

Concerning the term “species” in vertebrate paleontology

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Lately the author of this notice was occupied with the definition of remains of three different marine reptiles which were deposited in the Upper Cretaceous formations of the Don region. The remains consisted mostly of vertebrae, partly of fragments of limbs, and one tooth. They belonged to a mosasaur and to two different plesiosaurs, the short-necked *Polycotylus* and the long-necked *Elasmosaurus*. The attempt to place each into the proper position among the forms known from the literature brought with it the necessity to become closer acquainted with the structure of corresponding genera and also with those characters which differentiate one species from another.

Several considerations arising as a result of this study are the subject of this monograph.

It is well known how poor in most cases is the fossil material from which the paleontologist must analyze the organization of extinct vertebrates, especially the marine forms.

Thus, for instance, 7 separate species are distinguished each among the short-necked plesiosaurs of the genus *Polycotylus* Cope and its related genus *Trinacromerum* Cragin. These are as follows:

A. 1. *Polycotylus latipinnis* Cope

* Original citation: Pravoslavlev, P. 1918. O termine “vid” v paleontologii pozvonochnykh. *Ezhegodnik Russkogo Paleontologicheskogo Obshchestva* 1:43–60. Translated by J. Goldsmith. **Generously donated by the Biosciences Library, University of California, Berkeley, and courtesy of Patricia Holroyd and William Clemens.** Transferred to electronic copy and edited by Mark Uhen and Michell Kwon, Smithsonian Institution, 2007.

2. *Polycotylus dolichopus* Williston
3. *Polycotylus tenuis* Hector
4. *Polycotylus balticus* Schroder
5. *Polycotylus epigurgitis* Bogolubov
6. *Polycotylus brevispondylus* Bogolubov
7. *Polycotylus suprajurensis* Savage

- B. 1. *Trinacromerum bentonianum* Cragin
2. *Trinacromerum anonymum* Williston
3. *Trinacromerum latimanus* Williston
4. *Trinacromerum Osborni* Williston
5. *Trinacromerum ichthyospondylum* Seeley
6. *Trinacromerum orientale* Bogolubov
7. *Trinacromerum ultimum* Bogolubov

Of these the type species of the genus *Polycotylus* Cope, namely *P. latipinnis*, was established upon the basis of skeletal remains found in the Niobrara of Kansas: 21 vertebrae all more or less deformed and fractured, fragments of ilium, femur, and tibia, a few tarsalia, metatarsalia and digital phalanges.¹

¹ Cope, *Proc. Am. Philos. Soc.* 11, 1869, p. 117; *Am. Journ. Sci.* 1869. p. 278; Synopsis of the Extinct Batrachia Reptilia etc., *Transact. Am. Philos. Soc.* 14, 1871 p. 36-38; On the Fossil Reptiles and Fishes of the Cret. rocks of Kansas, *U.S. Geol. Survey of Wyoming* 1871, p. 388; On the Geology and Palaeontology of the Cretac. strata of Kansas, *U.S. Geol. Survey of Montana* 1872, pp. 320-335; Review of the Vertebrata of the Cret. period found west of Mississippi; R., *U.S. Geol. Sur.* 1874, 1, no. 2, p. 27; The Vertebrata of the Cret. formations of the West, *U.S. Geol. Sur.* 1875, p. 72.

It is assumed that the corresponding animal had 26 cervical and 28-29 spinal [lumbar?] vertebrae (of these 3 dorsal).² The skull, regions of appendicular bones (*poyasa konechnostei*), and the series of lacking appendicular bones can of course be established purely hypothetically.

The remaining species of the g. *Polycotylus* Cope established conformably to the characteristics of *P. latipinnis* are based upon the following skeletal remains: *P. dolychopus* - portion of the forefoot of another.¹ *P. tenuis* – 3 humeri of two different individuals; one cervical vertebra from one animal, several lumbar vertebrae from another, part of posterior girdle and one vertebra from a third animal.² *P. balticus* – one cervical and one dorsal vertebra, several costal fragments, two teeth and a humerus.³ *P. epigurgitis* – one spinal vertebra;⁴ *P. brevispondylus* – one spinal (or dorsal) vertebra;⁵ *P. suprajurensis* – one humerus.⁶

The genus *Trinacromerum* Cragin and its type species *T. bentonianum* were established upon the basis of the following remains:

Three “fractured crania” of different individuals, whereby one of these “crania” was found later to be a portion of pectoral girdle; then 12–14 cervical vertebrae, 15 dorsal and 3 lumbar vertebrae, parts of extremities and their girdles.¹ A complete skeleton of

² Cf. Williston. N. American Plesiosaurs, *Field Columb. Mus. Publ.* 73, 1903, p. 67-71; *Am. Journal Sci.* 1906, p. 233; *Journ. of Geology* 1908, pp. 715-732; Bogolubov, *Iz istorii plesiosavrov v Rossii*, 1913, p. 327-336.

¹ Williston, *Am. Journ. of Sci.* 1906, pp. 235-236; *Journal of Geol.* 1908, p. 735.

² Hector, *Transact. of the N. Zealand Inst.* 1873 (1874), 6, pp. 345-56; Lydekker, *Catalogue of fossil Rept. and Amph. in the Br. Museum*, 1889, II, p. 188.

³ Schröder, *Jahrb. Preuss. Geol. Landesanst.* 1884 (1885), 297-310, Lydekker, *Catalogue etc.*, p. 185; Bogolubov, *Iz istorii plesiosavrov v Rossii*, p. 337-339.

⁴ Bololubov, *Iz istorii plesiosavrov*, etc. 316.

⁵ Bololubov, *l.c.*, pp. 317-320.

⁶ Sauvage, *Bull. Soc. Geol. France* 4, 1876, pp. 435-438.

¹ Cragin, *Am. Geologist*, 1888, p. 404, 1891, 171; Williston, *Journ. of Geology*, 1908, pp. 716-729.

Trinacromerum is assumed to have not less than 23 cervical vertebrae.² The remaining species of the gen. *Trinacromerum* were established upon the basis of the following material:

T. anonymum - part of cranium, 20 cervical, 3 dorsal vertebrae and several appendicular bones;³ *T. latimanus* – posterior cranial portion, several vertebrae and several appendicular portions of one animal, humerus of another;⁴ *T. osborni* – almost an entire skeleton with the exception of a few vertebrae;⁵ *T. ichthyospondylum* – several scattered vertebrae from the green sands of Cambridge and the phosphorites of the Kursk Government (Owen).¹ Later a separate variety (var. *tanais* Bogolubov) was distinguished which was documented by “one almost entire cervical vertebra, fractured body of a dorsal [lumbar?] vertebra and the proximal portion of humerus” from the Cenomanian phosphorites of Voronezh Government.² *T. orientale* – 4 cervical, 2 spinal and 2 caudal vertebrae, radial metacarpal and digital phalanges of possibly different individuals;³ *T. ultimum* – 2 cervical vertebrae.⁴

For the long-necked plesiosaurs of the gen. *Elasmosaurus* Cope, 15 separate species are shown. However, not even in one species is the entire skeleton known, there being mostly separate bones.

Thus, of the type species of the gen., *Elasmosaurus platyurus*, neither the cranium nor extremities are known; bones of the appendicular girdles were found in incomplete

² Williston. *Am. Jour. Geology* 1908.

³ Williston. *Am. Jour. Geol.* 1908, pp. 729-732; *Field Columb. Mus. Publ.*, 1903, p. 66.

⁴ Williston. *Jour. Geol.* 1908, p. 732-734.

⁵ Williston. *Field Columb. Mus. Publ.* 1903, pp. 13-52; *Journ. Geology*, 1908, p. 715.

¹ Seeley, *Index to the foss. remains of Aves, Reptilia etc. in the Woodw. Museum* 1869; Owen, *Fossil Reptil. Russlands, Mem. Ac. Imp. S. Petersb.* 7 ser., 30, no. 6.

² Bogolubov, *Iz istorii plesiosavrov v Rossii*, p. 321-327.

³ Bogolubov, *Ibid.* p. 342-343.

⁴ Bogolubov, *Ibid.* p. 348-351.

articulation and were badly fragmented; we have less than 50 vertebrae in the vertebral column.¹ The majority of the other species of *Elasmosaurus* are documented by the following remains:

E. constrictus Cope (Owen) - one cervical vertebra;² *E. serdobensis* Bogolubov – one cervical vertebra;³ *E. orientalis* Cope – 2 cervical vertebrae from separate places in New Jersey;⁴ *E. sternbergi* Williston – 2 spinal vertebrae with a few supplemental fragments;⁵ *E. kurskensis* Bogolubov – 2 cervical 2 thoracic and 1 caudal vertebra and conjectural propodial bones of the animal;⁶ *E. helmerseni* Bogolubov (Kiprijanov) – 5 cervical, 4 thoracic and 4 caudal vertebrae;⁷ *E. orskensis* Bogolubov is known from several cervical and 5 caudal vertebrae;¹ *E. intermedius* Cope – 19 cervical vertebrae from the cervical and thoracic regions;² *E. snowi* Williston – 19 cervical vertebrae of one individual (U. of Kansas coll.) and several vertebrae, fragments of limbs and their girdles

¹ Cope *Proc. Acad. Nat. Sci. Phil.* 1868, 68; Notes on Geology, Leconte, 1868, 68; *Proc. Bost. Soc. Nat. Hist.* 1868, 266; *Am. Nat.* 3, 87; Synopsis of the extinct Batrachia, Reptilia and Aves of N. Amer., *Transact. Am. Philos. Soc.* 14, 1871. *U.S. Geol. Surv. Territ.* 1871, 393; 1872, 320, 336; *Cret. Verteb.* 1875, 44, 79, 256; *Bull. U.S. Geol. and Geogr. Surv.* 3, 1877, 578; *Am. Nat.*, 22, 724–726; Leidy, *Am. Journ. Sci.* 49, 1870, 392; *Proc. Acad. Nat. Sci. Phil.*, 1870, 9, 18; Lydekker, *Cat. Foss. Rept. Brit. Mus.*, 2, 181. Williston, N. Am. Plesiosaurs, *Field Columb. Mus. Publ.*, 73, 1903; *Am. J. Sci.*, 4th ser. 1906, 231–236. Bogolubov, *Iz istorii pleziosavrov v. Rossii*, 1911, 351.

² Owen, *Dixon's Geology and Fossils of the Tertiary and Cretac. Format. of Sussex*, 1850, p. 398; Monograph of the Foss. Reptil of the Cretac. Form., *Palaeontogr. Soc.* 1851–1864, pp. 61–62; Cope, *Proc. Bost. Soc. Nat. Hist.* 12, 1869, p. 266; Extinct Batrach. Reptil. and Aves. *l.c.* p. 47; Lydekker, *Cat. Foss. Rept Brit. Mus.* 2, 1889, pp. 212–213.

³ Bogolubov, *Iz istorii pleziosavrov etc.*, 374–377.

⁴ Cope, *Proc. Ac. Nat. Sci. Phil.* 1868, 313; *Proc. Bost. Soc. Nat. Hist.* 1869, 266; *Geolog. Surv. N. Jersey, Cooc*, [sic], Append. (1868), 1869, 733; *Am. Nat.*, 1869, 87; Ext. Batrach., Reptil. etc, *Transact. Am. Philos. Soc.* 14, 1871; *Am. Journ. Sci.*, 1870, 368; *Cretac. Verteb.*, 1875, 255. *Bull. U.S. Geol. and Geogr. Surv.* 3, 1877, 567, 578; *Am. Nat.* 11 1877, 311; Leidy, *Proc. Acad. Nat. Sci. Phil.*, 1870, 22; Lydekker, *Cat. Foss. Rept Brit. Mus.* 2, 1889, p. 247; Williston, *Am. Journ. Sci.* 4th ser. 1906.

⁵ Williston, *Am. Journ. Sci.*, 1906, p. 232.

⁶ Bogolubov, *Iz istorii pleziosavrov Rossii*, 353–359. Kiprijanov, *Studien uber d. Fossil. Reptil.* 2, 17–32.

⁷ Bogolubov, *Iz istorii pleziosavrov etc.* 359–363, Kiprijanov, *l.c.*

¹ Bogolubov, *l.c.*, 363–374.

² Cope, *Proc. Am. Phil. Soc.* 1894, p. 112; Williston, *Am. J. Sci.* 1906, p. 227.

from another individual (Coll. of the Yale Mus);³ *E. marschi* [*sic, marshii*] Williston – 33 vertebrae, scapula and bones of the forefoot;¹ *E. nobilis* Williston – several vertebrae, portions of the anterior and posterior appendicular girdles and a portion of hind foot.²

This refers to animals whose spine is assumed to have had more than 150 vertebrae, and whose cervical vertebrae alone reached the number of 76 while the total length of all vertebrae reached 23-24 feet — — —. Consequently the declaration of one of the best elasmosaurian connoisseurs Prof. Williston, appears quite natural, “At the present time,” he wrote in 1906, “we hardly know what an *Elasmosaurus* is.” And if I employ this name for the designation of some 10 species known to me, I do it only to the extent these can be recognized by their actual generic characters — —. “It is possible, or even probable, that among these species are 2 or more competing genera.”³ ”Up to now it is impossible to establish properly *Elasmosaurus* in all details since we do not know even in one species of these animals a complete skeleton.”⁴ No better is our state of knowledge concerning several representatives of the gen. *Mosasaurus* Conyb. These animals attaining a presumptive length of 75 feet or more, and having 131 vertebrae in its spinal column consist of the following species: *M. miersii* Marsh – 1 tooth;¹ *M. crassidens* – portion of maxilla with teeth;² *M. copeanus* Marsh, portion of skull with several upper

³ Williston, *Am. J. Sci.* 4th ser. 1906, pp. 228-229; *Field Columb. Mus. Publ.* 2, 1903, pp. 52-56; Cope, *Proc. Am. Phil. Soc.* 33, 1894; pp. 109-111.

¹ Williston, *Am. Jour. Sci.*, 1906, pp. 229-231.

² Williston, *l.c.*, 1906, pp. 232-233.

³ Williston, *l.c.*, 223-224.

⁴ Williston, *l.c.*, p. 224.

¹ Marsh, Notice of some new mosasauroid reptiles. *Am. Jour. Sci.* 1869, p. 395; Cope, *Extinct Batrach. etc.*, p. 199, *The verteb. of the Cret. form.* p. 270.

² Marsh, *Proc. Acad. Nat. Sci. Phil.* 1870 pp. 3-5; Cope, *Ext. Batr., Reptil. etc.* p. 198; *The Vertebrata of the Cret. form.* 1875, p. 270; *Rept. Geol. Surv. of N. Carolina* 1875, p. 41.

teeth part of mandible;³ *M. minor* Gibbes – portion of snout with teeth;⁴ *M. fulcatus* Cope – quadrate bone, 3 spinal vertebrae, fragment of humerus etc.⁵

In a similar state we find, as we know, many other groups of fossil vertebrates. There too, several species or even genera were established upon the basis of separate and often single bones.

Upon what characteristic bases are such species separated? Why are these animals, which are often scantily represented by such fossil remains as one or several teeth, separate vertebrae, portion of snout, or appendicular fragment, etc. separated into individual systematic units?

The common method is a comparative study of the found bones with the corresponding bones of other animals more or less related in organization and known in the literature. A little bigger structural deviation is often elevated to the degree of generic characteristic and the animal found gets a separate generic name; a minute deviation generally serves the segregation into a new specific entity etc.

The size of the found bone often serves as the character of specific deviations when compared with the known forms. Lately, we have taken recourse to so-called indexes (indices) i.e. to a comparison of relative measurements of the bones in different individuals. Thus, for instance, the dimensions of vertebral bodies are brought into the equation L:H:W:, where L = length, H = height, W = width of the vertebral centrum; appendicular bones are compared according to the ratio of their width to the length or to

³ Marsh, *Am. Jour. Sci.* 1866, p. 393; 1872, p. 455; Cope, *Ext. Batrach. Reptil. etc.*, p. 198, *The Verteb. of the Cret. form.*, p. 270.

⁴ Gibbes, A memoir on *Mosasaurus*; *Smiths. contr. to knowledge* 1851 p. 7; Cope, *Proc. Bost. Soc. Nat. Hist.* 1869, p. 261; *Ext. Batrachia Rept. etc.* pp. 186, 189, 198; *The Verteb. of the Cret. form.*; p. 270, Leidy, *Smiths. contr. to knowledge*, 1865, p. 118.

⁵ Cope, *Extinct Batrach. Reptil., etc.* p. 194; *The Verteb. Cret. Form.* p. 269.

some other diameter adopted as a unit, etc. The same is applied, as we know, in descriptive zoology. We agree with the Academician Zalenskii that the index method appears more positive and promising in the elucidation of osteological peculiarities of the animal than a simple indication of absolute dimensions of the bones.¹ Bones of an adult animal, for instance, in their absolute dimensions are different from the bones of an immature representative of the same form; the relative dimensions, or indices of bones of both are more or less close to a coincidence.

Thus, a noticeable difference in the indices of the compared bones with common generic characters often leads to the differentiation of the given animals and sometimes to their separation into specific groups.

This question appears natural: upon what basis, for instance, is the species *Elasmosaurus sternbergi*, of which we have only 2 dorsal vertebrae, different, let us say from the species *E. constrictus* and *E. serdobensis*, when each one is known to us only by 1 cervical vertebra? *Polycotylus epigurgitis* and *Polycotylus brevispondylus* each represented by one dorsal vertebra, from *Polycotylus suprajurensis* of which we have only a humerus? Or *Mosasaurus miersii* represented solely by one tooth, from *M. fulcatus*, of which we have the quadrate, 3 dorsal vertebrae and a fragment of a humerus? Upon the basis of what comparison are segregated into individual species *Elasmosaurus orskensis*, the few cervical and 5 caudal vertebrae, and an earlier species, *Elasm. sternbergi*, of which we possess only two dorsal vertebrae? Why should the solitary humerus of a *Polycotylus* represent a new, previously unknown species *Polyc. suprajurensis*? Upon what basis rests the supposition that this humerus is different from

¹ V. Zalenskii, Osteol. i osteograf. izsledov. nad mamontem i slonami. Nauch. result. exped. I. *Adad. Nauk dlya raskopki mamonta na r. Berezovke* I, 1903, p. 94.

that of *Polyc. epigurgitis* and *Polyc. brevispondylus*, each of which is known only through one vertebra? Why could not the quadrate, 3 dorsal vertebrae, and humeral fragment of a mosasaur be referred to the species *Mosasaurus miersi*, of which one tooth is known, instead being segregated into a specific unit, *Mosasaurus fulcatus*?

In short, where are the bases for suppositions that a newly found bone or group of bones of any particular animal are differentiated from factually unknown bones of other congeneric animals which have been previously described?

As is known, the basis for such differentiations commonly is the principle of correlation between separate bones of the animal or the so called law of organic correlation.¹ Cuvier shows frequent examples how from one bone the structure of the animal may be recognized.

However, in practice the application of this principle cannot be segregated from the individual views of the author. Thus, for instance Cope has referred the entire series of elasmosaurian vertebrae from the lower Senonian of Montana to the species *Elasm. orientalis* Cope, of which he has previously described two cervical vertebrae from the Turonian sandstones of N. Jersey;² Williston who later has studied these vertebrae, came to the conclusion that Cope's Montana elasmosaur should be referred to *E. platyurus* Cope, and by no means to *E. orientalis*.³ Likewise, the deformed vertebrae of another Montana elasmosaur, described by Cope under the specific name *Elasm. intermedius*,¹ are according to Williston undistinguishable from the vertebrae of Cope's *E. platyurus*

¹ Cf. Cuvier G., *Leçons d'anatomie comparée* 1, 1836 article 6 and others.

² Cope, *Bull. U.S. Geol. and Geogr. Surv.* III, 1877.

³ Williston, *Am. Jour. Sci.* 4th ser. 21, 1906.

¹ Cope, *Proc. Amer. Philos. Soc.* 1894.

and the animal should be referred to the latter species.² The separate bones described by Kiprijanov as those of *Plesiosaurus helmerseni*³ belong in reality, according to Bogolubov, some to *Elasm. kurskensis*, others to *Elasm. helmerseni*, while the rest should be placed among other plesiosaurid genera.⁴

The same could be stated concerning the determination of some plesiosaur bones by Schroder,⁵ Hector,⁶ Deecke,⁷ and others. I have had the opportunity of investigating the changes in shape and measurements in the vertebral bodies of the Don elasmosaur. All these vertebrae unmistakably belonged to one individual. I should confess that if for instance, the anterior cervical vertebrae should have been found separated from posterior ones, the caudal separated from cervical and others, it would have been hard to refer them to the spinal column of the same individual. The indices of the bodies of the anterior cervical vertebrae L:H:W – 1:0.58:0.9; of the middle cervical vertebrae 1:0.7:1; of the posterior cervical vertebrae 1:1:1.5; spinal 1:1.2:1.4; of caudal 1:1.3:1.7; There were even small deviations in measurements of the individual vertebrae within each group.¹ Let us admit, however, that the distinction among the different animals, whose fossilized remains are represented by single bones may be valid. That for instance, *Polycotylus epigurgitus* and *Polycotylus brevispondylus* of which we have one spinal vertebra each, are properly distinguished from *Polycotylus suprajurensis*, which is documented by only a humerus; *Mosasaurus miersii* of which we have only a tooth is validly distinguished

² Williston, *Am. Jour. Sci.* 1906, p. 227.

³ Kiprijanov, *Mem. de l'Acad. Imp. d. St-Petersb.* VII ser. 30, 1882.

⁴ Bogolubov, *Iz istorii plesiosavrov v Ros.* 1911.

⁵ Schröder, Saurierreste aus der Baltischen oberen Kreide, *Jahrb. K. Preuss. geol. Landesanst.* 1884 (1885); Bogolubov, *l.c.*

⁶ Hector, On the Fossil Reptilia of N. Zealand, *Transact. and Proc. N. Zealand Inst.* 6, 1874.

⁷ Deecke, Uber Saurierreste aus den Quiriquina Schichten, *N. Jahr. Min., Geol, Palaeont.*, X Beilage Band, 1895-1896, pp. 32-63; Bogolubov, *Iz istorii plesiosavrov v Rossii*, p. 82-83.

¹ Pravoslavlev, Elasmosaur iz verkhne-melovykh otlozhenii Donskoi Oblasti, *Trud. I. Petrogr. Obshch. Estestv.* 38, vyp. 5.

from *Mos. fulcatus* of which we know only the quadrate bone, 3 spinal vertebrae and a fragment of the humerus; *Elasmosaurus sternbergi* of which there are only two spinal vertebrae is specifically distinguishable from *E. constrictus* and *E. serdobensis*, which is each represented by one cervical vertebra. Now may these distinctions between these animals, whether they be actual or putative, have a specific character and consequently serve as a basis for specific determination of the corresponding animals?

May not the indicated osteological deviations represent, in many cases, peculiarities resulting from growth, sex, or even individuality?

It is known, for instance that the scapular girdle of young plesiosaurs is morphologically different from the scapular girdle of adult forms as has been shown by Andrews in *Cryptocleidus oxoniensis*. In the young forms the anterior portions of scapulae are undeveloped and between them rise the triangular clavicles. In the adult animals the expanded scapulae rise forward and force the clavicles upward and inward; the joined scapulae adopt the function of clavicles.¹

It is also possible that the plesiosaurs were viviparous² among them sexual differentiation is possible.

However let us leave the age and sexual deviations of the fossil animals; if we accept an individual variation in the osteology among closely related forms, how far can such variations extend? Where is their limit, whereby we may truly isolate a new species?

I do not intend to enter here into the question concerning the limits of “species” or of the so-called individual variations. I shall only mention that in contemporary

¹ Andrews, *Ann. Magaz. Nat. Hist.* 15, pp. 333-346 1895.

² Williston, *Water Reptiles of the Past and the Present*, p. 94, 1914; Seeley, *Rept. of the Yorkshire Phil. Soc.* 1895, pp. 20-29.

paleontology the boundaries between the fossil vertebrate species and often even genera is not always incontestable.

Thus for example at the time when Leidy, Cope, Hector, Seeley, Cragin et al. describe skeletal remains of various representatives of Plesiosauridae under separate generic names: *Discosaurus* Leidy, *Brimosaurus* Leidy, *Oligosomus* Leidy, *Elasmosaurus* Cope, *Polycotylus* Cope, *Piptomerus* Cope, *Mauisaurus* Hector, *Muraenosaurus* Seeley, *Colymbosaurus* Seeley, *Trinacromerum* Cragin – Lydekker sees in them the skeletons of the representatives of one genus: *Cimoliasaurus* Leidy.¹ According to Andrews, the genera *Sauranodon* Marsh, *Baptanodon* Marsh, and *Microdontosaurus* Gilmore should be united into a single genus, *Ophthalmosaurus* Seeley.¹

In the same way, Cope counted among the mosasaurs the following genera established by Marsh: *Lestosaurus* Marsh entered into gen. *Platecarpus* Cope; *Tylosaurus* (*Rhinosaurus*) Marsh = *Leiodon* Owen; *Holosaurus* Marsh = *Sironectes* Cope; *Edestosaurus* Marsh = *Clidastes* Cope.² Dollo has united the genera *Oterognathus* and *Phosphorosaurus*, previously established by him, into a single genus *Plioplatecarpus* Dollo.³

Also the differences indicated by authors for skeletal remains described under the names of *Plesiosaurus oxoniensis* Phillips, *Plesiosaurus eurymerus* Phillips, *Cimoliasaurus oxoniensis* Lydekker, *Cimoliasaurus eurymerus* Lydekker, *Plesiosaurus durobrivensis* Seeley, *Cimoliasaurus eumerus* Seeley, *Cryptocleidus platyurus* Seeley are

¹ Lydekker, *Catal. foss. rept. and amphib. in the Brit. Museum* 2, p. 180, 1889.

¹ Andrews, *Marine reptiles of the Oxford Clay* I, 1910.

² Cope, The vertebrata of the Cretac. format. of the West, *Report U.S. Geol. Surv. Territor.* II, 1875, Two new genera of Pythnomorpha, *Am. Nat.* 1883.

³ Dollo, *Bull. de la Soc. Belge de Geol.* 1892, p. 221; 1904, p. 208.

in reality of such a nature that according to Andrews these remains should be considered as belonging to the representatives of one species – *Cryptocleidus oxoniensis*.¹

It happens also that skeletal remains described by certain authors under one specific name are later divided by the same author into various specific groups or vice versa. Thus, of remains described by Andrews under the name *Muraenosaurus plicatus*, some were later referred by him to *Muraenosaurus leedsii* Seeley, others to *Muraenosaurus durobrivensis* Lydekker, etc.²

We obtain a situation, which in reference to certain plesiosaurs is characterized by Williston as follows: I have already stated and do repeat – he writes in 1906, that the taxonomy of plesiosaurs is in a very confused situation. I doubt that a similar condition prevails in another reptilian division. This is caused mainly by the fragmentary state of the known plesiosaurian material.³

As we have stated, the morphological peculiarities of the fossil bones which are being compared, and also their measurements are the characters used for specific differentiation. However, if we turn to the osteology of the best studied vertebrate group, *Homo sapiens*, we frequently encounter considerable variations in the skeletons of the representatives of the same zoological species. Thus, for instance, according to the measurements of Aeby in Berne, relative measurement of human vertebral centra (21 skeletons) revealed the following fluctuations which were due to age and to sex (separate vertebrae are taken for the illustration):¹

¹ Andrews, *Marine reptiles of the Oxford Clay*, part I, 1910.

² Andrews, *ibid.*

³ Williston, *Am. jour. Sci.* 4th ser. 1906, p. 221.

¹ Aeby, *Die Altersverschiedenheiten d. menschl. Wirbelsaule Archiv f. Anatomie u. Entwicklungsgeschichte*, 1879.

5 th cerv. vertebra (L:H:W)	9 th dorsal vertebra (L:H:W)	3 rd lumbar vert. (L:H:W)
1. 32:37:71–1:1.56:2.22	40:50:72–1:1.25:1.8	53:53:96–1:1:1.81
2. 29:34:63–1:1.172:2.172	40:51:73–1:1.275:1.825	52:57:98–1:1.09:1.9
3. 29:32:63–1:1.103:2.172	42:56:65–1:1.33:1.55	60:60:87–1:1:1.45
4. 29:25:52–1:0.862:1.8	45:48:65–1:1.66:1.44	68:55:93–1:0.81:1.37
5. 28:25:41–1:0.893:1.464	41:52:59–1:1.27:1.41	64:59:86–1:0.92:1.34
6. 28:24:40–1:0.86:1.43	41:50:54–1:1.22:1.32	66:54:79–1:0.82:1.2
7. 27:27:46–1:1:1.7	42:48:57–1:1.12:1.36	61:54:84–1:0.9:1.38
8. 27:32:45–1:1.185:1.67	40:52:58–1:1.3:1.45	59:58:80–1:0.983:1.36

Where 1 is newborn male child, 2 – 6-month-old male child, 3 – 2-year-old boy, 4 – eleven-year-old boy, 5 – adult male, 6 – adult female, 7 – sixteen-year-old girl and 8 – four-year-old girl.

Hasebe, Wetzel, and others testify concerning wide fluctuations in the measurements of the vertebrae among various nationalities – the former among Japanese,¹ the latter among Austrians.² These same authors as well as Le Double³ and others note the cases of purely individual or even abnormal deviations in the skeletons of various people, for instance in the structure of the atlas and epistropheus, of ribs etc. Cunningham's measurements point to the possibility of coincidence in the measurements of separate skeletal parts as e.g. in some lumbar vertebrae among the representatives of

¹ Hasebe, Die Wirbelsäule d. Japaner, *Zeitschr. z. Morphol. u. Anthropol.* 1913.

² Wetzel, Die Wirbelsäule d. Australier, *Zeitschr. z. Morphol. u. Anthropol.* 1910.

³ Le Double. *Traite d. variations de la colonne vertebrale de l'Homme*, Paris, 1912; Cotes cervical chez l'Homme *Bull. et Mem. de la Soc. Anthropol.* Paris 1911; Apophyse capitulaire thoracique, *Bull. et Mem. Soc. d'Anthropol.* 1912; Soudure chez l'Homme de l'atlas, *Bull. et Mem. Soc. d'Anthropol.* Paris 1912 and others.

various nationalities while the remaining skeletal measurements may be different.⁴ Hepburn remarks that the relative measurements of femora vary not only among the different nationalities and races but also in a single nationality, as for instance, among Britons.¹ Even the femora of an individual are not always exactly alike. These variations- he writes- have to do not only with a certain portion of the bone, but with almost all of its particulars. I have never seen a single pair of femora in which both bones were absolutely symmetrical, although a considerable approach to symmetry was found in the femora of a gibbon and one young chimpanzee.²

Variations in relative measurements of separate portions of the human skeleton are as is well known, so considerable, that osteologically we have to say concerning the human race that it is a combination of osteological characters in definite limits of variation.³

In this respect it is sufficient to inspect Klaatsch's comparative sketches of separate skeletal parts in the representatives of principal human races such as vertebrae, ribs, femora, humeri, tibia, etc.⁴ Cranial differentiation in the various representative of *Homo sapiens* are universally known.⁵ The concept that is paleontologically expressed as "species" is known. "Biological species," writes Diener, "are physiological unities. They comprise all individuals who are morphologically conformable or capable of conformity when developed under identical external conditions. Inasmuch as the biologist has to do with living organisms, he can in characterizing a species apply all the life manifestations

⁴ Cunningham, The proportion of bone and cartilage in the lumbar section of the vertebral column of the ape and several races of men, *Journ. of Anat. and Physiol.* 1890.

¹ Hepburn, The platymeric, pilastric and popliteal indices of the race. *Jour. Anatomy and Physiol.*, 1897.

² Hepburn, *l.c.* p. 123.

³ Klaatsch, Uber die Variationen am Skelette d. jetzigen Menschheit, *Corr. Blatt d.d. Gescl. z. Anthropol.* 33, 1903, p. 136.

⁴ Klaatsch. *l.c.*

⁵ Cf. Topinard, *Elements d'Anthropologie generale*; Klaatsch, *l.c.* and others.

of these organisms. In the fossil forms however, when separating the species, only morphological characters can be utilized (since only the hard portions of an organism are preserved) and observed. Paleontological species are not physiological, but rather descriptive unities.”¹

The same must be said concerning paleontological “genera” whenever these are formed from such “species.”²

Inasmuch as paleontology was created and grew up in a large measure in the service of stratigraphic geology, the attempt to note in greatest detail, the morphological differences of the encountered organic remains was natural. From these in many cases it was possible to obtain the guiding thread in the discernment of the separate stratigraphic [lit] monuments. [i.e. signs or markers.]

In this manner a series or systematic unities were obtained within certain fossil forms which were endowed with the biological terms “species,” “genus,” etc. Even Waagen is not excepted when he considers, in his works, as a separate “species,” “each form which can be characterized by description and depiction and can be differentiated from other forms.”

It is quite natural that in the search for “differentiations,” especially the “index differentiations” the biological nature of the fossil objects was frequently considered last. The fossilized remains of organisms were often treated almost in the same manner as

¹ Diener, *Palaeontologie und Abstammungslehre*, Leipzig 1910.

² However, according to Jaekel and others a “genus” may be to a large degree independent from the specific forms which it comprises. “Wie die Blätter vorübergehende Erscheinungen an dem langsam wachsenden Baume bilden,” he writes, “so sind die Arten (species) die schnell wechselnden Bilder in denen der jeweilige Entwicklungsstand der einzelnen Zweige in der Berührung mit der Aussenwelt Gestalt gewint und zeitweilig einen festen Ausdruck findet” (*cf.* Diener, *l.c.*). This is hardly applicable, however concerning a majority of paleontological genera which are predominantly morphological. Their genetic homogeneity as is known, is in many cases doubtful. Such for instance is the genus *Elasmosaurus* and others as has been shown above.

excavated ancient coins, weapons, implements, etc. are in archeology. In this sense a separate bone could be of almost equal interest to an entire skeleton of the animal. And the categories of “species” and “genera” were established alike for the extinct forms where the entire skeleton or its essential portions were known, and for those where there was only a tooth, or a fragment of a tooth or some other single bone.

We have witnessed the examples of this in *Polycotylus*, *Trinacromerum*, *Elasmosaurus*, and *Mosasaurus*.

Of course it is hardly proper to negate the utility of these morphological differentiations among the fossil organisms in the service of stratigraphic geology. But it would be likewise hardly proper to forget the real existence of thus formed “species” and “genera.”

The latter particularly must not be forgotten when attempting to construct phylogenetic branches of the organic tree. “Whosoever touches upon the questions concerning the evolutionary developments of organisms,” wrote Diener, “should recall the difference between the physiological species in biology and the descriptive species in paleontology.” There is so much more so we may add – because the “species” are represented by such defective remains as are some of the above-named *Polycotylus*, *Trinacromerum*, *Elasmosaurus*, *Mosasaurus*, etc. Hypothetical completion of the missing portions of the extinct animals as we have seen, does not bring, according to the principle of the correlation of organs, always incontestable deductions concerning the systematic position of the animal. For there exists as is known a valid correlations of organs in the

animal body, however in not so conspicuous a measure as to permit from the knowledge of one single organ the exact conclusions concerning the property of the remaining ones.¹

It appears to me it would be better to refrain as much as possible from a broad application of the term “species” in paleontology. Each scientific term should have a strictly defined contents, and it is hardly proper to denote by an identical designation such a widely divergent concepts as the “species” in biology (i.e. a definite physiological unity, with its aggregation of anatomical, embryological, biological and morphological characters) and the “species” in paleontology (a descriptive unity of morphological nature). I do not want to repeat the well known arguments of Depéret, Diener, and others concerning this problem. Anyhow, I think that several denotations of “n. sp.” in literature, on vertebrate paleontology should not be read as “nova species,” but rather “novum specimen.”

At the same time those phylogenetic branches which are the result of the establishment of such “n. sp.” must be taken “cum grano salis” when the genetic development of the organic world is schematized.

Although not contesting a certain utility and purpose of minute systematic subdivisions in paleontology for a stratigraphic geology, I believe that it would be better to employ a somewhat different terminology than that used in biology. Then employ the latter only in definite cases and in the case of fossil vertebrates only when the entire skeleton or its essential portions are present.

¹ Diener, *l.c.* Referring to reconstruction of extinct mammals of the Upper Eocene formations of Paris, Diener states: “Cuvier war vom Zufall ausserordentlich begünstigt worden. Ware ihm statt der obereozänen Säugetierfauna von Paris die paleozäne Fauna des Puerco oder Torrejon bed in Nordamerika zur Untersuchung vorgelegen, so hatte sien Korrelations gesetz klaglich Schiffbruch gelitten.”