

Niche divergence and diversification in South American freshwater turtles of the genus *Acanthochelys* (Chelidae)

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Abstract. Species distribution models (SDMs) are increasingly used to assess how ecological factors shape species distributions and diversification. Chelid turtles represent the richest family of chelonians in South America. Given the distributional disjunction and distinct habitats of four *Acanthochelys* species, we explored SDMs and niche overlap metrics between species pairs to evaluate the extent to which niche divergence or conservatism may have contributed to their geographic distribution patterns. None of the species pairs presented patterns consistent with niche conservatism suggesting that these species have different environmental requirements. However, when comparing species pairs co-occurring in the same watershed, results were conflicting. Niche divergence detected among *Acanthochelys* species indicate an interaction between ecological niche preference and geographical barriers for allopatric speciation. This interaction implies that ecological differentiation contributed to the diversification of *Acanthochelys* side-necked turtles that occur in South American freshwater environments.

Keywords: biogeography, chelonian, climatic niche, Neotropical, species distribution model.

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Supplementary material

Supplementary table S1. Records of South American *Acanthochelys* species (Chelidae) used to create the species distribution models (SDMs).

Species	Latitude	Longitude	Source
<i>Acanthochelys macrocephala</i>	-19.0454	-57.1440	Molina, 2009
<i>Acanthochelys macrocephala</i>	-19.4263	-56.6055	Molina, 2009
<i>Acanthochelys macrocephala</i>	-19.8328	-56.2667	Molina, 2009
<i>Acanthochelys macrocephala</i>	-21.6866	-57.7186	Souza et al., 2010
<i>Acanthochelys macrocephala</i>	-16.5759	-57.7319	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-17.3381	-56.7994	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-18.9541	-56.6245	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-19.5708	-56.2412	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-20.5876	-59.8548	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-20.9376	-59.8214	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-21.5876	-59.8881	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-22.2435	-57.9139	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-22.3471	-60.0487	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-22.5010	-59.7417	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-22.5376	-59.6714	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-22.5759	-59.3610	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-22.8401	-59.5567	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-23.1106	-59.8222	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-23.1867	-59.5923	Rhodin et al., 2009
<i>Acanthochelys macrocephala</i>	-16.5000	-56.7400	GBIF
<i>Acanthochelys macrocephala</i>	-16.2600	-56.6200	GBIF

<i>Acanthochelys pallidipectoris</i>	-26.8075	-60.4333	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-24.8667	-60.3440	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-29.8870	-60.2885	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-25.9833	-60.6333	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-27.4571	-59.2456	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-25.1031	-64.1179	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-29.5097	-60.1427	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-27.3362	-60.0229	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-24.5833	-63.1833	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-26.8980	-58.3641	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-24.2524	-62.6830	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-29.4207	-60.3535	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-26.8672	-58.3004	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-30.0000	-60.7500	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-26.9667	-58.5833	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-26.2500	-58.8333	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-21.6567	-62.4692	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.0723	-60.6124	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.6019	-59.8406	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.4086	-60.7206	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.3736	-60.6629	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.7514	-60.5474	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.9043	-59.4706	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.3511	-60.3206	Vinke et al., 2011

<i>Acanthochelys pallidipectoris</i>	-25.0726	-62.0333	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-26.2500	-60.2500	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-26.0276	-64.1372	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.3895	-60.6316	Vinke et al., 2011
<i>Acanthochelys pallidipectoris</i>	-22.4700	-60.3600	GBIF
<i>Acanthochelys pallidipectoris</i>	-28.5400	-60.3800	GBIF
<i>Acanthochelys pallidipectoris</i>	-27.4600	-58.9800	GBIF
<i>Acanthochelys pallidipectoris</i>	-29.3600	-60.2000	GBIF
<i>Acanthochelys radiolata</i>	-9.7900	-36.1040	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-9.2700	-35.4620	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-12.6810	-38.7430	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.1880	-39.7230	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-20.6360	-40.7500	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-17.9940	-39.6140	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.5740	-39.7960	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-20.6330	-40.4260	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9180	-42.2700	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.7740	-41.9090	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.7460	-41.8800	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-12.7420	-38.6170	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-15.2460	-40.2450	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-16.4200	-39.1020	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-20.3800	-40.3120	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.8330	-40.3690	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.8860	-42.0280	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.8240	-40.6680	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.4060	-39.9070	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-18.4080	-39.8240	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.1040	-40.0070	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-20.5870	-40.4100	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.9200	-40.6260	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.8120	-40.7110	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-16.5800	-39.1230	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.3110	-40.0180	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-20.3030	-40.3350	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.4490	-40.1700	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-18.0480	-39.5840	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-16.5020	-39.2620	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.9310	-40.5940	Garbin et al., 2016

<i>Acanthochelys radiolata</i>	-19.4940	-40.2880	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.9550	-40.5740	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-15.8640	-38.9050	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.1700	-39.8510	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.9550	-40.6210	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-19.9720	-40.6000	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-21.6630	-41.1000	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-21.6870	-41.0360	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-21.1030	-42.4040	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-21.7140	-41.0380	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9770	-43.4460	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.8900	-43.0610	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.2910	-41.7300	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.7290	-42.8730	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.4140	-41.7050	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9680	-43.2250	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9290	-43.2240	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9500	-42.0660	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.2870	-41.7420	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-23.0240	-43.4710	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9500	-42.8570	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-23.0000	-43.4850	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9100	-43.0860	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9400	-43.4500	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-12.0420	-53.6610	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-22.9820	-43.4170	Garbin et al., 2016
<i>Acanthochelys radiolata</i>	-20.6700	-40.5000	GBIF
<i>Acanthochelys radiolata</i>	-19.3900	-40.0700	GBIF
<i>Acanthochelys spixii</i>	-17.6000	-45.0000	Bager et al., 2016
<i>Acanthochelys spixii</i>	-32.5475	-52.5444	Bager et al., 2016
<i>Acanthochelys spixii</i>	-31.7294	-52.3642	Bager et al., 2016
<i>Acanthochelys spixii</i>	-33.2392	-53.1367	Bager et al., 2016
<i>Acanthochelys spixii</i>	-32.1000	-52.1667	Bager et al., 2016
<i>Acanthochelys spixii</i>	-27.5000	-58.8000	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-14.3333	-43.7500	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-19.6500	-43.7333	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-19.4833	-44.2500	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-24.5167	-49.9500	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-33.7500	-53.4000	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-29.9500	-50.9833	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-33.0000	-53.0000	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-30.0500	-51.1667	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-27.4167	-51.9167	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-31.3500	-52.0000	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-32.5000	-52.5833	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-30.0833	-52.0167	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-23.5500	-47.2333	Rhodin et al., 1984

<i>Acanthochelys spixii</i>	-23.6667	-46.5833	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-23.5500	-46.6500	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-23.5000	-47.4667	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-22.3333	-46.9167	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-34.3333	-53.8333	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-34.0833	-53.6667	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-34.0000	-53.5833	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-32.8333	-56.5000	Rhodin et al., 1984
<i>Acanthochelys spixii</i>	-31.6200	-56.2300	Iverson, 1992
<i>Acanthochelys spixii</i>	-25.4667	-49.0500	D'amato and Morato, 1991
<i>Acanthochelys spixii</i>	-25.4500	-49.1500	D'amato and Morato, 1991
<i>Acanthochelys spixii</i>	-25.5000	-49.2000	D'amato and Morato, 1991
<i>Acanthochelys spixii</i>	-25.5500	-49.3333	D'amato and Morato, 1991
<i>Acanthochelys spixii</i>	-25.2333	-50.0167	D'amato and Morato, 1991
<i>Acanthochelys spixii</i>	-24.7500	-50.0000	D'amato and Morato, 1991
<i>Acanthochelys spixii</i>	-24.1667	-49.7833	D'amato and Morato, 1991
<i>Acanthochelys spixii</i>	-25.4167	-51.4667	D'amato and Morato, 1991
<i>Acanthochelys spixii</i>	-30.3833	-51.0000	Filho and Verrastro, 2012
<i>Acanthochelys spixii</i>	-15.6880	-47.9409	Fraxe-Neto et al., 2011
<i>Acanthochelys spixii</i>	-15.6667	-48.0000	Brandão et al., 2002
<i>Acanthochelys spixii</i>	-15.5833	-47.3333	Brandão et al., 2002
<i>Acanthochelys spixii</i>	-28.2794	-58.6928	Waller et al., 2000
<i>Acanthochelys spixii</i>	-25.5933	-49.4075	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-24.9667	-53.4333	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-25.2833	-49.2500	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-25.4300	-49.2708	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-25.3906	-51.4553	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-25.4172	-49.9992	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-25.2500	-50.0833	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-25.4333	-49.1833	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-25.4950	-49.0581	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-25.8533	-52.0094	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-24.3250	-50.6167	Ribas and Monteiro-Filho, 2002
<i>Acanthochelys spixii</i>	-31.1158	-55.4236	Carreira et al., 2005
<i>Acanthochelys spixii</i>	-31.7103	-55.7936	Carreira et al., 2005
<i>Acanthochelys spixii</i>	-31.6844	-56.0256	Carreira et al., 2005
<i>Acanthochelys spixii</i>	-29.8029	-58.7366	Cabrera, 1998

<i>Acanthochelys spixii</i>	-28.5575	-59.0567	Cabrera, 1998
<i>Acanthochelys spixii</i>	-27.5740	-58.8113	Cabrera, 1998
<i>Acanthochelys spixii</i>	-31.7935	-52.4080	Mascarenhas et al., 2016
<i>Acanthochelys spixii</i>	-32.0667	-52.1667	Assmann et al., 2013
<i>Acanthochelys spixii</i>	-28.3922	-48.7494	Ghizoni Jr. et al., 2009
<i>Acanthochelys spixii</i>	-28.5167	-48.7667	Ghizoni Jr. et al., 2009
<i>Acanthochelys spixii</i>	-26.8844	-51.6217	Ghizoni Jr. et al., 2009
<i>Acanthochelys spixii</i>	-27.3808	-50.6219	Ghizoni Jr. et al., 2009
<i>Acanthochelys spixii</i>	-27.2011	-50.6917	Ghizoni Jr. et al., 2009
<i>Acanthochelys spixii</i>	-32.8333	-52.4333	Gomes and Krause, 1982
<i>Acanthochelys spixii</i>	-21.7500	-48.1333	Monteiro-Filho et al., 1994
<i>Acanthochelys spixii</i>	-12.5698	-41.3790	RAN, 2016
<i>Acanthochelys spixii</i>	-30.0158	-59.5363	RAN, 2016
<i>Acanthochelys spixii</i>	-20.2472	-46.3772	RAN, 2016
<i>Acanthochelys spixii</i>	-30.2608	-50.2388	RAN, 2016
<i>Acanthochelys spixii</i>	-30.8565	-51.8142	RAN, 2016
<i>Acanthochelys spixii</i>	-29.6425	-49.9582	RAN, 2016
<i>Acanthochelys spixii</i>	-32.0196	-52.1532	RAN, 2016
<i>Acanthochelys spixii</i>	-29.3424	-49.7319	RAN, 2016
<i>Acanthochelys spixii</i>	-29.8869	-50.2535	RAN, 2016
<i>Acanthochelys spixii</i>	-31.7461	-52.4067	RAN, 2016
<i>Acanthochelys spixii</i>	-17.8792	-43.8342	RAN, 2016
<i>Acanthochelys spixii</i>	-36.1161	-57.9709	RAN, 2016
<i>Acanthochelys spixii</i>	-31.1100	-50.9200	RAN, 2016
<i>Acanthochelys spixii</i>	-32.5336	-52.5556	RAN, 2016
<i>Acanthochelys spixii</i>	-32.1844	-52.1658	RAN, 2016
<i>Acanthochelys spixii</i>	-32.1703	-52.1814	RAN, 2016
<i>Acanthochelys spixii</i>	-30.0311	-51.2519	RAN, 2016
<i>Acanthochelys spixii</i>	-30.5488	-53.6199	RAN, 2016
<i>Acanthochelys spixii</i>	-20.3417	-46.7535	RAN, 2016
<i>Acanthochelys spixii</i>	-20.3453	-46.7502	RAN, 2016
<i>Acanthochelys spixii</i>	-19.1232	-43.6722	RAN, 2016
<i>Acanthochelys spixii</i>	-19.1410	-43.6717	RAN, 2016
<i>Acanthochelys spixii</i>	-30.1100	-51.2200	RAN, 2016
<i>Acanthochelys spixii</i>	-21.2800	-44.6600	RAN, 2016
<i>Acanthochelys spixii</i>	-21.0000	-44.3100	RAN, 2016
<i>Acanthochelys spixii</i>	-29.7500	-50.0100	RAN, 2016
<i>Acanthochelys spixii</i>	-24.8833	-53.9021	GBIF
<i>Acanthochelys spixii</i>	-31.2333	-51.0000	GBIF
<i>Acanthochelys spixii</i>	-34.6667	-55.7946	GBIF
<i>Acanthochelys spixii</i>	-27.7833	-59.3640	GBIF

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