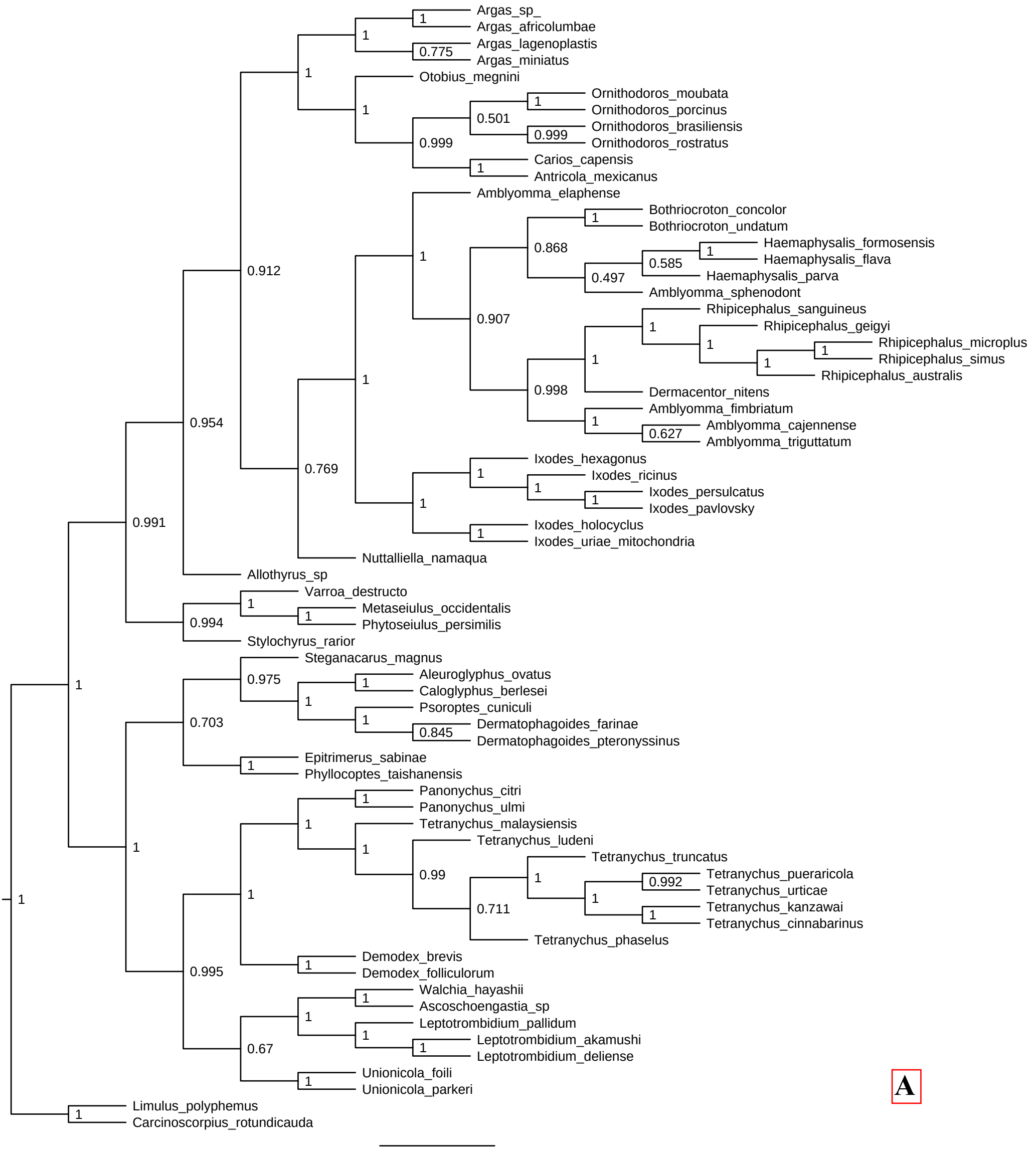
Supplementary Figure S1. Maximum likelihood credibility trees inferred with: A) nucleotide sequences by 16 partitions; B) nucleotide sequences by 6 partitions; C) nucleotide sequences by 16 partitionsexcluding the third codon positions of PCGs; D) nucleotide sequences by 6 partitions excluding the third positions of the PCGs; E) amino acid sequences partitioned by 13 genes; and F) nucleotide sequences of PCGs of 86 taxa by 13 partitions. Maximum likelihood bootstrap proportions (BSPs) are indicated at each node.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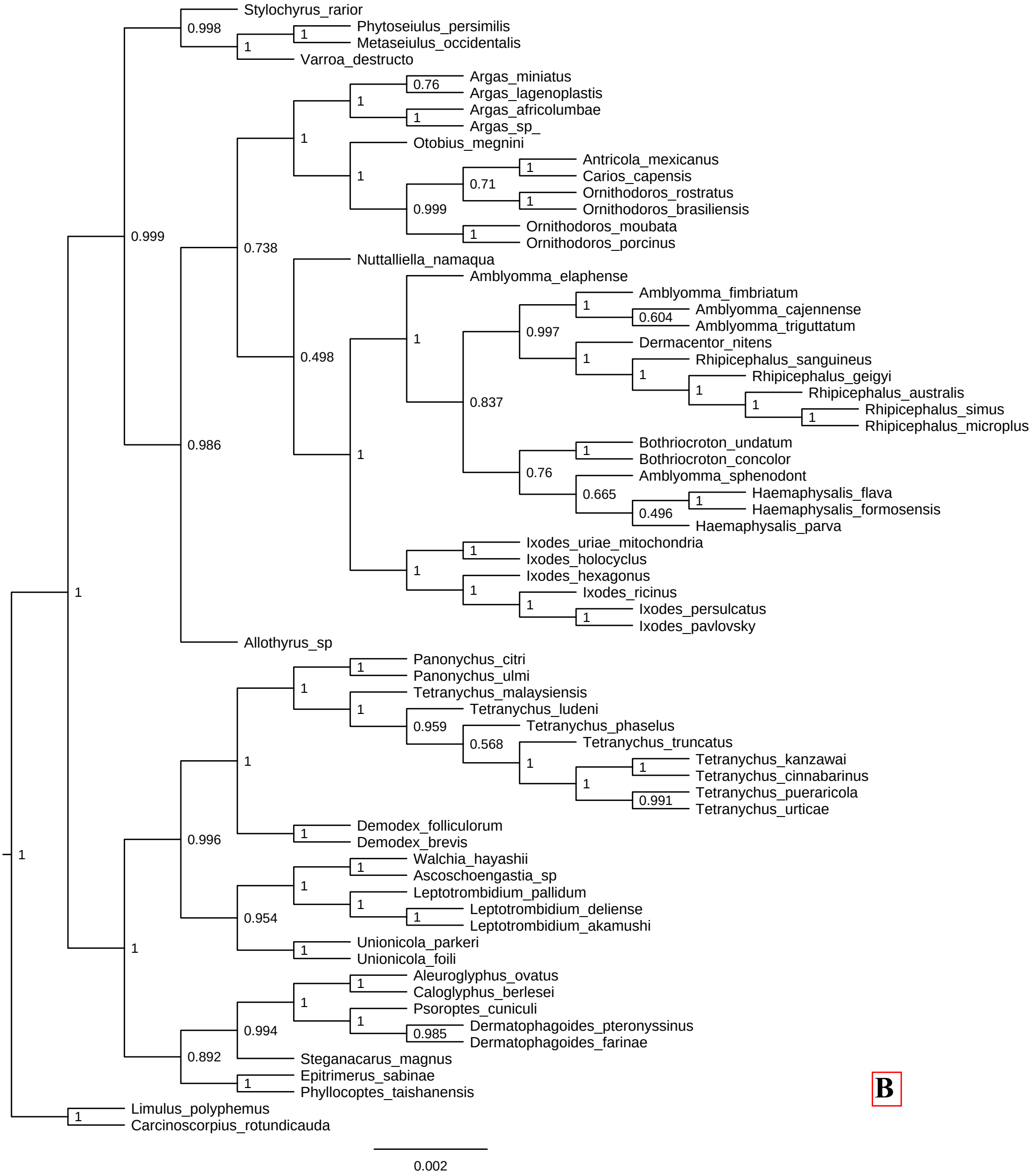
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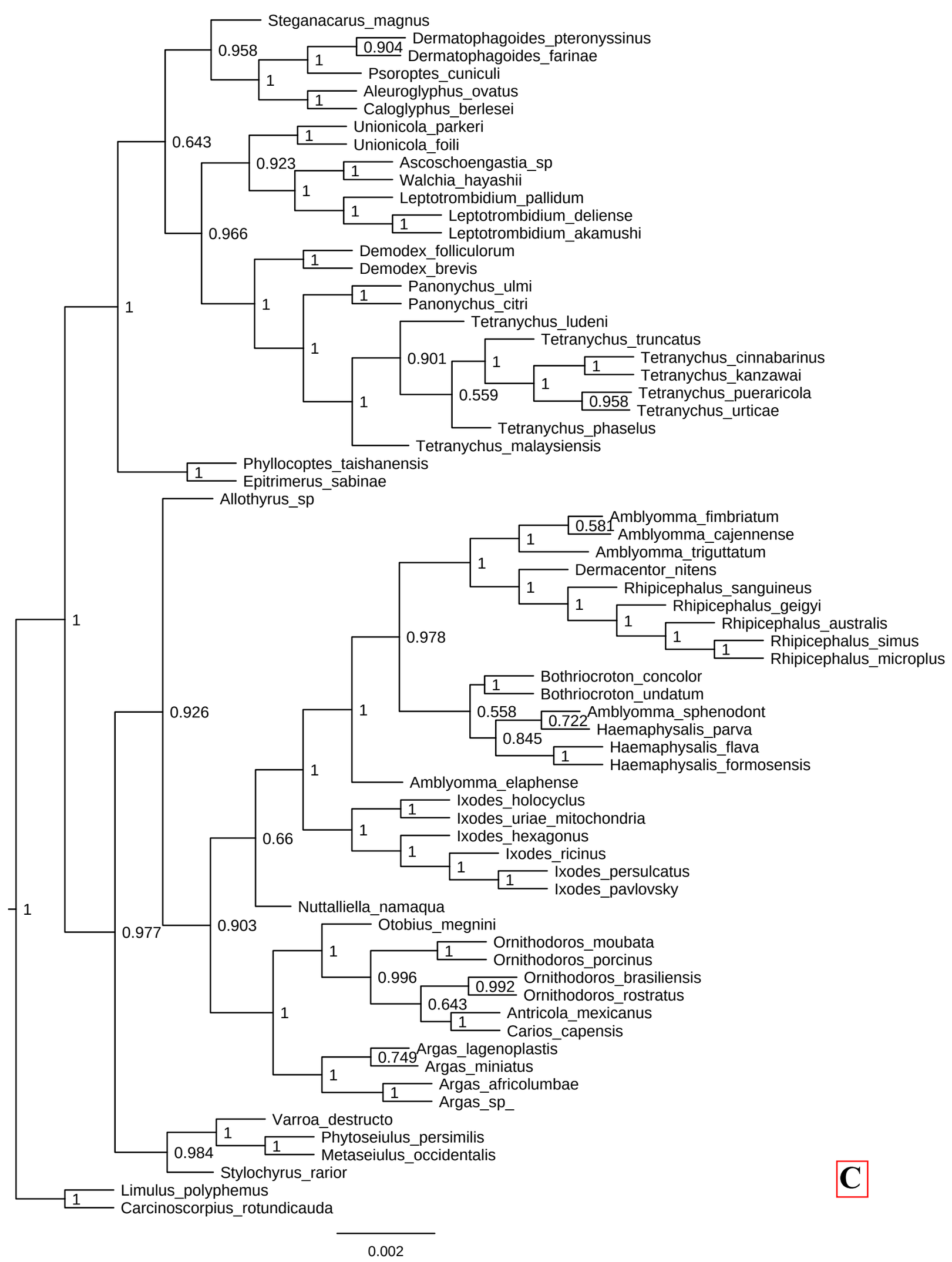
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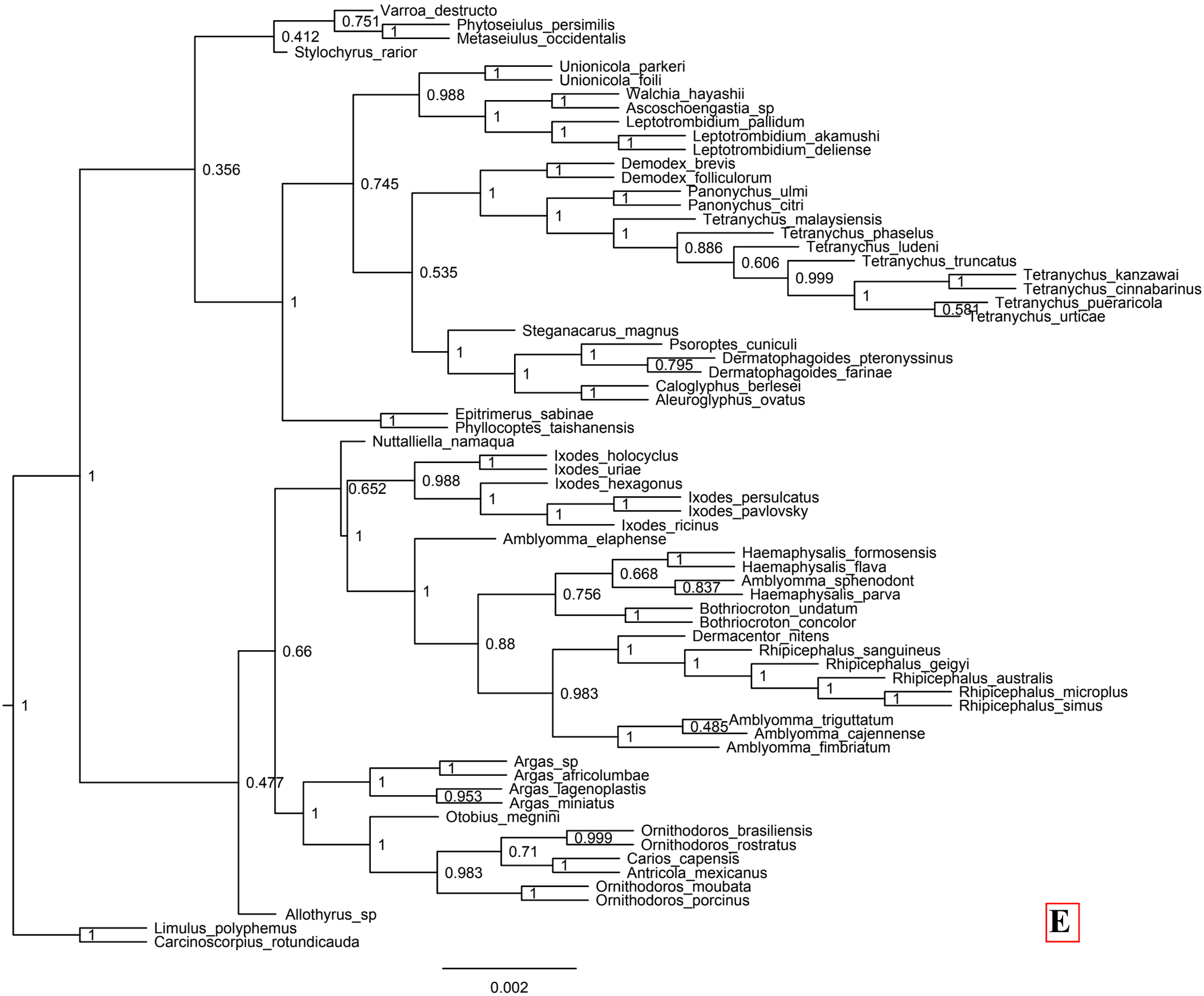
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Outgroups
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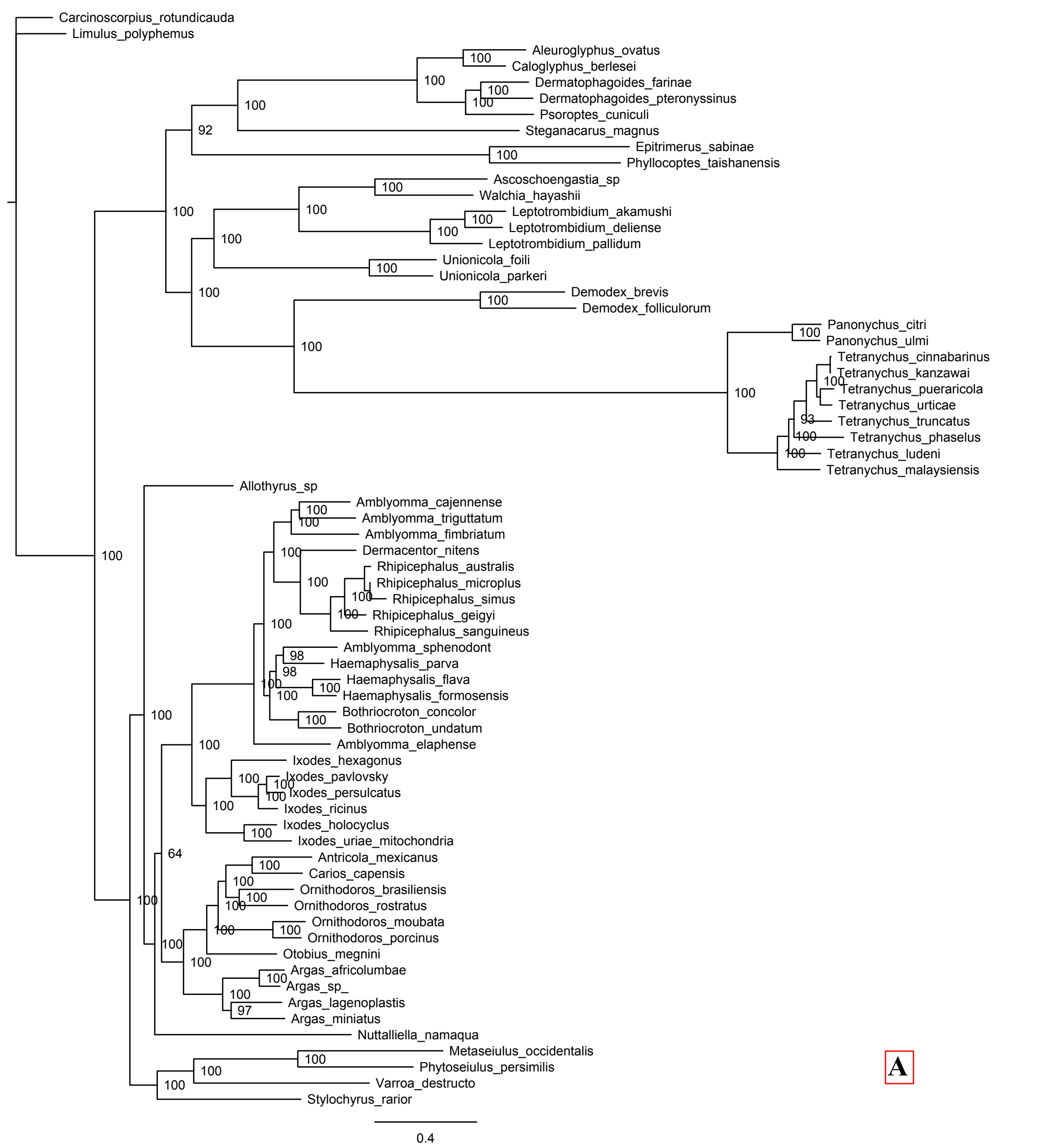
Supplementary Figure S2. Bayesian maximum credibility trees inferred by: A) nucleotide sequences by 16 partitions; B) amino acid sequences partitioned by 13 genes; C) nucleotide sequences by 16 partitions, except the third positions of the PCGs; D) nucleotide sequences by 6 partitions; E) nucleotide sequences by 6 partitions, except the third positions of the PCGs; F) the best partitions of nucleotide sequences found by PartitionFinder; G) the best partitions of nucleotide sequences found by PartitionFinder with truncated taxon; H) the best partitions of nucleotide sequences found by PartitionFinder with 13PCGs; and I) nucleotide sequences of PCGs of 86 taxa by 13 partitions. Bayesian posterior probabilities (BPPs) are indicated at each node.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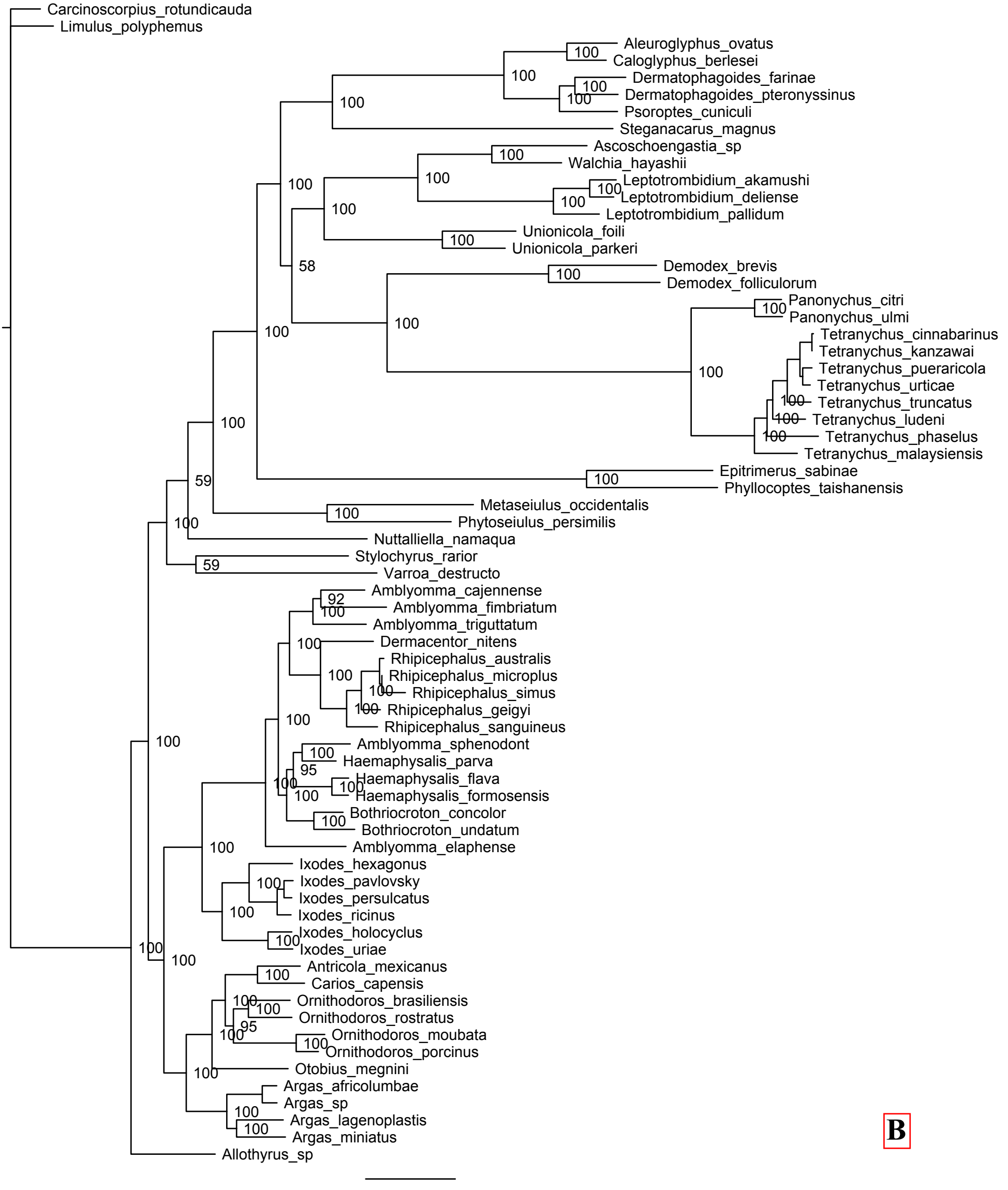
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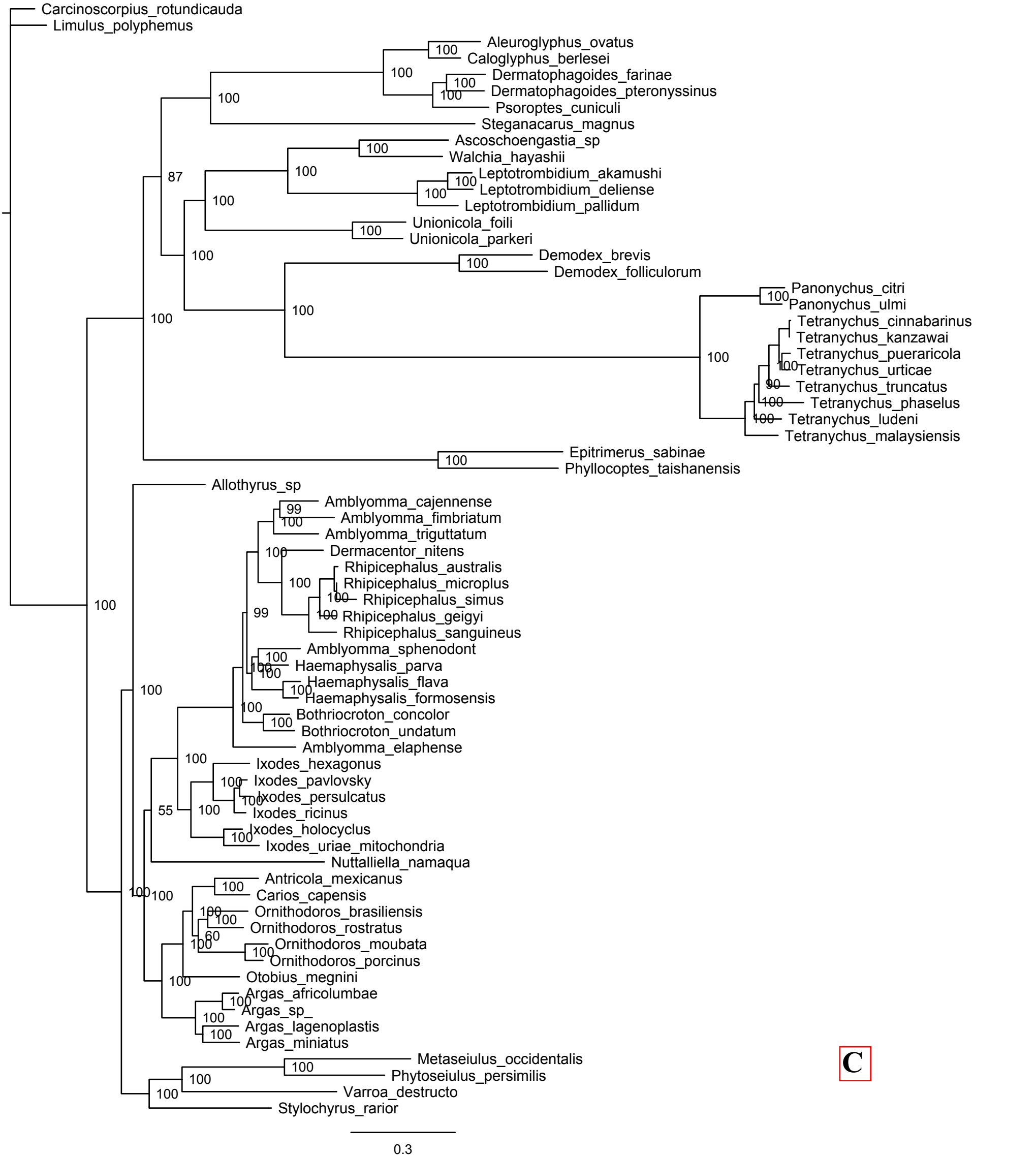
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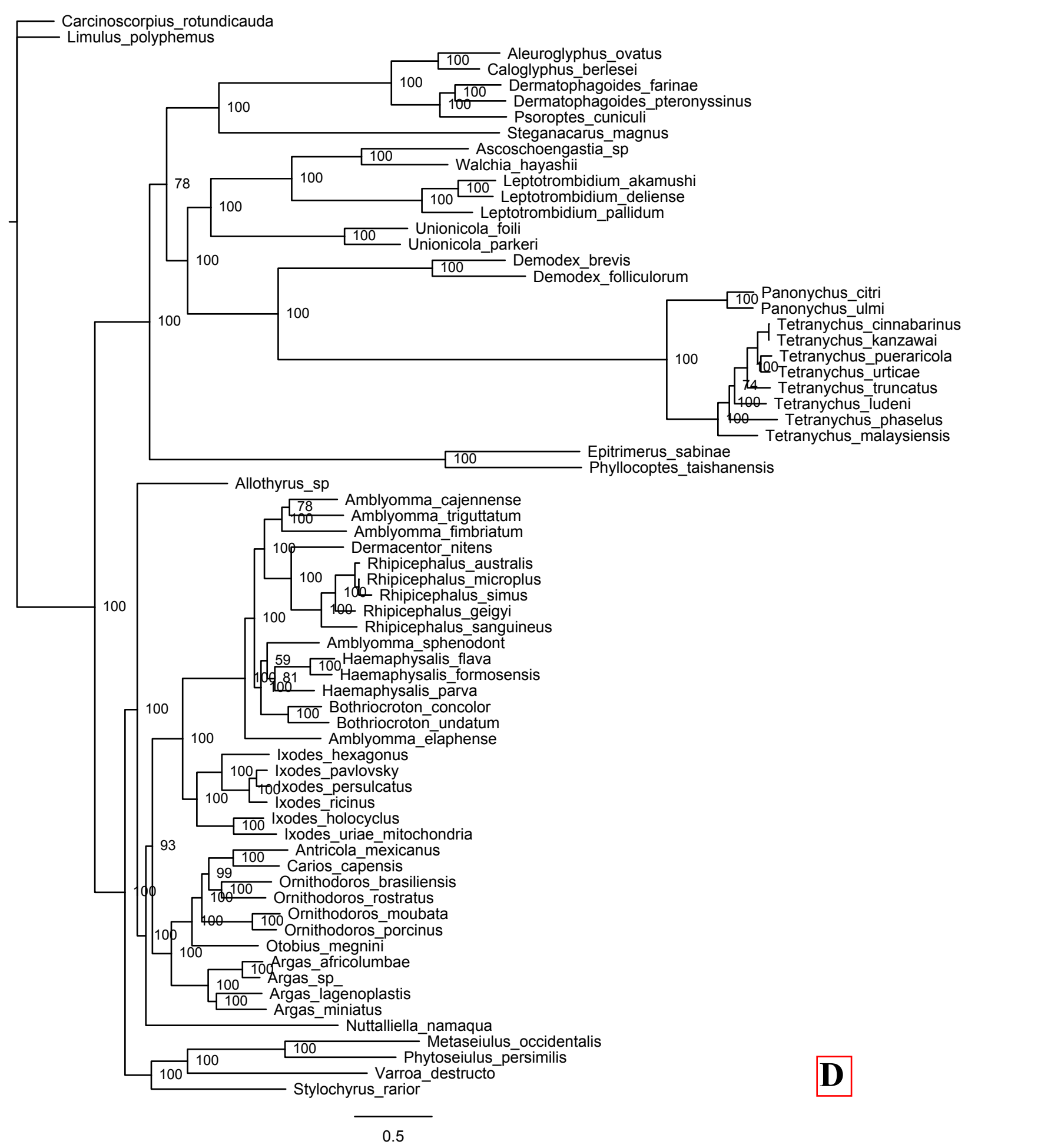
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Tetranychus_malaysiensis
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Ornithodoros_moubata
Ornithodoros_porcinus
Otobius_megnini
Argas_africolumbae
Argas_sp_
Argas_lagenoplastis
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Phytoseiulus_persimilis
Varroa_destructo
Stylochyrus_rarior
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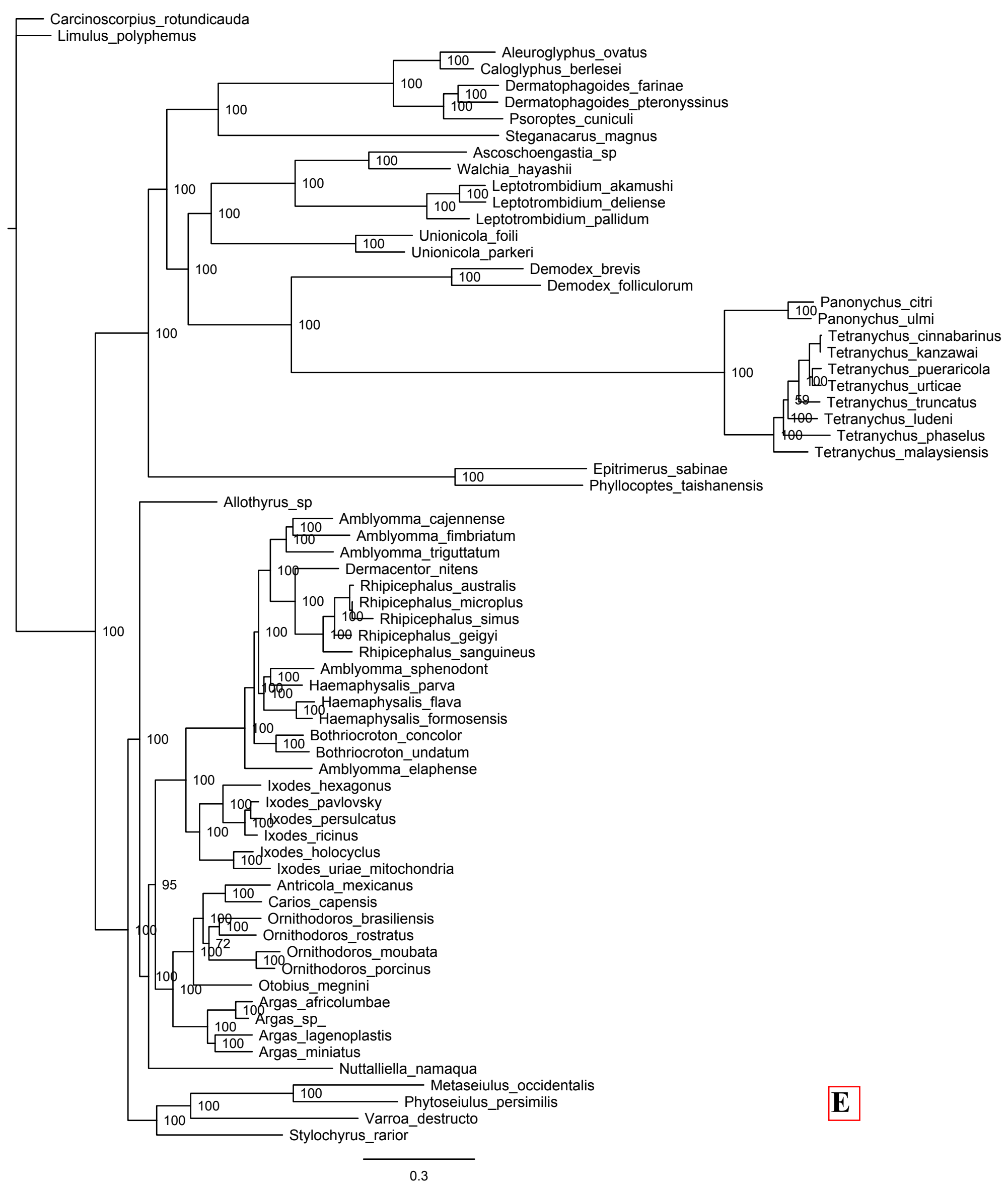
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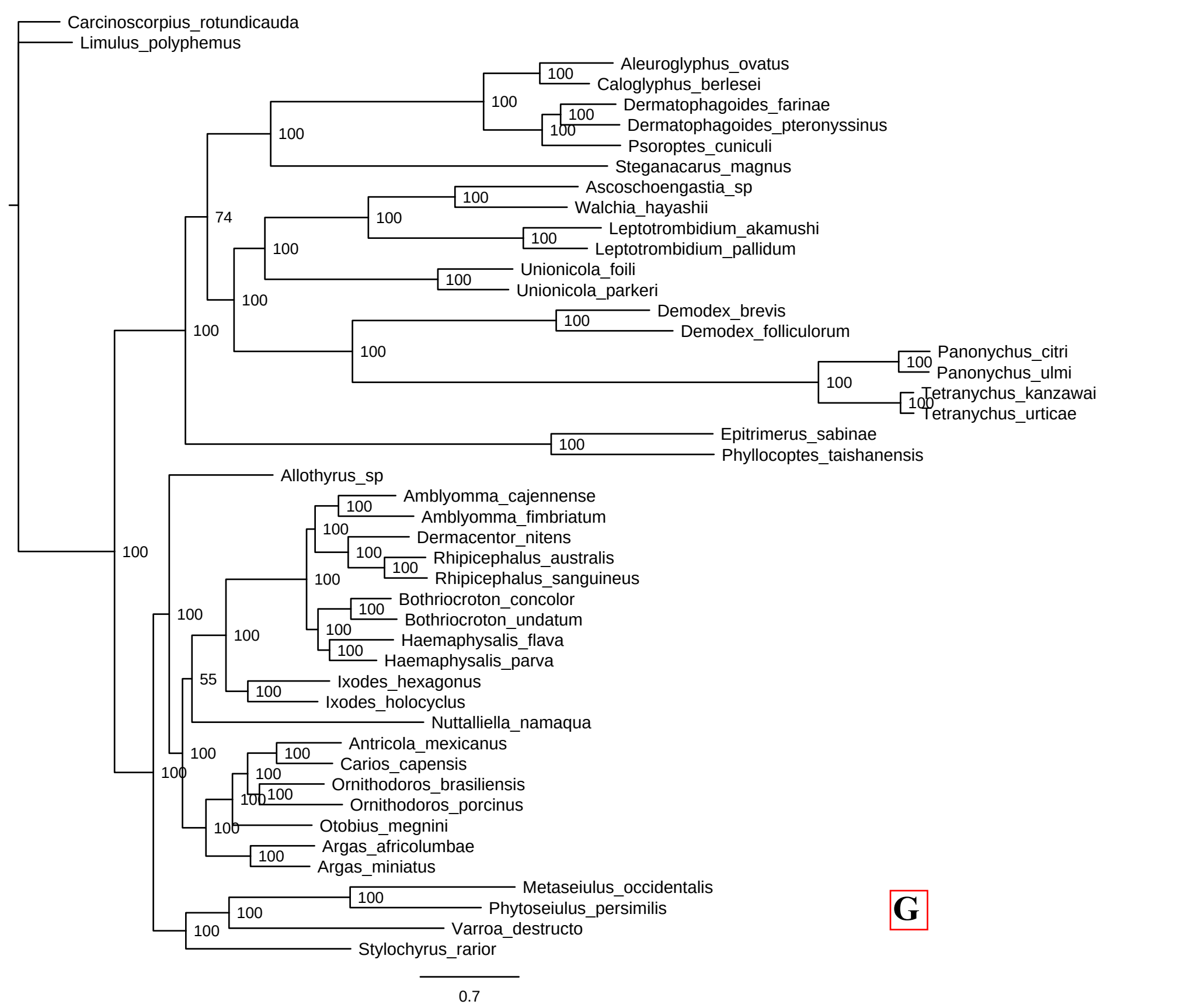
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Leptotrombidium_pallidum
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Tetranychus_kanzawai
Tetranychus_urticae
Epitrimerus_sabinae
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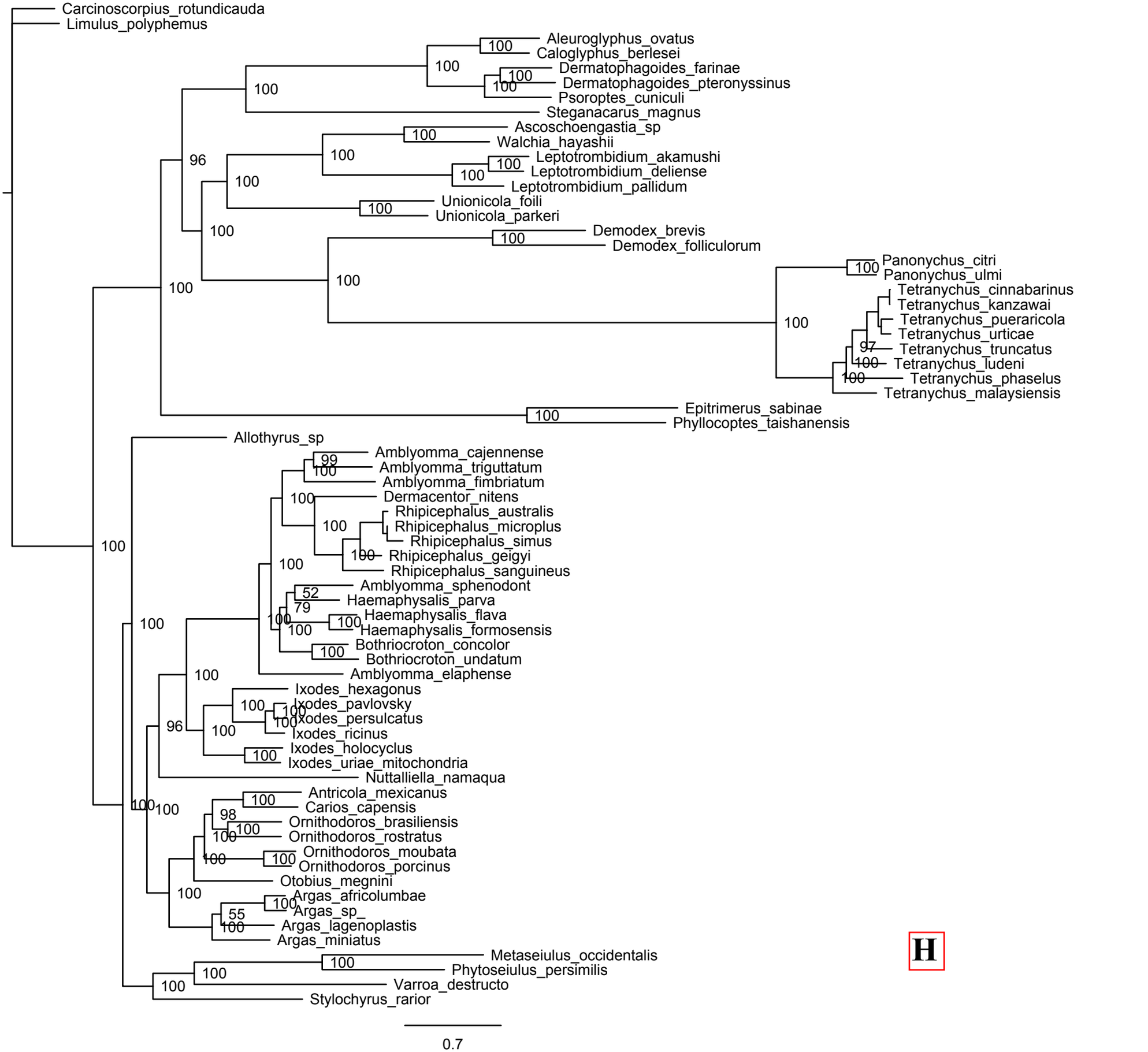
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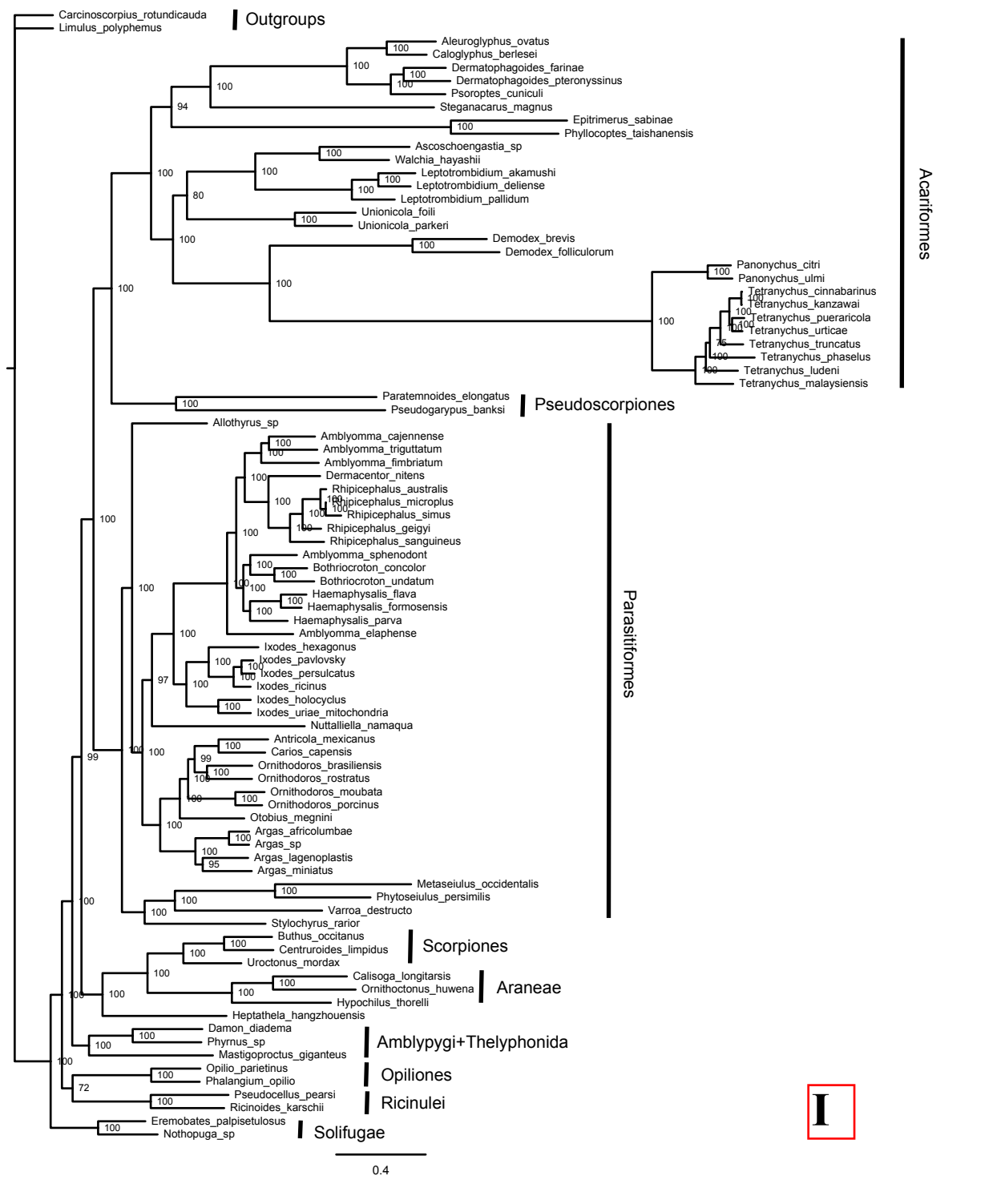
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Mastigoproctus_giganteus
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Phalangium_opilio
Opiliones
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Ricinoides_karschii
Ricinulei
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Nothopuga_sp
Solifugae
0.4
I

Supplementary Table S1 D- or T-ram loss of tRNAs in the Acariformes.

Family	Species	*A*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*K*	*L*$_1$	*L*$_2$	*M*	*N*	*P*	*Q*	*R*	*S*$_1$	*S*$_2$	*T*	*V*	*W*	*Y*
Eriophyidae	*Phyllocoptes taishanensis*	├	┤	┤	┤	┤	┼	┤	├	┼	┼	┼	┼	┤	┤	┤	├	├	├	┤	┤	┼	├
	Epitrimerus sabinae	├	┤	┤	┤	┤	┼	┤	├	┼	┼	┼	┼	┤	┤	┤	├	├	├	┤	┤	┼	├
Tetranychidae	*Panonychus citri*	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	┤	├	┤	├	├	┤	├	┤	┤
	Panonychus ulmi	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	│	├	┤	├	├	┤	├	┤	┤
	Tetranychus truncates	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	┤	│	┤	├	├	┤	├	┤	┤
	Tetranychus urticae	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	┤	│	┤	├	├	┤	├	┤	┤
	Tetranycus kanzawai	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	│	├	┤	├	├	┤	├	┤	┤
	Tetranycus ludeni	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	│	│	┤	├	├	┤	├	┤	┤
	Tetranycus malaysiensis	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	├	│	┤	│	├	┤	├	┤	┤
	Tetranycus phaselus	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	│	│	┤	├	├	┤	├	┤	┤
	Tetranycus puearicola	┤	┤	├	├	┤	┤	┤	┤	┼	┤	┼	┤	┼	│	│	┤	├	├	┤	├	┤	┤
Demodicidae	*Demodex brevis*	│	┤	│	┼	┤	┤	┤	├	┼	┤	┼	┼	┼	┤	┼	│	├	│	│	┤	┼	├
	Demodex folliculorum	│	┤	│	┼	┤	┤	┤	├	┼	┤	┼	┼	┼	┤	┼	│	├	│	│	┤	┼	├
Trombiculidae	*Leptotrombidium pallidum*	├	┤	┼	┼	┤	├	┤	├	┼	├	┤	┼	├	┤	┤	├	├	├	┤	├	┤	├
	Leptotrombidium akamushi	├	┤	┼	┼	┤	├	┤	├	┼	├	┼	┼	├	┤	┤	├	├	├	┤	├	┤	├
	Leptotrombidium deliense	├	┤	┼	┼	┤	├	┤	├	┼	├	┼	┼	├	┤	┤	├	├	├	┤	├	┤	├
	Walchia hayashii	├	┤	┼	┼	┤	├	┤	├	┼	├	┼	┼	├	┤	┼	├	├	├	┤	├	┤	├
Unionicolidae	*Unionicola foili*	├	┤	┼	┤	┤	├	┤	├	┼	┼	┼	┼	┼	┤	┼	├	├	├	┤	├	┤	┤
	Unionicola parkeri	├	┤	┼	┤	┤	├	┤	├	┼	┼	┼	┼	┼	┤	┼	├	├	├	┤	├	┤	┤
Acaridae	*Aleuroglyphus ovatus*	├	┤	┤	┤	┤	┤	┤	┤	┼	┤	┤	┤	┤	┤	┤	├	├	├	┤	├	┤	├
	Caloglyphus berlesei	├	┤	┤	┤	┤	┤	┤	┤	┼	┤	┤	┤	┤	┤	┤	├	├	├	┤	├	┤	├
Pyroglyphidae	*Dermatophagoides pteronyssinus*	├	┤	┤	┤	┤	┤	┤	┤	┼	┤	┤	┤	┤	┤	┤	├	├	├	┤	├	┤	├
	Dermatophagoides farinae	├	┤	┤	┤	┤	┤	┤	┤	┼	┤	┤	┤	┤	┤	┤	├	├	├	┤	├	┤	├
Steganacaridae	*Steganacarus magnus*	-	-	-	-	-	-	┤	-	-	-	├	-	-	┤	┤	-	-	├	-	-	┤	-

Psoroptidae	*Psoroptes cuniculi*	├	┤	┤	┤	┤	┤	┤	┤	┼	┤	┤	┤	┤	┤	┤	┤	├	├	┤	├	┤	├

"├" means D-armless, "┤" means T-armless, "│" means both T-armless and D-armless, "┼" means typical cloverleaf structure, "-" means tRNA gene loss, tRNA genes are indicated by the single letter IUPAC-IUB abbreviation for their corresponding amino acid. Unpublished data of *Ascoschoengastia* sp. was not included in this analysis.

Supplementary Table S2 PCR primers used in this study.

Primer	Sequence (5’-3’)	Source
LR-J-122887	CCGGTCTGAACTCAGATCACGT	Simon et al. (1994)
LR-N-13398	CGCCTGTTTAACAAAAACAT	Simon et al. (1994)
LCO1490	GGTCAACAAATCATAAAGATATTGG	Folmer et al. (1994)
HCO2198	TAAACTTCAGGGTGACCAAAAAATCA	Folmer et al. (1994)
ECOISR3	CCGACAAATCCGTATGAAATAAGACACC	This study
E16SSR2	ACCTATTCTCACAAGAGTTTGCGACC	This study
PF2	GCAGGTCAGAATCAAGACAAACAATAACAAA	This study
PR2	TCCCTTTGATGCTAGGTGCCCACGATAT	This study
TY16sR1	TGAAATAACACAAAATAATAAACTACTT	This study
TYCB3R2	ATCGTGAAACGCTAAAGAACCAGGCT	This study
RTY16sF4	AGATTAACTTGTAGGGTCTTCTCGTCTTGCAG	This study
RTYCB3F5	TTGGCCGGGGCGATTACTATGCTTCTAACGGA	This study

Supplementary Table S3 Species used in this study.

Class	Superorder	Order	Superfamily	Family	Species	GenBank number	Size (bp)	Reference
Merostomata		Xiphosura		Limulidae	*Limulus polyphemus*	AF216203	14,985	Lavrov et al. 2000
					Carcinoscorpius rotundicauda	JX437074	15,037	Unpublished
Arachnida		Amblypygi		Phrynidae	*Phyrnus* sp.	EU520641	14,764	Masta and Boore, 2008
				Phrynichidae	*Damon diadema*	NC_011293	14,786	Unpublished
		Araneae		Nemesiidae	*Calisoga longitarsis*	EU523754	14,070	Masta and Boore, 2008
				Hypochilidae	*Hypochilus thorelli*	EU523753	13,991	Masta and Boore, 2008
				Heptathelidae	*Heptathela hangzhouensis*	AY309258	14,215	Qiu et al., 2005
				Theraphosidae	*Ornithoctonus huwena*	AY309259	13,874	Qiu et al., 2005
		Opiliones		Phalangiidae	*Phalangium opilio*	EU523757	14,968	Masta and Boore, 2008
					Opilio parietinus	NC_014700	15,400	Podsiadlowski and Fahrei, 2010
		Scorpiones		Buthidae	*Buthus occitanus*	EU523755	15,060	Masta and Boore, 2008
					Centruroides limpidus	NC_006896	14,519	Dávila et al., 2005
				Chactidae	*Uroctonus mordax*	EU523756	14,840	Masta and Boore, 2008
		Solifugae		Eremobatidae	*Eremobates palpisetulosus*	EU520642	15,083	Masta and Boore, 2008
				Ammotrechidae	*Nothopuga* sp.	NC_009984	14,985	Fahrein et al., 2007
		Thelyphonida		Thelyphonidae	*Mastigoproctus giganteus*	EU520643	14,416	Masta and Boore, 2008
		Pseudoscorpiones		Feaelloidea	*Pseudogarypus banksi*	JQ040544	16,546	Ovchinnikov and Masta, 2012
				Cheliferoidea	*Paratemnoides elongatus*	JQ040543	14,368	Ovchinnikov and Masta, 2012
		Ricinulei			*Pseudocellus pearsi*	NC_009985	15,099	Fahrein et al., 2007
				Ricinoididae	*Ricinoides karschii*	NC_023452	14,614	Unpublished
	Parasitiformes	Holothyrida	Holothyroidea	Allothyridae	*Allothyrus* sp.	KC769586	14,578	Burger *et* al. 2014
		Ixodida	Ixodoidea	Argasidae	*Antricola mexicanus*	KC769591	14,415	Burger *et* al. 2014
					Argas africolumbae	JQ665720	14,440	Mans *et al.* 2012(Mans et al.,

					2012)
		*Argas lagenoplastis**	KC769587	14,478	Burger *et* al. 2014
		Argas miniatus	KC769590	14,416	Burger *et* al. 2014
		Argas sp.*	KC769588	14,450	Burger *et* al. 2014
		Carios capensis	AB075953	14,418	Shao *et al*. 2004
		Ornithodoros brasiliensis	KC769593	14,489	Burger *et* al. 2014
		*Ornithodoros moubata**	AB073679	14,398	Shao *et al*. 2004
		Ornithodoros porcinus	AB105451	14,378	Shao *et al*. 2005
		*Ornithodoros rostratus**	KC769592	14,452	Burger *et* al. 2014
		Otobius megnini	KC769589	14,430	Burger *et* al. 2014
	Ixodidae	*Amblyomma cajennense*	JX573118	14,780	Burger *et al*. 2013
		*Amblyomma elaphense**	JN863729	14,627	Burger *et al*. 2012
		Amblyomma fimbriatum	JN863729	14,705	Burger *et al*. 2012
		*Amblyomma sphenodonti**	JN863731	14,772	Burger *et al*. 2012
		*Amblyomma triguttatum**	AB113317	14,704	Shao *et al*. 2005
		Bothriocroton concolor	JN863727	14,809	Burger *et al*. 2012
		Bothriocroton undatum	JN863728	14,769	Burger *et al*. 2012
		Dermacentor nitens	KC503258	14,839	Burger *et* al. 2014
		Haemaphysalis flava	AB075954	14,686	Shao *et al*. 2004
		*Haemaphysalis formosensis**	JX573135	14,676	Burger *et al*. 2013
		Haemaphysalis parva	JX573136	14,846	Burger *et al*. 2013
		Ixodes hexagonus	AF081828	14,539	Black & Roehrdanz, 1998
		Ixodes holocyclus	AB075955	15,007	Shao *et al*. 2005
		*Ixodes pavlovskyi**	KJ000060	14,575	Unpublished
		*Ixodes persulcatus**	AB073725	14,539	Shao *et al*. 2005
		*Ixodes ricinus**	JN248424	14,566	Montagna *et al*. 2012

				*Ixodes uriae**	AB087746	15,053	Shao *et al*. 2005
				Rhipicephalus australis	KC503255	14,891	Burger *et* al. 2014
				*Rhipicephalus geigyi**	KC503263	14,948	Burger *et* al. 2014
				*Rhipicephalus microplus**	KC503260	14,903	Burger *et* al. 2014
				Rhipicephalus sanguineus	AF081829	14,710	Shao *et al*. 2004
				*Rhipicephalus simus**	KJ739594	14,929	Xu et al. 2014
			Nuttalliellidae	*Nuttalliella namaqua*	NC_019663	14,425	Mans *et al*. 2012
	Mesostigmata	Dermanyssoidea	Varroidae	*Varroa destructor*	AJ493124	16,476	Navajas *et al*. 2002
		Phytoseioidea	Phytoseiidae	*Phytoseiulus persimilis*	GQ222414	16,199	Dermauw *et al*. 2010
				Metaseiulus occidentalis	EF221760	24,961	Jeyaprakash and Hoy, 2007
		Rhodacaroidea	Ologamasidae	*Stylochyrus rarior*	GQ927176	14,900	Swafford and Bond 2009
Acariformes	Trombidiformes	Cheyletoidea	Demodicidae	*Demodex brevis*	KM114225	14,211	Palopoli *et al*. 2014
				Demodex folliculorum	KM114226	14,150	Palopoli *et al*. 2014
		Eriophyoidea	Eriophyidae	*Phyllocoptes taishanensis*	KR604967	13,475	This study
				Epitrimerus sabinae	KR604966	13,531	This study
		Tetranychoidea	Tetranychidae	*Panonychus citri*	HM189212	13,077	Yuan *et al*. 2010
				Panonychus ulmi	NC_012571	13,115	Unpublished
				*Tetranychus truncates**	KM111296	13,089	Chen *et al*. 2014
				Tetranychus urticae	NC_010526	13,103	Van Leeuwen *et al*. 2008
				Tetranycus kanzawai	KJ729017	13,091	Chen *et al*. 2014
				*Tetranycus ludeni**	KJ729018	13,064	Chen *et al*. 2014
				*Tetranycus malaysiensis**	KJ729019	13,049	Chen *et al*. 2014
				*Tetranycus phaselus**	KJ729020	13,084	Chen *et al*. 2014
				*Tetranycus puerariсola**	KJ729021	13,084	Chen *et al*. 2014
				*Tetranychus cinnabarinus**	NC_014399	13,092	Unpublished
		Trombiculoidea	Trombiculidae	*Leptotrombidium pallidum*	AB180098	16,779	Shao *et al*. 2005

				Leptotrombidium akamushi	AB194045	13,698	Shao *et al*. 2006
				*Leptotrombidium deliense**	AB194044	13,731	Shao *et al*. 2006
				Walchia hayashii	NC_010595	14,857	Unpublished
				Ascoschoengastia sp.	NC_010596	16,067	Unpublished
		Hygrobatoidea	Unionicolidae	*Unionicola foili*	EU856396	14,738	Ernsting *et al*. 2009
				Unionicola parkeri	HQ386015	14,734	Edwards *et a*l. 2011
	Sarcoptiformes	Acaroidea	Acaridae	*Aleuroglyphus ovatus*	KC700022	14,328	Sun *et al*. 2014
				Caloglyphus berlesei	KF499016	14,273	Sun *et al*. 2014
		Analgoidea	Pyroglyphidae	*Dermatophagoides pteronyssinus*	EU884425	14,203	Dermauw *et al*. 2009
				Dermatophagoides farinae	NC_013184	14,266	Klimov & OConnor 2009
		Phthiracaroidea	Steganacaridae	*Steganacarus magnus*	EU935607	13,818	Domes *et al*. 2008
		Sarcoptoidea	Psoroptidae	*Psoroptes cuniculi*	KJ957822	14,247	Gu *et al*. 2014

Species with asterisk were deleted in the truncated Baysian inference.

Supplementary Table S4 Partition strategies used in this study.

Date sets	Analysis methods	Number of partitions	Models and Partition scheme
Amino acid	Bayesian	13	MTREV+I+G+F: Atp6, Atp8, Cob, Cox1, Cox2, Cox3, Nad1, Nad2, Nad3, Nad4, Nad4L, Nad5, Nad6
	ML	13	MTREV: Atp6, Atp8, Cob, Cox1, Cox2, Cox3, Nad1, Nad2, Nad3, Nad4L, Nad5, Nad6 JTT: Nad4
By genes	Bayesian	16	GTR+I+G: Atp6, Atp8, Cob, Cox1, Cox2, Cox3, Nad1, Nad2, Nad3, Nad4, Nad4L, Nad5, Nad6, 12S, 16S, tRNAs
	ML	16	GAMMAI: Atp6, Atp8, Cob, Cox1, Cox2, Cox3, Nad1, Nad2, Nad3, Nad4, Nad4L, Nad5, Nad6, 12S, 16S, tRNAs
By genes, exclude third codon	Bayesian	16	GTR+I+G: Atp6, Atp8, Cob, Cox1, Cox2, Cox3, Nad1, Nad2, Nad3, Nad4, Nad4L, Nad5, Nad6, 12S, 16S, tRNAs
	ML	16	GAMMAI: Atp6, Atp8, Cob, Cox1, Cox2, Cox3, Nad1, Nad2, Nad3, Nad4, Nad4L, Nad5, Nad6, 12S, 16S, tRNAs
By codon	Bayesian	6	GTR+I+G: 1st codon, 2nd codon, 3rd codon, *rrnS*, *rrnL*, tRNAs
	ML	6	GAMMAI: 1st codon, 2nd codon, 3rd codon, 12S, 16S, tRNAs
By codon, exclude third codon	Bayesian	5	GTR+I+G: 1st codon, 2nd codon, 12S, 16S, tRNAs
	ML	5	GAMMAI: 1st codon, 2nd codon, 12S, 16S, tRNAs
Nucleotide sequences by PartitionFinder	Bayesian	8	GTR+I+G: (Atp6_pos1, Cob_pos1, Cox1_pos1, Cox2_pos1, Cox3_pos1, Nad3_pos1), (Atp6_pos2, Cob_pos2, Cox1_pos2, Cox2_pos2, Cox3_pos2, Nad1_pos2, Nad2_pos2, Nad3_pos2, Nad4L_pos2, Nad5_pos2, Nad6_pos2), (Atp8_pos1, Atp8_pos2, Nad1_pos1, Nad2_pos1, Nad4L_pos1, Nad5_pos1, Nad6_pos1), (Nad4_pos1, Nad4_pos2) GTR+G: (Atp6_pos3, Atp8_pos3, Cob_pos3, Cox1_pos3, Cox2_pos3, Cox3_pos3, Nad2_pos3, Nad3_pos3, Nad6_pos3), (Nad1_pos3, Nad4L_pos3, Nad4_pos3, Nad5_pos3), (12S, 16S), (tRNAs)
Nucleotide sequences by PartitionFinder, with truncated taxa	Bayesian	8	GTR+I+G: (Atp6_pos1, Cob_pos1, Cox1_pos1, Cox2_pos1, Cox3_pos1, Nad3_pos1), (Atp6_pos2, Cob_pos2, Cox1_pos2, Cox2_pos2, Cox3_pos2, Nad1_pos2, Nad2_pos2, Nad3_pos2, Nad4L_pos2, Nad5_pos2, Nad6_pos2), (Atp8_pos1, Atp8_pos2, Nad1_pos1, Nad2_pos1, Nad4L_pos1, Nad5_pos1,

			Nad6_pos1), (Nad4_pos1, Nad4_pos2) GTR+G: (Atp6_pos3, Atp8_pos3, Cob_pos3, Cox1_pos3, Cox2_pos3, Cox3_pos3, Nad2_pos3, Nad3_pos3, Nad6_pos3), (Nad1_pos3, Nad4L_pos3, Nad4_pos3, Nad5_pos3), (12S, 16S), (tRNAs)
Nucleotide sequences of PCGs by PartitionFinder	Bayesian	6	GTR+I+G: (Atp6_pos1, Cob_pos1, Cox1_pos1, Cox2_pos1, Cox3_pos1, Nad3_pos1), (Atp6_pos2, Cob_pos2, Cox1_pos2, Cox2_pos2, Cox3_pos2, Nad1_pos2, Nad2_pos2, Nad3_pos2, Nad4L_pos2, Nad5_pos2, Nad6_pos2), (Atp8_pos1, Atp8_pos2, Nad1_pos1, Nad2_pos1, Nad4L_pos1, Nad5_pos1, Nad6_pos1), (Nad4_pos1, Nad4_pos2) GTR+G: (Atp6_pos3, Atp8_pos3, Cob_pos3, Cox1_pos3, Cox2_pos3, Cox3_pos3, Nad2_pos3, Nad3_pos3, Nad6_pos3), (Nad1_pos3, Nad4L_pos3, Nad4_pos3, Nad5_pos3)

Supplementary Table S5 Inferred second structur of *trnC*, *trnY* and *trnV* of *Dermatophagoides pteronyssinus*.

tRNA	AA-arm		D-arm		AC-arm	V-loop	T-arm	AA-arm
trnC	ATCTCTT	AA	GTTTTAAAAATAC	A	TTAGATTGCAAATCTAA	AATTTT		AAGAGGTT
trnY	AGACTTT			TAAT	GAAAGCTGTAAACTTTC	TTTT	TTGTGCTATTATGG	AGGGTTTA
trnV	*TTAAGAG*			TTTCATTATT	TTTTGCTTACAACAAAA	AATC	TTTTAA	CTCTTCTG