

SUPPLEMENTARY FILES

Giant Late Triassic Ichthyosaurs from the Kössen Formation of the Swiss Alps and
Their Paleobiological Implications

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Figure S1. RTMP 98.75.9, fragmentary ichthyosaur skull from the Sikkanni Chief River locality, right lateral view.



Figure S2. RTMP 98.75.9, fragmentary ichthyosaur skull from the Sikanni Chief River locality, palatal view of the right maxilla.

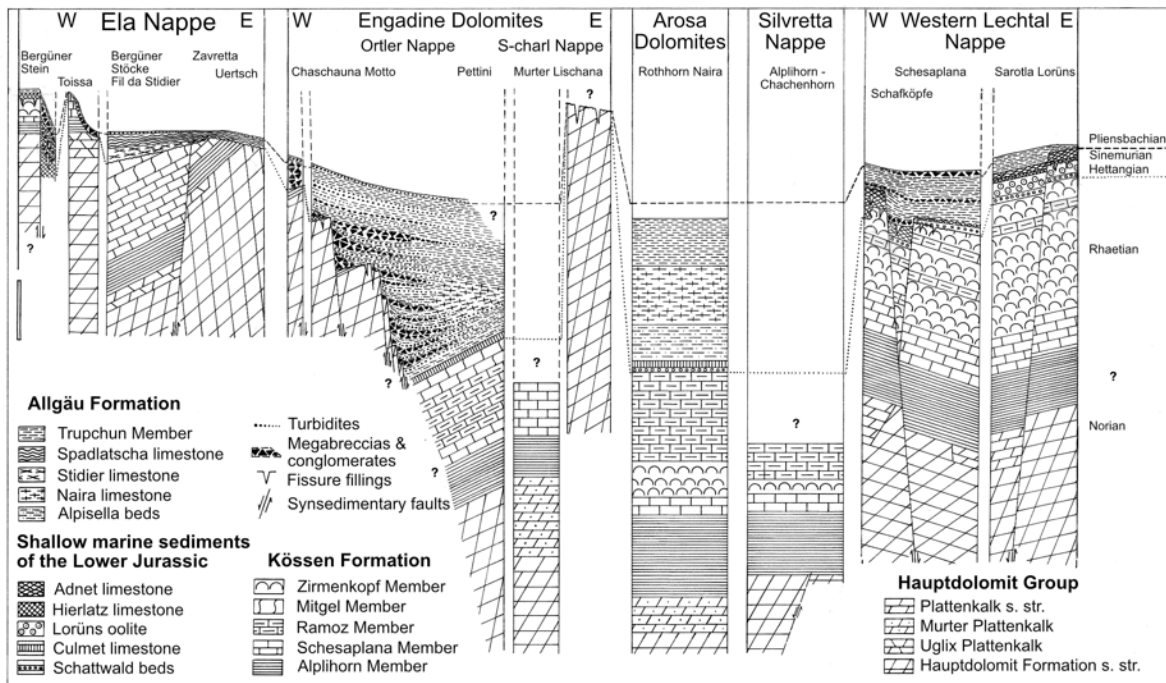


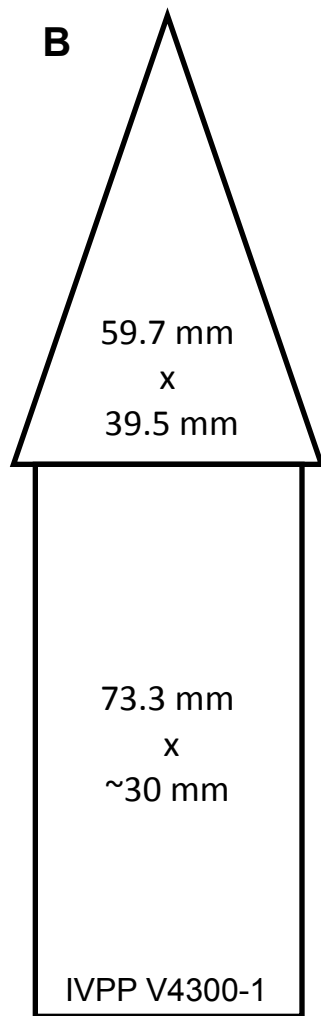
Figure S3. Stratigraphic diagram of Triassic-Jurassic boundary beds in the Austroalpine nappes of the Grisons, Switzerland, and surrounding areas. The average thickness of the stratigraphic units is plotted on the basis of a hypothetical topography in the Lower Jurassic (Pliensbachian). Modified from Furrer (1993).



Figure S4. A, PIMUZ A/III 4363, accumulation of ichthyosaurian bones and teeth of moderate size, late Norian-early Rhaetian Alpihorn Member, Kössen Formation, Schesaplana Mountain, Grisons, Switzerland. **B**, PIMUZ A/III 751, late Norian to early Rhaetian Alpihorn Member, Kössen Formation. Fil da Stidier, Grisons, Switzerland. The specimen may represent a sacral rib or unusually large dorsal ribs or an element of the shoulder girdle.



Figure S5. PIMUZ A/III 4625 in different views, late Norian to early Rhaetian Alplihorn Member, Kössen Formation, Fil da Stidier, Grisons, Switzerland. The specimen probably is skull fragment of a giant shastasaurid ichthyosaur, possibly a fragment of the surangular or angular. Photos U. Oberli.



5 cm

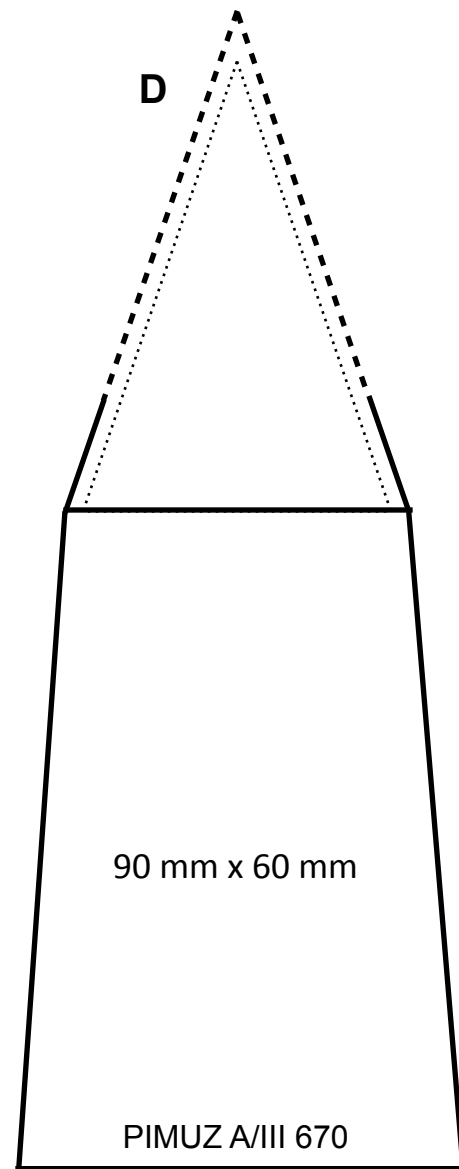


Figure S6. Comparison of the two largest ichthyosaur teeth known and graphical size estimate. **A**, The only complete tooth preserved with the holotype of *Himalayasaurus* IVPP V4300-1. **B**, Graphical representation of the tooth root and crown of IVPP V4300-1. **C**, Giant incomplete tooth PIMUZ A/III 670. **D**, Graphical representation of the tooth root and crown base of PIMUZ A/III 670, with crown size estimated from IVPP V4300-1. The (largest) crown diameter of both teeth is nearly identical, but the root of the Swiss tooth is distinctly larger, and thus the reconstructed crown size is probably a minimum estimate. See Table 1 for measurements.



Figure S7. RTMP 94.378.2, holotype of *Shonisaurus sikkanniensis*, two views of the same anterior dorsal vertebral centrum (V14 of Nicholls and Manabe, 2014). Note the sharp “lip” surrounding the articular surface and the lack of radial ridges.

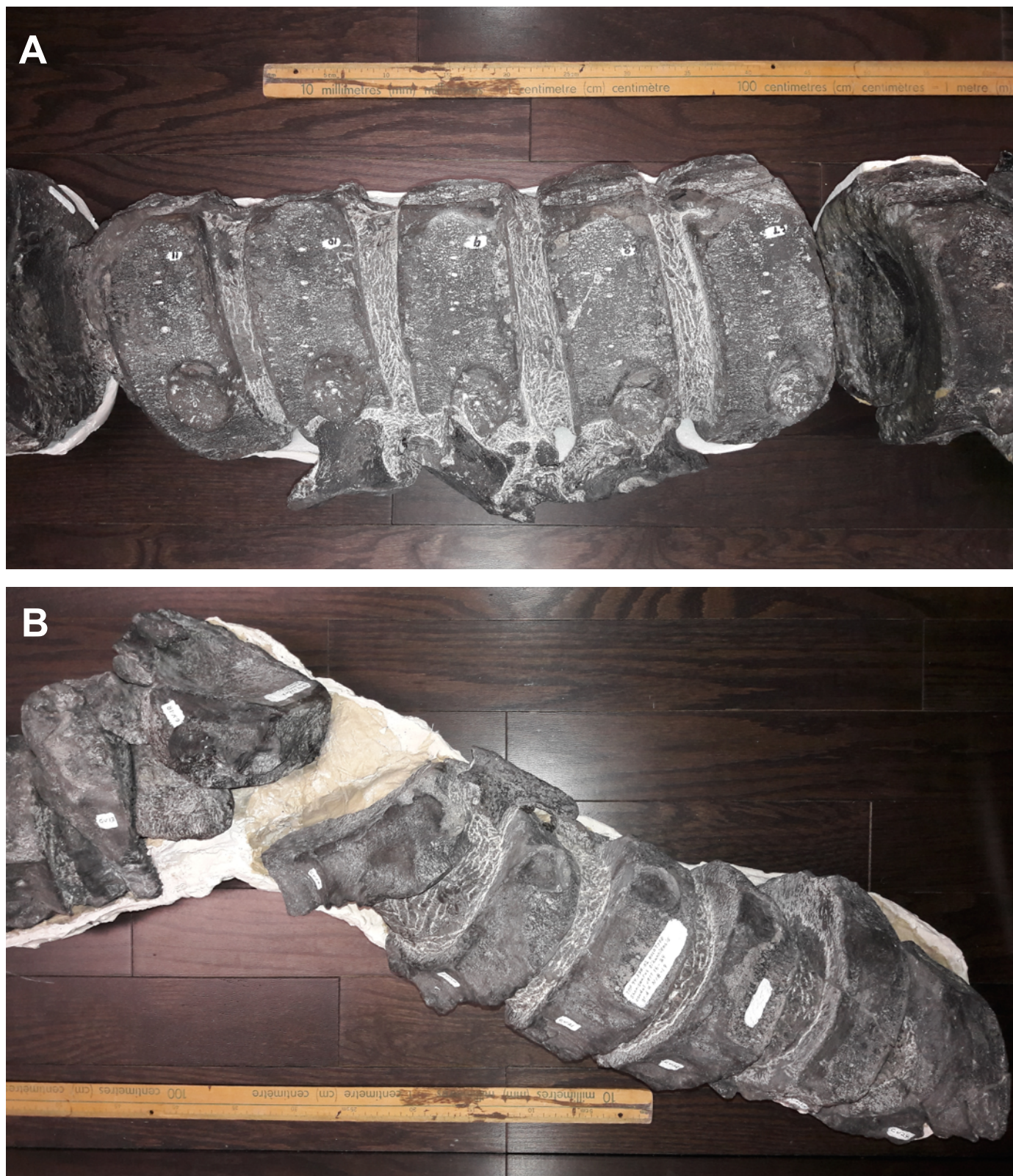


Figure S8. RTMP 94.378.2, holotype of *Shonisaurus sikkanniensis*, caudal vertebral centra. **A**, Caudal centra 6-12. **B**, Caudal centra 16-24. Note the sharp "lip" surrounding the articular surface.



Figure S9. *Shonisaurus popularis*, specimens “T” and “W” in situ at BISP.

Literature Cited

- Furrer, H. 1993. Stratigraphie und Facies der Trias/Jura-Grenzsichten in den oberostalpinen Decken Graubündens. Dissertation. 114 pp. University of Zurich, Zurich.
- Nicholls, E. L., and M. Manabe. 2004. Giant ichthyosaurs of the Triassic-A new species of *Shonisaurus* from the Pardonet Formation (Norian, Late Triassic) of British Columbia. *Journal of Vertebrate Paleontology* 24:838-849.

TABLE S1. List of ichthyosaur specimens from the Kössen Formation of the eastern Swiss Alps (Austroalpine nappes of the Grisons) discussed in this study. Underlined specimen numbers denotes specimens included in the main text.

Element	PIMUZ number	Number of elements	Taxonomy	Age	Member of Kössen Formation	Locality / community in Canton Grisons, Switzerland	Coordinates	Tectonic unit of the Austroalpine	Year Collected
Tooth fragment	<u>A/III 670</u>	1	Ichthyosauria gen. et sp. indet.	Rhaetian	Schesaplana Member	Gretji, SW Chrachenhorn / Davos Monstein	46.6850323N/ 9.8036022E	Silvretta Nappe	1990
Rib fragment	A/III 732	1	Shastasauridae gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana N P. 2737 / Seewis	47.0515975N/ 9.6999658E	Lechtal Nappe	1977
Vertebra	<u>A/III 744a</u>	1	Shastasauridae sp. A	Rhaetian	Schesaplana Member	Fil da Stidier east side / Filisur	46.6214052N/ 9.6790171E	Ela Nappe	1976
Rib fragments	<u>A/III 744b-l</u>	10	Shastasauridae sp. A	Rhaetian	Schesaplana Member	Fil da Stidier east side / Filisur	46.6204533N/ 9.6816551E	Ela Nappe	1976
?Sacral rib	A/III 751	1	Shastasauridae gen. et sp. indet.	Rhaetian	Schesaplana Member	Fil da Stidier west side / Filisur	46.6214052N/ 9.6790171E	Ela Nappe	1975
Vertebra	A/III 1294	2	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana N P. 2737 / Seewis	47.0515975N/ 9.6999658E	Lechtal Nappe	1977
Vertebra	A/III 1295	6	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana N P. 2737 / Seewis	47.0515975N/ 9.6999658E	Lechtal Nappe	1977
Rib fragments	A/III 1296	2	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Aroser Rothorn, southeast crest / Arosa	46.7350901N/ 9.6173173E	Arosa Dolomites	1978
Partial vertebra centra	<u>A/III 1470a</u>	1	Shastasauridae sp. B	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana S P. 2728 / Seewis	47.0518547N/ 9.6983309E	Lechtal Nappe	1977
Vertebra centra	<u>A/III 1470b-g</u>	6	Shastasauridae sp. B	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana S P. 2728, Seewis	47.0518547N/ 9.6983309E	Lechtal Nappe	1977
Vertebra	A/III 4362	1	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana S P. 2728, Seewis	47.0518547N/ 9.6983309E	Lechtal Nappe	1977
Teeth, vertebrae	A/III 4363	1	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana, Seewis		Lechtal Nappe	1977
Vertebra	A/III 4364	1	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana N P. 2737, Seewis	47.0515975N/ 9.6999658E	Lechtal Nappe	1977

TABLE S1. (Continued)

Radius	A/III 4366	1	Ichthyosauria gen. et sp. indet.	Rhaetian	Schesaplana Member	Murter, Zernez	46.6519241N/ 10.1390343E	S-charl Nappe	1977
Bone fragments	A/III 4367	2	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana N P. 2737, Seewis	47.0515975N/ 9.6999658E	Lechtal Nappe	1977
Rib fragments	A/III 4534	6	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana N P. 2737, Seewis	47.0515975N/ 9.6999658E	Lechtal Nappe	1978
Bone fragments	A/III 4535	6	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Schesaplana N P. 2737, Seewis	47.0515975N/ 9.6999658E	Lechtal Nappe	1978
Rib fragment	A/III 4590	3	Ichthyosauria gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Erzhorntälli, Arosa	46.7408531N/ 9.6260587E	Arosa Dolomites	1976
Angular?	A/III 4625	1	Shastasauridae gen. et sp. indet.	Late Norian to early Rhaetian	Alplihorn Member	Fil da Stidier (scree)	46.621283N/9. 6852161E	Ela Nappe	1985