

Supporting Information for

Evolution of diverse host fish infection mechanisms delineates an adaptive radiation of lampsiline freshwater mussels centered on their larval ecology

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Table S1: Summary of samples used in our analyses including; where samples were obtained, host infection mechanism used, primary host fish, and sources cited for determining host use and host infection mechanisms. NCS = North Carolina State University, UF = University of Florida, INHS = Illinois Natural History Survey, and AABC = Alabama Aquatic Biodiversity Center.

Sample name	Species name	Infection Strategy	infection citations	Tissue Source	Museum ID	Host	host citation
Aplic	Amblema plicata	Broadcast (larval threads)	Haag, 2012	T. Hewitt (River Raisin, MI).	306255	Generalist	Haag, 2012
TH_32	Cambarunio taeniata	Mantle lure and simple brood lure	Barnhart et al., 2008; Haag, 2012	NCS	29180	Bass	Gordon et al., 1994
TH131	Cyrtonaias tampicoensis	Broadcast	Zanatta and Murphy, 2007	UF	438173	Gar	Howells, 1997
TH132	Cyrtonaias tampicoensis	Broadcast	Zanatta and Murphy, 2007	UF	438173	Gar	Howells, 1997
TLH59	Epioblasma triquetra	Host Trapping	Barnhart et al., 2008	INHS	36609	Darter/Sculpin	Barnhart et al., 2008; Haag, 2012
Edila2	Eurynia dilatata	Broadcast (larval threads)	Zanatta and Murphy, 2007; Barnhart et al., 2008	T. Hewitt (River Raisin, MI).	306256	Generalist	Ford and Oliver, 2015
Edila1	Eurynia dilatata	Broadcast (larval threads)	Zanatta and Murphy, 2007; Barnhart et al., 2008	T. Hewitt (River Raisin, MI).	306256	Generalist	Ford and Oliver, 2015
TH125	Glebula rotundata	Broadcast	Zanatta and Murphy, 2007	UF	440636	Sunfish	Parker et al., 1984
TH126	Glebula rotundata	Broadcast	Zanatta and Murphy, 2007	UF	440636	Sunfish	Parker et al., 1984
TH_36	Hamiota altilis	Mantle Lure and tethered brood lure	Barnhart et al., 2008	From Paul Johnson (AABC)	306257	Bass/Sunfish	Haag and Warren, 1999
TH_7	Hamiota australis	Tethered brood lure	Barnhart et al., 2008	UF	441239	Bass	Haag, 2012
TH_37	Hamiota perovalis	Tethered brood lure	Barnhart et al., 2008	From Paul Johnson (AABC)	306258	Bass	Haag and Warren, 1997; Haag, 2012
TH152	Hamiota subangulata	Tethered brood lure	Barnhart et al., 2008	UF	438064	Bass	O'Brien and Box, 1999; Haag, 2012
TLH9	Lampsilis bracteata	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	439084	Bass/Sunfish	Haag, 2012
LCFL68	Lampsilis cardium	Mantle lure and simple brood lure	Barnhart et al., 2008	J. Bergner (Flatt River, MI).	NA	Bass	Haag, 2012
LCEE70	Lampsilis cardium	Mantle lure and simple brood lure	Barnhart et al., 2008	T. Hewitt (Eel River, IN).	306259	Bass	Haag, 2012
LCEE71	Lampsilis cardium	Mantle lure and simple brood lure	Barnhart et al., 2008	T. Hewitt (Eel River, IN).	306259	Bass	Haag, 2012
LCFL69	Lampsilis cardium	Mantle lure and simple brood lure	Barnhart et al., 2008	J. Bergner (Flatt River, MI).	NA	Bass	Haag, 2012
LFre2	Lampsilis fasciola	Mantle lure and simple brood lure	Barnhart et al., 2008	T. Hewitt (Huron River, MI).	306260	Bass	Mummert et al., 2003; Haag, 2012
TH_2	Lampsilis fasciola	Mantle lure and simple brood lure	Barnhart et al., 2008	T. Hewitt (River Raisin, MI).	NA	Bass	Mummert et al., 2003; Haag, 2012
TH_77	Lampsilis fasciola	Mantle lure and simple brood lure	Barnhart et al., 2008	T. Hewitt (Huron River, MI).	306260	Bass	Mummert et al., 2003; Haag, 2012
LFHM04	Lampsilis fasciola	Mantle lure and simple brood lure	Barnhart et al., 2008	T. Hewitt (Huron River, MI).	306260	Bass	Mummert et al., 2003; Haag, 2012
LFHM07	Lampsilis fasciola	Mantle lure and simple brood lure	Barnhart et al., 2008	T. Hewitt (Huron River, MI).	306260	Bass	Mummert et al., 2003; Haag, 2012
TLH4	Lampsilis floridensis	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	340525	Bass/Gar	Keller and Ruessler, 1997; Haag, 2012
TH_45	Lampsilis higginsii	Mantle lure and simple brood lure	Barnhart et al., 2008	INHS	49425	Bass/Walleye	Waller and Holland, 1988; Haag, 2012
TH_87	Lampsilis hydiana	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	440994	Bass	Draxler et al., 2006; Haag, 2012
TH_88	Lampsilis hydiana	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	440994	Bass	Draxler et al., 2006; Haag, 2012
TH_5	Lampsilis ornata	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438031	Bass	Haag and Warren, 2003; Haag, 2012
TH_96	Lampsilis ovata	Mantle lure and simple brood lure	Barnhart et al., 2008; Haag and Warren, 2003	UF	438255	Bass	Williams et al., 2008; Haag, 2012
TH_94	Lampsilis ovata	Mantle lure and simple brood lure	Barnhart et al., 2008; Haag and Warren, 2003	UF	438255	Bass	Williams et al., 2008; Haag, 2012
TH_95	Lampsilis ovata	Mantle lure and simple brood lure	Barnhart et al., 2008; Haag and Warren, 2003	UF	438255	Bass	Williams et al., 2008; Haag, 2012
TH117	Lampsilis radiata	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	439013	Bass and perch	Eads et al., 2015
TH_8	Lampsilis satura	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	441167	Bass	Haag, 2012
TLH51	Lampsilis siliquoidea	Mantle lure and simple brood lure	Barnhart et al., 2008	INHS	25963	Bass	Keller and Ruessler, 1997
TH_23	Lampsilis splendida	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438354	Bass	Haag, 2012
TLH6	Lampsilis straminea	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	383152	Bass	Keller and Ruessler, 1997; Haag, 2012
TH_38	Lampsilis virescens	Mantle lure and simple brood lure	Barnhart et al., 2008	Paul Johnson (AABC)	306261	Bass	Williams et al., 2008; Haag, 2012
TH_22	Leaunio umbrans	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438189	Sunfish/Sculpin	Williams et al., 2008
TLH26	Leaunio vanuxemensis	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438796	Sculpin	Haag, 2012
TH_34	Lemiox rimosus	Mantle lure	Zanatta and Murphy, 2007	NCS	47243	Darter/Sculpin	Haag, 2012
TH_57	Leptodea fragilis	Mantle lure	Sietman et al., 2018	INHS	79830	Drum	Haag, 2012
TH133	Leptodea ochracea	broadcast	Haag et al., 2012	UF	438459	white perch	Wick and Huryn, 2003
TH_91	Ligumia recta	Mantle lure and simple brood lure	Barnhart et al., 2008; Corey et al., 2006	UF	438249	Walleye	Haag, 2012
TH_39	Medionidus acutissimus	Mantle lure	Haag and Warren, 2003	Paul Johnson (AABC)	306262	Darter/Sculpin	Haag and Warren, 1997; Haag and Warren, 2003; Haag, 2012
TH_40	Medionidus conradicus	Mantle lure	Zanatta and Murphy, 2007	UF	438914	Darter/Sculpin	Zale and Neves, 1982; Haag, 2012
TH_41	Medionidus parvulus	Mantle lure	Haag, 2012	Paul Johnson (AABC)	306263	Darter/Sculpin	Haag, 2012
TLH28	Medionidus parvulus	Mantle lure	Haag, 2012	Paul Johnson (AABC)	306263	Darter/Sculpin	Haag, 2012
TH_16	Medionidus penicillatus	Mantle lure	Haag, 2012	Paul Johnson (AABC)	306264	Darter/Sculpin	O'Brien and Williams, 2002; Haag, 2012
TLH20	Medionidus simpsonianus	Mantle lure	Haag, 2012	Paul Johnson (AABC)	306265	Darter/Sculpin	Haag, 2012

TH_17	Medionidus walkeri	Mantle lure	Haag, 2012	Paul Johnson (AABC)	306266	Darter/Sculpin	Johnson et al., 2016; Haag, 2012
TLH18	Obovaria choctawensis	Mantle lure	Haag, 2012	UF	441237	Darter/Sculpin	Haag, 2012
TH146	Obovaria subrotunda	Mantle lure	Haag, 2012	UF	438391	Darter/Sculpin	Haag, 2012
TH145	Obovaria subrotunda	Mantle lure	Haag, 2012	UF	438391	Darter/Sculpin	Haag, 2012
TH144	Potamilus ohiensis	broadcast	Zanatta and Murphy, 2007; Barnhart et al., 2008	UF	438806	Drum	Haag, 2012
TH143	Potamilus ohiensis	broadcast	Zanatta and Murphy, 2007	UF	438806	Drum	Haag, 2012
TH142	Ptychobranchus fasciolarus	complex brood lure	Barnhart et al., 2008	UF	438254	Darter/Sculpin	Haag, 2012
TH141	Ptychobranchus fasciolarus	complex brood lure	Barnhart et al., 2008	UF	438254	Darter/Sculpin	Haag, 2012
TLH42	Ptychobranchus foremanianus	complex brood lure	Barnhart et al., 2008	Paul Johnson (AABC)	306267	Darter/Sculpin	Haag, 2012
TH153	Ptychobranchus jonesi	complex brood lure	Barnhart et al., 2008	UF	441272	Darter/Sculpin	Haag, 2012
TH_89	Quadrula quadrula	Mantle lure	Barnhart et al., 2008	UF	438787	Catfish	Haag, 2012
TLH21	Sagittunio nasuta	Mantle lure and simple brood lure	Barnhart et al., 2008; Haag, 2012	UF	438285	Sunfish and Perch	Eads et al., 2015
TH147	Sagittunio subrostrata	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	441304	Sunfish	Stern and Felder, 1978
TH148	Sagittunio subrostrata	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	441304	Sunfish	Stern and Felder, 1978
TH_19	Toxolasma corvunculus	Mantle lure	Barnhart et al., 2008	UF	440843	Sunfish	Haag, 2012
TLH44	Toxolasma cylindrellus	Mantle lure	Barnhart et al., 2008; Haag et al. 2012	INHS	49319	Sunfish	Haag, 2012
TH130	Toxolasma lividum	Mantle lure	Roe, 2002; Barnhart et al., 2008	UF	438185	Sunfish	Haag, 2012
TH129	Toxolasma lividum	Mantle lure	Roe, 2002; Barnhart et al., 2008	UF	438185	Sunfish	Haag, 2012
TH128	Toxolasma texasiensis	Mantle lure	Zanatta and Murphy, 2007; Barnhart et al., 2008	UF	438567	Sunfish	Haag, 2012
TH127	Toxolasma texasiensis	Mantle lure	Zanatta and Murphy, 2007; Barnhart et al., 2008	UF	438567	Sunfish	Haag, 2012
TH119	Truncilla macrodon	broadcast	Haag et al., 2012	UF	441301	Drum	Haag, 2012
TH120	Truncilla macrodon	broadcast	Haag et al., 2012	UF	441301	Drum	Haag, 2012
TH122	Truncilla truncata	Mantle lure	Sietman et al., 2018	UF	438976	Drum	Haag, 2012
TH121	Truncilla truncata	Mantle lure	Sietman et al., 2018	UF	438976	Drum	Haag, 2012
TH_63	Venustaconcha ellipsiformis	Mantle lure and simple brood lure	Hove and Anderson, 1997; Barnhart et al., 2008	INHS	87179	Darter/Sculpin	Haag, 2012
TLH25	Venustaconcha trabalis	Mantle lure and simple brood lure	Barnhart et al., 2008	Paul Johnson (AABC)	NA	Darter/Sculpin	Haag, 2012
TH_43	Venustaconcha trabalis	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438909	Darter/Sculpin	Haag, 2012
TH124	Venustaconcha trabalis	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438909	Darter/Sculpin	Haag, 2012
TH123	Venustaconcha trabalis	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438909	Darter/Sculpin	Haag, 2012
TH_11	Villosa amygdala	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	441054	Presumed Bass	
TLH12	Villosa delumbis	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	437984	Bass	Johnson et al., 2002
TH_24	Villosa vibex	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438545	Sunfish	Haag et al., 1997
TH_13	Villosa vibex	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	438021	Sunfish	Haag et al., 1997
TLH14	Villosa villosa	Mantle lure and simple brood lure	Barnhart et al., 2008	UF	441268	Bass/Sunfish	Keller and Ruessler, 1997

Table S2: Summary of the final number of ddRAD-seq loci for each individual at the 85% and 90% clustering similarity threshold and for 25% and 46% minimum samples per loci.

Sample name	Species name	Raw Reads	85% Similarity		90% Similarity	
			25%	46%	25%	46%
Aplic	<i>Amblema plicata</i>	2900279	301	134	19	8
TH131	<i>Cyrtonaias tampicoensis</i>	858098	208	113	10	3
TH132	<i>Cyrtonaias tampicoensis</i>	1506226	366	170	22	7
TLH59	<i>Epioblasma triquetra</i>	5459944	1678	479	129	18
Edila2	<i>Eurynia dilatata</i>	1726245	203	107	9	4
Edila1	<i>Eurynia dilatata</i>	790501	96	55	5	3
TH125	<i>Glebula rotundata</i>	1070046	303	140	11	4
TH126	<i>Glebula rotundata</i>	2490529	537	216	27	8
TH_36	<i>Hamiota altilus</i>	5387472	1827	497	134	23
TH_7	<i>Hamiota australus</i>	3109960	1494	459	115	19
TH_37	<i>Hamiota perovalis</i>	5270101	1826	513	144	24
TH152	<i>Hamiota subangulata</i>	668819	722	255	62	10
TLH9	<i>Lampsilis bracteata</i>	2568126	1594	476	151	19
LCFL68	<i>Lampsilis cardium</i>	7216326	2545	589	213	21
LCEE70	<i>Lampsilis cardium</i>	6965414	2562	597	215	24
LCEE71	<i>Lampsilis cardium</i>	4974228	2424	590	214	22
LCFL69	<i>Lampsilis cardium</i>	4710408	2470	573	213	23
LFre2	<i>Lampsilis fasciola</i>	1929585	2863	496	163	21
TH_2	<i>Lampsilis fasciola</i>	2188128	3296	560	165	18
TH_77	<i>Lampsilis fasciola</i>	3435913	3816	622	186	24
LFHM04	<i>Lampsilis fasciola</i>	1931502	3403	586	164	18
LFHM07	<i>Lampsilis fasciola</i>	1561315	3216	562	156	17
TLH4	<i>Lampsilis floridensis</i>	3303826	1595	473	107	22
TH_45	<i>Lampsilis higginsii</i>	1009895	512	173	66	12
TH_87	<i>Lampsilis hydiana</i>	2000552	1743	480	175	18
TH_88	<i>Lampsilis hydiana</i>	2183348	1945	519	175	21
TH_5	<i>Lampsilis ornata</i>	4893511	2177	514	161	21
TH_96	<i>Lampsilis ovata</i>	3235994	2320	575	206	23
TH_94	<i>Lampsilis ovata</i>	1807208	1935	526	177	17
TH_95	<i>Lampsilis ovata*</i>	3933699	3232	604	184	23
TH117	<i>Lampsilis radiata</i>	800488	1262	426	120	16
TH_8	<i>Lampsilis satruna</i>	4904722	2328	570	208	23
TLH51	<i>Lampsilis siliquoidea</i>	2111249	1786	498	166	19
TH_23	<i>Lampsilis splendida</i>	1149372	1237	390	129	18
TLH6	<i>Lampsilis straminea</i>	4914716	2123	531	195	22

TH_38	<i>Lampsilis virescens</i>	4169896	2043	527	190	23
TH_34	<i>Lemiox rimosus</i>	1911799	460	200	17	8
TH_57	<i>Leptodea fragilis</i>	3519359	484	204	32	9
TH133	<i>Leptodea ochracea</i>	287978	82	49	4	2
TLH21	<i>Sagittunio nasuta</i>	4608659	1513	452	106	20
TH_91	<i>Ligumia recta</i>	1659317	1382	412	88	15
TH147	<i>Sagittunio subrostrata</i>	1814864	998	352	100	19
TH148	<i>Sagittunio subrostrata</i>	2530822	1184	381	106	20
TH_39	<i>Medionidus acutissimus</i>	1851620	475	205	31	10
TH_40	<i>Medionidus conradicus</i>	7718202	619	226	36	10
TH_41	<i>Medionidus parvulus</i>	9957817	633	233	45	12
TLH28	<i>Medionidus parvulus</i>	6651085	604	228	35	11
TH_16	<i>Medionidus penicillatus</i>	7915534	660	242	43	11
TLH20	<i>Medionidus simposonianus</i>	4362329	583	235	35	12
TH_17	<i>Medionidus walkeri</i>	3139933	559	221	26	8
TLH18	<i>Obovaria choctawensis</i>	1470462	1052	374	98	20
TH146	<i>Obovaria subrotunda</i>	1790649	1238	399	105	18
TH145	<i>Obovaria subrotunda</i>	1672141	1157	383	102	18
TH144	<i>Potamilus ohioensis</i>	2454656	310	148	26	9
TH143	<i>Potamilus ohioensis</i>	2251207	294	142	24	9
TH142	<i>Ptychobranhus fasciolarus</i>	2517640	454	184	28	9
TH141	<i>Ptychobranhus fasciolarus</i>	2576902	494	188	29	9
TLH42	<i>Ptychobranhus foremanianus</i>	14377252	659	224	37	10
TH153	<i>Ptychobranhus jonesi</i>	1455454	355	155	21	7
TH_89	<i>Quadrula quadrula</i>	4999562	148	87	5	3
TH_19	<i>Toxolasma corvunculus</i>	2924381	275	131	15	8
TLH44	<i>Toxolasma cylindrellus</i>	11371070	361	158	27	8
TH130	<i>Toxolasma lividum</i>	817733	43	24	1	0
TH129	<i>Toxolasma lividum</i>	779097	113	65	6	4
TH128	<i>Toxolasma texasiensis</i>	1298761	139	84	6	4
TH127	<i>Toxolasma texasiensis</i>	1454598	204	117	13	5
TH119	<i>Truncilla macrodon</i>	878924	269	152	13	8
TH120	<i>Truncilla macrodon</i>	685468	109	64	10	7
TH122	<i>Truncilla truncata</i>	950716	303	158	18	9
TH121	<i>Truncilla truncata</i>	1613852	421	182	19	8
TH_63	<i>Venustaconcha ellipsiformis</i>	4434860	1702	501	141	20
TLH25	<i>Venustaconcha trabalis</i>	5295838	1825	520	169	21
TH_43	<i>Venustaconcha trabalis</i>	5121294	1829	529	173	23
TH124	<i>Venustaconcha trabalis</i>	2642641	1744	520	166	22
TH123	<i>Venustaconcha trabalis</i>	1660491	1469	495	137	19

TH_11	Villosa amygdala	2021257	1133	377	93	19
TLH12	Villosa delumbis	4433617	1544	447	106	22
TH_32	Cambarunio taeniata	1472633	1004	328	68	16
TH_22	Leaunio umbrans	5607023	1738	492	126	20
TLH26	Leaunio vanuxemensis	1120139	504	188	31	8
TH_24	Villosa vibex	1272879	941	322	74	14
TH_13	Villosa vibex	2427081	1424	454	102	21
TLH14	Villosa villosa	2756754	1340	427	103	22

Table S3: Displays the AIC, AICc, and log likelihood values for a set of state dependent speciation models performed independently for three different traits: Mantle lure, Brood lure, and broadcast strategy. The four models performed for each trait include a BiSSE model (2 state trait dependent), a HiSSE model (4 state model with two trait states and two hidden states), a 2-state trait independent null model, and a 4 state trait independent null model. Analysis Performed with the topology recovered using 85% clustering threshold and 46% minimum samples per locus.

Model Name	Mantle Lure			Brood Lure			Broadcast Strategy		
	AIC	AICc	Log Likelihood	AIC	AICc	Log Likelihood	AIC	AICc	Log Likelihood
	544.1								
2-state CID	7	545.4	-267.0859	527.25	528.47	-258.8246	518.18	519.43	-254.0909
	549.3	550.5							
BiSSE	3	5	-269.6641	525.25	526.47	-257.6246	516.72	517.98	-253.3635
	549.2	553.2							
4-state CID	8	8	-265.6379	530.2	534.2	-256.0995	517.84	521.93	-249.9179
	550.1	554.1							
HiSSE	2	2	-266.058	532.16	536.16	-257.0816	516.94	521.03	-249.469

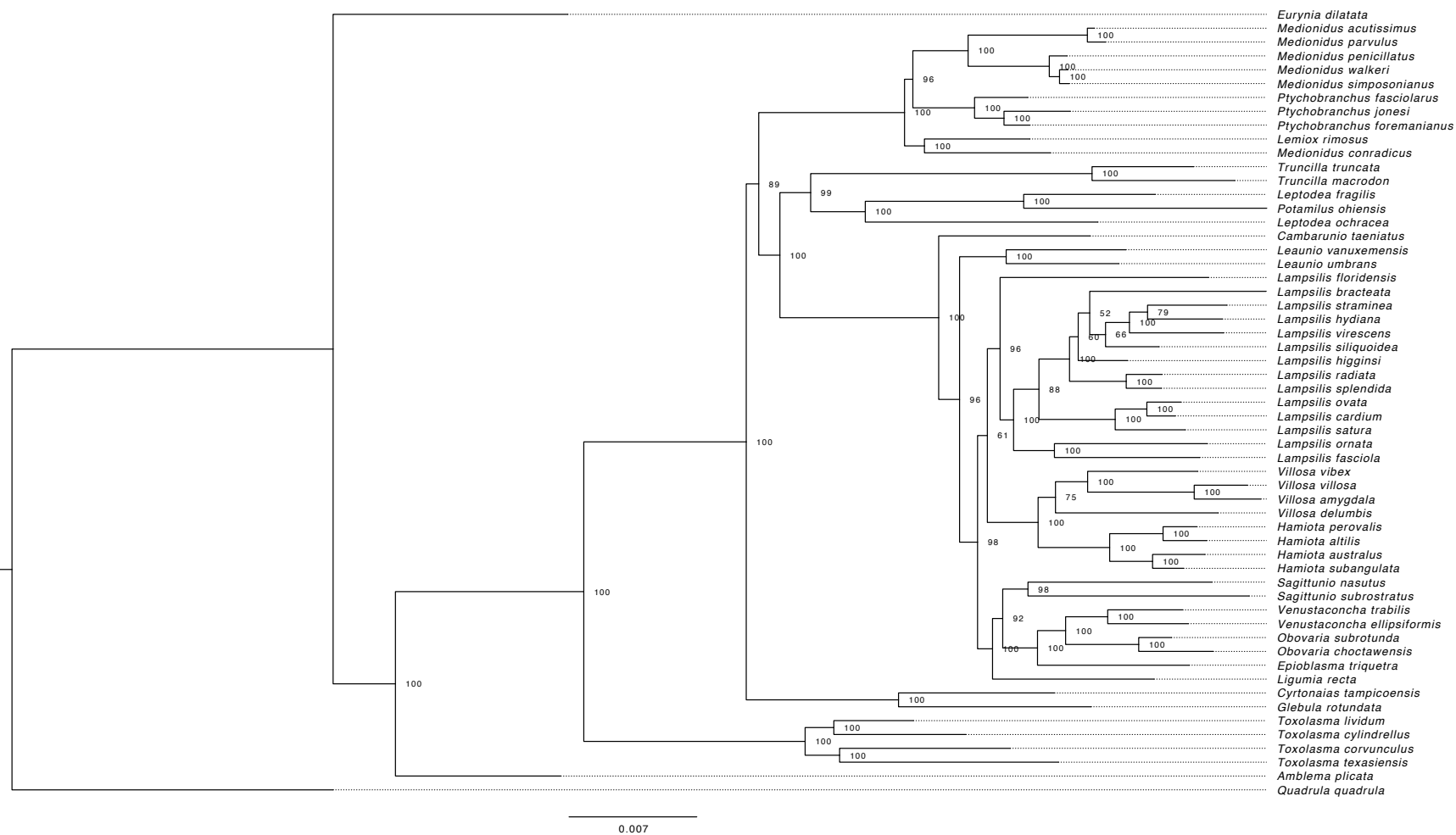


Figure S1: Maximum likelihood phylogeny of North American lamsiline mussels created with RAxML v8.2.8 using a general time reversible model from the 85% clustering threshold with 46% minimum samples per locus dataset. Support for each node was determined using 100 fast parametric bootstrap replications. Bootstrap values are adjacent to each node. Scale bar represents mean number of base pair substitutions per site.

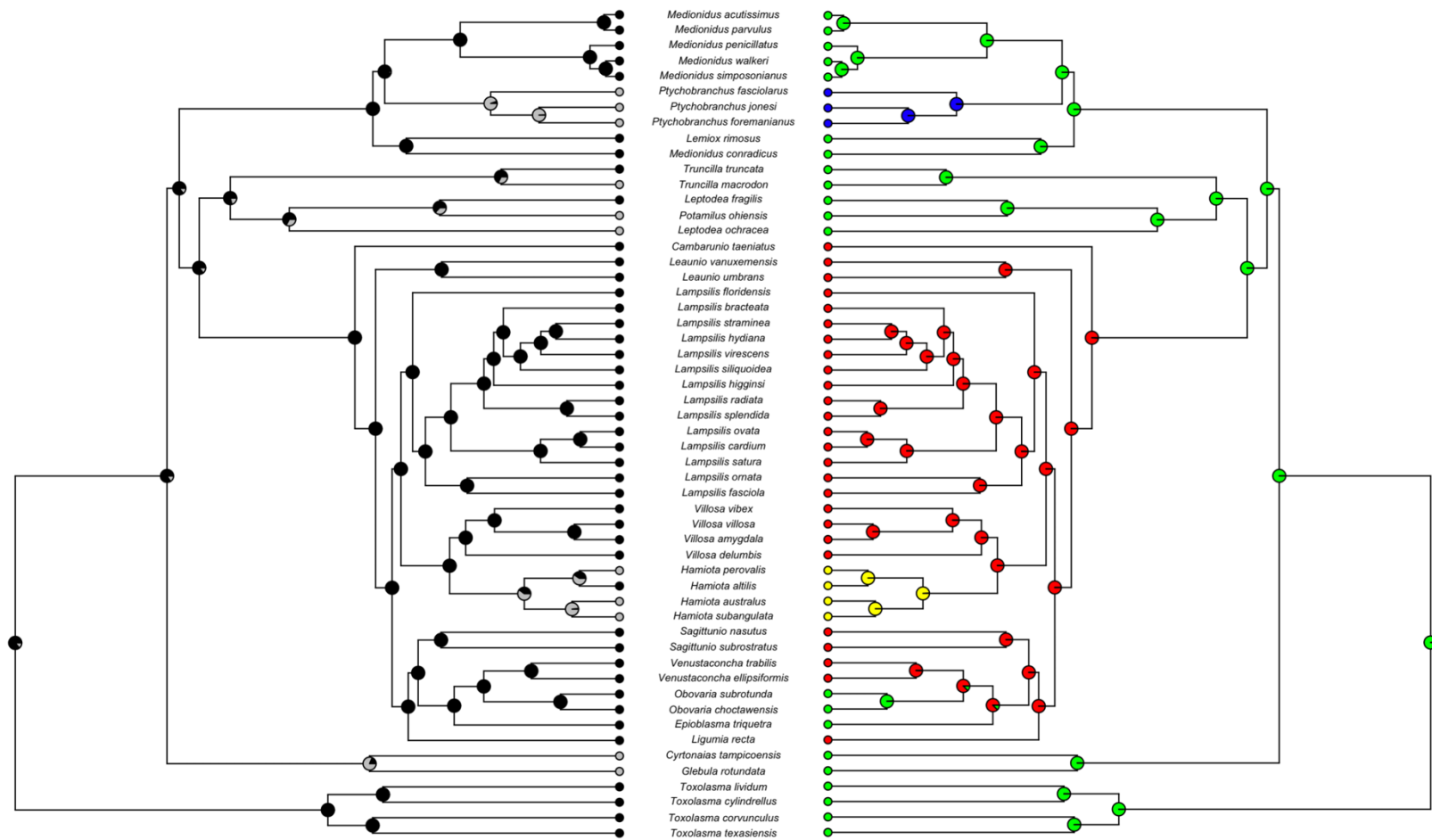


Figure S2: Ultrametric phylogenies created from maximum likelihood phylogeny of Lampsiline mussels (Fig. S1; 85%-46%) using TreePL. These trees were trimmed to remove outgroups and retain only a single individual per species. A) Ancestral state reconstruction of mantle lures using a symmetrical rates model: Grey = presence of a mantle lure (fig. 2d), Black = no mantle lure. B) Ancestral state reconstruction of brood lures using a symmetrical rates model: Blue = complex brood lure (fig. 2f), Red = simple brood lure (fig. 2e), Yellow = tethered brood lure (fig. 2h), Green = no brood lure.

Supplementary data literature cited

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