

460	<p>Skin colour, response to environmental colour conditions: (*) (NEW)</p> <p><i>State (0) occurs in Alligatoridae (i.e. Caiman, Melanosuchus, Paleosuchus and Alligator), Mecistops and Osteolaemus.</i></p> <p><i>State (1) occurs in the genus Crocodylus (i.e. C. rhombifer, C. moreletti, C. acutus, C. intermedius, C. niloticus, C. suchus, C. siamensis, C. palustris, C. porosus, C. mindorensis, C. novaeguineae, C. johnstoni).</i></p> <p><i>State (2) occurs in Gavialis and Tomistoma.</i></p> <p><i>This character cannot be scored for fossil taxa.</i></p> <p><i>All data from Merchant et al. (2018).</i></p> <p>0. no, or very little, skin colouration change</p> <p>1. dorsolateral skin surfaces change to a lighter colour in a light environment</p> <p>2. dorsolateral skin surfaces change to a darker colour in a lighter environment</p>
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SOM 1.3. Character and OTUs breakdowns of the merged, and parent, datasets

Table 1. Character break-down from the iterations of the Hastings dataset, ultimately merged into the Hastings and Young (H+Y) matrix. Hastings *et al.* (2015) utilised two datasets: 1) Hastings *et al.* (2010, 2011); and 2) adapted from Jouve *et al.* (2006). Young *et al.* (2016) utilised two datasets: 1) first iteration of a merged dataset, an updated version of the matrix of Hastings *et al.* (2015) with characters used by Young; and 2) an updated version of Young (2014) matrix.

Type of characters	Hastings <i>et al.</i> (2010, 2011, 2015, ds 1-Hastings)	Hastings <i>et al.</i> (2015, ds 2-Jouve)	Young <i>et al.</i> (2016, ds 1-Hastings)
Skull geometry & dimensions	1	3	1
Craniomandibular ornamentation	2	3	2
Cranial rostrum	17	32	19
Skull roof	11	24	21
Orbit & temporal region	7	30	7
Palate & perichoanal structures	4	27	4
Occipital	5	9	5
Braincase, basicranium & suspensorium	8	28	14
Mandibular geometry	-	2	-
Mandible	9	22	9
Dental & alveolar	17	20	22
Vertebrae & ribs	-	6	5
Pectoral girdle & forelimbs	-	11	2
Pelvic girdle & hind limbs	-	7	1
Osteoderms	1	10	8
Total character number	82	234	120
<i>Total dental+craniomandibular</i>	81	200	104
<i>Total post-cranial</i>	1	34	16
<i>Dental+craniomandibular osteology %</i>	98.8	85.47	86.667
<i>Post-cranial osteology%</i>	1.2	14.53	13.333

Table 2. Character break-down from the major different iterations of the Young dataset, ultimately merged into the Hastings and Young (H+Y) matrix. Young *et al.* (2016) utilised two datasets: 1) first iteration of a merged dataset, an updated version of the matrix of Hastings *et al.* (2015) with characters used by Young; and 2) an updated version of Young (2014) matrix. * note, the analysis for Young *et al.* (2013a) is actually a precursor to the Young *et al.* (2012) paper, which ended up being published first.

Type of characters	Young (2006)	Wilkinson <i>et al.</i> (2008)	Young (2009) / Young & Andrade (2009)	Young <i>et al.</i> (2011)	Young <i>et al.</i> (2013a) *	Young <i>et al.</i> (2012)	Young <i>et al.</i> (2013b) / Young (2014)	Young <i>et al.</i> (2016, ds2-Young)
Skull geometry & dimensions	1	1	1	1	1	3	3	5
Craniomandibular ornamentation	1	1	2	2	2	2	2	2
Craniomandibular pneumaticity	-	-	2	2	2	3	3	3
Rostral neurovascular foramina	-	-	-	-	-	-	-	1
Cranial rostrum	9	11	21	22	25	29	31	35
Skull roof	5	14	33	33	31	34	34	41
Orbit & temporal region	4	7	16	16	15	19	19	22
Palate & perichoanal structures	-	3	7	10	9	13	14	15
Occipital	-	3	6	7	8	8	8	9
Braincase, basicranium & suspensorium	-	2	10	10	13	14	15	17
Mandibular geometry	-	-	-	2	2	2	2	2
Mandible	6	9	16	18	18	22	22	26
Dental & alveolar	7	9	13	20	20	26	30	43
Vertebrae & ribs	6	6	15	17	18	22	23	24
Pectoral girdle & forelimbs	5	6	9	13	14	16	16	18
Pelvic girdle & hind limbs	7	7	11	11	16	18	20	21
Osteoderms	3	3	4	6	6	9	9	14
Total character number	54	82	166	190	201	240	251	298
Total dental+craniomandibular	33	60	127	143	147	175	183	221
Total post-cranial	21	22	39	47	54	65	68	77
Dental+craniomandibular osteology %	61.111	73.171	76.506	75.263	73.134	72.917	72.908	74.161
Post-cranial osteology%	38.889	26.829	23.494	24.737	26.866	27.083	27.092	25.839

Table 3. Character break-down from the different iterations of the merged Hastings + Young (H+Y) matrix.

Type of characters	Ristevski <i>et al.</i> (2018)	Ósi <i>et al.</i> (2018)	Current
Skull geometry & dimensions	6	10	10
Craniomandibular ornamentation	4	6	6
Internal neuroanatomy & sensory systems	1	1	3
Craniomandibular pneumaticity	4	4	4
Rostral neurovascular foramina	2	6	6
Cranial rostrum	53	58	58
Skull roof	50	52	52
Orbit & temporal region	27	29	29
Palate & perichoanal structures	19	22	23
Occipital	13	15	15
Braincase, basicranium & suspensorium	26	26	26
Mandibular geometry	4	8	8
Mandible	28	32	32
Dental & alveolar	52	65	65
Vertebrae & ribs	26	31	33
Pectoral girdle & forelimbs	17	23	23
Pelvic girdle & hind limbs	28	37	37
Osteoderms	23	24	24
Gastralia	1	1	1
Soft tissue	3	4	5
Total character number	387	454	460
<i>Total dental+craniomandibular</i>	<i>289</i>	<i>334</i>	<i>337</i>
<i>Total post-cranial</i>	<i>95</i>	<i>116</i>	<i>118</i>
<i>Total soft tissue</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>Dental+craniomandibular osteology %</i>	<i>74.677</i>	<i>73.568</i>	<i>73.261</i>
<i>Post-cranial osteology%</i>	<i>24.548</i>	<i>25.551</i>	<i>25.652</i>
<i>Soft tissue %</i>	<i>0.775</i>	<i>0.881</i>	<i>1.087</i>

Table 4. Break-down of the OTUs per clade from iterations of the Hastings dataset, ultimately merged into the Hastings and Young (H+Y) matrix. Hastings *et al.* (2015) utilised two datasets: 1) matrix of Hastings *et al.* (2010, 2011); and 2) adapted from Jouve *et al.* (2006). Young *et al.* (2016) utilised two datasets: 1) first iteration of a merged dataset, an updated version of the matrix of Hastings *et al.* (2015) with characters used by Young; and 2) an updated version of Young (2014) matrix. Note, the taxonomic break-down is based on the current topology, which for some OTUs will differ from the position they had in earlier less complete analyses.

Clades of OTUs	Hastings <i>et al.</i> (2010)	Hastings <i>et al.</i> (2011)	Hastings <i>et al.</i> (2015, ds 1-Hastings)	Hastings <i>et al.</i> (2015, ds 2-Jouve)	Young <i>et al.</i> (2016, ds 1-Hastings)
Non-crocodylomorph outgroup	-	-	-	-	1
‘Sphenosuchia’ s. l.	-	-	-	2	2
Basal crocodyliforms	-	-	-	7	1
Notosuchia s. l.	-	-	-	15	-
Teleosauroidea	-	-	-	1	1
Basal metriorhynchoids	-	-	-	1	1
Basal metriorhynchines	-	-	-	1	1
Indet. Neosuchia	-	-	-	1	-
Atoposauridae	-	-	-	1	-
Bernissartiidae	-	-	-	1	-
Paralligatoridae	-	-	-	2	-
Hylaeochampsidae	-	-	-	1	-
Crown-Crocodylia	-	-	-	3	2
Goniopholididae	-	-	-	4	2
Pholidosauridae	3	3	3	5	8
Basal to dyrosaurids	-	-	-	-	3
Dyrosauridae	13	14	15	4	15
Total number of OTUs	16	17	18	49	37
Total character number	82	82	82	234	120
OTU # / Characters #	5.125 : 1	4.824 : 1	4.556 : 1	4.776 : 1	3.243 : 1

Table 5. Break-down of the OTUs per clade from the major different iterations of the Young dataset, ultimately merged into the Hastings and Young (H+Y) matrix. Young *et al.* (2016) utilised two datasets: 1) first iteration of a merged dataset, an updated version of the matrix of Hastings *et al.* (2015) with characters used by Young; and 2) an updated version of Young (2014) matrix. Note, the taxonomic break-down is based on the current topology, which for some OTUs will differ from the position they had in earlier less complete analyses. * note, the analysis for Young *et al.* (2013a) is actually a precursor to the Young *et al.* (2012) paper, which ended up being published first.

Clades of OTUs	Young (2006)	Wilkinson <i>et al.</i> (2008)	Young (2009) / Young & Andrade (2009)	Young <i>et al.</i> (2011)	Young <i>et al.</i> (2013a) *	Young <i>et al.</i> (2012)	Young <i>et al.</i> (2013) / Young (2014)	Young <i>et al.</i> (2016, ds2-Young)
Non-crocodylomorph outgroup	-	-	1	1	1	1	1	1
‘Sphenosuchia’ s. l.	-	2	3	1	1	3	3	4
Basal crocodyliforms	1	1	1	1	1	1	1	1
Notosuchia s. l.	-	-	11	-	-	11	11	12
Atoposauridae	1	1	2	-	-	2	2	2
Goniopholididae	1	1	5	3	3	4	4	5
Susisuchidae	-	-	2	1	1	2	2	2
Hylaeochampsidae	-	-	-	-	-	-	-	2
Crown-Crocodylia	-	2	4	3	3	3	3	4
Pholidosauridae	-	-	6	1	1	1	1	7
Basal to dyrosaurids	-	-	-	-	-	-	-	3
Dyrosauridae	-	-	7	-	-	-	-	8
Teleosauroidea	1	1	4	1	1	9	9	12
Basal metriorhynchoids	2	2	6	6	6	6	6	6
Basal metriorhynchines	4	5	6	5	5	5	5	3
Rhacheosaurini	4	5	12	11	11	11	11	13
Basal geosaurines	3	3	5	5	5	5	5	5
Geosaurini	4	5	11	11	12	9	11	14
Total number of OTUs	21	28	86	50	51	73	75	104
Total character number	54	82	166	190	201	240	251	298
<i>OTU # / Characters #</i>	<i>2.571 : 1</i>	<i>2.929 : 1</i>	<i>1.930 : 1</i>	<i>3.800 : 1</i>	<i>3.941 : 1</i>	<i>3.288 : 1</i>	<i>3.467 : 1</i>	<i>2.865 : 1</i>

Table 6. Break-down of the OTUs per clade from the different iterations of the merged Hastings + Young (H+Y) matrix. Note, the taxonomic break-down is based on the current topology, which for some OTUs will differ from the position they had in earlier less complete analyses.

Clades of OTUs	Ristevski <i>et al.</i> (2018)	Ösi <i>et al.</i> (2018)	Current
Non-crocodylomorph outgroup	1	1	1
‘Sphenosuchia’ s. l.	5	5	5
Basal crocodyliforms	5	5	5
Notosuchia s. l.	12	12	12
Atoposauridae	2	2	2
Goniopholididae	8	7	7
Bernissartiidae	2	2	2
Susisuchidae	2	2	2
Hylaeochampsidae	2	2	2
Crown-Crocodylia	4	4	4
Pholidosauridae	10	11	11
Basal to dyrosaurids	1	2	2
Dyrosauridae	16	17	17
Teleosauroidea	18	18	18
Basal metriorhynchoids	7	8	8
Basal metriorhynchines	4	4	4
Rhacheosaurini	14	14	15
Basal geosaurines	5	5	5
Geosaurini	19	19	19
Total number of OTUs	137	140	141
Total character number	387	454	460
<i>OTU # / Characters #</i>	<i>2.825 : 1</i>	<i>3.243 : 1</i>	<i>3.262 : 1</i>

SOM 1.4. 3D files (SOM 2) and orthophoto (SOM 3) creation information and viewing instructions

Data capture

For data capture, the Plexiglas cover of the fossil was removed. The specimen remained mounted on the wall in the exhibit of the NKMB, with regular exhibit illumination (room lights and spotlights) turned on. With a Canon EOS 80D DSLR, a Canon EF-S 10-18 mm lens, and a Neewer LED ring light, a total of 1348 photographs in JPEG format (9.43 GB) were taken of the specimen, rastering its surface. The camera was held freehand and aimed approximately perpendicular to the surface of the fossil. Images were captured so that each overlapped at least 60% with neighboring images. The camera settings were: ISO 800, exposure -0.3, manual white balance 5000K, automatic exposure and f-stop, autofocus. Additionally, 1010 JPEG images (8.15 GB) were taken of regions of interest of the skeleton (skull, girdles and limbs) in the same way with a Canon EOS 80D DSLR, a Canon EF 100mm f/2.8L Macro lens, and a Neewer LED ring light. Settings were as above, but with exposure set to 1/400 s.

For scaling we included two Palaeo3D (www.palaeo3d.com) 25 cm linear photogrammetric scale bars and one 2x25 cm orthogonal photogrammetric scale bar.

Photogrammetric reconstruction

The 2358 images were loaded into Reality Capture (PGM license, www.capturingreality.com) and aligned on default settings, with the exception of *Image overlap* set to *Low*, *Max features per mpx* set to *200.000*, *Max features per Image* set to *400.000*, *Detector sensitivity* set to *High*, and *Distortion model* set to *Brown4 with tangential2*. The alignment produced two separate components, one of the main slab with 2153 images aligned, and one of the tail slab with 197 images aligned.

Of the scale bars, one linear scale bar fell into the tail slab component, and the other linear bar along with the orthogonal bar fell into the main slab component.

Attempts to align the two components into one resulted into a false positive alignment, with the tail slab partially superimposed on the main slab. This failure was caused by false positive feature matching on the very uniform limestone around the skeleton.

Automatic marker detection (*Circular, single-ring, 20 bit*) was employed to create markers on the scale bar targets. All detected markers placements with error greater than 2.0 pixels were deleted. The scale bars created from these markers deviate from their actual length of 25 cm by 0.000228 m, 0.000129 m, and -0.000174 m (main slab) and 0.000004 m (tail slab), for a maximal error of less than 0.1% for the main slab. The tail slab error is meaningless, as it originates from program-specific scaling algorithms and cannot be compared to a second scale bar.

Model creation

Settings for model creation were ‘Normal’ resolution, *Image downscale factor* set to *2*, and *Detail decimation factor* set to *1*. The reconstruction region was set to include only the fossil and a small strip of surrounding matrix, not the entire slabs, to reduce computation time and file size.

For the main slab, the software created a model with ca. 289 million polygons. Cropping irrelevant regions reduced the number of polygons to just short of 260 million, with an

average edge length of 0.004 mm. For the tail slab, a model with nearly 13.5 million polygons resulted, with an average edge length of 0.08 mm.

Both models were reduced in polygon count to achieve tolerable file sizes, with the main slab at 1 million polygons and the tail slab at 100,000 polygons. They were exported as PLY files with vertex color and form SOM 2.

Main slab: http://app.pan.pl/SOM/app64-Sachs_etal_SOM/SOM_2_1.ply

Tail slab: http://app.pan.pl/SOM/app64-Sachs_etal_SOM/SOM_2_2.ply

Orthophoto creation

Based on the high resolution models described above, a 16k orthophoto was calculated for each part. These images were combined in Corel PaintShopPro X9 (www.corel.com) into one JPEG image of ca. 100 MB file size to form SOM 3

http://app.pan.pl/SOM/app64-Sachs_etal_SOM/SOM_3.jpg

As Reality Capture lacks the capability of embedding a scale bar in the orthophoto render, one of the linear 25 cm scale bars was modelled separately, and the resulting model also rendered as an orthophoto at the same scale and resolution as the models of the main and tail slabs. Then, a scale bar was created in PaintShopPro to match the centers of the two targets visible in the model, and scaled to 40% to achieve a scale bar length of 10 cm in the figure.

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SOM 1.5. List of institutional abbreviations

- AMNH**, American Museum of Natural History, New York City, NY, USA
BPI, Bernard Price Institute, Johannesburg, South Africa
BRLSI, Bath Royal Literary and Scientific Institute, Bath, England, UK
BRSMG, Bristol City Museum & Art Gallery, Bristol, England, UK
BSPG, Bayerische Staatssammlung für Paläontologie und Historische Geologie, München, Germany
CAMSM, Sedgwick Museum of Earth Science, University of Cambridge, England, UK
CM, Carnegie Museum of Natural History, Pittsburgh, PA, USA
CMC, Cincinnati Museum Center, Cincinnati, OH, USA
DORCM, Dorchester County Museum, Dorchester, United Kingdom
DGM, Departamento Nacional de Produção Mineral, Rio de Janeiro, Brazil
FEF, Fundação Educacional de Fernandópolis, Fernandópolis, Brazil
FMNH, Field Museum of Natural History, Chicago, Illinois, USA
GLAHM, Hunterian Museum, Glasgow, Scotland, UK
IGM, Mongolian Institute of Geology, Ulaan Bataar, Mongolia
IRSNB, Institut Royal des Sciences Naturelles de Bruxelles, Belgium
IVPP, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China
IWCMS, Isle of Wight County Museums Services (Dinosaur Isle Museum and visitor attraction) Sandown, UK
LACM, Natural History Museum of Los Angeles County, Los Angeles, California, USA
MACN, Museo Argentino de Ciencias Naturales ‘Bernardino Rivadavia’, Buenos Aires, Argentina
MANCH, Manchester Museum, Manchester, United Kingdom
MB, Museum für Naturkunde der Humboldt Universität, Berlin, Germany
MCZ, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA
ME, Musée d’Elbeuf, Elbeuf, Normandie, France
MHNG, Muséum d’histoire Naturelle de la Ville de Genève, Switzerland
MHNSR, Museo de Historia Natural de San Rafael, San Rafael, Argentina
MJML, Museum of Jurassic Marine Life, Kimmeridge, Dorset, England, UK
MLP, Museo de La Plata, La Plata, Argentina
MNHN.F, fossil collection of the Muséum national d’Histoire naturelle, Paris, France (ALG, Algiers locality; CNJ, Canjeurs locality; GDF, Gadoufaoua (Tegema Beds); INA, In Abangharit locality; MRS, Maroc Sud, i.e. Kem Kem localities; SAM, Gara Samani locality)
MN-UFRJ, Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil
MOZ, Museo Profesor J. Olsacher, Zapala, Argentina
MPCA, Museo Provincial “Carlos Ameghino”, Cipolletti, Rio Negro, Argentina
MPEF, Museo Paleontologico Egidio Feruglio, Trelew, Argentina
MPMA, Museu de Paleontologia de Monte Alto, Monte Alto, Brazil
MTM, Magyar Természettudományi Múzeum, Budapest, Hungary
MUCPv, Museo de la Universidad Nacional del Comahue, Neuquén, Argentina
NHMUK PV, vertebrate palaeontology collection of the Natural History Museum, London, England, UK (OR, old register; R, reptiles)
NJSM, New Jersey State Museum, Trenton, New Jersey, USA
OMN, Musée de l’Office National Des Mines, Tunis, Tunisia
OUMNH, Oxford University Museum of Natural History, Oxford, England, UK
PETMG, Peterborough Museum & Art Gallery, Peterborough, England, UK

PVL, Instituto Miguel Lillo, Tucuman, Argentina
RCL, Museu de Ciências Naturais da Pontifícia Universidade Católica de Minas Gerais, Belo Horizonte, Brazil
RMS, Royal Museum Scotland, Edinburgh, Scotland, UK
SAM, Iziko-South African Museum, Cape Town, South Africa
SMNK, Staatliches Museum für Naturkunde Karlsruhe, Germany
SMNS, Staatliches Museum für Naturkunde Stuttgart, Germany
UA, University of Antananarivo, Madagascar
UCMP, University of California Museum of Paleontology, Berkeley, California, USA
UF/IGM, University of Florida, Florida Museum of Natural History, Gainesville, Florida, USA / Museo Geológico, at the Instituto Nacional de Investigaciones en Geociencias, Minería y Química, Bogotá, Colombia
UFRJ-DG, Departamento de Geologia, Universidade Federal do Rio de Janeiro, Brazil
URC, IGCE-UNESP, Museu “Paulo Milton Barbosa Landim”, Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista, Rio Claro, Brazil
USNM, National Museum of Natural History, Washington DC, USA
YPM, Peabody Museum of Natural History, Yale University, New Haven, Connecticut, USA
ZPAL, Instytut Paleobiologii PAN, Warszawa, Poland