Quantifying the early ecomorphological diversification of Eosauropterygia

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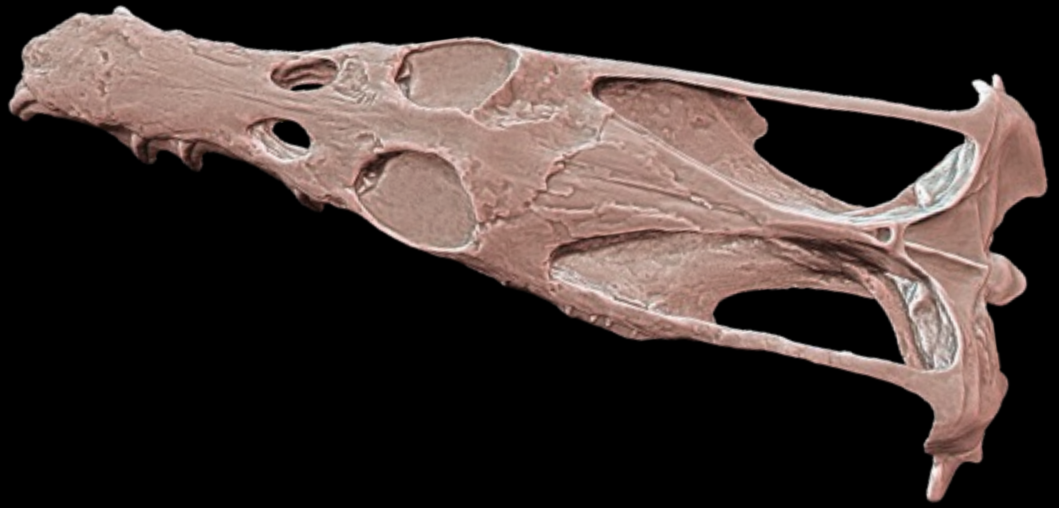
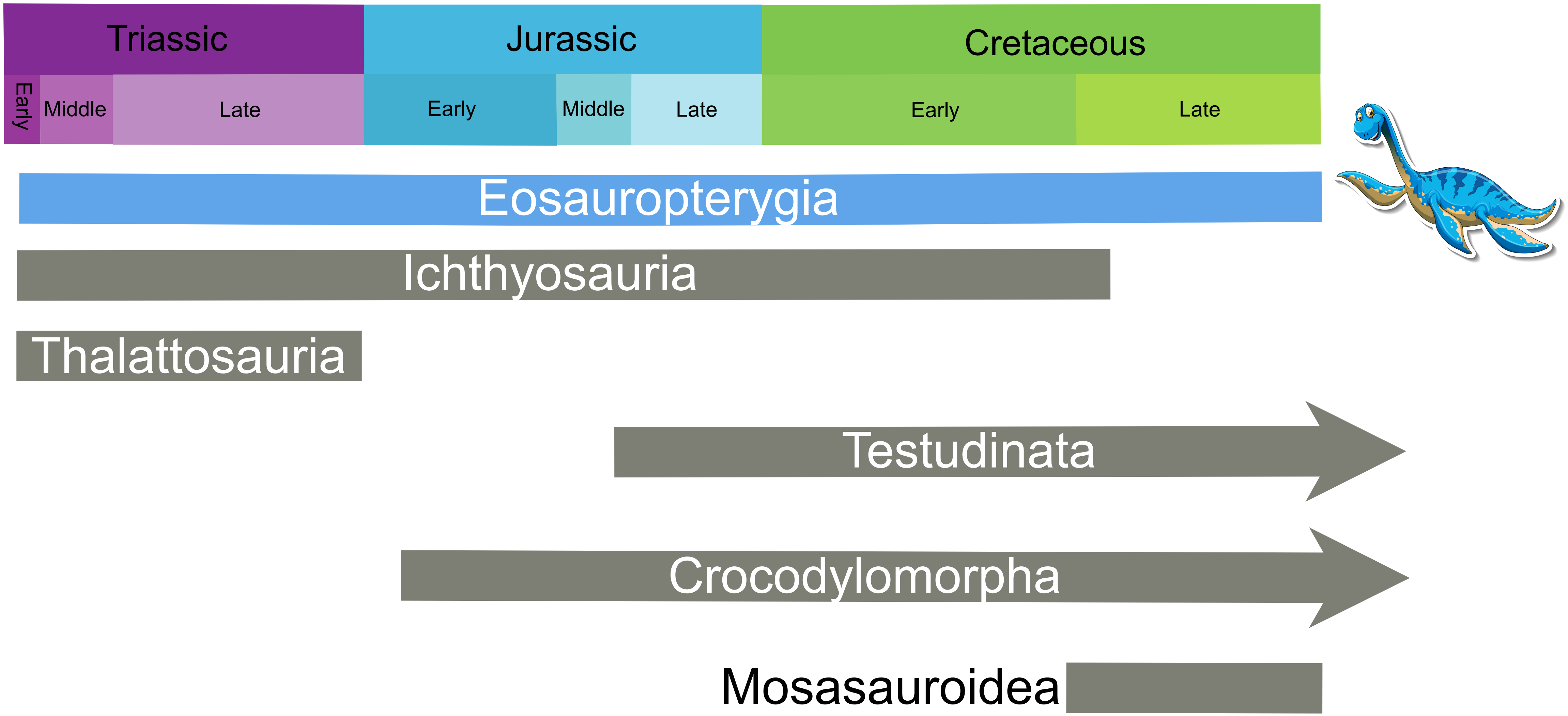
LabouryA

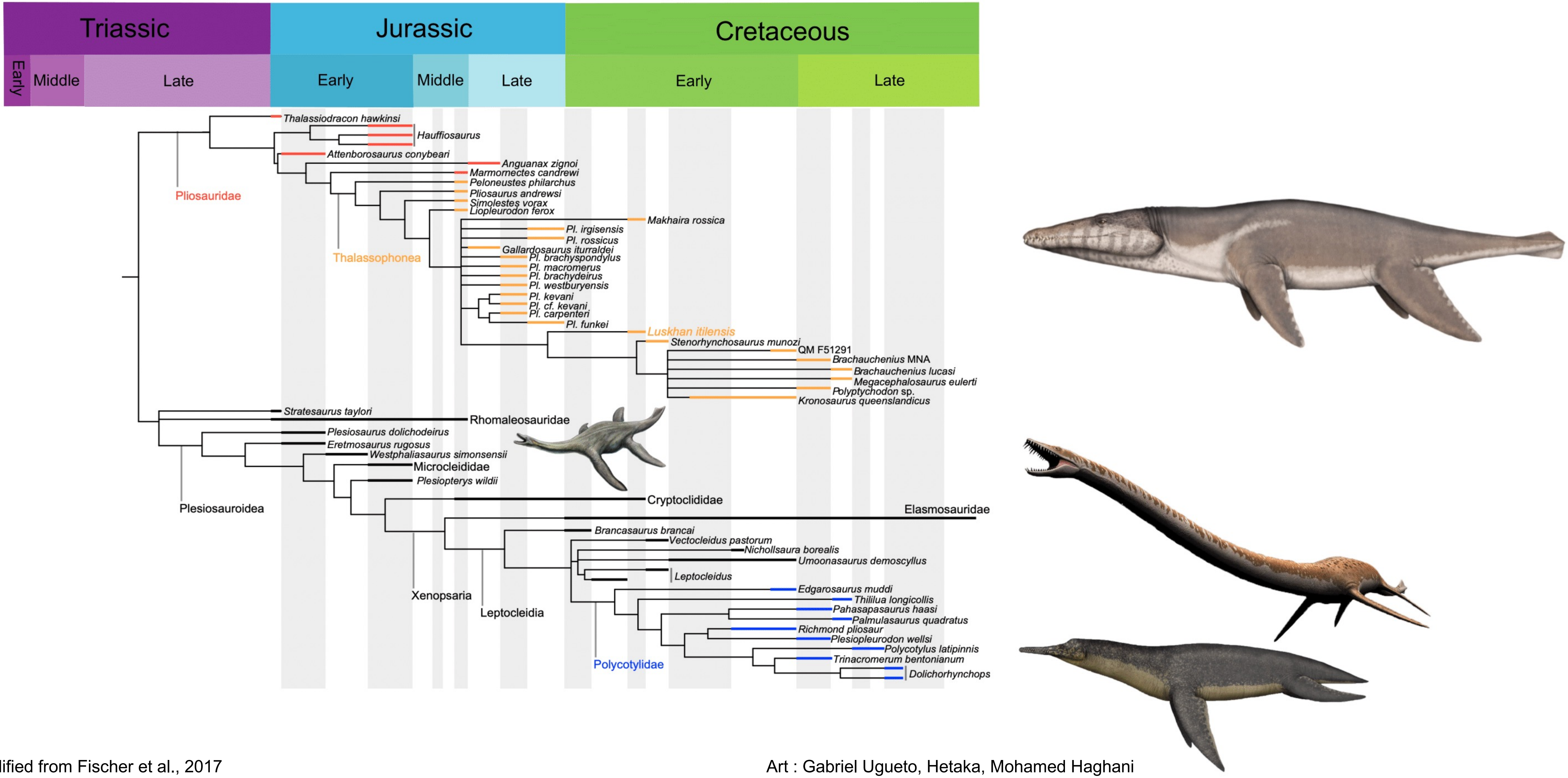


Eosauropterygia, the marine reptile longest-surviving group of the Mesozoic



Art: Freepik.com

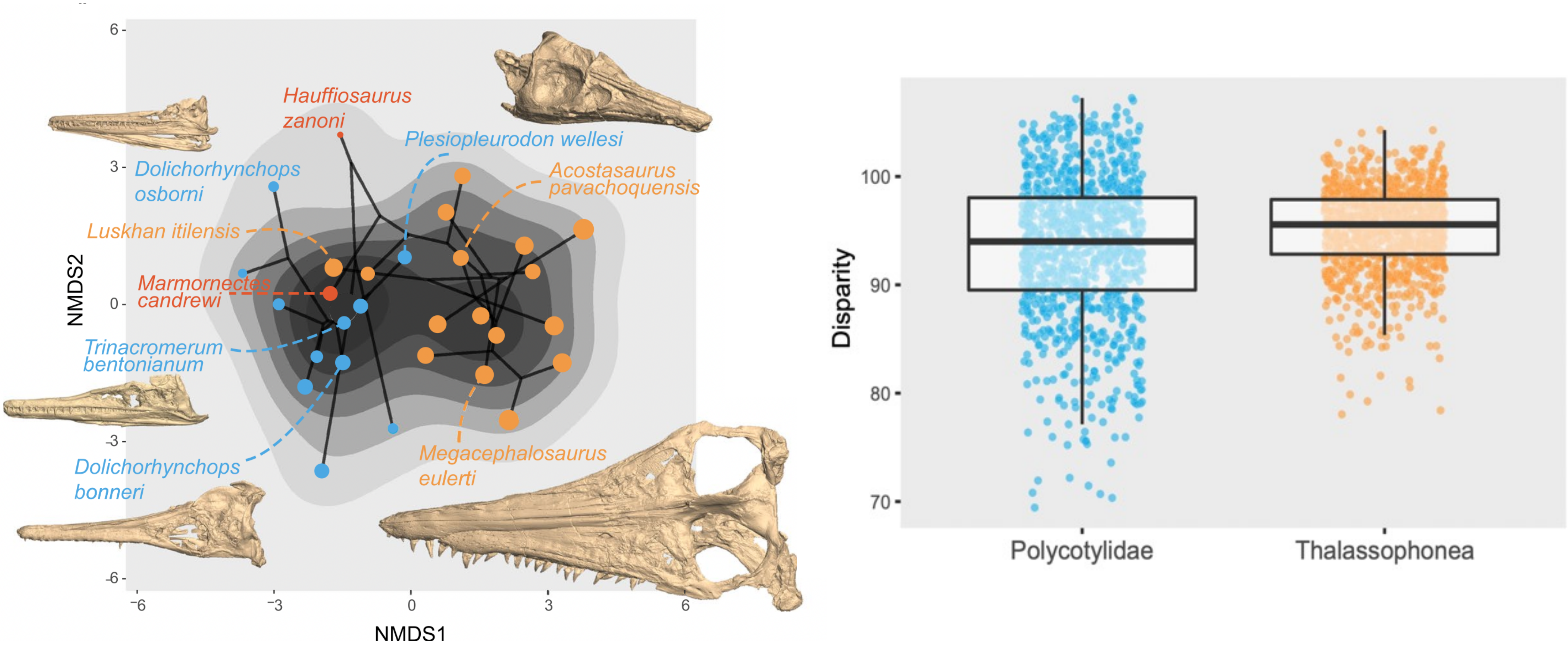
With iconic morphologies among plesiosaurians



Modified from Fischer et al., 2017

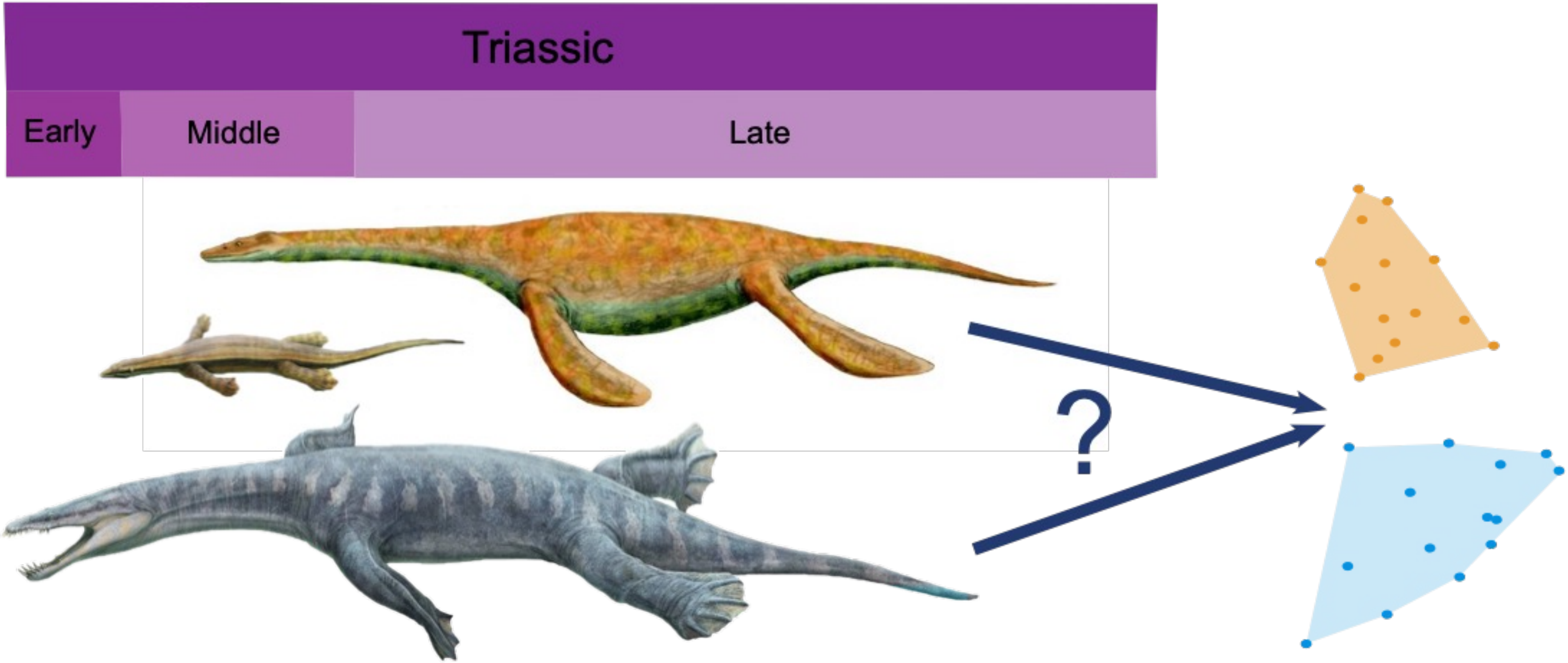
Art : Gabriel Ugueto, Hetaka, Mohamed Haghani

Recent studies investigated the disparity of plesiosaurians



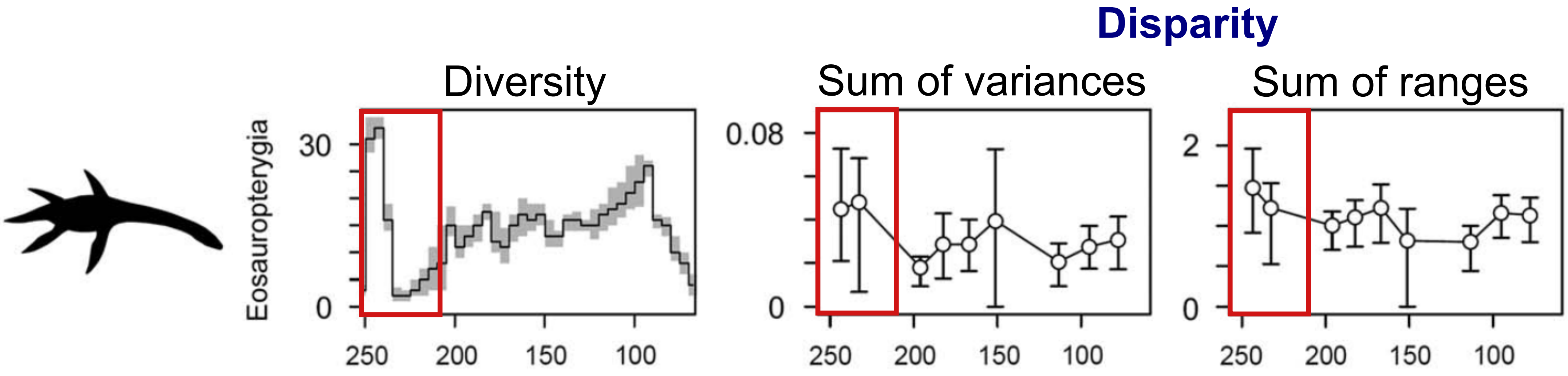
Modified from Fischer *et al.*, 2020

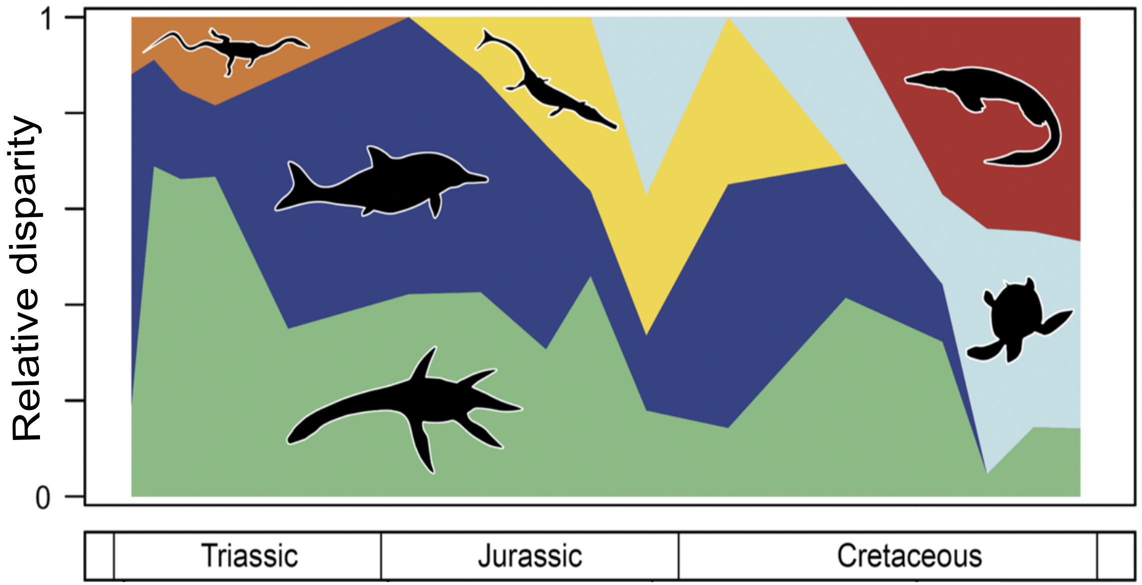
But what do we know concerning Triassic eosauropterygians ?



Art : Gabriel Ugueto, Nobu Tamira

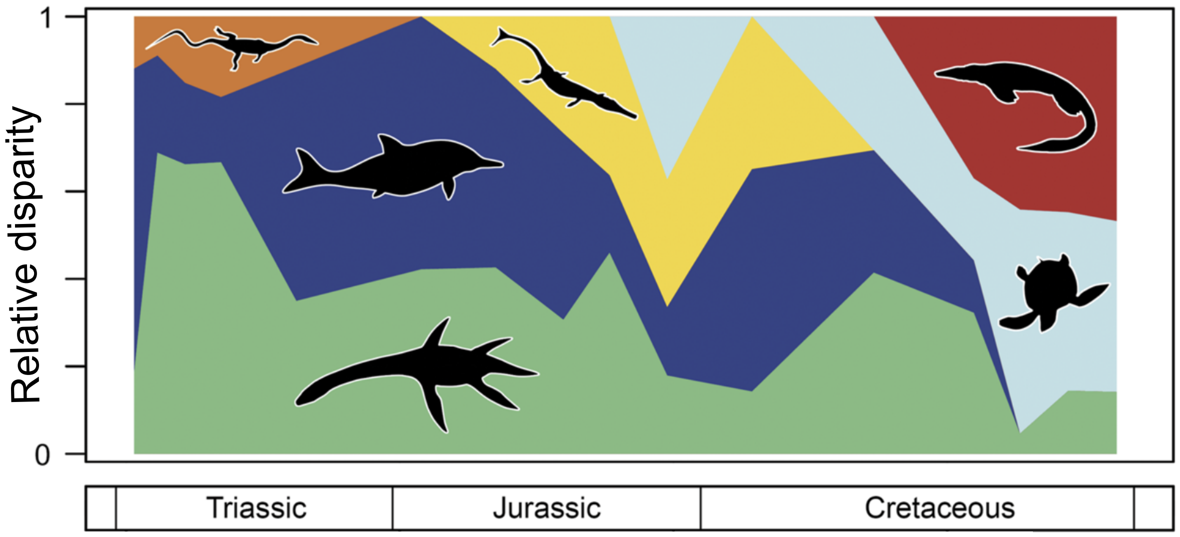
Middle Triassic records the maximum of disparity and diversity



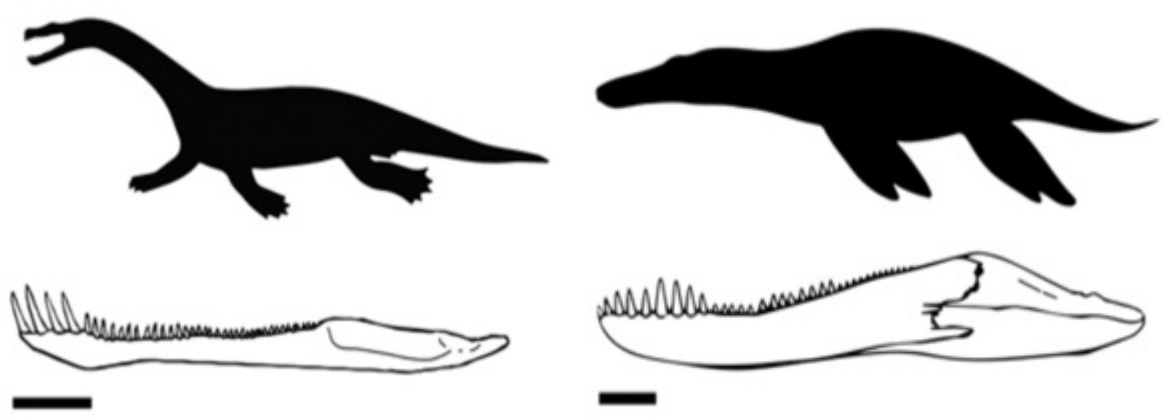


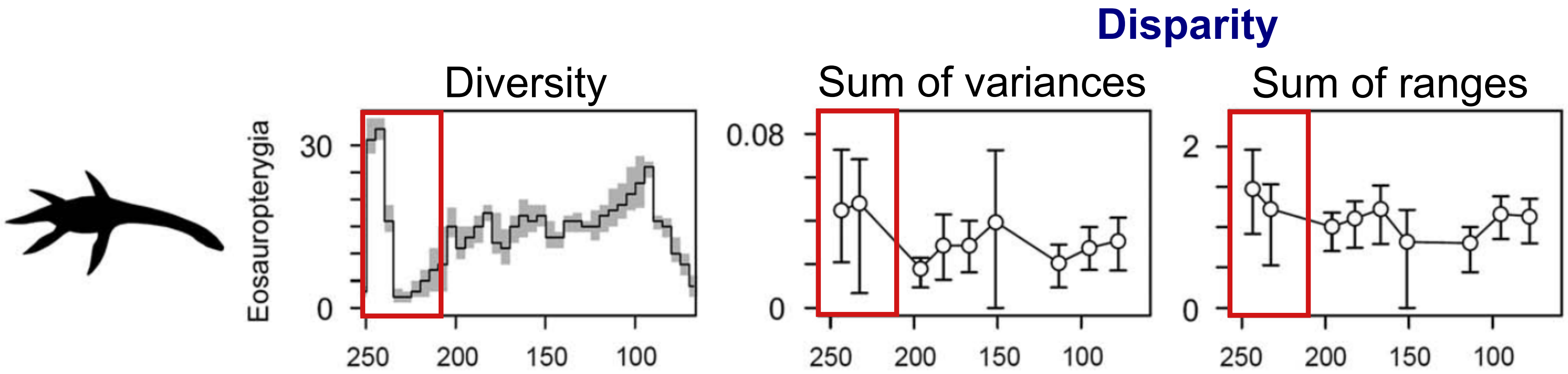
Modified from Stubbs & Benton., 2016

Middle Triassic records the maximum of disparity



Analyses based on the morphology of the mandible and the teeth !





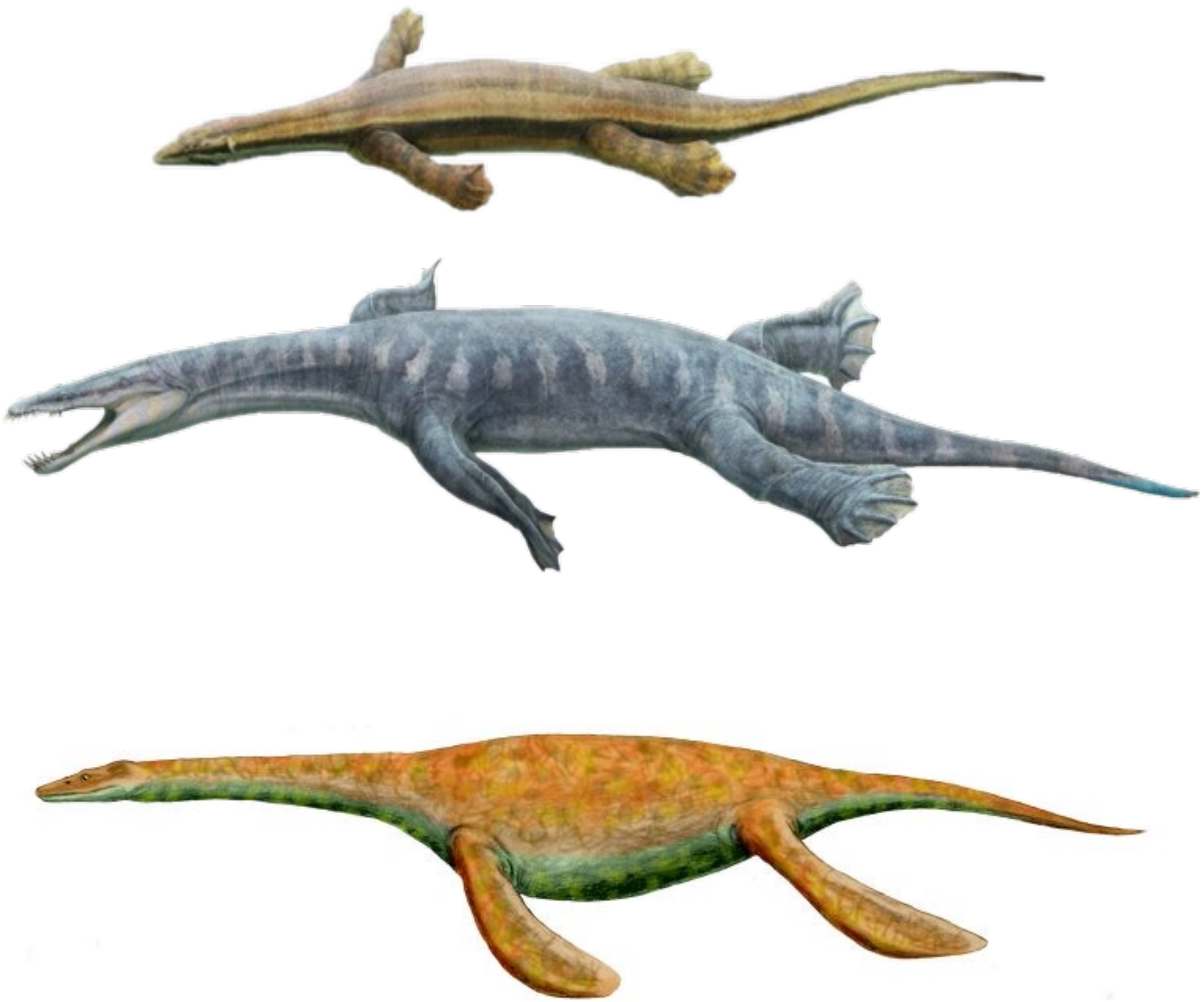
Modified from Stubbs & Benton., 2016

AIM OF THE STUDY

- How did eosauropterygians diversify ecologically during the Middle Triassic ?

- Which clade experienced the highest disparity ?

A large spectrum of Triassic eosauropterygians



Art : Gabriel Ugueto, Nobu Tamira

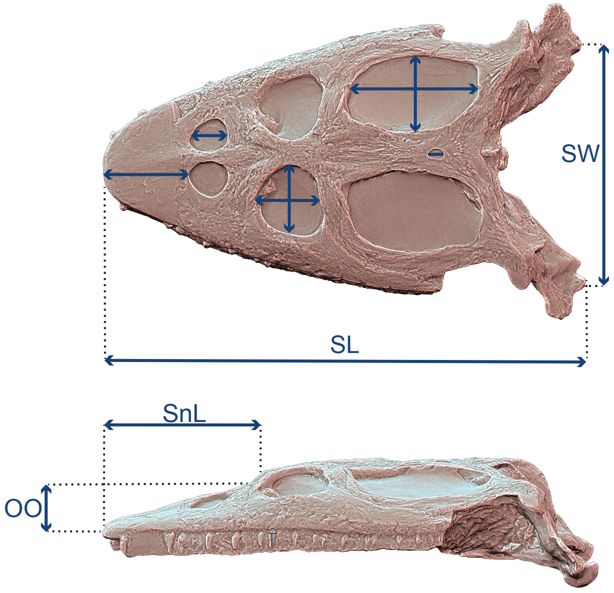
13 species of **pachypleurosauroideans** (115 specimens)

14 species of **nothosauroideans** (45 specimens)

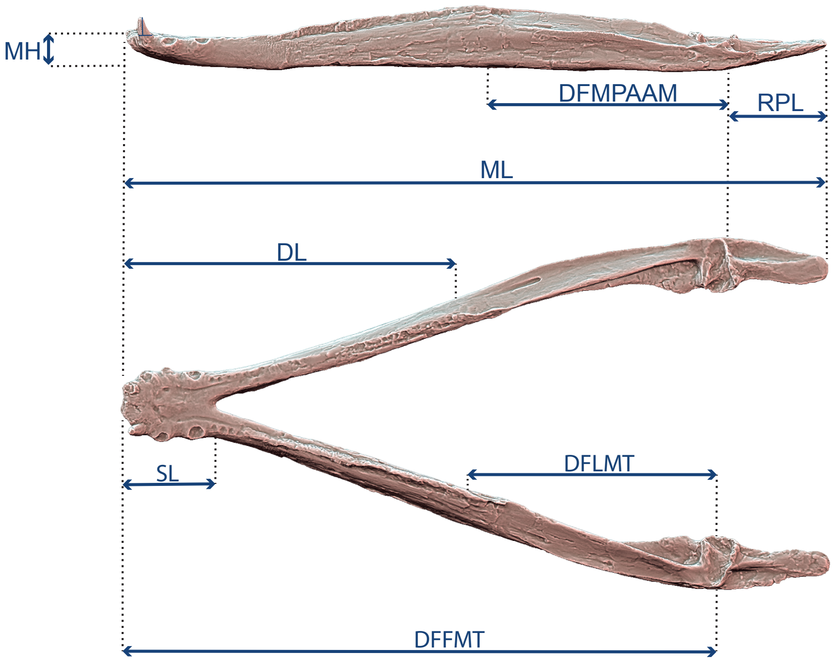
3 species of **pistosauroideans** (4 specimens)

Morphological data to create biomechanically-informative traits

Craniodental data

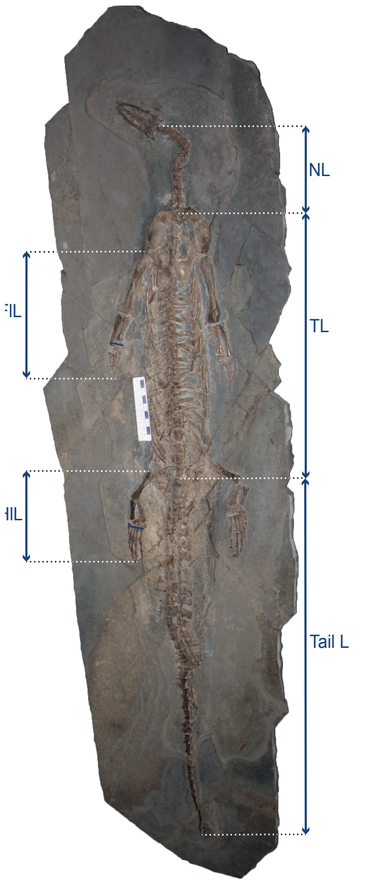


Simosaurus gaillardoti (SMNS 16363)

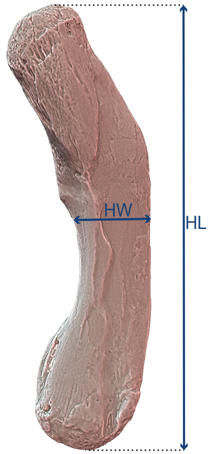


Nothosaurus giganteus (SMNS 18058)

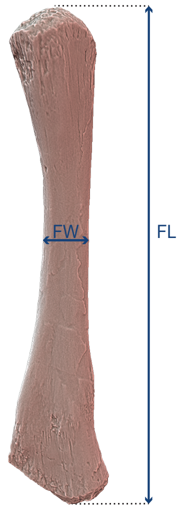
Postcranial data



Neusticosaurus edwardsii (PIMUZ T 3460)



Nothosaurus mirabilis (SMNS 84550)



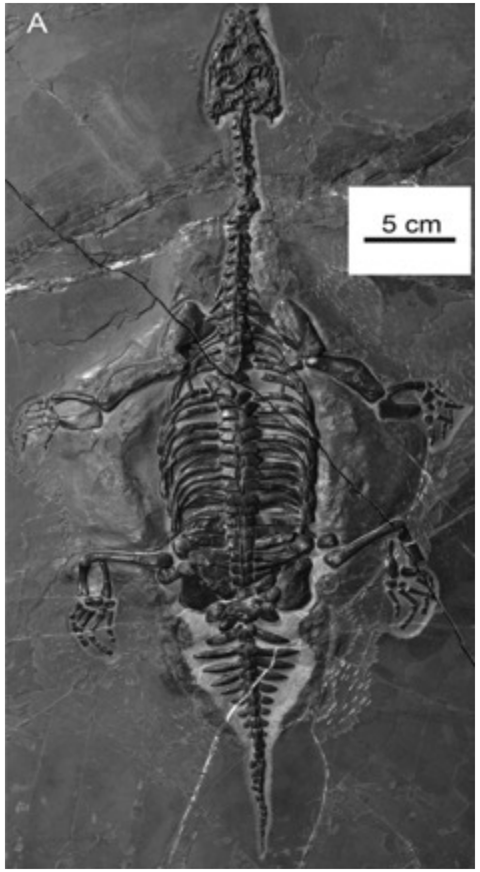
Nothosaurus giganteus (SMNS 1589b)

How were these data collected ?

First-hand measurements

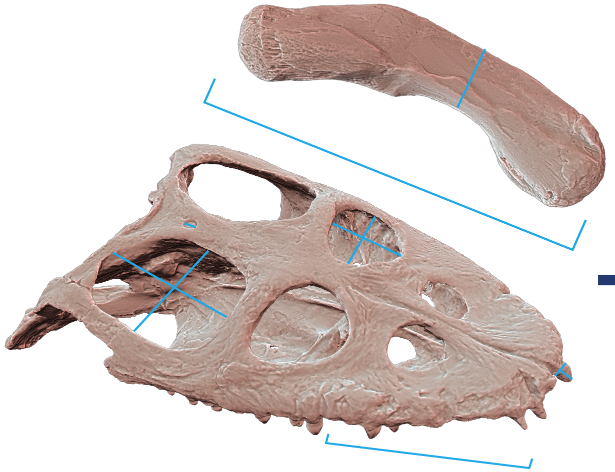
On 3D surface scans

In the literature



Brevicaudosaurus jiyangshanensis (IVPP 18625)
Shang *et al.*, (2020)

A protocol that has been successfully tested



biomechanically informative traits

Dissimilarity matrix based on continuous and binary traits

	Species A	Species B	Species C
Species A	0		
Species B		0	
Species C			0

A protocol that has been successfully tested

biomechanically informative traits

Dissimilarity matrix based on continuous and binary traits

	Species A	Species B	Species C
Species A	0		
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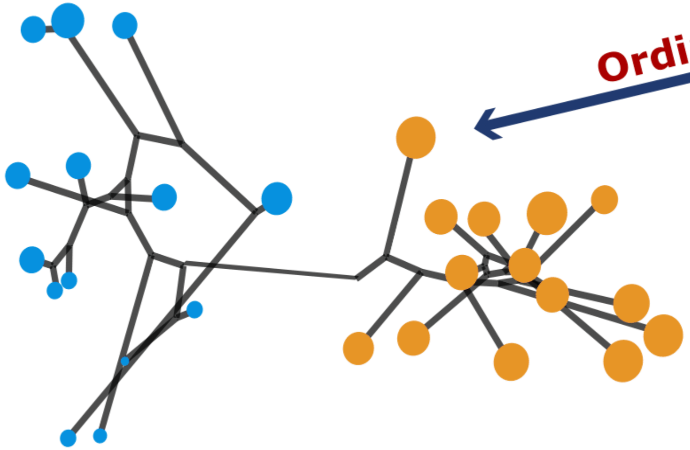
Species C			0

Ordination method + phylogeny



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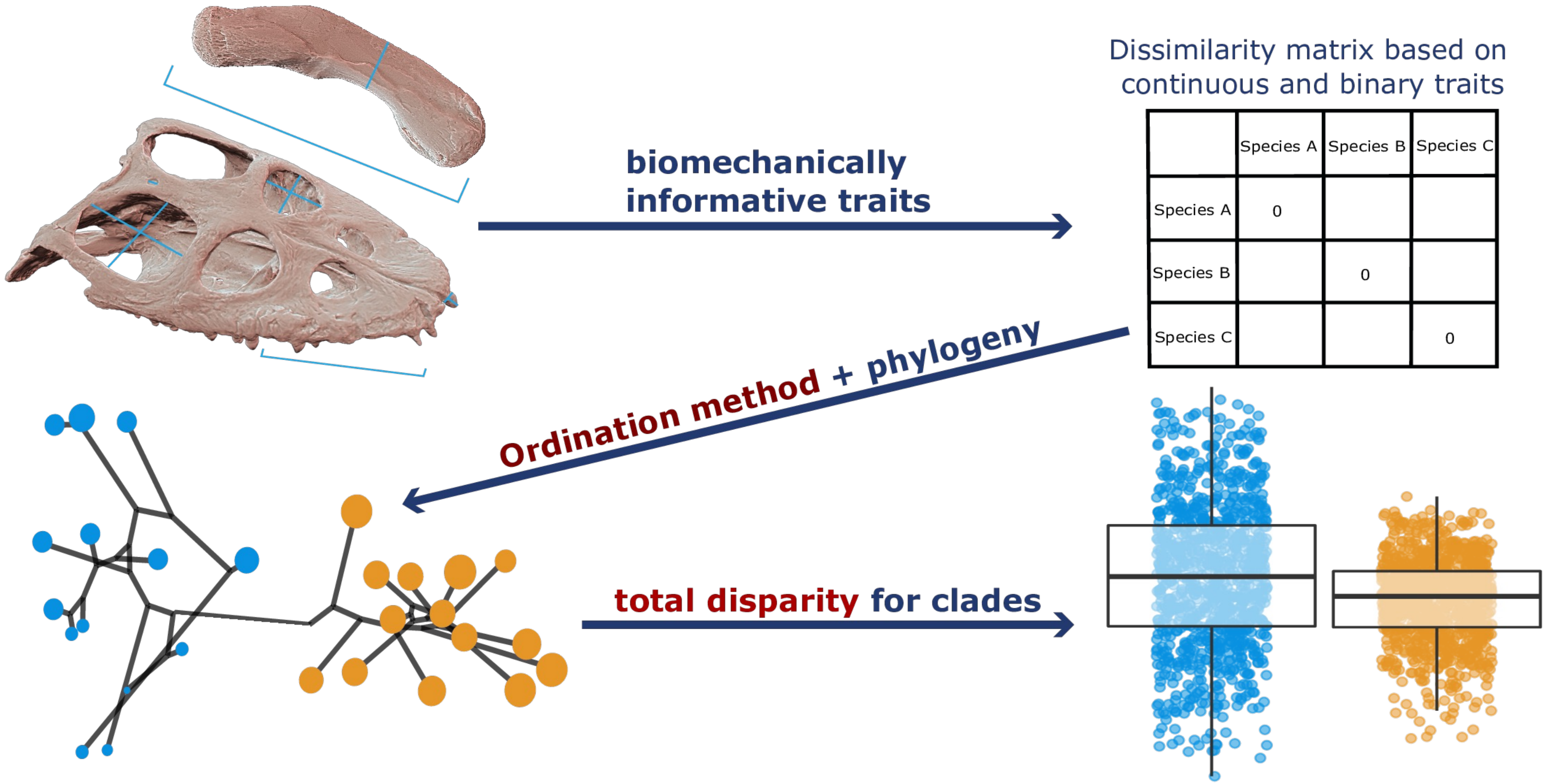
OPEN **A long-tailed marine reptile from China provides new insights into the Middle Triassic pachypleurosaur radiation**

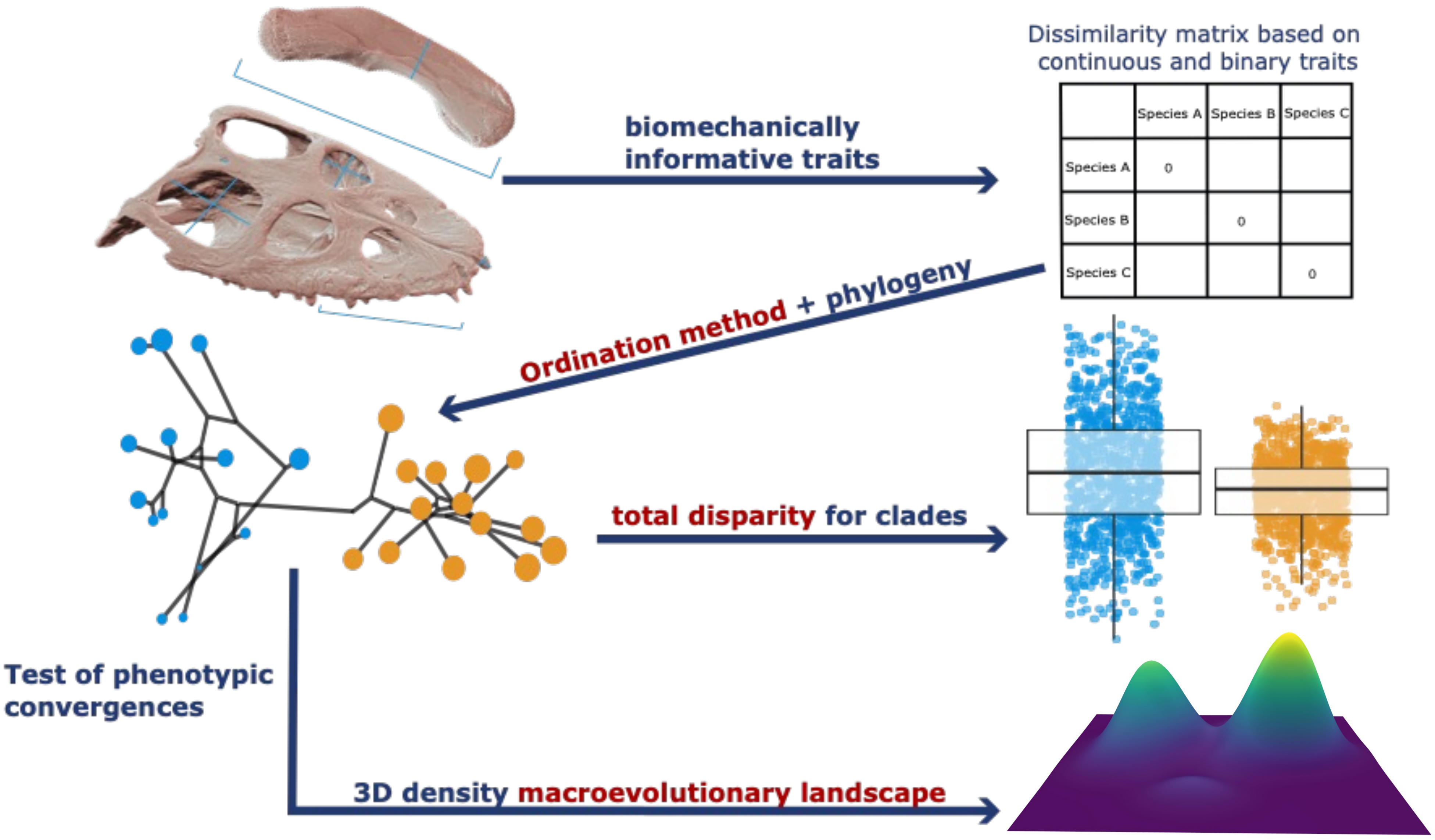
Guang-Hui Xu[1,2], Yi Ren[1,2,3], Li-Jun Zhao[4], Jun-Ling Liao[5,6] & Dong-Hao Feng[1,2,3]

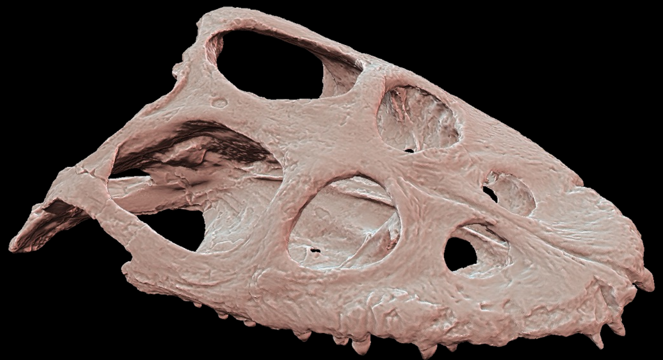
Implied weighting - parsimony ratchet with k = 12, in TNT

A protocol that has been successfully tested

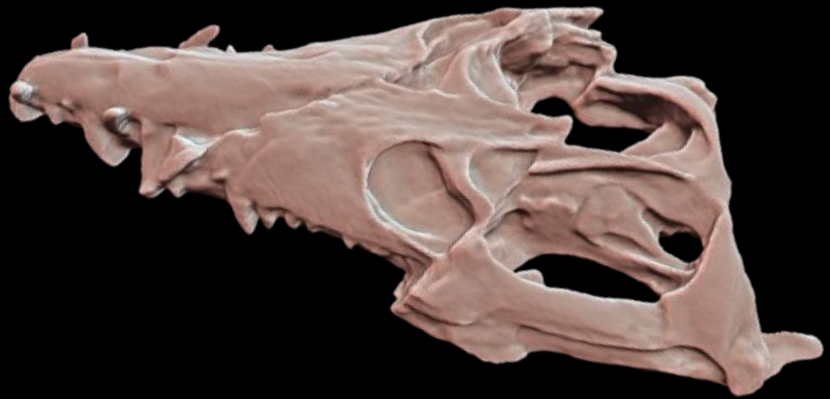


A protocol that has been successfully tested

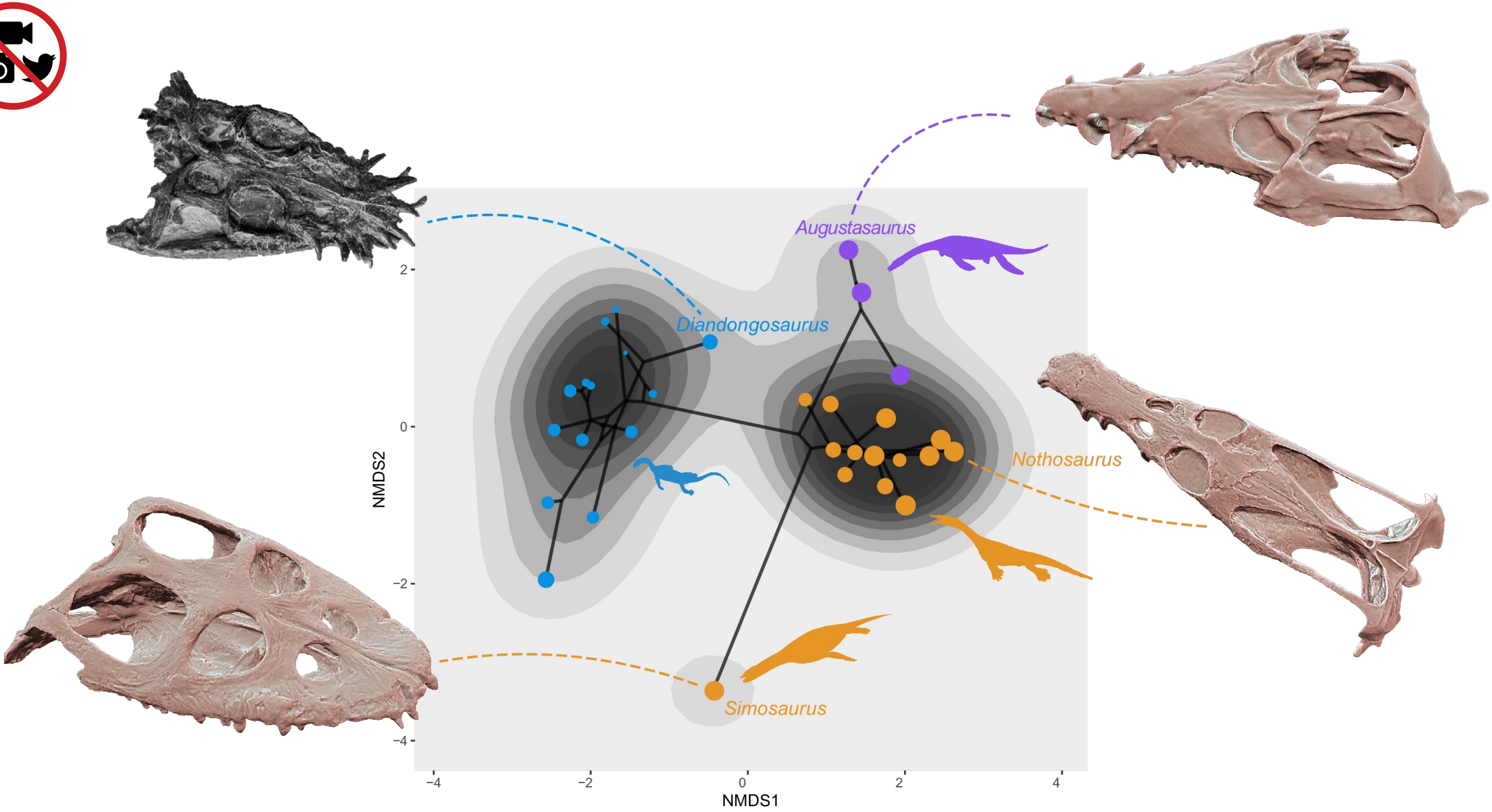



Craniodental analyses

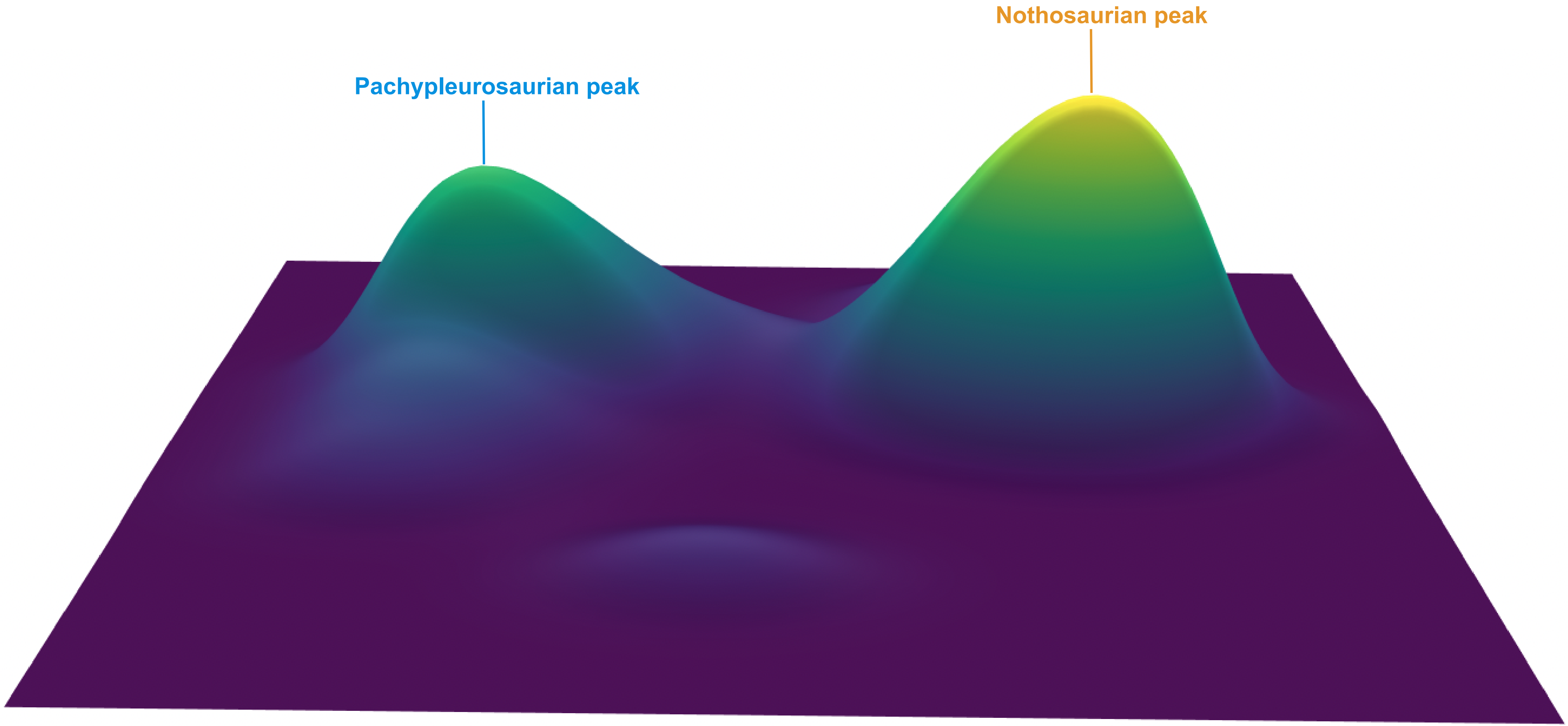



Morphospace occupation driven by phyletic heritage



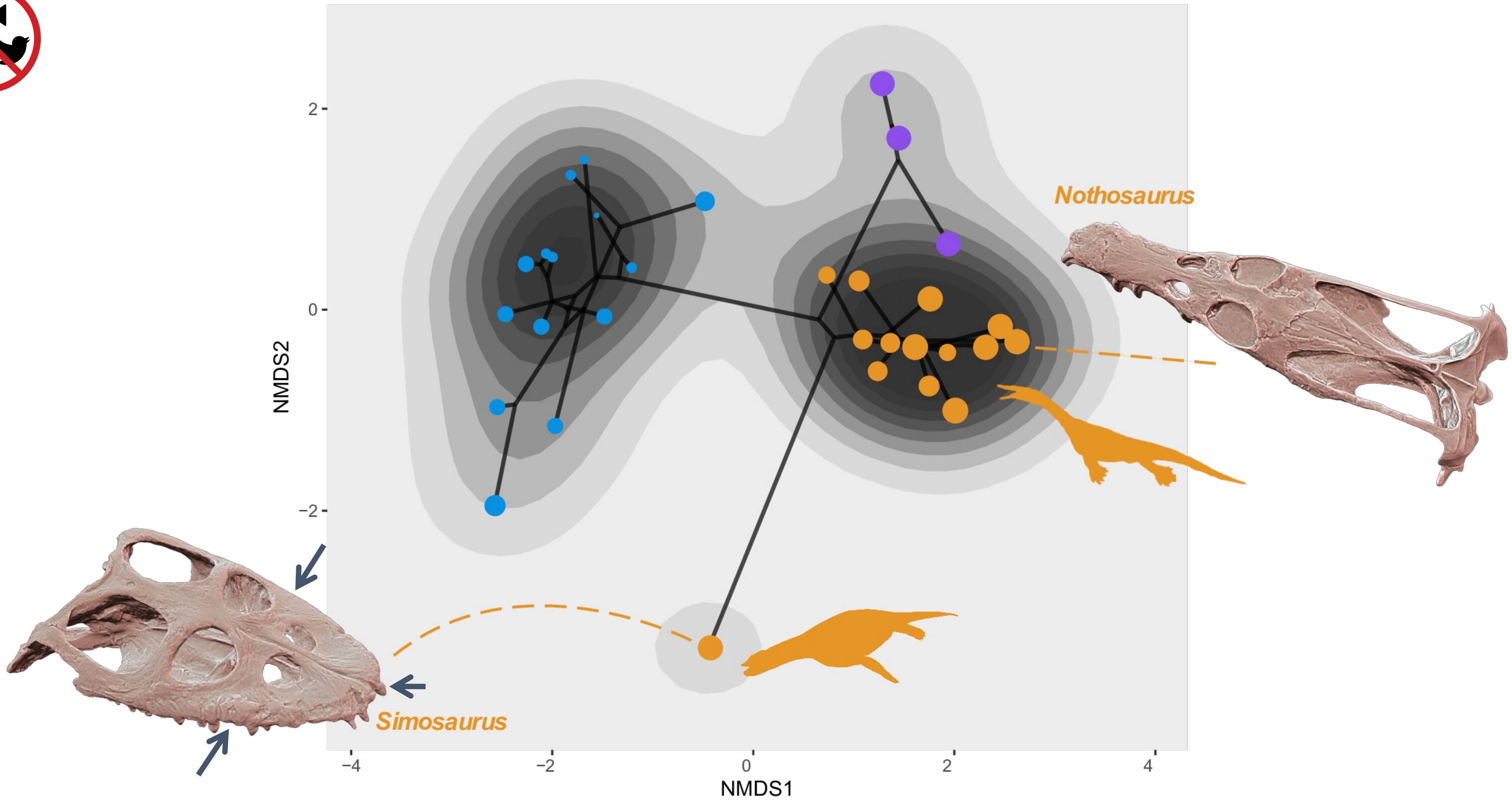
Diandongosaurus acutidentatus (IVPP V 17761). Modified from Shang *et al.*, 2011

Clear distinction in cranial architecture of non pistosauroids

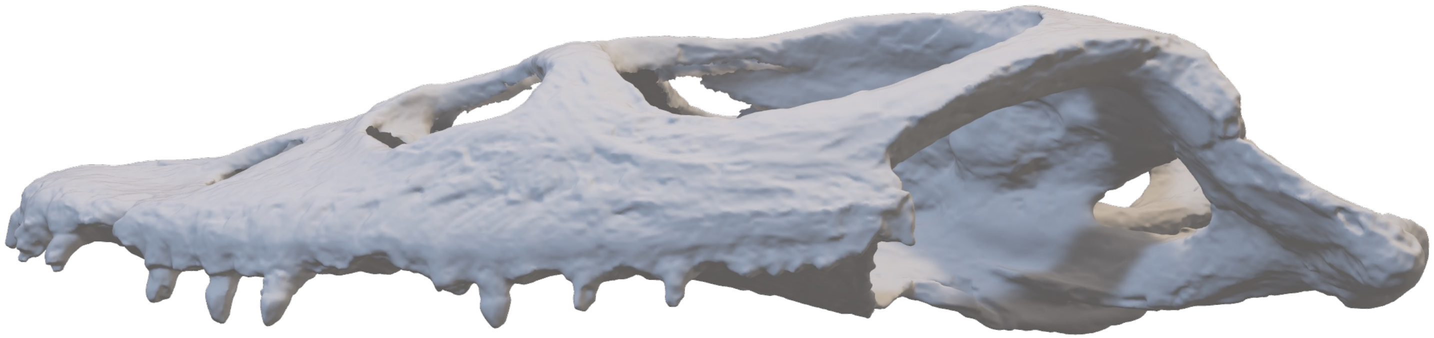


3D craniodental macroevolutionary landscape

Simosaurus has a different evolutionary trajectory than other nothosauroids…

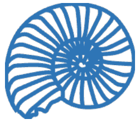


Reflected by two distinct cranial architecture and feeding strategies



Simosaurus gaillardoti (GPIT PV-60638)

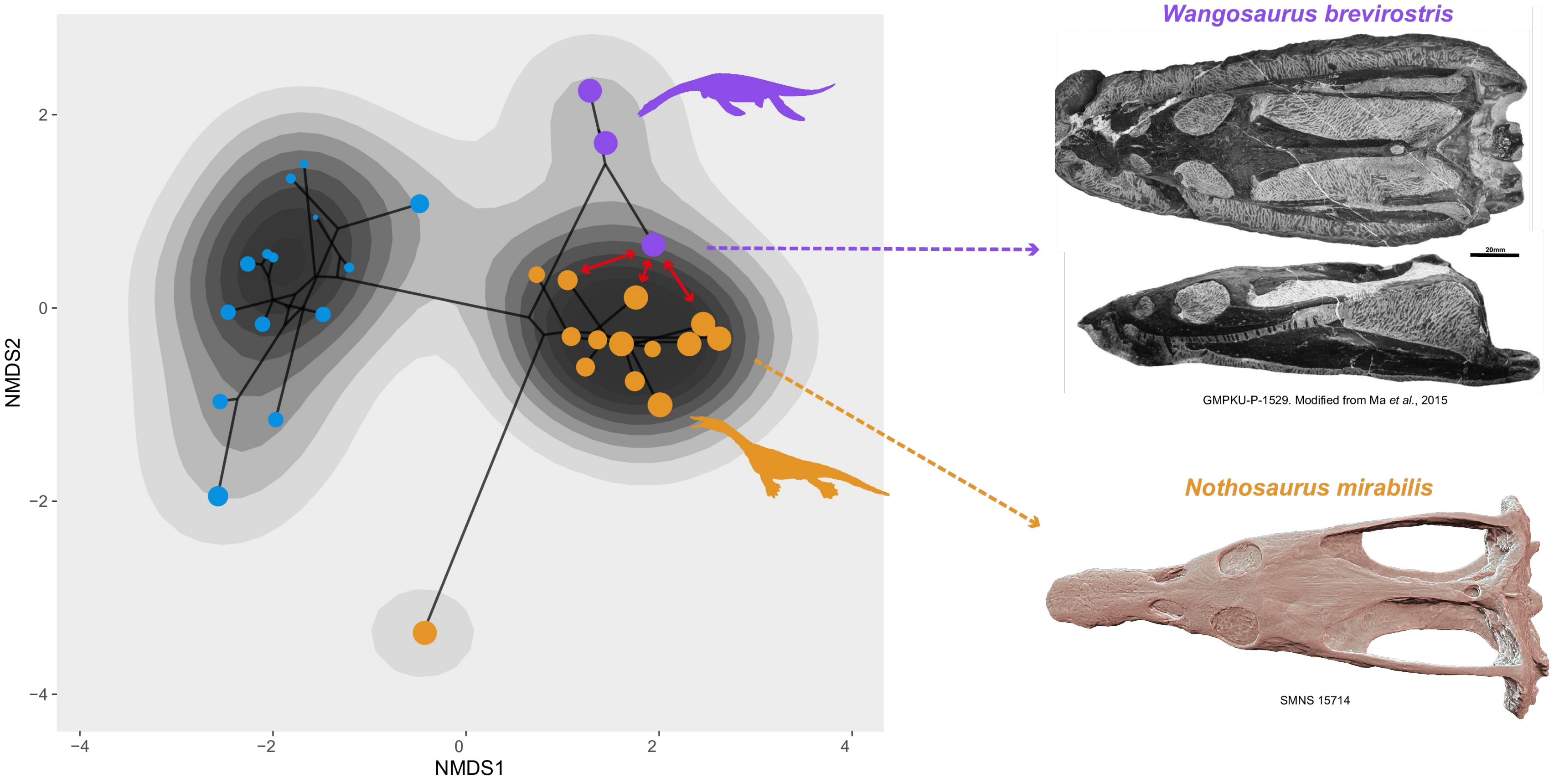
- Broad brevirostrine snout with no constriction
- Short and blunt teeth → **durophagous**
- Predator of moderately hard-shelled prey



- Longirostrine snout with no constriction
- Long fangs + needle like teeth → **fish-trap dentition**
- Piscivorous and vertebrates diet

Nothosaurus mirabilis (SMNS 13155)

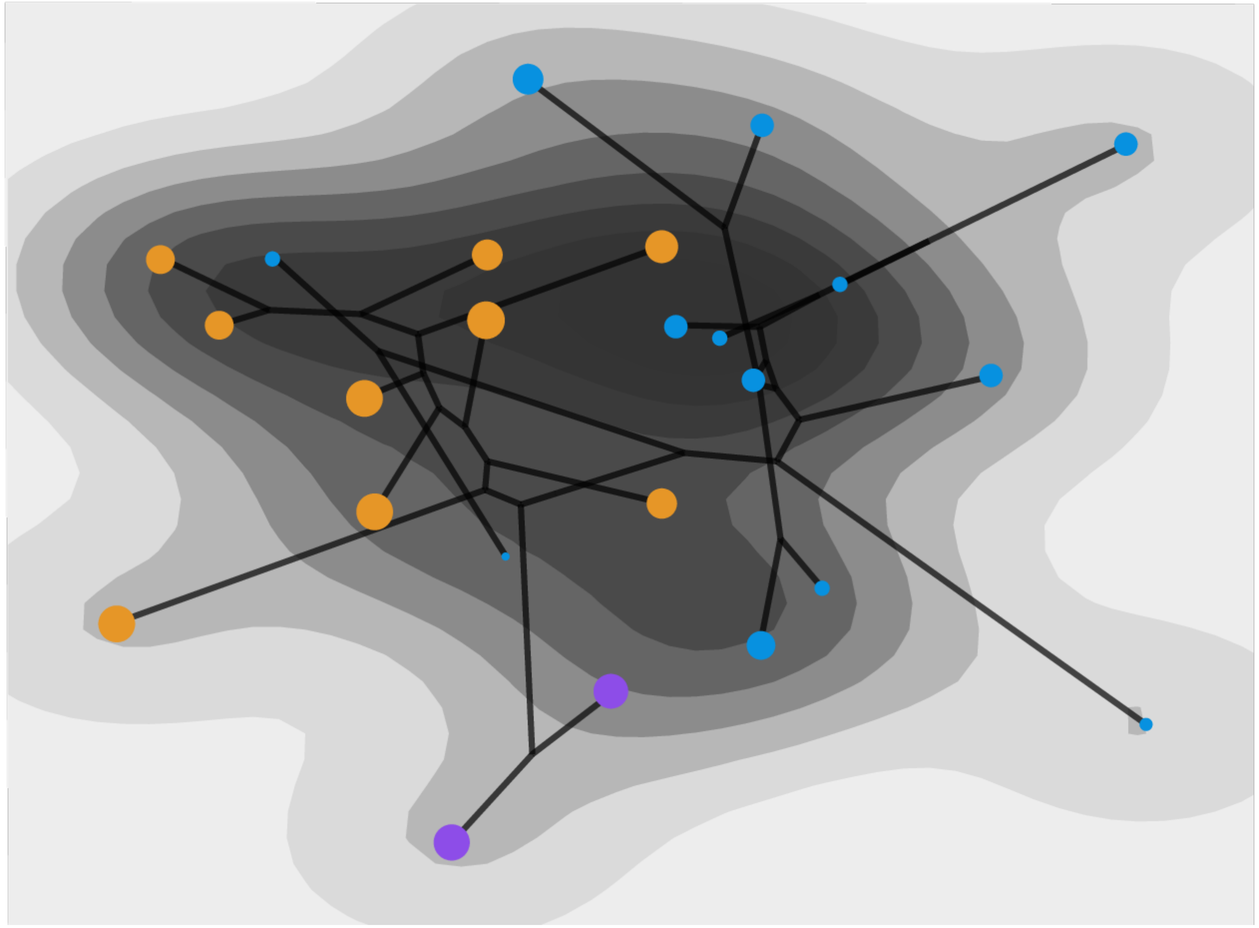
Wangosaurus has a convergent skull morphology with nothosaurians



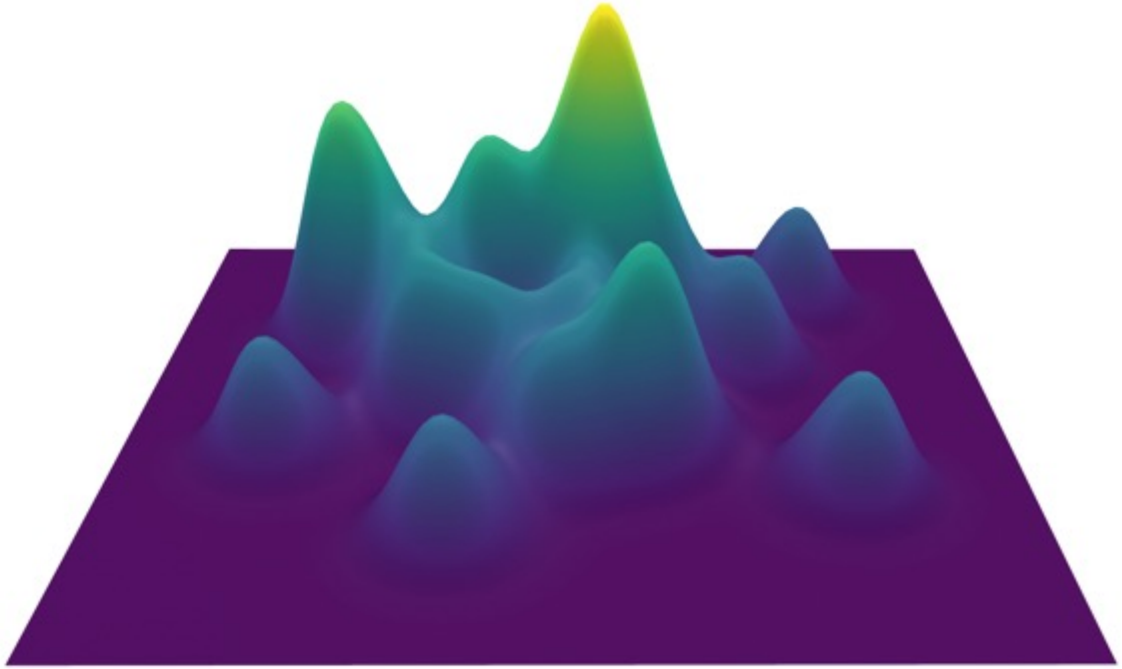
	Stayton metric C1 on all axes of PCoA	p-value
Wangosaurus - *N. giganteus*	0.5219842	0.000999001
Wangosaurus - *Brevicaudosaurus*	0.5219842	0.00000000

Postcranial analyses

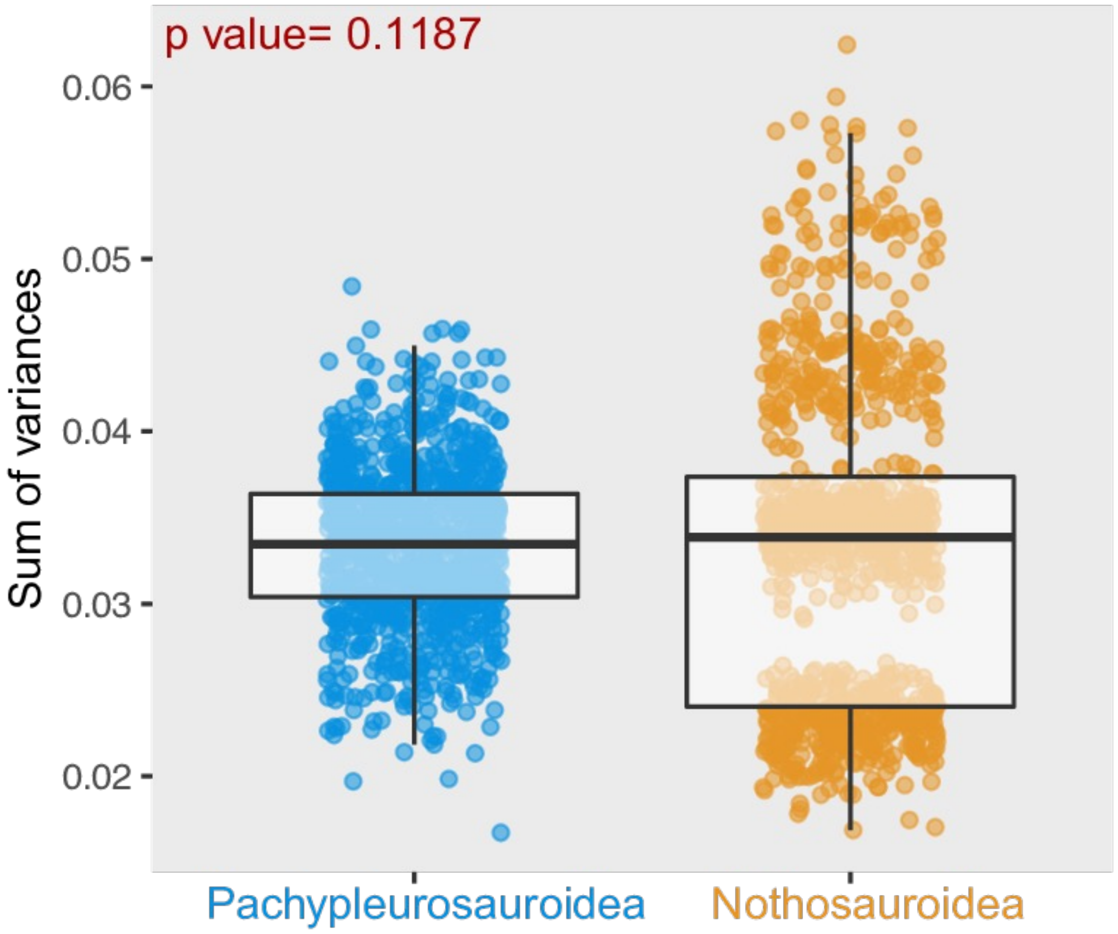
No clear trajectory in the evolution of postcranial region



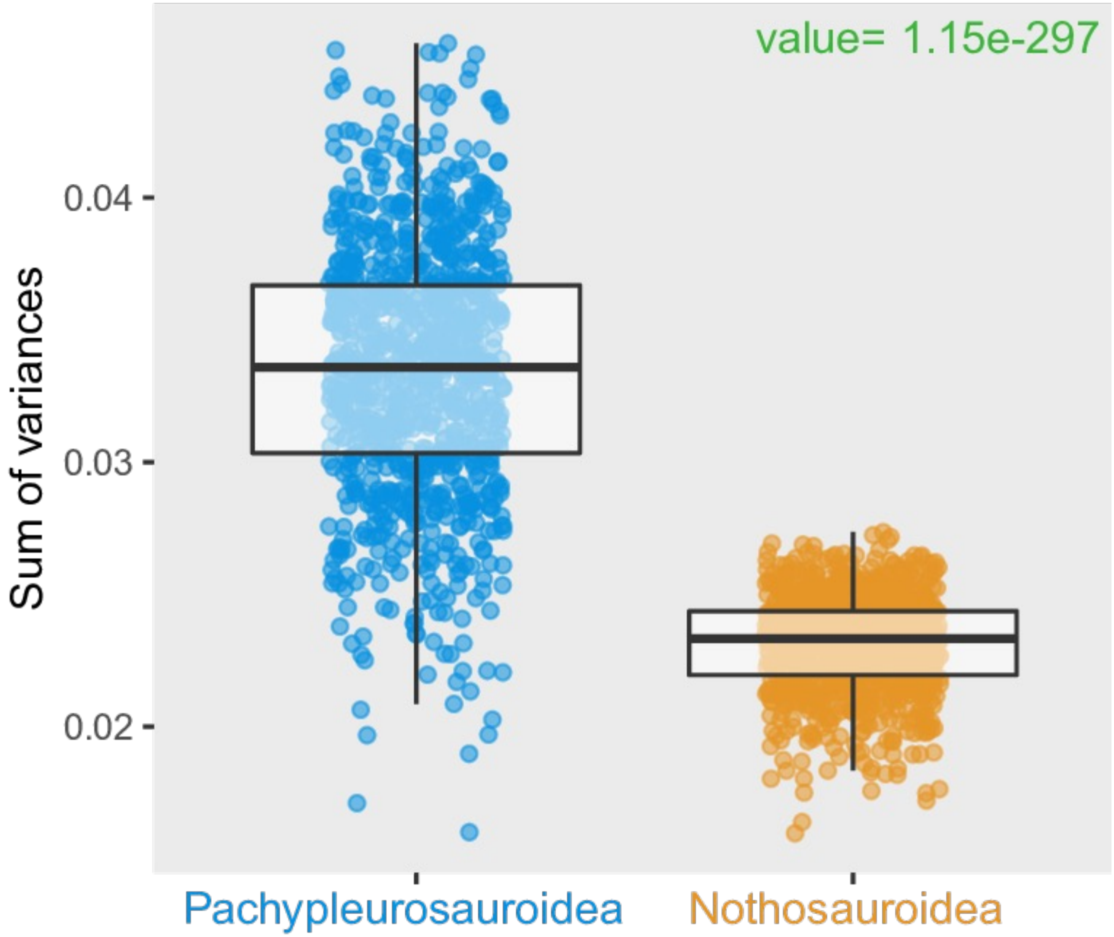
No peak distinction as
for craniodental traits



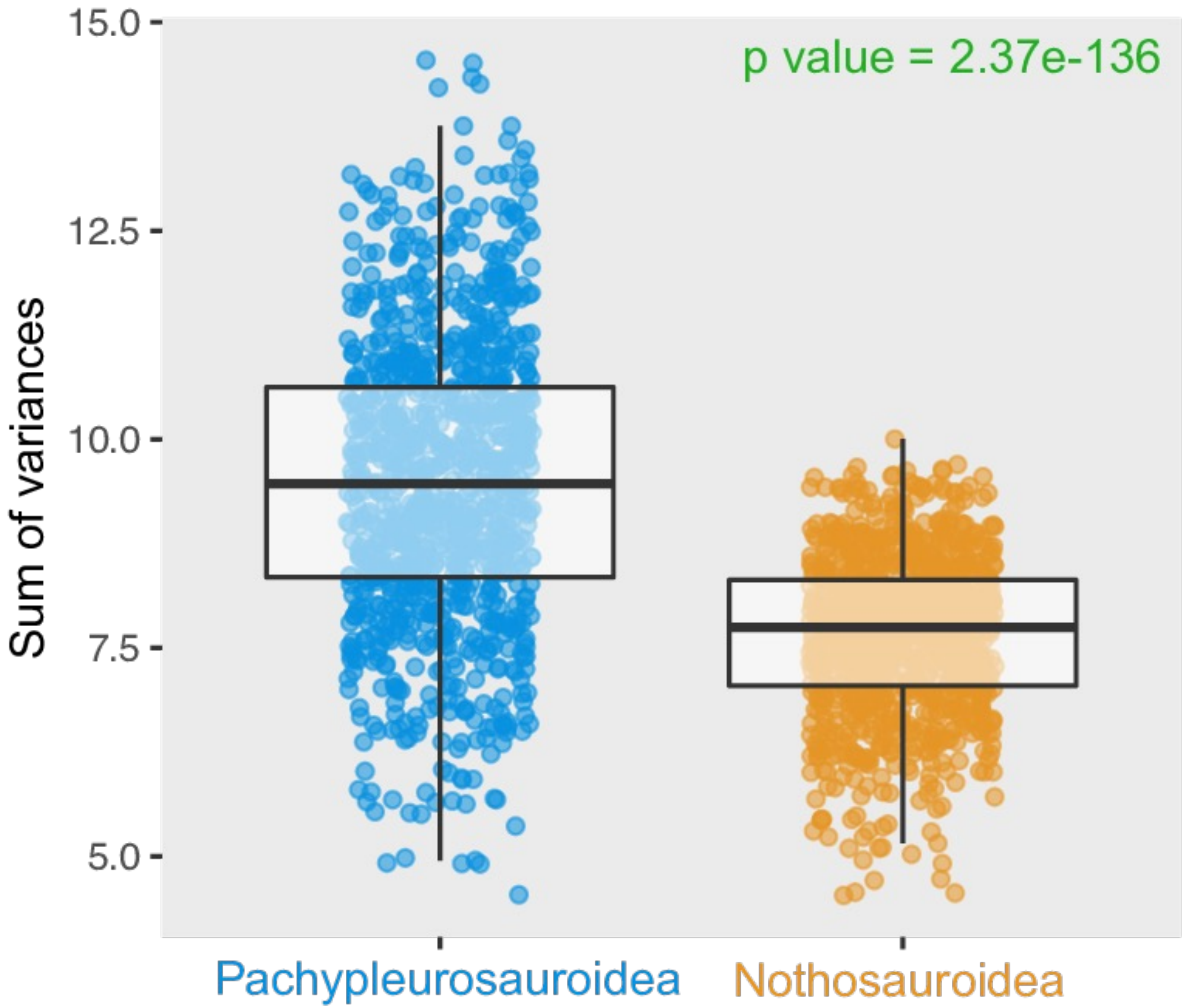
Pachypleurosauroidea is craniodentally the most disparate clade



Simosaurus removed



Pachypleurosauroidea is postcranially the most disparate clade 🥇



KEY MESSAGE 😉

Morphological diversification of Triassic eosauropterygians

- Clear craniodental ecomorphopace distinction → **different feeding strategies**
- Decoupling in the evolution of craniodental and postcranial regions
- Pachyleurosauroids are found to be more disparate

FUNDING : fnrs
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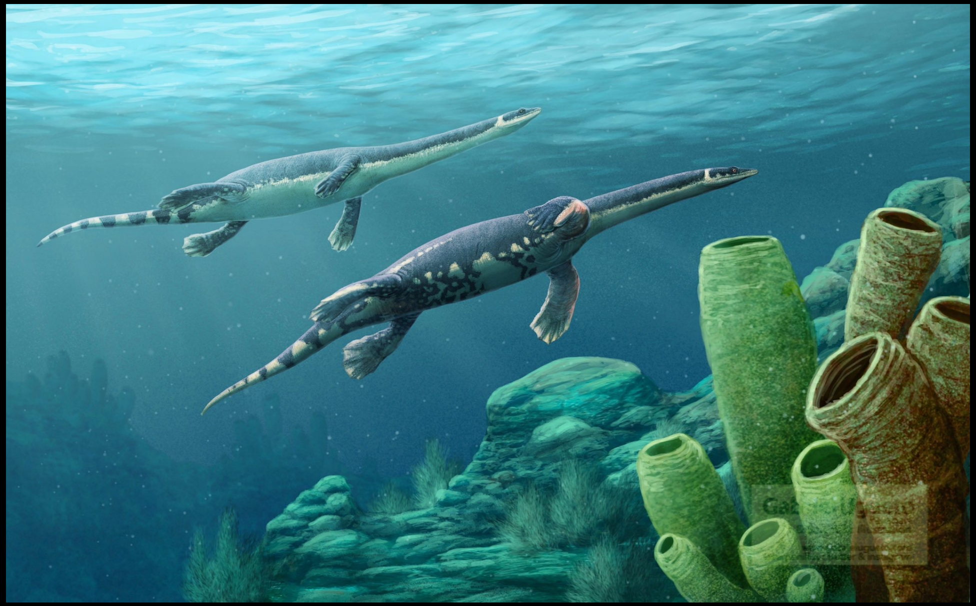
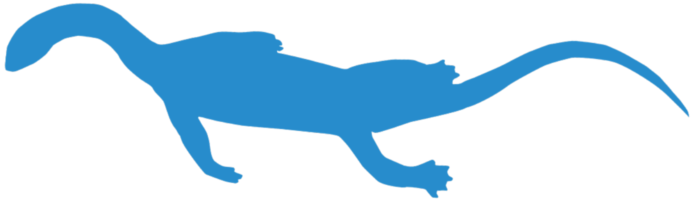
Many thanks to : Erin Maxwell (SMNS), Christian Klug (PIMUZ), Ingmar Werneburg (GPIT), Natasja den Ouden (NHML)



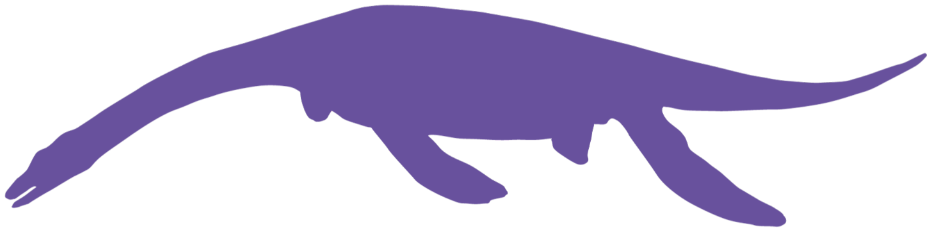
Thank you for your attention!

Supplementary information



	Specimens	Data collection
Qianxisaurus chajiangensis	NMNS-KIKO-F044630	Based on Cheng et al., 2012
Anarosaurus heterodontus	NME 480000125 , NME 480000130, NMNHL RGM 443856, SIPG R 594, SIPG R 595, SIPG R 596, NMNHL Wijk06-38, NMNHL Wij06-266, NMNHL Wijk09-582	Based on Klein, 2009, 2012
Diandongosaurus acutidentatus	IVPP V17760, WIGM SPC V 1105	Based on Shang *et al.,* 2011 and Liu *et al.,* 2021
Dianmeisaurus gracilis	IVPP V 18630	Based on Shang & Li, 2015
Dianopachysaurus dingi	LPV 31365	Based on Liu *et al.*, 2011
Honghesaurus longicaudalis	IVPP V30380	Based on Xu *et al.*, 2022
Keichousaurus	NMNS-cyn-2003-25, NMNS-cyn-2005-05, NMNS-cyn-2005-12, SMNS 81780, SMNS 59705	Based on Holmes & Cheng, 2008, First-hand examination
Neusticosaurus edwardsii	PIMUZ T2810, PIMUZ T2811, PIMUZ T3430, PIMUZ T3439, PIMUZ T3453, PIMUZ T3452, PIMUZ T3460, PIMUZ T3708, PIMUZ T3758, PIMUZ T3759, PIMUZ T3776, PIMUZ T4761	First-hand examination
Neusticosaurus peyeri	PIMUZ specimens	First-hand examination
Neusticosaurus pusillus	PIMUZ specimens	First-hand examination
Odoiporosaurus teruzzii	BES SC 1893	Based on Renesto et al., 2014
Panzhousaurus rotundirostris	GMPKU-P- 1059	Based on Jiang *et al.*, 2019
Prosantosaurus scheffoldi	PIMUZ A/III 1197, PIMUZ A/III 1240, PIMUZ A/III 1273, PIMUZ A/III 1274, PIMUZ A/III 1275, PIMUZ A/III 4566	First-hand examination
Serpianosaurus mirigiolensis	PIMUZ specimens	First-hand examination

	Specimens	Data collection
Brevicaudosaurus jiyangshanensis	IVPP V 18625	Based on Shang *et al.*, 2020
Ceresiosaurus calcagnii	PIMUZ T2463 , PIMUZ T2460, PIMUZ T2461, PIMUZ T2462, PIMUZ T2464, PIMUZ T4836, PIMUZ T5151, PIMUZ T5559	First-hand examination
Lariosaurus balsami	PIMUZ T4856	First-hand examination
Lariosaurus buzzii	PIMUZ T2804	First-hand examination
Lariosaurus hongguoensis	GMPKU-P-1011	Based on Jiang *et al.*, 2006
Lariosaurus xingyiensis	IVPP V 11866, XNGM WS-30-R19	Based on Rieppel *et al.*, 2003 and Lin *et al.*, 2017
Lariosaurus vosseveldensis	TWE 480000504	Based on Klein *et al.*, 2016
Lariosaurus youngi	WS-30-R24	Based on Ji *et al.*, 2014
Nothosaurus cristatus	GPIT-PV-75067	First-hand examination
Nothosaurus luopingensis	IVPP V 24895	Based on Shang et al., 2022
Nothosaurus giganteus	PIMUZ T4829, SMNS 18058, SMNS 57047, SMNS 80217, SMNS 1589b, SMNS 159157, SMNS 17822c, SMNS 81311	3D scan and first-hand examination
Nothosaurus jagisteus	SMNS 56618	First-hand examination
Nothosaurus mirabilis	SMNS 13155, SMNS 15714, SMNS 16433, SMNS 56826, SMNS 59074, SMNS 84550	3D scan
Simosaurus gaillardoti	GPIT-PV-60638, SMNS 10360, SMNS 16363, SMNS 16638, SMNS 50714, SMNS 59366, SMNS 7861, SMNS 14733, SMNS 7956, SMNS 17223, SMNS 17590, SMNS 18287	3D scan



	Specimens	Data collection
Augustasaurus hagdorni	FMNH PR1974	3D scan
Wangosaurus brevirostris	GMPKU-P-1529	Based on Ma *et al*., 2015
Yunguisaurus liae	NMNS 004529/F003826, ZMNH M8738	Based on Cheng *et al*., 2006 and Sato *et al*., 2014

Craniodental biomechanically informative traits

Longirostry	Nares position	Jaw or snout anterior constriction
Gullet (snout width)	Relative nares size	Pointed and recurved tooth crowns
Functionnal jaw robusticity	Orbit size	Enlarge procumbent dentary fangs
Relative symphysial length	Occular offset	Bulbous crushing dentition
Functional toothrow	Parietal foramen size	Crown deep striations
Anterior mechanical advantage	Postorbital region length	
Posterior mechanical advantage	Tooth crown shape	
Opening mechanical advantage	Crown curvature	
Supratemporal Fenestra Area	Heterodonty index	

Discrete characters

Postcranial biomechanically informative traits

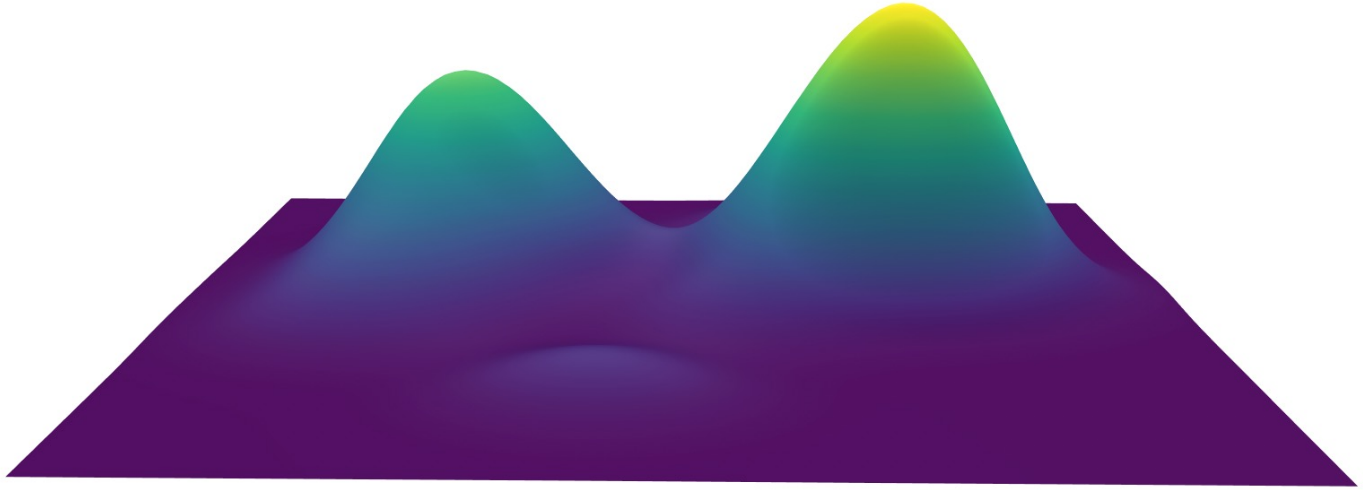
Relative skull length	Humerus gracility
Relative neck length	Femur gracility
Trunk proportion	Forelimb Aspect Ratio
Tail proportion	Hindlimb Aspect Ratio
Propodial variation	
Propodial size	

Two requirements before computing density of taxa and generate landscape vizualisation

- Use of morphological data which have clear biomechanical and dietary implications and **INDEPENDANT** of phylogenetic data used to compute the phylomorphospace.
- Clear statistical significant of clusters → separation in groups of groups in dataset which result of a non-random patterns of phenotypic evolution

Requirement to validate landscape vizualisation

- Interclade convergence → distribution of species in morphospace does not reflect the occurrence of phylogenetically-distinct groups



Convergence metrics of Stayton

Metrics C1 and C2: comparison of the phenotypic distance of possible convergent taxa to the pair of ancestor showing the maximum phenotypic dissimilarity

Metrics C3 and C4: incorporation of the total amount of phenotypic evolution from ancestor to descendant.

Simulation of character evolution under Brownian motion 1000 times