

The first 80 million years of snake evolution: the Mesozoic fossil record of snakes and its implications for origin hypotheses, biogeography, and mass extinction

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Supplementary Table 3.S1 Published latest Albian–Turonian snake records. “Serpentes indet.” indicates either systematic ambiguity or undescribed records.

Taxon	Systematic Hypothesis	Formation and Location	Stage	References
(?) Lapparentophiidae indet.	cf. <i>Lapparentophis</i> sp.	El Kohol, Algeria	Upper Albian	[64]
Serpentes indet.	cf. <i>Lapparentophis</i> sp.	El Kohol, Algeria	Upper Albian	[64]
<i>Lapparentophis defrennei</i>	Stem snake	Continental intercalaire, In Akhamil, Algeria	Upper Albian to lower Cenomanian	[74]
<i>Coniophis</i> sp.	Stem snake indeterminate, two taxa	Cedar Mountain Formation, Utah, USA	Upper Albian to lower Cenomanian	[65]
<i>Coniophis</i> sp.	Stem snake indeterminate	Dakota Formation, Kane County, Utah	Cenomanian	[83]
<i>Xiaophis myanmarensis</i>	Stem snake	Angbamo site, Kachin Province, Myanmar	Lower Cenomanian	[67]
<i>Seismophis septentrionalis</i>	Stem snake	Alcântara Formation, Brazil	Lower Cenomanian	[68]
<i>Norisophis begaa</i>	Stem snake	Kem Beds, South Eastern Morocco	Cenomanian	[75]
<i>Pouitella pervetus</i>	Stem snake	Brézé, France	Lower to middle Cenomanian	[70]

<i>Najash rionegrina</i>	Stem snake	Candeleros Formation, Argentina	Cenomanian	[8, 11]
Madtsoiidae indet.	Stem snake indeterminate	Kem Beds, Aoufous Formation, Morocco	Early Cenomanian	[77]
Serpentes indet.		Kem Beds, Aoufous Formation, Morocco	Lower Cenomanian	[77]
<i>Lunaophis aquaticus</i>	Stem snake	La Luna Formation, La Aguada Member, Trujillo State, Venezuela	Cenomanian	[69]
Serpentes indet.		Sables de Varennes, France	Middle Cenomanian	[169]
Serpentes indet.		Pays de la Loire, France	Lower to middle Cenomanian	[170]
?Nigerophiidae indet.		Kem Kem Beds, Aoufous Formation, Morocco	Lower Cenomanian	[77]
<i>Simoliophis cf. S. libycus</i>	Simoliophiidae	Kem Kem Beds, Aoufous Formation, Morocco	Lower Cenomanian	[77]
<i>Simoliophis libycus</i>	Simoliophiidae	Draa Ubairi, Libya	Cenomanian [123]	[79]
<i>Simoliophis rochebrunei</i>	Simoliophiidae	Cadeuil quarry, Saint-Nadeau quarry, Font-de-Benon quarry, Aix Island cliff, Les Renardières quarry, Fouras-Vauban cliff, Fouras-Bois Vert tidal flat, Montagan road works, La Buzinie road works, Traslemaine road works, France	Lower Cenomanian	[71–73, 171]
<i>Simoliophis rochebrunei</i>	Simoliophiidae	Central west and southwest of France, Portugal	Cenomanian	[71, 172]
<i>Haasiophis terrasanctus</i>	Simoliophiidae	Bed-Meir Formation, Palestinian territory	Lower to middle Cenomanian	[7]
<i>Pachyrhachis problematicus</i>	Simoliophiidae	Bed-Meir Formation, Palestinian territory	Lower Cenomanian	[6, 59, 80]
<i>Eupodophis descouensi</i>	Simoliophiidae	Al Nammoura, Lebanon	Middle Cenomanian	[25, 60]
<i>Pachyophis woodwardi</i>	Simoliophiidae	Selista quarry, Bilek, East Herzegovina	Upper Cenomanian	[5, 81]

<i>Mesophis nopcsai</i>	Simoliophiidae	Selista quarry, Bilek, East Herzegovina	Upper Cenomanian	[82]
Pachyophiidae indet.	Simoliophiidae	Dubovac Quarry, Bileca, Bosnia & Herzegovina	Lower Turonian	[84]
<i>Madtsoia</i> aff. <i>madagascariensis</i>	<i>Madtsoia</i> sp. [87]	In Beceten Formation, Tahoua, Niger	Upper Coniacian-Santonian	[86]
Serpentes indet.		In Beceten Formation, Tahoua, Niger	Upper Coniacian-Santonian	[85]
<i>Coniophis</i> sp.	Stem snake indeterminate	John Henry Member, Straight Cliffs Formation, Garfield County, Utah	Santonian	[83]
<i>Dinilysia</i> <i>patagonica</i>	Stem snake	Red sandstone deposits Neuquén province; Rio Colorado Formation; Rio Negro Province. Argentina	Santonian	[90–92, 173, 174]
<i>Dinilysia</i> sp.	Stem snake	Anacleto Formation, Neuquén province, Argentina	Lower Campanian	[93, 175]

Supplementary Table 3.S2 Published Campanian–Maastrichtian snake records. “Serpentes indet.” indicates either systematic ambiguity or undescribed records.

Taxon	Systematic Hypothesis	Formation and Location	Stage	Reference
Lapparentophiidae indet. A, B	Stem snakes	Wadi Milk Formation, Sudan	Campanian	[96]
aff. <i>Coniophis</i>	Stem snakes	Aguja Formation, Texas, USA	Lower Campanian	[97]
<i>Coniophis dabiebus</i>	Stem snakes?	Wadi Milk Formation, Sudan	Campanian	[96]
<i>Coniophis</i> cf. <i>C. dabiebus</i>	Stem snakes?	Wadi Milk Formation, Sudan	Campanian	[96]
<i>Coniophis</i> cf. <i>C. precedens</i>	Serpentes indet.	Upper Milk River Formation, Alberta, Canada	Lower Campanian	[176]
<i>Coniophis cosgriffi</i>	Serpentes indet.	Fruitland Formation, New Mexico, USA; Bug Creek anthills, Hell Creek Formation, Montana, USA	Upper Campanian; Maastrichtian	[177, 178]
<i>Coniophis</i> sp.	Stem snakes, Alethinophidia (multiple taxa)	Kaiparowits Formation, Garfield County, Utah	Lower Campanian	[83]
<i>Coniophis</i> sp.	Stem snake	Wahweap Formation, Utah, USA	Lower Campanian- middle Campanian	[83]
<i>Coniophis</i> sp.	Serpentes indet.	Cerro del Pueblo Formation, Coahuila, Mexico	Lower Campanian	[179]
<i>Coniophis precedens</i>	Stem snake	Hell Creek Formation, Montana; Lance Formation, Wyoming; Laramie Formation, Wyoming, USA	Maastrichtian	[94, 95, 177]
Alethinophidia indet.	<i>Coniophis precedens</i>	Lance Formation, Wyoming, USA	Maastrichtian	[109]
<i>Coniophis</i> sp.	Serpentes indet.	Deccan intertrappean beds, Naskal, India	Maastrichtian	[180]

<i>Coniophis</i> sp.	Serpentes indet.	Frenchman Formation, Saskatchewan, Canada	Upper Maastrichtian	[181]
<i>Sanajeh indicus</i>	Stem Snake	Lameta Formation, India	Maastrichtian	[26]
<i>Boipeba tayasuensis</i>	Scolecophidia	Adamantina Formation, Brazil	Campanian-Maastrichtian,	[104]
<i>Menarana laurasiae</i>	Madtsoiidae	Vitoria Formation, Spain	Upper Campanian	[182]
<i>Alamitophis argentinus</i>	Madtsoiidae	Los Alamos Formation, Rio Negro, Argentina; La Colonia Formation, Argentina; Bajo de Santa Rosa Locality, Allen Formation, Argentina	Campanian-Maastrichtian	[183–185]
<i>Alamitophis elongatus</i>	Madtsoiidae	Los Alamos Formation, Rio Negro, Argentina	Campanian-Maastrichtian	[186]
<i>Eomadtsoia ragei</i>	Madtsoiidae	La Colonia Formation, Patagonia, Argentina	Campanian-Maastrichtian	[126]
<i>Herensugea caristiorum</i>	Madtsoiidae	Laño, Basque County, Spain; Laño section, Vitoria Formation, Burgos County, Spain	Upper Campanian-Maastrichtian	[182, 187]
<i>Madtsoia laurasiae</i>	Madtsoiidae	Laño Site, Iberian Peninsula, Basque-Cantabrian Region, Spain; Laño, Basque County, Spain	Upper Campanian-lower Maastrichtian	[187–188]
<i>Patagoniophis parvus</i>	Madtsoiidae	Los Alamos Formation; Allen Formation, Argentina	Campanian-Maastrichtian	[183–185]
<i>Rionegrophis madtsoioides</i>	Madtsoiidae	Los Alamos Formation, Argentina	Campanian- Maastrichtian	[183]
cf. <i>Rionegrophis madtsoioides</i>	Madtsoiidae	Chorillo Formation, Santa Cruz Province, Argentina	Campanian-Maastrichtian	[189]
<i>Adinophis fisaka</i>	Madtsoiidae	Maevarano Formation, Madagascar	Maastrichtian	[100]
<i>Madtsoia madagascariensis</i>	Madtsoiidae	Maevarano Formation, Madagascar	Maastrichtian	[87, 190–192]
<i>Menarana nosymena</i>	Madtsoiidae	Maevarano Formation, Madagascar	Maastrichtian	[87]

<i>Madtsoia pisdurensis</i>	Madtsoiidae	Lameta Formation, Maharashtra State, India	Maastrichtian	[125]
<i>Nidophis insularis</i>	Madtsoiidae	Densuş-Ciula Formation, Romania	Maastrichtian	[135]
Madtsoiidae indet.	Madtsoiidae	Languedoc-Roussillon, France	Campanian	[193]
Madtsoiidae indet.	Madtsoiidae	Wadi Milk Formation, Sudan	Campanian	[96, 119]
Madtsoiidae indet.	Madtsoiidae	Allen Formation, Argentina	Upper Campanian-lower Maastrichtian	[185]
Madtsoiidae indet.	Madtsoiidae	Deccan intertrappean beds, Kelapur, India	Maastrichtian	[180]
Madtsoiidae indet.	Madtsoiidae	Maevarano Formation, Madagascar	Maastrichtian	[87]
Madtsoiidae indet.	?Madtsoiidae	El Mollino Formation, Bolivia	Middle Maastrichtian	[194]
Madtsoiidae indet.	Madtsoiidae	Sânpetru Formation, Romania	Upper Maastrichtian	[195]
?Madtsoiidae indet.	?Madtsoiidae	Allen Formation, Argentina	Upper Campanian-lower Maastrichtian	[185]
?Madtsoiidae indet.	?Madtsoiidae	La Colonia Formation, Argentina	Campanian-Maastrichtian	[184]
<i>Nubianophis afaahus</i>	Nigerophiidae	Wadi Milk Formation, Sudan	Campanian	[96]
<i>Nubianophis</i> cf. <i>N. afaahus</i>	Nigerophiidae	Wadi Milk Formation, Sudan	Campanian	[96]
<i>Indophis fanambinana</i>	Nigerophiidae	Maevarano Formation, Madagascar	Maastrichtian	[100]
<i>Indophis sahnii</i>	Nigerophiidae	Naskal, India; Deccan intertrappean beds, Anjar and Kelapur, India	Maastrichtian	[180, 196]
<i>Indophis</i> sp.	Nigerophiidae	Maevarano Formation, Madagascar	Maastrichtian	[197]
<i>Kelyophis hechti</i>	Nigerophiidae	Maevarano Formation, Madagascar	Maastrichtian	[87, 197]
<i>Palaeophis</i> sp.	Palaeophiidae	Phosphates between Khouribga and Beni Mellal, Morocco	Maastrichtian	[99]
<i>Australophis anilioides</i>	Aniliidae	Bajo Trapalcó, Rio Negro Province, Argentina	Upper Campanian-lower Maastrichtian	[105]
<i>Krebsophis thobanus</i>	Russellophiidae	Wadi Milk Formation, Sudan	Campanian	[96]
Colubroidea indet.	Colubroidea	Wadi Milk Formation, Sudan	Campanian	[96]

Alethinophidia indet.	?Alethinophidia	Blasi 2 site, Huesca, Spain	Upper Maastrichtian	[198]
Aniliidae indet.	Serpentes indet.	Upper Milk River Formation, Alberta, Canada	Lower Campanian	[176]
Aniliidae indet.	Serpentes indet.	Laño, Basque County, Spain; Laño section, Vitoria Formation, Burgos County, Spain	Upper Campanian-Maastrichtian	[199]
Boidae indet.	Serpentes indet.	Loncoche Formation	Upper Campanian-lower Maastrichtian	[200]
Boidae indet.	Serpentes indet.	Takli Formation, Maharashtra, India	Maastrichtian	[201]
Boidae indet.	Serpentes indet.	Languedoc-Roussillon, France	Campanian	[193]
Boidae indet.	Serpentes indet.	Maevarano Formation, Madagascar	Maastrichtian	[202]
Boidae/Madtsoiidae indet.	Serpentes indet.	La Colonia Formation, Argentina	Campanian-Maastrichtian	[184]
Booidea indet.	Serpentes indet.	Lameta Formation, Maharashtra, India	Maastrichtian	[203]
<i>Cerberophis rex</i>	Serpentes indet.	Hell Creek Formation, Montana, USA	Maastrichtian	[109]
Serpentes indet.		La Colonia Formation, Patagonia	Campanian-Maastrichtian	[184]
Serpentes indet.		Adamantina Formation, Brazil	Upper Campanian-lower Maastrichtian	[204]
Serpentes indet.		Lance Formation, Wyoming, USA	Maastrichtian	[205]
Serpentes indet.		Maevarano Formation, Madagascar	Maastrichtian	[87]
Serpentes indet.		Aguja Formation, Texas, USA	Campanian	[206]
Serpentes indet.		Chorillo Formation, Argentina	Campanian-Maastrichtian	[189]
Serpentes indet.		Kaiparowits Formation, Utah, USA	Upper Campanian	[83]
Serpentes indet.		Maevarano Formation, Madagascar	Maastrichtian	[100]
Serpentes indet.		Wadi Milk Formation Sudan	Campanian	[96, 119]
Serpentes indet.		Deccan intertrappean beds, Naskal, India	Maastrichtian	[180]
Serpentes indet.		Maevarano Formation, Madagascar	Maastrichtian	[197]

Serpentes indet.	Aguja Formation, Texas, USA	Campanian	[207]
Serpentes indet.	Andhra Pradesh, India	Maastrichtian	[208]
Serpentes indet.	Pinto Butte, between Val Marie and Mankota, Saskatchewan, Canada	Maastrichtian	[209]

Supplementary Table 3.S3 Collections and formation data for squamates and snakes for the Cretaceous binned at age intervals. Data derived from www.paleobiodb.org on 18/12/2020 using search terms “Squamata” and “Ophidia” for all geological contexts and for environment type “terrestrial”. Data for *Pachyophis woodwardi* were added manually because that taxon is classified as a dolichosaur in the online database. “Mid Age” is the mid-point age for the corresponding Cretaceous stages. Age abbreviations represent Cretaceous ages recognized by the International Commission on Stratigraphy [168].

Age	Mid Age (Mya)	Squamate formations	Squamate collections	Snake collections	Squamate terrestrial formations	Squamate terrestrial collections	Snake terrestrial collections
Maa.	69.1	100	248	47	37	122	42
Cam.	77.9	135	382	24	53	179	18
San.	85.0	24	42	7	8	17	7
Con.	88.1	17	38	1	3	4	1
Tur.	91.9	26	50	2	2	9	1
Cen.	97.2	34	92	33	13	35	13
Alb.	106.8	14	23	1	12	17	1
Apt.	119.0	16	23	0	16	22	0
Bar.	127.2	13	23	0	11	20	0
Hau.	131.2	1	2	0	1	2	0
Val.	136.4	7	9	0	7	9	0
Ber.	142.4	6	12	0	4	7	0

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See main text for References 1–167.

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