A NEW ENDOCRANIAL CAST OF TRICERATOPS HORRIDUS

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ABSTRACT

Variations previously reported for the endocast of *Triceratops* represent poorly preserved, incomplete or misidentified material as well as questionable interpretations. A new endocranial cast of *Triceratops horridus* produced from a complete, undistorted cranium provides new knowledge of the brain structure. The present endocast has the 12 main nerves, some with unreported branches. Those nerves have been extended as far as their tracks could be followed within the walls of the braincase. This specimen is arguably the most informative cast available including unknown and inadequately described aspects of the brain of *Triceratops.*

INTRODUCTION

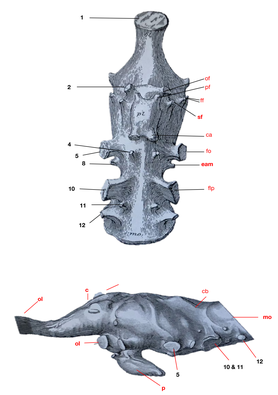
Of the dinosaurs of the Late Cretaceous of North America,*Triceratops* is arguably one of the most prolific and abundant and is represented by numerous well preserved skulls. The paleoneurology of *Triceratops* was first interpreted by O.C. Marsh (1890) who identified no structures and noted six cranial nerves **(FIG.1).** Burkhardt (1892) gave a more complete interpretation of the braincase of *Triceratops*. In the past 126 years, numerous authors have reviewed and/or reinterpreted the paleoneurology of *Triceratops* Hatcher,et.al.(1907), Hay (1909), von Huene (1914), Gilmore (1919, Edinger (1929) and Hopson (1979), with agreement on some aspects and differing conclusions on other points. Limited studies of the paleoneurology of other ceratopsians have reached the same conclusions. Forster (1996) described an endocast of *Triceratops horridus* with a reconstruction of the olfactory lobe and correctly noting the basal attachments of all nerves while dismissing various regions of the skull **(Fig.2).** The authors present here a nearly complete endocast of *Triceratop horridus* that produces complete crainial nerve structures with new interpretations and implications **(Fig 3).**

MATERIALS AND METHODS

A cranium of *Triceratops horridus* from the Hell Creek Formation (*Late Maastrichtian*) of Garfield County Montana was prepared and during preparartion it was observed that the cranial cavity was virtually free of matrix. The cavity was filled with latex and once dyed was removed. The latex mold was then filled with plaster. A silicone mold was then made and filled with ModelCast resulting in the current endocast, The nerve stalks have been slightly extended for better illustration and labelling **(Fig.4).**

Fig.4 SMM P.63.16.1 ***Triceratops horridus*** **cranial and endocast (SMM P.16.1c).**

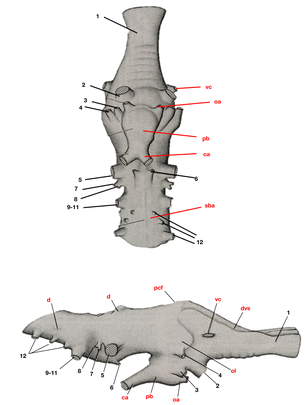
Fig.1



MARSH 1890

USNM 2065. ca, *Carotid artery*; **c**, *Cerebral hemispheres*; **cb**, *Cerebellum*; **m**. *Medulla;* **ol**, *Olfactory lobe*; **on**, *optic nerve*; **p**, *Pituitary body*; **pl,** *Pituitary lobe;*, **pf,** *foramen entering anterior extremity of pituitaery fossa*; **fo.** *Foramen ovale*; **flp**,*Foramen lacerum posterius*; **iam,** *internal auditory meatus?*; **sf**, *Sphenoidal fissure.* **1-12,** *Cranial nerves.*

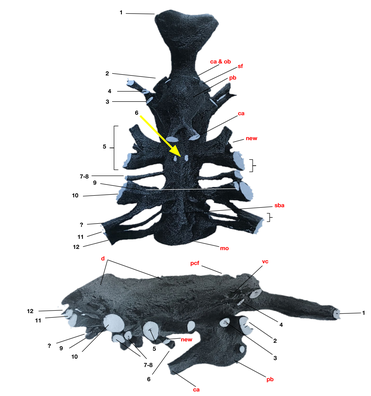
Fig. 2



FORSTER 1996

SMM P62.1.1c ca, *carotid artery*; **d**, *diverticulum*; **dvs**, *dorsal venous sinus*; **oa**,*ophthalmic artery*; **ol**, *optic lobe*; **pcf**, *post cerebral flexure*; **pb**, *pituitary body*; **sba** *sinus for the basilar artery*; **vc**, *venous canal*; **1**, *olfactory nerve*; **2**, *optic nerve*; **3**, *ophthalmic nerve*; **4**, *trochlear nerve*; **5**, *trigeminal nerve*; **6**, *abducens nerve*; **7**, *facial nerve*, **8**, *vestibulocochlear nerve*, **9-11**, *glossopharyngeal, vagus and accessory nerves*; **12**, *hypoglossal nerve.*

Fig. 3



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SMM P93.16.1c ca, *carotid artery*; **d**, *diverticulum*; **dvs**, *dorsal venous sinus*; **oa**,*ophthalmic artery*; **ol**, *optic lobe*; **pcf**, *post cerebral flexure*; **pb**, *pituitary body*; **sba** *sinus for the basilar artery*; **vc**, *venous canal*; **1**, *olfactory nerve*; **2**, *optic nerve*; **3**, *ophthalmic nerve*; **4**, *trochlear nerve*; **5**, *trigeminal nerve*; **6**, *abducens nerve*; **7**, *facial nerve*, **8**, *vestibulocochlear nerve*, **9-11**, *glossopharyngeal, vagus and accessory nerves*; **12**, *hypoglossal nerve.*

DISCUSSION

In the current endocast the nasal stalk emerges through an aperture of 62x20 mm and develops an expansion which projects as two stalks with a wide opening of 1.6x2.8 cm dorsally near the base of the olfactory stem and connects with a cranial sinus. The large pituitary body has been partly restored ventrally , however, both carotid and ophthalmic arteries were preserved in bony depressions. The large optic nerve just above the pituitary is the largest of the nerves. The cerebellum gives rise to the large trigeminal nerve which divides within the walls of the braincase into two branches. The largest of those produces a smaller ventrally directed branch. Posterior to this a small single nerve projects through the braincase. The last three nerves originate separately from the medulla. Number 10 is the largest producing two additional branches. Nerves 11 and 12 originate separately from the medulla**.**

CONCLUSIONS

SMM P.63.1.1c. produces elements not recognized or preserved in previous endocasts of *Triceratops.* The olfactory lobe is bifurcated and the opening for the pituitary is larger than noted by previous authors. The nerves vary in position, eg. 8, on the new endocast which is uncertain in previous endocasts. Nerve 7 has an origin on the mid-line and shares a large canal with 9-11 before branching from to the posterior terminus as one of three. The nerve stalks can be traced and are readable on all 12 and give new insights and interpretations of their neurological functions **(Fig.5).**

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Number and Name of Nerve	Function
1.**OLFACTORY**	**SENSORY : SMELL**
2.**OPTIC**	**SENSORY : SIGHT**
3.**OCULOMOTOR**	**MOTOR : MOVEMENT OF EYEBALL AND LID**
4.**TROCHLEAR**	**MOTOR : ROTATION OF EYEBALL**
5.**TRIGEMINAL**	**SENSORY : FEELING ON FACE AND TONGUE** **MOTOR : MOVEMENT OF TONGUE**
6.**ABDUCENS**	**MOTOR : ROTATION OF EYEBALL**
7-8 FACIAL AND AUDITORY	**SENSORY : HEARING AND EQUILIBRIUM**
9 GLOSSOPHARYNGEAL	**SENSORY : LUNGS AND ESOPHOGUS**
10 VAGUS	**MOTOR : STOMACH AND HEART**
11 **SPINAL ACCESSORY**	**MOTOR : MUSCLES OF PHARYNX AND NECK**
12 **HYPOGLOSSAL**	**MOTOR : MOVEMENTS OF TONGUE**

Fig. 5 Sensory and motor functions of the brain of ***Triceratops horridus.***

LITERATURE CITED

Burchhardt, R. 1892. Das Gehirine von *Triceratops fabellatus Marsh*. Neues Jahrbuch fur minerologie, Geologie, und Palaeontologie 1892:71-72

Edinger, T. 1929. Die fossilen Gehirne. Springer Vertag, Berlin, 249 pp.

Forster, C.A. 1996. New Information on the skull of T*riceratops.* Journal of Vertebrate Paleontology Vol.16, Issue 2

Gilmore, C.W. 1919. A new restoration of *Triceratops* with notes on the osteology of the genus. Proceedings of the U.S. National Museum. 55:97-112

Hatcher, J.B.; Marsh, O.C.; Lull, R.S. 1907. The Ceratopsia. U.S. Geological Survey Monograph 49. 300pp.

Hay, O.P. 1909. On the skull and brain of *Triceratops*, with notes on the braincase of *Iguanodon* and *Megalosaurus*. Proceedings of the U.S. National Museum 36:95-108

Huene, F, von. 1914. Uber die zweistammigkeit der dinosaurier mit Beitragen zur Kerntnis einiger Shadel. Neues Jahrbuch fur mineralogy, geologie, und Palaeontologie Beiage-Band, 37: 577-581

Hopson, J.A. 1979. Paleonuerology; pp13-146 *in* C.Gans (ed), Biology of the Reptilia, Nuerology A. Academic Press

Marsh, O.C. 1890. Description of new dinosaurian reptiles. American Journal of Science, series 3, 38: 501-506