**Online Supplementary Information For:**

Torosaurus *is not* Triceratops*: Ontogeny in Chasmosaurine Ceratopsids as a Case Study in Dinosaur Taxonomy*

**Contents:**

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**1. Character List**

1. Basioccipital: participates in foramen magnum [0] or excluded by exoccipitals [1]
2. Postorbital horns, length: horns short stubs [0] elongate [1]
3. Postorbital horns, curvature: straight [0] curved posteriorly [1] curved forward [2]
4. Palpebral: separate from postorbital [0] or fused to postorbital [1]
5. Squamosal: short and narrow [0] or with long caudal blade and prominent anterolateral wing [1]
6. Parietals and squamosals: margins strongly scalloped [0] margins weakly scalloped or smooth [1]
7. Jugal: suborbital bar slender [0] or deep [1]
8. Postorbital horns, diameter: postorbital horns with narrow base [0] or base of horncore massive, expanded to cover the area posterodorsal to the orbit [1]
9. Postorbital horns, cornual sinuses: cornual sinuses weakly developed or absent [0] or cornual sinuses extensive and hollowing base of horncore [1]
10. Epoccipital ossifications with narrow bases [0] broad bases [1]
11. Nasals: narial bar depressed in lateral view, snout low [0] narial bar horizontal or upturned in lateral view, rostrum deep [1]
12. Parietosquamosal frill, texture: frill with smooth or striated texture [0] rugose texture and vascular grooves covering anterior part of frill [1] rugosity extends to caudal margin of frill [2]
13. Occipital condyle, fusion: exoccipitals and basioccipitals separate [0] or completely fused [1]
14. Frontals, fusion: frontals separate [0] or frontals fused along midline [1]
15. Epinasal, fusion: epinasal separate from nasals [0] or epinasal fused to nasals [1]
16. Nasals, fusion: nasals separate [0] or nasals fused along midline [1]
17. Postorbital and frontal: separate [0] or fused [1]
18. Lacrimal and prefrontal: separate [0] or fused [1]
19. Nasals, fusion: nasals separate from frontals, [0] or nasals fused to frontals [1]
20. Episquamosals: episquamosals separate [0] or episquamosals fused to squamosals [1]
21. Epiparietals: epiparietals separate [0] or epiparietals fused to parietal [1]
22. Epijugal, fusion: epijugal separate [0] or epijugal fused to jugal [1]
23. Rostral, fusion: rostral separate from premaxillae [0] or rostral fused to premaxillae [1]
24. Premaxillae, fusion: premaxillae separate from nasals [0] premaxillae fused to nasals [1]

**2. Character-Taxon Matrix**

MATRIX

UW\_40634\_Chasmosaurinae\_indet. 000????00???????0???????

UCMP\_154452\_Triceratops\_sp. 000000000??00???00?000??

SMNH\_P2613.1\_Chasmosaurinae\_indet. 000????00???????????????

AMNH\_5006\_Chasmosaurinae\_indet. 100????00???????0???????

MOR\_1199\_Triceratops\_?horridus 111111100000000000000000

MOR\_1110\_Triceratops\_prorsus 111?11111100000000000000

YPM\_1821\_Triceratops\_prorsus\_ 21??1111?1111?00?0000000

YPM\_1823\_Triceratops\_prorsus\_ 211?1111?112110000000000

MOR\_\_1120\_Triceratops\_horridus\_ 211?111111021?1110000000

AMNH\_5116\_Triceratops\_horridus\_ ?11?1111?111?1111000000?

GMNH-PV 124 Triceratops prorsus 211?11?1???1111110000000

UCMP\_113697\_Triceratops\_prorsus 211?1111???0?11110000000

USNM\_15583\_Torosaurus\_utahensis 211?1111?????????0?0?0??

YPM\_1831\_Torosaurus\_latus 211111?1???10?11?1?0000?

USNM\_1201\_Triceratops\_horridus\_ 21??1111??111?1111000000

USNM\_4928\_Triceratops\_horridus 211?1111?11???11?110000?

USNM\_5740\_Triceratops\_sp. ??1????11??{1 2}1???11?1????

YPM\_1830\_Torosaurus\_latus ?11?11?111?21?111111????

YPM\_1828\_Triceratops\_horridus 211?11?1?112?????1111???

MNHN\_1912.20\_Triceratops\_horridus 211?1111?1121?11?111?1??

AMNH\_970\_Triceratops\_prorsus ??1?11?1?1?21??????1110?

ANSP\_15192\_Torosaurus\_latus 211?1111?1121111?1111100

YPM\_1820\_Triceratops\_horridus 211???111?1{1 2}1111111??110

MOR\_1122\_Torosaurus\_latus 211?1111111{1 2}111111?11110

MPM\_VP6841\_Torosaurus\_latus ????111??1?2???????1111?

USNM\_1205\_Triceratops\_sp. ??1?111111121??11111?11?

USNM\_4741\_Triceratops\_sp. ???????????2???????1??1?

OMNH\_10170\_Triceratops\_prorsus 21??11?111?21?11???11?11

USNM\_2100\_Triceratops\_horridus 211?1111?1121111111111?1

USNM\_2412\_Triceratops\_horridus 211?1111?11211111?11??11

USNM\_4720\_Triceratops\_horridus 211?1111?1?211111111?1?1

YPM\_1822\_Triceratops\_prorsus 21111111?112111111111111

UCMP\_128561\_Triceratops\_horridus ??????????????1???????11

CM\_1221\_Triceratops\_prorsus 211?1111?112??1??1111111

BSP\_1964\_I\_458\_Triceratops\_prorsus 211?1111?11211111?111111

BHI\_6226\_Tatankaceratops\_sacrisonorum 211??1?00??21?1111?11?11

**3. Material Studied**

Specimens examined in the course of this study include ANSP 15192, AMNH 970, AMNH 5116, MPM VP6841, OMNH 10170, TMM 41480-1, UCMP 113697, USNM 1201, USNM 1205, USNM 2100, USNM 2412, USNM 4720, USNM 4741, USNM 5740, UW 40634, YPM 1820, YPM 1821, YPM 1822, YPM 1831, YPM 1823, YPM 1828, and YPM 1830.

Specimens coded from the literature include AMNH 5006 [[1](#_ENREF_1),[2](#_ENREF_2)], BHI\_6226 [[3](#_ENREF_3)], BSP 1964 I 458/YPM 1834 [[4](#_ENREF_4)], CM 1221 [[5](#_ENREF_5),[6](#_ENREF_6)], MOR 1199, MOR 1110, and MOR 1120 [[7](#_ENREF_7),[8](#_ENREF_8)], MOR 1122, MNHN 1912.20 [[9](#_ENREF_9)], SMNH P2613.1 [[10](#_ENREF_10)], UCMP 128561 [[11](#_ENREF_11)], UCMP 154452 [[12](#_ENREF_12)], USNM 4928 [[13](#_ENREF_13)] and USNM 15583 [[14](#_ENREF_14)].

J. Scannella provided additional codings for MOR 1110, MOR 1120, and MOR 1199.

**4. Results of Clustering Analyses**

Analysis 1

Tree length = 33

Consistency index (CI) = 0.7879

Homoplasy index (HI) = 0.2121

CI excluding uninformative characters = 0.7500

HI excluding uninformative characters = 0.2500

Retention index (RI) = 0.9381

Rescaled consistency index (RC) = 0.7391/------------------------------------------------------------- UW 40634 Chasmos

|

+------------------------------------------------------------- UCMP 154452 Tric

|

+------------------------------------------------------------- SMNH P2613.1 Cha

|

| /--------------------------------------------------- AMNH 5006 Chasmo

| |

| | /----------------------------------------- MOR 1199 Tricera

| | |

| | | /------------------------------- MOR 1110 Tricera

\---------+ | |

| | | /-------------------- YPM 1821 Tricera

| | | |

| | | +-------------------- YPM 1823 Tricera

\---------+ | |

| | +-------------------- MOR 1120 Tricer

| | |

| | +-------------------- AMNH 5116 Tricer

| | |

| | +-------------------- GMNH-PV 124 Tric

\---------+ |

| +-------------------- UCMP 113697 Tric

| |

| +-------------------- USNM 15583 Toros

| |

| +-------------------- YPM 1831 Torosau

| |

| +-------------------- USNM 1201 Tricer

| |

| +-------------------- USNM 4928 Tricer

| |

\----------+ /---------- USNM 5740 Tricer

| |

| +---------- YPM 1830 Torosau

| |

| +---------- YPM 1828 Tricera

| |

| +---------- MNHN 1912.20 Tri

| |

| +---------- AMNH 970 Tricera

| |

| +---------- ANSP 15192 Toros

| |

| +---------- YPM 1820 Tricera

| |

| +---------- MOR 1122 Torosau

| |

| +---------- MPM VP6841 Toros

| |

| +---------- USNM 1205 Tricer

\---------+

+---------- USNM 4741 Tricer

|

+---------- OMNH 10170 Trice

|

+---------- USNM 2100 Tricer

|

+---------- USNM 2412 Tricer

|

+---------- USNM 4720 Tricer

|

+---------- YPM 1822 Tricera

|

+---------- UCMP 128561 Tric

|

+---------- CM 1221 Tricerat

|

+---------- BSP 1964 I 458 T

|

Strict consensus of 250000 trees: \--------- BHI 6226 Tatanka

/------------------------------------------------------------- UW 40634 Chasmos

|

+------------------------------------------------------------- UCMP 154452 Tric

|

+------------------------------------------------------------- SMNH P2613.1 Cha

|

| /------------------------------------------------------- AMNH 5006 Chasmo

| |

| | /------------------------------------------------- MOR 1199 Tricera

| | |

| | | /------------------------------------------- MOR 1110 Tricera

| | | |

\-----+ | | /------------------------------------- YPM 1821 Tricera

| | | |

| | | +------------------------------------- YPM 1823 Tricera

| | | |

| | | | /------------------------------- MOR 1120 Tricer

\-----+ | | |

| | | +------------------------------- AMNH 5116 Tricer

| | | |

| | | +------------------------------- GMNH-PV 124 Tric

| | | |

| | | +------------------------------- UCMP 113697 Tric

| | | |

| | | | /------ YPM 1831 Torosau

| | | +------------------------+

\-----+ +-----+ \------ USNM 1201 Tricer

| | |

| | | /------------------------ USNM 4928 Tricer

| | | |

| | | | /------------------ USNM 5740 Tricer

| | | | |

| | | | +------------------ YPM 1830 Torosau

| | | | |

| | | | +------------------ YPM 1828 Tricera

| | | | |

| | \------+ +------------------ MNHN 1912.20 Tri

| | | |

| | | +------------------ AMNH 970 Tricera

| | | |

| | | +------------------ ANSP 15192 Toros

\-----+ | |

| | | /------------ YPM 1820 Tricera

| \-----+ |

| | +------------ MOR 1122 Torosau

| | |

| | +------------ MPM VP6841 Toros

| | |

| | +------------ USNM 1205 Tricer

| | |

| | +------------ USNM 4741 Tricer

| | |

| | +------------ OMNH 10170 Trice

| | |

| | | /------ USNM 2100 Tricer

| \-----+ |

| | +------ USNM 4720 Tricer

| | |

| | +------ YPM 1822 Tricera

| | |

| +-----+------ UCMP 128561 Tric

| | |

| | +------ CM 1221 Tricerat

| | |

| | +------ BSP 1964 I 458 T

| | |

| | \------ BHI 6226 Tatanka

| |

| \------------ USNM 2412 Tricer

|

Adams Consensus \------------------------------------- USNM 15583 Toros

Analysis 2

MNHN 1912.20, USNM 5740, YPM 1828, YPM 1830, USNM 15583 (T. utahensis) deleted

Tree length = 33

Tree length = 33

Consistency index (CI) = 0.7879

Homoplasy index (HI) = 0.2121

CI excluding uninformative characters = 0.7500

HI excluding uninformative characters = 0.2500

Retention index (RI) = 0.9358

Rescaled consistency index (RC) = 0.7373

Strict consensus of 250000 trees:

/------------------------------------------------------------- UW 40634 Chasmos

|

+------------------------------------------------------------- UCMP 154452 Tric

|

+------------------------------------------------------------- SMNH P2613.1 Cha

|

| /----------------------------------------------------- AMNH 5006 Chasmo

| |

| | /---------------------------------------------- MOR 1199 Tricera

\-------+ |

| | /-------------------------------------- MOR 1110 Tricera

| | |

\------+ | /------------------------------- YPM 1821 Tricera

| | |

| | +------------------------------- YPM 1823 Tricera

\-------+ |

| | /----------------------- MOR 1120 Tricer

| | |

| | +----------------------- AMNH 5116 Tricer

| | |

\------+ +----------------------- GMNH-PV 124 Tric

| |

| +----------------------- UCMP 113697 Tric

| |

| +----------------------- YPM 1831 Torosau

| |

| +----------------------- USNM 1201 Tricer

| |

\-------+----------------------- USNM 4928 Tricer

|

| /--------------- AMNH 970 Tricera

| |

| +--------------- ANSP 15192 Toros

| |

| | /-------- YPM 1820 Tricera

| | |

| | +-------- MOR 1122 Torosau

| | |

| | +-------- MPM VP6841 Toros

\-------+ |

| +-------- USNM 1205 Tricer

| |

| +-------- USNM 4741 Tricer

| |

| +-------- OMNH 10170 Trice

| |

| +-------- USNM 2100 Tricer

\------+

+-------- USNM 2412 Tricer

|

+-------- USNM 4720 Tricer

|

+-------- YPM 1822 Tricera

|

+-------- UCMP 128561 Tric

|

+-------- CM 1221 Tricerat

|

+-------- BSP 1964 I 458 T

|

\-------- BHI 6226 Tatanka

Adams consensus of 250000 trees:

/------------------------------------------------------------- UW 40634 Chasmos

|

+------------------------------------------------------------- UCMP 154452 Tric

|

+------------------------------------------------------------- SMNH P2613.1 Cha

|

| /------------------------------------------------------- AMNH 5006 Chasmo

| |

| | /------------------------------------------------- MOR 1199 Tricera

\-----+ |

| | /------------------------------------------- MOR 1110 Tricera

| | |

\-----+ | /------------------------------------- YPM 1821 Tricera

| | |

| | +------------------------------------- YPM 1823 Tricera

\-----+ |

| | /------------------------------- MOR 1120 Tricer

| | |

| | +------------------------------- AMNH 5116 Tricer

\-----+ |

| +------------------------------- GMNH-PV 124 Tric

| |

| +------------------------------- UCMP 113697 Tric

| |

| | /------ YPM 1831 Torosau

\-----+------------------------+

| \------ USNM 1201 Tricer

|

| /------------------------ USNM 4928 Tricer

| |

| | /------------------ AMNH 970 Tricera

| | |

| | +------------------ ANSP 15192 Toros

| | |

\------+ | /------------ YPM 1820 Tricera

| | |

| | +------------ MOR 1122 Torosau

| | |

| | +------------ MPM VP6841 Toros

\-----+ |

| +------------ USNM 1205 Tricer

| |

| +------------ USNM 4741 Tricer

| |

| +------------ OMNH 10170 Trice

| |

| | /------ USNM 2100 Tricer

\-----+ |

| +------ USNM 4720 Tricer

| |

| +------ YPM 1822 Tricera

| |

+-----+------ UCMP 128561 Tric

| |

| +------ CM 1221 Tricerat

| |

| +------ BSP 1964 I 458 T

| |

| \------ BHI 6226 Tatanka

|

\------------ USNM 2412 Tricer

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