

SUPPORTING INFORMATION

Title:

Parallel selective pressures drive convergent diversification of phenotypes in pythons and boas

Authors:

Damien Esquerré and J. Scott Keogh

Abstract:

Pythons and boas are globally distributed and distantly related radiations with remarkable phenotypic and ecological diversity. We tested whether pythons, boas and their relatives have evolved convergent phenotypes when they display similar ecology. We collected geometric morphometric data on head shape for 1,073 specimens representing over 80% of species. We show that these two groups display strong and widespread convergence when they occupy equivalent ecological niches and that the history of phenotypic evolution strongly matches the history of ecological diversification, suggesting that both processes are strongly coupled. These results are consistent with replicated adaptive radiation in both groups. We argue that strong selective pressures related to habitat-use have driven this convergence. Pythons and boas provide a new model system for the study of macro-evolutionary patterns of morphological and ecological evolution and they do so at a deeper level of divergence and global scale than any well-established adaptive radiation model systems.

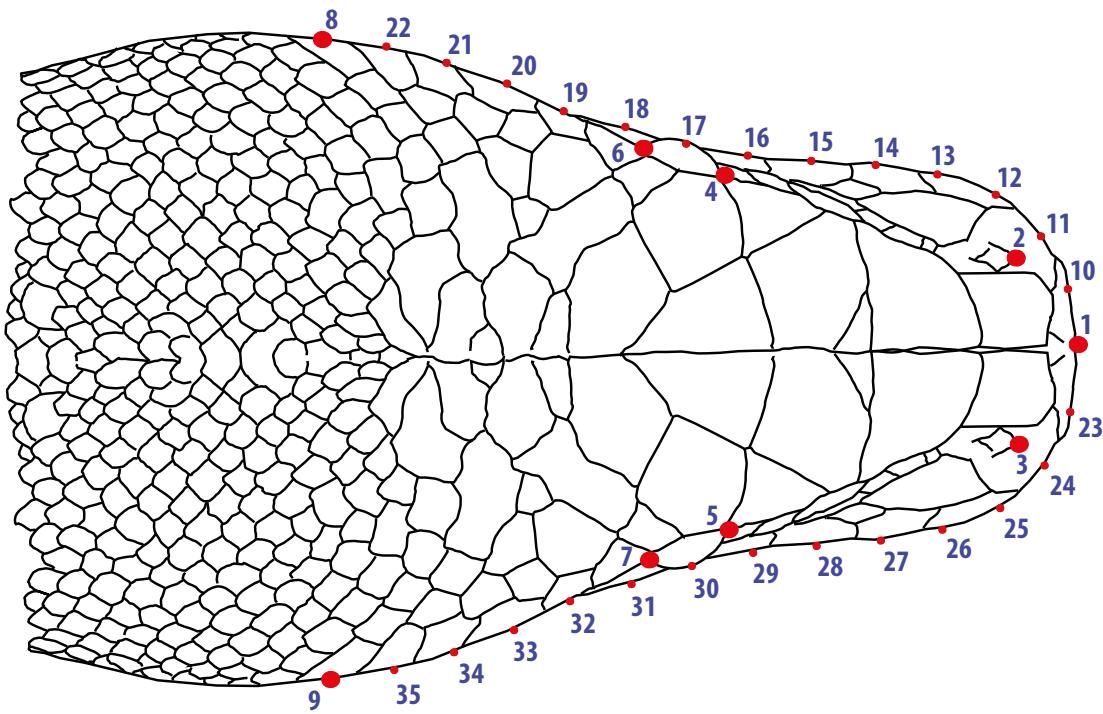


Fig. S1. Landmark configuration used to describe dorsal head shape in pythons and boas. Description of numbered landmarks (big red dots) and semi-landmarks (small red dots) is as follows: 1, tip of the snout; 2-3 anterior most points of the nostrils; 4-5, anterior most points of the eyes; 6-7, posterior most points of the eyes; 8-9, corners of the mouth; 10-22 and 23-35, semi-landmark curves describing the outline of the head going from the tip of the snout to the corner of the mouth for each side.

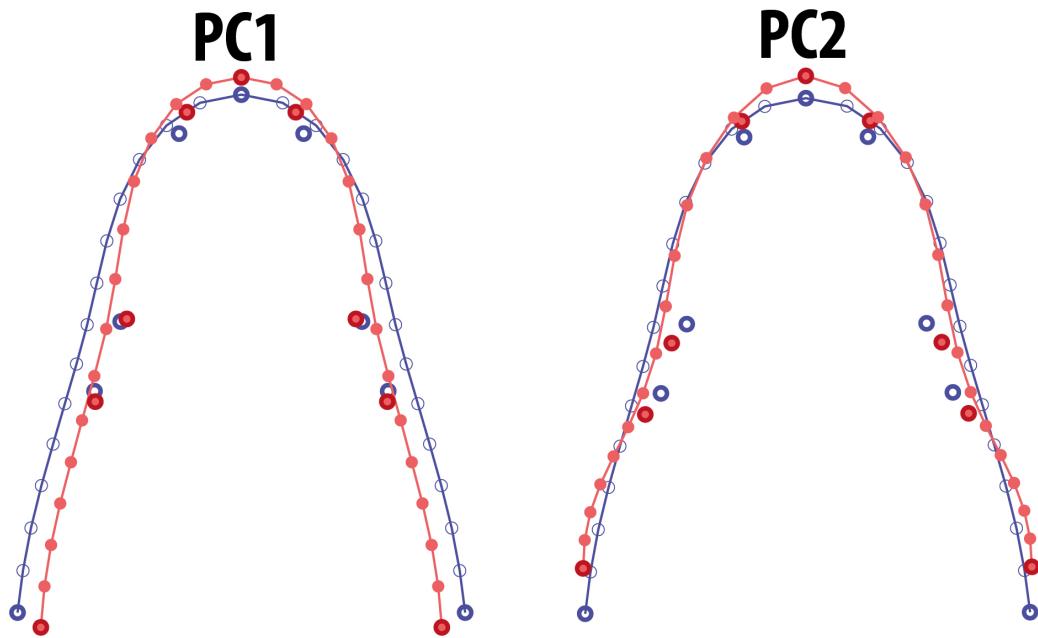


Fig. S2. Head shape change along the Principal Component (PC) axes 1 and 2 (PC1 on the left and PC2 on the right). The blue shape drawings represent the mean shape and the red shape drawings represent the shape at 0.1 units in the positive direction along each PC axis.

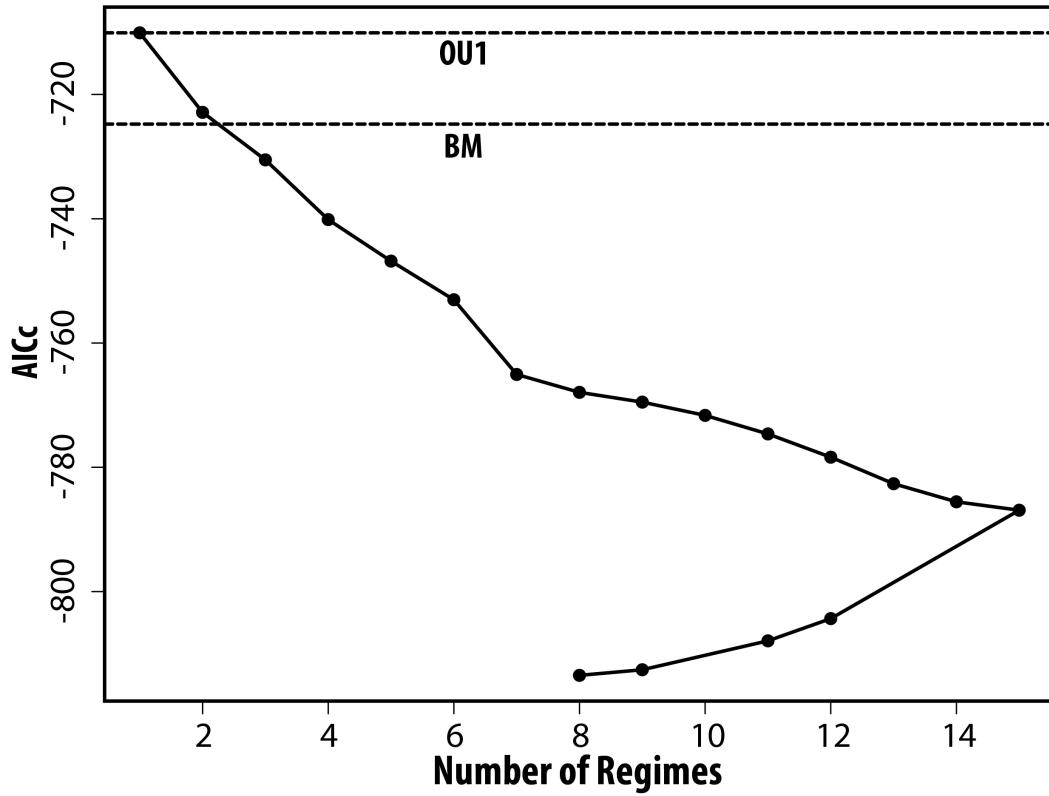


Fig. S3. SURFACE steps. Change in corrected Akaike Information Criterion (AICc) during the forward (left to right) step adding regimes and the backward step (right to left) collapsing regimes in SURFACE. The dashed lines indicate the AICc for the Ornstein-Uhlenbeck 1 (OU1) and Brownian Motion (BM) models.

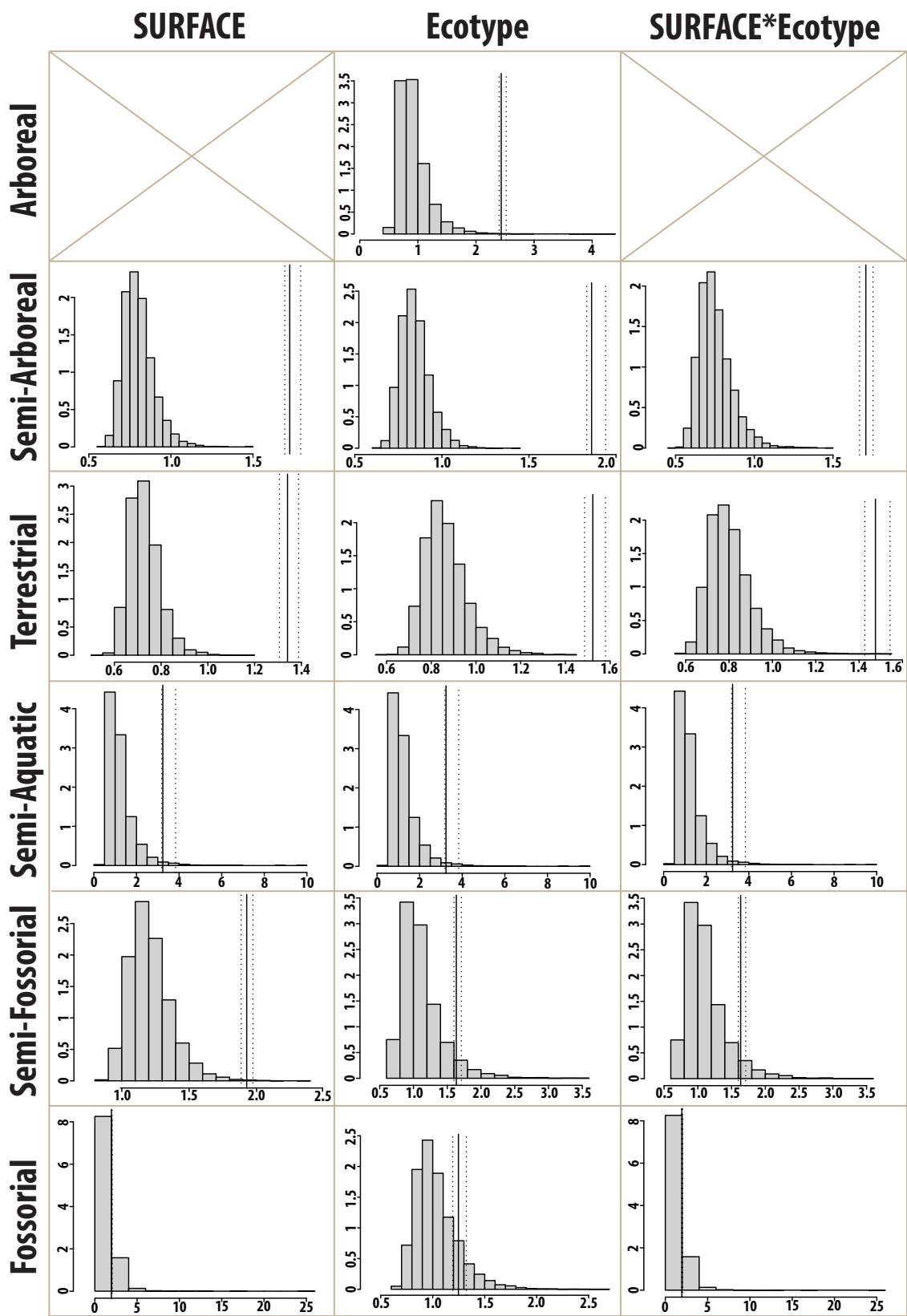


Fig. S4. Wheatsheaf index (w) and bootstrap results. For each three convergent ecomorph alternative groupings for each of the six guild categories (see ‘Methods’); the solid line represents the Wheatsheaf index calculated for that ecomorph grouping. Dashed lines represent 95% confidence intervals for w obtained from jackknifing. Histograms display Wheatsheaf index values obtained from the 10,000 bootstrap permutations. X axis represents Wheatsheaf values, Y axis represents frequency $\times 1,000$.

Table S1.Taxa used for this study grouped by family or superfamily (in case of Booidea), indicating the number of specimens included for each taxa (n), their assigned guild and the references from where the ecological information was obtained. References can be found in at the bottom of this file.

Species	n	Guild	References
PYTHONIDAE (34)			
<i>Leiopython albertisii</i>	14	Terrestrial	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
<i>Leiopython meridionalis</i>	12	Terrestrial	Same as <i>L. albertisii</i> (recently described species)
<i>Bothrocophias boa</i>	19	Terrestrial	1, 8, 10, 15, 16 p. 269, 17, 18
<i>Aspidites melanocephalus</i>	59	Semi-fossilorial	1, 2, 3, 8, 9, 10, 14, 19, 20, 21, 22, 23, 24
<i>Aspidites ramsayi</i>	35	Semi-fossilorial	1, 2, 3, 8, 9, 10, 14, 19, 20, 21, 24, 25, 26, 27, 28, 29, 30
<i>Simalia kinghorni</i>	32	Semi-arboreal	1, 2, 8, 9, 10, 14, 19, 20, 21, 24, 31, 32, 33
<i>Simalia nauta</i>	5	Semi-arboreal	1 and inferred from <i>S. kinghorni</i>
<i>Simalia clastolepis</i>	7	Semi-arboreal	1, 34, 35 and inferred from <i>S. kinghorni</i>
<i>Simalia amethystina</i>	23	Semi-arboreal	1, 6, 11, 15 and inferred from <i>S. kinghorni</i>
<i>Simalia tracyae</i>	2	Semi-arboreal	1, 34 and inferred from <i>S. kinghorni</i>
<i>Simalia boeleni</i>	15	Semi-arboreal	1, 15, 23, 36
<i>Simalia oenpelliensis</i>	10	Semi-arboreal	1, 9, 14, 19, 20, 24, 37, 38, 39, 40
<i>Liasis mackloti mackloti</i>	25	Semi-aquatic	1, 2, 3, 9, 10, 13, 14, 15, 19, 20, 24, 37, 41, 42, 43, 44, 45
<i>Liasis fuscus</i>	25	Semi-aquatic	Same as <i>L. mackloti</i> , generally treated as conspecific
<i>Liasis olivaceus olivaceus</i>	22	Terrestrial	1, 2, 3, 8, 9, 10, 14, 19, 20, 21, 24, 37
<i>Liasis papuana</i>	17	Terrestrial	1, 5, 7, 8, 11, 12, 15, 46
<i>Antaresia childreni</i>	47	Terrestrial	1, 2, 3, 9, 10, 14, 19, 20, 21, 24, 37, 42, 47
<i>Antaresia stimsoni orientalis</i>	39	Terrestrial	1, 3, 9, 10, 14, 19, 20, 21, 42, 48
<i>Antaresia perthensis</i>	40	Terrestrial	1, 3, 9, 10, 14, 19, 20, 21, 24, 42
<i>Antaresia maculosa</i>	34	Terrestrial	1, 3, 9, 10, 14, 19, 20, 21, 42
<i>Morelia viridis</i>	34	Arboreal	1, 2, 9, 10, 11, 13, 14, 15, 19, 20, 24, 49, 50, 51, 52, 53
<i>Morelia spilota variegata</i>	23	Semi-arboreal	1, 8, 10, 14, 21, 24
<i>Morelia spilota spilota</i>	17	Semi-arboreal	1, 10, 14, 21, 24, 51, 54, 55, 56
<i>Morelia bredli</i>	17	Semi-arboreal	1, 9, 14, 20, 24, 57
<i>Morelia carinata</i>	2	Arboreal	1, 9, 14, 19, 20, 58
<i>Malayopython reticulatus</i>	20	Semi-arboreal	1, 8, 59, 60, 61, 62, 63, 64
<i>Malayopython timoriensis</i>	5	Semi-arboreal	1, 8
<i>Python sebae</i>	11	Terrestrial	1, 8, 59, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74
<i>Python anchietae</i>	1	Terrestrial	1, 8, 16 p. 101, 17, 75
<i>Python molurus</i>	6	Terrestrial	1, 8, 59, 71, 76, 77, 78, 79, 80
<i>Python bivittatus</i>	8	Terrestrial	1, 59, 60, 81, 82, 83, 84
<i>Python bronversmai</i>	10	Terrestrial	1, 85
<i>Python curtus</i>	1	Terrestrial	1, 8
<i>Python regius</i>	22	Terrestrial	1, 8, 65, 67, 68, 70, 72, 86
LOXOCEMIDAE (1)			
<i>Loxocemus bicolor</i>	8	Semi-fossilorial	1, 8, 51, 87, 88, 89, 90, 91, 92
XENOPELTIDAE (1)			
<i>Xenopeltis unicolor</i>	6	Semi-fossilorial	1, 60, 64, 87, 93, 94, 95
BOOIDEA (45)			

<i>Chilabothrus strigilatus</i>	11	Semi-arboreal	96, 97, 98
<i>Chilabothrus exsul</i>	4	Semi-arboreal	99
<i>Chilabothrus striatus</i>	11	Semi-arboreal	1, 96, 99
<i>Chilabothrus chrysogaster</i>	2	Semi-arboreal	96, 99, 100
<i>Chilabothrus fordii</i>	11	Semi-arboreal	1, 8, 96, 99
<i>Chilabothrus subflavus</i>	3	Semi-arboreal	1, 99, 101
<i>Chilabothrus monensis granti</i>	1	Semi-arboreal	16 p. 117, 96, 99, 102, 103, 107
<i>Chilabothrus inornatus</i>	8	Semi-arboreal	96, 99, 104, 105, 106, 107, 108, 109
<i>Chilabothrus angulifer</i>	12	Semi-arboreal	1, 8, 96, 99
<i>Epicrates crassus</i>	3	Terrestrial	10, 105, 110, 111, 112
<i>Epicrates assisi</i>	2	Terrestrial	10, 105, 110, 112
<i>Epicrates maurus</i>	11	Terrestrial	1, 8, 96, 105, 110, 112
<i>Epicrates cenchria</i>	8	Terrestrial	1, 8, 10, 96, 105, 110, 112, 113, 114, 115, 116, 117
<i>Epicrates alvarezi</i>	1	Terrestrial	110, 112, 115, 118
<i>Eunectes murinus</i>	10	Semi-aquatic	1, 10, 51, 59, 110, 114, 115, 116, 117, 120, 121
<i>Eunectes notaeus</i>	4	Semi-aquatic	1, 10, 115, 122, 123
<i>Corallus hortulanus</i>	16	Arboreal	1, 10, 51, 105, 111, 115, 116, 117, 124, 125, 126, 127, 135
<i>Corallus ruschenbergerii</i>	14	Arboreal	1, 51, 105, 125, 128, 135
<i>Corallus caninus</i>	10	Arboreal	1, 10, 51, 105, 116, 121, 125, 129, 130, 135
<i>Corallus batesii</i>	6	Arboreal	117, 129, 131, 135 and inferred from <i>C. caninus</i>
<i>Corallus annulatus</i>	7	Arboreal	1, 51, 105, 115, 125, 132, 133, 134, 135
<i>Boa constrictor constrictor</i>	8	Semi-arboreal	1, 10, 51, 105, 111, 113, 114, 115, 116, 136
<i>Boa constrictor amarali</i>	4	Semi-arboreal	1, 10, 51, 105, 111, 136, 137
<i>Boa constrictor occidentalis</i>	1	Semi-arboreal	1, 51, 105, 111, 115, 118, 136, 138, 139, 140, 141
<i>Boa imperator</i>	15	Semi-arboreal	1, 51, 105, 111, 115, 136, 142, 143, 144
<i>Boa imperator sabogae</i>	5	Semi-arboreal	Inferred from other boa constrictors
<i>Candoia superciliosa</i>	10	Semi-arboreal	145 and inferred from <i>C. carinata</i>
<i>Candoia carinata</i>	15	Semi-arboreal	1, 8, 10, 15, 105, 145, 146, 147
<i>Candoia aspera</i>	12	Terrestrial	1, 10, 12, 15, 51, 105, 147
<i>Candoia bibroni</i>	7	Arboreal	1, 8, 10, 51, 105, 146, 147, 148
<i>Eryx miliaris</i>	23	Fossorial	51, 66, 79, 149
<i>Eryx jaculus</i>	9	Fossorial	1, 51, 66, 149, 150, 151, 152
<i>Eryx colubrinus</i>	7	Fossorial	1, 51, 66, 72, 73, 149, 153
<i>Eryx johnii</i>	10	Fossorial	1, 51, 66, 79, 121, 149
<i>Eryx conicus</i>	7	Fossorial	1, 8, 51, 66, 79, 149, 153, 154, 155
<i>Eryx jayakari</i>	10	Fossorial	51, 66, 156, 157
<i>Eryx muelleri</i>	1	Fossorial	8, 51, 66, 153
<i>Charina bottae</i>	10	Semi-fossorial	1, 8, 51, 92, 149, 158, 159, 160, 161, 162, 163
<i>Lichanura trivirgata</i>	9	Semi-fossorial	1, 8, 51, 92, 149, 164
<i>Exiliboa placata</i>	10	Semi-fossorial	1, 8, 51, 89, 92, 121, 165
<i>Ungaliophis continentalis</i>	4	Semi-fossorial	1, 8, 51, 92, 166, 167, 168
<i>Acrantophis dumerili</i>	5	Terrestrial	1, 8, 51, 105, 169, 170
<i>Acrantophis madagascariensis</i>	5	Terrestrial	1, 8, 51, 171, 172, 173, 174
<i>Sanzinia madagascariensis</i>	12	Arboreal	1, 8, 10, 16 p. 49, 105, 169, 170, 171, 172, 174
<i>Calabaria reinhardtii</i>	11	Fossorial	1, 8, 16 p. 268, 51, 67, 68, 74, 146, 149, 175

CYLINDROPHIIDAE (2)

<i>Cylindrophis maculatus</i>	3	Fossorial	1, 51, 80
<i>Cylindrophis ruffus</i>	3	Fossorial	1, 51, 60, 94, 176
UROPELTIDAE (3)			
<i>Rhinophis oxyrhynchus</i>	3	Fossorial	1, 51
<i>Rhinophis blythii</i>	1	Fossorial	1, 51
<i>Uropeltis ceylanicus</i>	1	Fossorial	1, 51, 177
TROPIDOPHIIDAE (6)			
<i>Trachyboa boulengeri</i>	5	Terrestrial	1, 8, 92, 168, 178
<i>Tropidophis greenwayi</i>	2	Terrestrial	1, 8, 51, 92, 99, 179, 180, 181, 182
<i>Tropidophis haetianus</i>	4	Terrestrial	1, 8, 51, 92, 99, 179, 180, 181, 182, 183, 184
<i>Tropidophis wrighti</i>	1	Semi-arboreal	1, 8, 51, 92, 179, 180, 181, 182
<i>Tropidophis melanurus</i>	3	Semi-arboreal	1, 8, 51, 92, 99, 179, 180, 181, 182, 183, 185, 186
<i>Tropidophis feicki</i>	3	Semi-arboreal	1, 8, 51, 92, 99, 179, 180, 181, 182, 183, 184
ANILIIDAE (1)			
<i>Anilius scytale</i>	5	Fossorial	1, 51, 116, 117, 187
BOLYERIIDAE (1)			
<i>Casarea dussumieri</i>	1	Terrestrial	1, 51, 188, 189, 190, 191

Table S2. Individual C1-C4 measures for pair-wise comparisons between convergent lineages. For each comparison the two linages are named with their chosen representatives between parentheses, which are the closest taxa of those two lineages in morphospace. Convergent groupings that have the same number in parenthesis have the same comparisons because they include the same lineages. Values in bold indicate statistically significant values.

	C1	C2	C3	C4
SURFACE Semi-Arboreal				
<i>Acrantophis (A. dumerili)</i> vs. Semi-Arboreal Boidae (<i>C. subflavus</i>)	0.97 (p=0)	0.105 (p=0)	0.055 (p=0.003)	0.026 (p=0.002)
<i>Acrantophis (A. dumerili)</i> vs. Semi-Arboreal <i>Morelia (M. spilota spilota)</i>	0.513(p=0.187)	0.063 (p=0.073)	0.018 (p=0.131)	0.016 (p=0.129)
Semi-Arboreal <i>Morelia (M. bredli)</i> vs. Semi-Arboreal Boidae (<i>C. monensis granti</i>)	0.889 (p=0.007)	0.084 (p=0.023)	0.024 (p=0.061)	0.021(p=0.057)
Mean	0.791 (p=0.065)	0.084 (p=0.032)	0.032 (p=0.065)	0.021 (p=0.063)
SURFACE Terrestrial (1)				
Bolyeriidae (<i>C. dussumieri</i>) vs. <i>Epicrates (E. maurus)</i>	0.951 (p=0.001)	0.133 (p=0)	0.034 (p=0.002)	0.033 (p=0.001)
Bolyeriidae (<i>C. dussumieri</i>) vs. Terrestrial Pythonidae (<i>L. albertisii</i>)	0.893 (p=0.005)	0.129 (p=0.001)	0.035 (p=0.001)	0.032 (p=0.001)
<i>Epicrates (E. assisi)</i> vs. Terrestrial Pythonidae (<i>P. regius</i>)	0.971 (p=0)	0.125 (p=0)	0.035 (p=0.003)	0.031 (p=0.002)
Mean	0.938 (p=0.002)	0.129 (p=0)	0.035 (p=0.002)	0.032 (p=0.001)
SURFACE Semi-Aquatic (2)				
<i>Euncetes (E. notaeus)</i> vs. Semi-Aquatic <i>Liasis (L. mackloti mackloti)</i>	0.623 (p=0.111)	0.08 (p=0.039)	0.022 (p=0.086)	0.02 (p=0.084)
SURFACE Semi-Fossil				
<i>Aspidites (A. melanocephalus)</i> vs "Semi-Fossil" Henophidia (<i>T. greenwayi</i>)	0.983 (p=0)	0.106 (p=0.003)	0.026 (p=0.015)	0.026 (p=0.015)
SURFACE Fossil (3)				
<i>Eryx jayakari</i> vs. <i>Cylindrophis (C. maculatus)</i>	0.773 (p=0.034)	0.093 (p=0.015)	0.026 (p=0.031)	0.023 (p=0.027)
Guild Arboreal (convergent)				
<i>Morelia viridis</i> vs. <i>Candoia bibroni</i>	0.821 (p=0.019)	0.09 (p=0.012)	0.025 (p=0.039)	0.023 (p=0.036)
<i>Morelia viridis</i> vs. <i>Corallus (C. annulatus)</i>	0.78 (p=0.034)	0.091 (p=0.016)	0.026 (p=0.063)	0.023 (p=0.059)
<i>Candoia bibroni</i> vs. <i>Corallus (C. annulatus)</i>	0.897 (p=0.005)	0.07 (p=0.008)	0.081 (p=0.003)	0.018 (p=0.023)
Mean	0.832 (p=0.02)	0.084 (p=0.012)	0.044 (p=0.036)	0.021 (p=0.039)
Guild Arboreal (all): including the above				
<i>S. madagascariensis</i> vs. <i>M. carinata</i>	0.252 (p=0.4)	0.029 (p=0.32)	0.008 (p=0.4)	0.007 (p=0.39)
<i>S. madagascariensis</i> vs. <i>C. bibroni</i>	0 (p=1)	0 (p=1)	0 (p=1)	0 (p=1)
<i>S. madagascariensis</i> vs. <i>Corallus (C. hortulanus)</i>	0.0545 (p=0.62)	0.007 (p=0.57)	0.004 (p=0.6)	0.002 (p=0.6)
Mean	0.47 (p=0.35)	0.05 (p=0.32)	0.02 (p=0.35)	0.01 (p=0.35)
Guild Semi-Arboreal (convergent)				
Semi-Arboreal Boidae (<i>C. subflavus</i>) vs. <i>Malayopython (M. reticulatus)</i>	0.918 (p=0.006)	0.111 (p=0.003)	0.031 (p=0.011)	0.028 (p=0.008)
Semi-Arboreal Boidae (<i>C. inornatus</i>) vs. <i>Simalia (S. tracyae)</i>	0.977 (p=0.001)	0.092 (p=0.016)	0.026 (p=0.059)	0.023 (p=0.053)
Semi-Arboreal <i>Morelia (M. bredli)</i> vs. Semi-Arboreal Boidae (<i>C. monensis granti</i>)	0.889 (p=0.007)	0.084 (p=0.023)	0.024 (p=0.061)	0.021 (p=0.057)
<i>Simalia (S. clastolepis)</i> vs. <i>Malayopython (M. timoriensis)</i>	0.805 (p=0.019)	0.02 (p=0.188)	0.021 (p=0.254)	0.005 (p=0.25)
Semi-Arboreal <i>Morelia (M. s. spilota)</i> vs. <i>Malayopython (M. timoriensis)</i>	0.663 (p=0.049)	0.023 (p=0.151)	0.025 (p=0.227)	0.006 (p=0.218)
Semi-Arboreal <i>Morelia (M. s. spilota)</i> vs. <i>Simalia (S. clastolepis)</i>	0.788 (p=0.027)	0.029 (p=0.085)	0.033 (p=0.161)	0.007 (p=0.139)
Mean	0.84(p=0.018)	0.06 (p=0.078)	0.027 (p=0.129)	0.015 (p=0.121)
Guild Semi-Arboreal (all)				
Semi-Arboreal Tropidophiids (<i>T. melanurus</i>) vs. <i>Malayopython (M. timoriensis)</i>	0.42 (p=0.23)	0.047 (p=0.2)	0.012 (p=0.3)	0.012 (p=0.3)
Semi-Arboreal Tropidophiids (<i>T. melanurus</i>) vs. S.A. Boidae (<i>C. monensis granti</i>)	0.48 (p=0.2)	0.056 (p=0.16)	0.014 (p=0.25)	0.014 (p=0.25)
Semi-Arboreal Tropidophiids (<i>T. melanurus</i>) vs. <i>Simalia (S. boehleni)</i>	0.63 (p=0.09)	0.071 (p=0.07)	0.018 (p=0.12)	0.018 (p=0.12)
Semi-Arboreal Tropidophiids (<i>T. melanurus</i>) vs. S.A. <i>Morelia (M. s. variegata)</i>	0.51 (p=0.16)	0.055 (p=0.14)	0.014 (p=0.23)	0.014 (p=0.23)
Mean	0.84 (p=0.018)	0.06 (p=0.078)	0.027 (p=0.13)	0.015 (p=0.12)
Guild Terrestrial (convergent)				
Bolyeriidae (<i>C. dussumieri</i>) vs. <i>Acrantophis (A. dumerili)</i>	0.771 (p=0.021)	0.101 (p=0.001)	0.027 (p=0.007)	0.025 (p=0.006)
Bolyeriidae (<i>C. dussumieri</i>) vs. <i>Epicrates (E. maurus)</i>	0.951 (p=0.002)	0.133 (p=0)	0.036 (p=0.004)	0.033 (p=0.004)
<i>Candoia aspera</i> vs. Bolyeriidae (<i>C. dussumieri</i>)	0.22 (p=0.365)	0.029 (p=0.282)	0.008 (p=0.333)	0.007 (p=0.33)
<i>Acrantophis (A. dumerili)</i> vs. <i>Epicrates (E. assisi)</i>	0.766 (p=0.037)	0.091 (p=0.004)	0.047 (p=0.018)	0.023 (p=0.017)
<i>Acrantophis (A. dumerili)</i> vs. <i>Candoia aspera</i>	0.226 (p=0.354)	0.025 (p=0.262)	0.013 (p=0.35)	0.006 (p=0.326)
<i>Acrantophis (A. dumerili)</i> vs. Terrestrial Pythonidae (<i>P. brongersmai</i>)	0.89 (p=0.005)	0.109 (p=0.001)	0.031 (p=0.015)	0.027 (p=0.013)
<i>Candoia aspera</i> vs. <i>Epicrates (E. assisi)</i>	0.43 (p=0.233)	0.043 (p=0.14)	0.05 (p=0.131)	0.011 (p=0.22)
<i>Epicrates (E. assisi)</i> vs. Terrestrial Pythonidae (<i>P. regius</i>)	0.971 (p=0)	0.125 (p=0)	0.035 (p=0.003)	0.031 (p=0.002)
<i>Candoia aspera</i> vs. Terrestrial Pythonidae (<i>A. maculosa</i>)	0.659 (p=0.086)	0.056 (p=0.137)	0.016 (p=0.223)	0.014 (p=0.22)
Bolyeriidae (<i>C. dussumieri</i>) vs. Terrestrial Pythonidae (<i>L. albertisii</i>)	0.893 (p=0.005)	0.129 (p=0.001)	0.035 (p=0.001)	0.032 (p=0.001)
Mean	0.66 (p=0.12)	0.079(p=0.092)	0.029 (p=0.12)	0.02 (p=0.13)
Guild Terrestrial (all): including the above				
Terrestrial Tropidophiids (<i>T. haetinus</i>) vs. Bolyeriidae (<i>C. dussumieri</i>)	0.2 (p=0.4)	0.031 (p=0.25)	0.0078 (p=0.32)	0.0078 (p=0.32)
Terrestrial Tropidophiids (<i>T. haetinus</i>) vs. <i>Acrantophis (A. dumerili)</i>	0.2 (p=0.46)	0.029 (p=0.37)	0.0072 (p=0.45)	0.0072 (p=0.45)
Terrestrial Tropidophiids (<i>T. haetinus</i>) vs. <i>Epicrates (E. assisi)</i>	0.4 (p=0.28)	0.061 (p=0.15)	0.015 (p=0.24)	0.015 (p=0.24)
Terrestrial Tropidophiids (<i>T. haetinus</i>) vs. <i>Candoia aspera</i>	0.59 (p=0.11)	0.056 (p=0.15)	0.014 (p=0.23)	0.014 (p=0.23)
Terrestrial Tropidophiids (<i>T. haetinus</i>) vs. Pythonidae (<i>A. maculosa</i>)	0.69 (p=0.049)	0.074 (p=0.052)	0.019 (p=0.11)	0.019 (p=0.11)
Mean	0.59 (p=0.16)	0.072(p=0.12)	0.024 (p=0.16)	0.018 (p=0.17)
Guild Semi-Aquatic (2)				
<i>Euncetes (E. notaeus)</i> vs. Semi-Aquatic <i>Liasis (L. mackloti mackloti)</i>	0.623 (p=0.111)	0.08 (p=0.039)	0.022 (p=0.086)	0.02 (p=0.084)
Guild Semi-Fossil				
Charinidae (<i>L. trivirgata</i>) vs. <i>Aspidites (A. ramsayi)</i>	0.861 (p=0.009)	0.09 (p=0.005)	0.025 (p=0.016)	0.023 (p=0.016)
Loxocemidae (<i>L. bicolor</i>) vs. Charinidae (<i>E. placata</i>)	0.743 (p=0.031)	0.066 (p=0.027)	0.018 (p=0.066)	0.016 (p=0.059)
Xenopeltidae (<i>X. unicolor</i>) vs. Charinidae (<i>U. continentalis</i>)	0.277 (p=0.302)	0.012 (p=0.423)	0.003 (p=0.45)	0.003 (p=0.448)

Loxocemidae (<i>L. bicolor</i>) vs <i>Aspidites</i> (<i>A. melanocephalus</i>)	0.632 (p=0.038)	0.094 (p=0)	0.078 (p=0.001)	0.024 (p=0.005)
Xenopeltidae (<i>X. unicolor</i>) vs. <i>Aspidites</i> (<i>A. melanocephalus</i>)	0.745 (p=0.028)	0.072 (p=0.01)	0.057 (p=0.022)	0.018 (p=0.03)
Xenopeltidae (<i>X. unicolor</i>) vs. Loxocemidae (<i>L. bicolor</i>)	0.299 (p=0.19)	0.026 (p=0.104)	0.021 (p=0.144)	0.007 (p=0.158)
Mean	0.593 (p=0.1)	0.06 (p=0.095)	0.034 (p=0.116)	0.015 (p=0.119)
Guild Fosorial (convergent)				
Erycidae (<i>E. colubrinus</i>) vs. Calabariidae (<i>C. reinhardtii</i>)	0.883 (p=0.01)	0.087 (p=0.007)	0.045 (p=0.022)	0.022 (p=0.02)
Erycidae (<i>E. colubrinus</i>) vs. Aniliidae (<i>A. scytale</i>)	0.797 (p=0.031)	0.097 (p=0.005)	0.024 (p=0.021)	0.024 (p=0.021)
Aniliidae (<i>A. scytale</i>) vs. Calabariidae (<i>C. reinhardtii</i>)	0.716 (p=0.029)	0.081 (p=0.019)	0.02 (p=0.038)	0.02 (p=0.038)
Mean	0.799 (p=0.023)	0.088 (p=0.01)	0.03 (p=0.027)	0.022 (p=0.026)
Guild Fosorial (all): including the above				
<i>Rhinophis</i> (<i>R. oxyrhinhus</i>) vs. Erycidae (<i>E. jaculus</i>)	0.357 (p=0.31)	0.042 (p=0.25)	0.012 (p=0.34)	0.011 (p=0.33)
<i>Rhinophis</i> (<i>R. oxyrhinhus</i>) vs. Calabariidae (<i>C. reinhardtii</i>)	0.23 (p=0.37)	0.027 (p=0.32)	0.008 (p=0.40)	0.007 (p=0.40)
<i>Rhinophis</i> (<i>R. oxyrhinhus</i>) vs. Aniliidae (<i>A. scytale</i>)	0.08 (p=0.54)	0.009 (p=0.52)	0.002 (p=0.55)	0.002 (p=0.55)
Mean	0.51 (p=0.21)	0.057 (p=0.19)	0.019 (p=0.23)	0.014 (p=0.23)
SURFACE*Guild Semi-Arboreal				
Semi-Arboreal Morelia (<i>M. bredli</i>) vs. Semi-Arboreal Boidae (<i>C. monensis granti</i>)	0.889 (p=0.007)	0.084 (p=0.023)	0.024 (p=0.061)	0.021 (p=0.057)
SURFACE*Guild Terrestrial (1)				
Bolyeriidae (<i>C. dussumieri</i>) vs. <i>Epicrates</i> (<i>E. maurus</i>)	0.951 (p=0.001)	0.133 (p=0)	0.034 (p=0.002)	0.033 (p=0.001)
Bolyeriidae (<i>C. dussumieri</i>) vs. Terrestrial Pythonidae (<i>L. albertisii</i>)	0.893 (p=0.005)	0.129 (p=0.001)	0.035 (p=0.001)	0.032 (p=0.001)
<i>Epicrates</i> (<i>E. assisi</i>) vs. Terrestrial Pythonidae (<i>P. regius</i>)	0.971 (p=0)	0.125 (p=0)	0.035 (p=0.003)	0.031 (p=0.002)
Mean	0.938 (p=0.002)	0.129 (p=0)	0.035 (p=0.002)	0.032 (p=0.001)
SURFACE*Guild Semi-Aquatic (2)				
<i>Euncetes</i> (<i>E. notaeus</i>) vs. Semi-Aquatic <i>Liasis</i> (<i>L. mackloti mackloti</i>)	0.623 (p=0.111)	0.08 (p=0.039)	0.022 (p=0.086)	0.02 (p=0.084)
SURFACE*Guild Semi-Fosorial (4)				
Charinidae (<i>L. trivirgata</i>) vs. <i>Aspidites</i> (<i>A. ramsayi</i>)	0.861 (p=0.009)	0.09 (p=0.005)	0.025 (p=0.016)	0.023 (p=0.016)
Loxocemidae (<i>L. bicolor</i>) vs. Charinidae (<i>E. placata</i>)	0.743 (p=0.031)	0.066 (p=0.027)	0.018 (p=0.066)	0.016 (p=0.059)
Xenopeltidae (<i>X. unicolor</i>) vs. Charinidae (<i>U. continentalis</i>)	0.277 (p=0.302)	0.012 (p=0.423)	0.003 (p=0.45)	0.003 (p=0.448)
Loxocemidae (<i>L. bicolor</i>) vs <i>Aspidites</i> (<i>A. melanocephalus</i>)	0.632 (p=0.038)	0.094 (p=0)	0.078 (p=0.001)	0.024 (p=0.005)
Xenopeltidae (<i>X. unicolor</i>) vs. <i>Aspidites</i> (<i>A. melanocephalus</i>)	0.745 (p=0.028)	0.072 (p=0.01)	0.057 (p=0.022)	0.018 (p=0.03)
Xenopeltidae (<i>X. unicolor</i>) vs. Loxocemidae (<i>L. bicolor</i>)	0.299 (p=0.19)	0.026 (p=0.104)	0.021 (p=0.144)	0.007 (p=0.158)
Mean	0.593 (p=0.1)	0.06 (p=0.095)	0.034 (p=0.116)	0.015 (p=0.119)
SURFACE*Guild Fosorial (3)				
<i>Eryx jayakari</i> vs. <i>Cylindrophis</i> (<i>C. maculatus</i>)	0.773 (p=0.034)	0.093 (p=0.015)	0.026 (p=0.031)	0.023 (p=0.027)

Bolyeriidae (<i>C. dussumieri</i>) vs. <i>Epicrates</i> (<i>E. maurus</i>)	0.21-0.28 (0.68)	0.02-0.023 (0.068)	0.007-0.008 (0.023)	0.006-0.007 (0.02)
Bolyeriidae (<i>C. dussumieri</i>) vs. Terrestrial Pythonidae (<i>L. albertisii</i>)	0.2-0.23 (0.71)	0.017-0.02 (0.06)	0.006-0.007 (0.02)	0.005-0.006 (0.018)
<i>Epicrates</i> (<i>E. assisi</i>) vs. Terrestrial Pythonidae (<i>P. regius</i>)	0.25-0.28 (0.7)	0.026-0.029 (0.076)	0.009-0.01 (0.026)	0.008-0.009 (0.029)
SURFACE*Guild Semi-Aquatic (2)				
<i>Euncetes</i> (<i>E. notaeus</i>) vs. Semi-Aquatic Liasias (<i>L. mackloti mackloti</i>)	0.27-0.3 (0.76)	0.026-0.029 (0.074)	0.009-0.01 (0.026)	0.008-0.009 (0.023)
SURFACE*Guild Semi-Fossil (4)				
Charinidae (<i>L. trivirgata</i>) vs. <i>Aspidites</i> (<i>A. ramsayi</i>)	0.24-0.27 (0.72)	0.02-0.22 (0.059)	0.007-0.008 (0.02)	0.006-0.007 (0.018)
Loxocemidae (<i>L. bicolor</i>) vs. Charinidae (<i>E. placata</i>)	0.18-0.22 (0.7)	0.016-0.018 (0.061)	0.005-0.006 (0.022)	0.005-0.006 (0.019)
Xenopeltidae (<i>X. unicolor</i>) vs. Charinidae (<i>U. continentalis</i>)	0.17-0.2 (0.68)	0.014-0.019 (0.049)	0.005-0.006 (0.02)	0.004-0.005 (0.018)
Loxocemidae (<i>L. bicolor</i>) vs <i>Aspidites</i> (<i>A. melanocephalus</i>)	0.17-0.2 (0.7)	0.011-0.013 (0.043)	0.01-0.012 (0.041)	0.003-0.004 (0.013)
Xenopeltidae (<i>X. unicolor</i>) vs. <i>Aspidites</i> (<i>A. melanocephalus</i>)	0.19-0.21 (0.67)	0.013-0.015 (0.045)	0.01-0.014 (0.041)	0.004-0.005 (0.014)
Xenopeltidae (<i>X. unicolor</i>) vs. Loxocemidae (<i>L. bicolor</i>)	0.13-0.16 (0.67)	0.008-0.01 (0.043)	0.008-0.009 (0.038)	0.0026-0.0031 (0.013)
SURFACE*Guild Fossil (3)				
<i>Eryx jayakari</i> vs. <i>Cylindrophis</i> (<i>C. maculatus</i>)	0.22-0.25 (0.7)	0.02-0.22 (0.066)	0.007-0.008 (0.023)	0.006-0.007 (0.02)

Table S4. Confidence intervals for the C5 simulations and the cut-off value needed for statistical significance for ecomorph grouping comparison. Convergent groupings that have the same number in parenthesis have the same comparisons because they include the same lineages.

	C5
SURFACE Semi-Arboreal	7.29-7.78 (15)
SURFACE Terrestrial ¹	6.27-6.74 (14)
SURFACE Semi-Aquatic ²	0.33-0.44 (2)
SURFACE Semi-Fossorial	7.49-7.98 (15)
SURFACE Fossorial ³	0.99-1.22 (4)
Guild Arboreal (convergent)	3.13-3.52 (9)
Guild Arboreal (all)	6.02-6.54 (14)
Guild Semi-Arboreal (convergent)	7.49-7.42 (14)
Guild Semi-Arboreal (all)	4.76-5.2 (12)
Guild Terrestrial (convergent)	6.27-6.73 (13)
Guild Terrestrial (all)	4.1-4.5 (11)
Guild Semi-Aquatic ²	0.33-0.44 (2)
Guild Semi-Fossorial ⁴	7.73-8.23 (15)
Guild Fossorial (convergent)	6.98-7.5 (15)
Guild Fossorial (all)	8.36-8.9 (16)
SURFACE*Guild Semi-Arboreal	7.4-7.8 (14)
SURFACE*Guild Terrestrial ¹	6.27-6.74 (14)
SURFACE* Guild Semi-Aquatic ²	0.33-0.44 (2)
SURFACE* Guild Semi-Fossorial ⁴	7.73-8.23 (15)
SURFACE* Guild Fossorial ³	0.99-1.22 (4)

Supplementary Text

Taxonomic comments. We consider *Eryx tataricus* (Lichenstein, 1823) the same as *E. miliaris* (Pallas, 1773), *E. elegans* (Gray, 1849) the same as *E. jaculus* (Linnaeus, 1758) (192), *Corallus grenadiensis* (Barbour, 1814) and *C. cookii* (Gray, 1842) the same as *C. hortulanus* (Linnaeus, 1758) (193) and *Morelia azurea* (Meyer, 1874) the same as *M. viridis* (Schlegel, 1872). The latter case because the sampling was designed and performed before the formal recognition of this taxon.

Guild descriptions and results.

When measuring w and C, we did not include taxa in the ‘Guild’ groupings that were clearly not convergent in morphology by observing the phylomorphospace. More specifically, we considered arboreals without *Sanzinia madagascariensis* (Duméril & Bibron, 1844), semi-arboreals and terrestrials without tropidophiids and fossorials without *Rhinophis*.

Arboreal. One of the best known examples of convergent evolution is the emerald tree boa (*Corallus caninus* (Linnaeus, 1758)) and the green tree python (*Morelia viridis*); each has adapted to life in the tree canopy and have remarkably similar morphology, coloration and behavior. Both they even go through the same ontogenetic color changes, from bright yellow or orange juveniles to green adults. A number of other boas (*Corallus*, *Sanzinia*, *Candoia bibroni* (Duméril & Bibron, 1844)) and a python (*Morelia carinata* (Smith, 1981)) have evolved extreme arboreal habitats, spending most of their lives high in the rainforest canopy. They also display the same ovarian morphology and body shape adaptations to life in trees (10).

In the phylomorphospace plot (Fig. 2), all the arboreal pythons and boas (with the exception of *Sanzinia madagascariensis*) are clustered in the same region, forming a clear ecomorph. However, SURFACE did not find any convergent regimes for the arboreal species. The Wheatsheaf index is high in comparison to other convergent ecomorphs and has a significant p value (Table 2). According to C1, in average convergent evolution has reduced 83.2% of the distance between the two taxa (Table 3).

Semi-Arboreal. This is the most common micro-habitat use found among pythons and boas. These species are more habitat generalists, foraging in trees as much as on the ground. This guild comprises several boas (*Chilabothrus*, *Boa*, *Candoia*), pythons (*Malayopython*, *Similia*, *Morelia spilota* complex) and some tropidophids (e.g. *Tropidophis feicki* (Schwartz, 1957)).

All semi-arboreal pythons and boas share the same region of phylomorphospace (Fig. 2). Some terrestrial pythons (*Python*) and boas (*Acrantophis*, *Epicrates assisi* Machado, 1945 and *Candoia aspera* (Günther, 1877)) also share the same morphospace. SURFACE identified a regime with the semi-arboreal *Boa*, *Chilabothrus* and *Candoia* on the boa side, and the *Morelia spilota* complex on the python side. The Wheatsheaf index for all semi-arboreals (‘Guild’ grouping) had the highest value showing stronger convergence (Table 2). C1 finds high and significant convergent evolution for all three convergent groupings, in all cases evolution has closed above 80% of the similarities between the lineages (Table 3).

Terrestrial. Snakes in this guild forage on the ground, in rocky outcrops, grasslands, savannahs or the forest floor. This guild is displayed in a phylogenetically diverse group of boas (*Epicrates*, *Acrantophis*, *Candoia aspera*), pythons (*Python*, *Liasis olivaceus/papuana*, *Leiopython*, *Bothrochilus*, *Antaresia*), tropidophids (e.g. *T. greenwayi* Barbour & Shreve, 1936 and *Trachyboa*) and the Mascarene bolyerid *Casarea dussumieri*.

All terrestrial pythons and boas are in the same region of phylomorphospace plot (Fig. 2), however there is overlap with some semi-arboreal species. SURFACE identified a regime that includes the terrestrial rainbow boas (*Epicrates*), all terrestrial pythons (*Python*, *Antaresia*, *Liasis olivaceus* Gray 1842, *L. papuana* Peters & Doria 1878, *Leiopython* and *Bothrochilus*) and *Casarea dussumieri* (Bolyeriidae). The regime also includes the semi-arboreal *Simalia* and *Malayopython*. The highest Wheatsheaf index was calculated for the ‘Guild’ alternative grouping (Table 2). C1 on the other hand found that the highest amount of convergence happened between the lineages identified by SURFACE (Table 3). This is because in the ‘Guild’ grouping *Candoia aspera* is not found convergent with any of the other lineages, therefore reducing the average for the whole group.

Semi-Aquatic. This guild forages actively in fresh-water bodies such as swamps, marshes, streams, rivers and lakes. Among extant henophidians it has only evolved twice, once in boas (*Eunectes* or anacondas) and once in pythons (*Liasis fuscus/mackloti* complex).

In the phylomorphospace plot (Fig. 2) this is the most phenotypically isolated ecomorph, comprising only semi-aquatic henophidians; the anacondas (*Eunectes*) and the water pythons (*Liasis fuscus* Peters, 1873 and *L. mackloti* Duméril & Bibron, 1844). SURFACE identified a regime comprised exclusively of these semi-aquatic species. According to the Wheatsheaf index it is the strongest case of convergence identified in this study (Table 2). They exhibit high and significant C2 and C5 values (Table 3).

Semi-Fossorial. This guild forages under-ground, under leaf-litter, logs, rocks or in caves, but still spends a considerable amount of time hunting above the surface. It can be observed in the charinid boas (Charinidae), the black-headed and woma pythons (*Aspidites*) and in the sister lineages to pythons, *Loxocemus* and *Xenopeltis*.

The semi-fossorial species exhibit narrow variation in PC2 (mostly represented by an anterior broadening of the head, a sharpening of the snout and a lateral placement of eyes and nostrils) and wide variation on PC1 (mostly an elongation and broadening of the head), in a region of the phylomorphospace plot shared with some fossorial species and the tropidophiids (Fig. 2). SURFACE identified a regime that includes all the semi-fossorial henophidians (the charinid boas, the *Aspidites* pythons, *Loxocemus* and *Xenopeltis*), but it also includes all the arboreal and semi-arboreal Tropidophiidae, the arboreal *Sanzinia*, the fossorial *Anilius*, *Calabaria*, and most *Eryx*. The ‘SURFACE’ alternative grouping had the highest and only significant Wheatsheaf index (Table 2). The same happens with C1, but individual comparisons between the “Guild” grouping lineages show high convergence between most of the semi-fossorial lineages (Table 3).

Fossorial. No python has adopted this life-style but it has evolved in boas (*Eryx* and *Calabaria reinhardtii* (Schlegel, 1851)) as well as in other henophidian lineages such as Aniliidae, Cylindrophiidae and Uropeltidae.

The fossorial snakes occupy a unique region in the phylomorphospace plot (Fig. 2), but also exhibit the greatest morphological disparity. SURFACE identified a regime that only includes fossorial species: the boa *Eryx jayakari* Boulenger, 1888 and *Uropeltis* and *Cylindrophis*. The Wheatsheaf index indicates that this ecomorph has the weakest convergence of all six ecomorph groups (Table 2). However, C1 identifies high and significant convergence in all three groupings (Table 3). Besides the convergence between the above-mentioned taxa, there is another instance of strong convergence between some of the *Eryx* and *Calabaria* and *Anilius*.

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