II.—ON THE PALÆONTOLOGY OF THE SELACHIAN GENUS NOTIDANUS, CUVIEB.

By A. SMITH WOODWARD, F.G.S., of the British Museum (Natural History).

(PLATE VI.)

A MONG the Selachians of the existing fauna, there are none of greater interest and higher morphological importance than *Notidanus, Cestracion*, and the recently-discovered *Chlamydoselachus* from Japanese seas. These are the solitary survivors of once flourishing types, whose immediate congeners are only known to Biological science through the fragmentary remains preserved in the geological record; and the value of the archaic features they present is even further enhanced by the slight information already acquired regarding the geological distribution of their numerous extinct allies.

Hitherto, however, there appears to have been no attempt at a systematic treatment of the Palaeontology of the first of these genera, although the Cestraciont and Cladodont types have received a large share of attention. I therefore propose to offer a short account of the present state of knowledge of this subject—summarizing the results of previous research, making known a few interesting fossils that have not yet been described, and adding some general remarks on the extinct congeners of the Notidanidæ, so far as they can be determined from the evidence of detached teeth.

Briefly reviewing the main anatomical features of the living Notidanus, in the first place, there are several peculiarities especially worthy of note. The skull is remarkable from its close approach to the amphistylic type of Professor Huxley.¹ Unlike all other living Selachians, the upper element of the hyoid arch is extremely slender and takes no part in the support of the pterygo-quadrate and mandibular cartilages; but this is compensated for by a distinct facette upon the otic process which articulates with the post-orbital process of the chondrocranium.² The mandibular and hyoid arches thus most nearly retain their primitive condition, and there is also only a very slight advance upon this stage in Cestracion:³ in this genus, the pterygo-quadrate articulates with the pre-orbital region of the chondrocranium, and the "hyomandibular" is only just becoming worthy of that name. These characters are so important, when taken in conjunction with others exhibited by the same types, that in dividing the Selachii into four great suborders, Prof. Theodore

¹ T. H. Huxley, "On *Ceratodus Forsteri*, with Observations on the Classification of Fishes," Proc. Zool. Soc. 1876, pp. 40-45. ² See excellent figures by C. Gegenbaur, "Das Kopfskelet der Selachier" (1872),

plate x.

³ T. H. Huxley, loc. cit. p. 42, fig. 8.

Gill¹ regards the Notidanidæ and the Cestraciontidæ as the sole existing representatives of the first two.

Notidanus is also remarkable for the persistence of the notochord. One section of the genus (Hexanchus) exhibits this gelatinous rod merely subdivided by transverse membranous septa, while the other (Heptanchus) has annular cartilages in the sheath which only show traces of calcification in the region of the tail.²

As regards fins, the genus under consideration differs from other Sharks (except Chlamydoselachus) in possessing only a single dorsal, without spine, which is placed far back, partly opposite the anal. The latter is well marked off from the caudal. The structure of these locomotory appendages in Notidanus is also interesting, but there is much difference of opinion as to the conclusions to be drawn from them. Prof. Huxley has given reasons³ for regarding the pectorals as of a more primitive type than those of other living Selachians and as most nearly related to the so-called "archipterygium" of Ceratodus; while Prof. Mivart⁴ is led to dissent entirely from this interpretation, and to look upon it as nothing more than "an ingenious speculation." The latter has also shown (loc. cit.) how the basal cartilages of the dorsal and ventral fins, and, to a less extent, those of the anal, have become fused together into a nearly continuous mass,—a fact of considerable significance if, as seems probable, the basals were a parallel series of thin cartilaginous bars in the earliest forms of fin.

Another curious feature of Notidanus consists in its possession of more than five gill-openings besides the spiracle, and in this peculiarity it differs from all other living Sharks except the Chlamydoselachus. Some of the species have six of these openings and others seven; and most ichthyologists prefer to regard each of these types as constituting a distinct genus, the first named being termed Hexanchus, and the second Heptanchus or Heptranchias. Dr. Günther,⁵ however, is inclined to admit no such separation, and as it is quite impossible for palæontological purposes, it cannot be adopted here.

But the points to which the palæontologist is naturally led to devote most minute attention are those relating to the harder structures capable of preservation in the fossil state. And it fortunately

¹ In Jordan and Gilbert's "Synopsis of the Fishes of North America," Bull. U.

<sup>S. National Museum, No. 16 (1883), p. 967.
² See detailed descriptions of C. Hasse, "Das Natürliche System der Elasmobranchier-Besonderer Theil" (1882), pp. 39-52, pls. vi. vii.</sup>

³ Loc. ett. p. 50.
⁴ St. G. Mivart, "Notes on the Fins of Elasmobranchs," Trans. Zool. Soc. vol. x. (1879), p. 477.
⁵ A. Günther, "Catalogue of Fishes Brit. Mus," vol. viii, (1870), pp. 397-399.

happens that in the living Notidanidæ there are very decided differences in the teeth of the various species. It is also true, on the other hand, that the dentition of each individual exhibits a certain variability in its components according to their situation in the jaw; but a careful comparison of actual specimens, descriptions, and figures, appears to reveal a few characters that are practically constant, and suggests the possibility of at least determining detached *side* teeth.

In a typical species like N. indicus the upper teeth on and near to the junction of the pterygo-quadrate cartilages have some resemblance to very thick, depressed teeth of Lamna, without lateral denticles, but placed upon a fibrous base undivided into The side teeth exhibit one or two distinct denticles or radicles. denticulations in front of the principal cone, and an increasing number of small cones behind this, the latter being larger in proportion to the main cone the more remote is the tooth from the front of the jaw. The mandible exhibits a single symphysial tooth, with three or four laterally directed toothlets on each side, but no median cone; and then follow six nearly similar comb-shaped teeth, both to the right and the left. In these, the principal cone is serrated anteriorly, and the hindermost tooth-as in the upper jaw-shows the principal cone least predominant. At the back of both jaws, there are also minute teeth-diminutive knife-edges of enamel, each upon the characteristic form of base.

Besides the widely distributed species whose dentition has just been described, Dr. Günther recognizes three others in his British Museum Cat. Fishes, and about three more have subsequently been determined in America.¹ Ichthyologists thus distinguish about seven living forms of Notidanus, and on referring to their published diagnoses, it appears that at least three features in their dentition are specially looked upon as of specific value. These are (i.) the presence or absence of a median tooth, and the presence or absence of a median cone in such a lower tooth; (ii.) the relative prominence of the principal cone in the mandibular side teeth-whether inconspicuous, proportionately stout, or notably elongated; and (iii.) the character of the denticulations in front of the principal cone of the lower teeth. It is obvious that, of these distinctive features, only the two latter are available to the palæontologist, except on rare occasions ; but it is satisfactory to find that the upper teeth apparently exhibit the same specific modifications as the lower-e.g. a stout or long cone in the one corresponding to a stout or long cone in the

¹ Jordan and Gilbert, "Fishes of N. America," *loc. cit.*, p. 62: and S. Garman, Bull. Essex Institute, vol. xvi. (1884), pp. 56, 57. other-and it is thus possible to restore the dentition of some of the extinct types with a considerable approach to accuracy.

Of fossil Notidanidæ, no undoubted traces have hitherto been recorded from beds beneath the Middle Oolite. Münster,¹ it is true, mentions a small tooth from the Lias as belonging to Notidanus, but no figure is given, and there is not sufficient proof of the accuracy of the determination. Oppel² also makes known another tooth from the Upper Lias of Swabia, which he ventures to name specifically N. Amalthei, though evidently recognizing the slenderness of the grounds for this procedure; his figure shows nothing beyond a laterally-compressed cone, and neither this nor the description suffices to distinguish it from the tooth of a large Oxygnathus. It is further interesting to note that Tate and Blake³ have recorded Oppel's species from the Middle Lias of Whitby, and this determination is equally unreliable: the original fossil is said to be preserved in the Whitby Museum, but Mr. Martin Simpson has failed to discover it during a search he has kindly undertaken in response to my inquiries, and I am also indebted to Professor Blake for a reference to his note-books, which likewise afford no definite particulars.

The Oxfordian N. contrarius and N. Münsteri are thus the earliest species of the genus at present described, and with these we com-mence an enumeration of the different specific types that appear to be distinguishable upon the evidence of detached teeth.

1. N. CONTRARIUS, Münster.

1843. N. contrarius, Graf von Münster, "Beitr. zur Petrefaktenkunde," pt. vi. p. 54, pl. ii. fig. 3.

Founded upon a broken tooth from the Lower Oxfordian⁴ of Rabenstein, Bavaria. The fossil exhibits two small diverging cones, with a denticle behind, but is much too fragmentary for specific determination, and does not appear to have been recorded since Münster's original description.

2. N. MÜNSTERI, Agassiz.

1843. N. Münsteri, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 222, pl. 27, figs. 2, 3.

A species founded by Agassiz upon some detached teeth from the Oxfordian (Weiss Jura γ , Quenstedt) of Streitberg, Franconia, and of Randen, Schaffhausen, Switzerland. The type specimen figured exhibits a principal cone destitute of anterior servations and relatively large both in breadth and height; this is followed by three wellmarked secondary cones, closely approximated, and rapidly decreasing in size, and the crown terminates in a small denticulation.

 Münster, "Beiträge zur Petrefaktenkunde," pt. vi. (1843), p. 55.
 A. Oppel, "Der mittlere Lias Schwabens," Württb, Jahresh. vol. x. (1854), p. 62, pl. i. fig. 1.
³ Tate and Blake, "The Yorkshire Lias" (1876), p. 256.
⁴ This and the other Jurassic horizons have been kindly supplied by Mr. Etheridge.

m 11

100.000



G M Woodward del et lith

Fossil Notidanidæ.

West, Newman & C° imp.

There seems to be no undoubted reference to teeth of this type since Agassiz' original description, though the name is mentioned in several lists of Continental Jurassic fossils. The specimens from Schnaitheim figured by Quenstedt as N. Münsteri are almost certainly referable to a distinct form next to be considered.

3. N. EXIMIUS, Wagner. Pl. VI. Figs. 3-5.

N. Münsteri, Beyrich and Frischmann, Zeitschr. Deutsch. Geol. Gesell. vol. i. 1849. p. 436, pl. vi. ,, F. A. Quenstedt, "Handb. Petr." p. 167, pl. 13, fig. 4. ,, F. A. Quenstedt, "Der Jura," p. 662, pl 96, figs. 33, 34. N. eximius, A. Wagner, Abh. k. bayer. Akad. d. Wiss. cl. ix. vol. ix. pp.

1852.

1858.

1861. 292-296, pl. iv. fig. 2.

The Lithographic Stone (Lower Kimmeridgian) of Bavaria is the only deposit that has hitherto yielded remains of Notidanus other than detached teeth. But from this fine-grained rock at least three comparatively perfect fishes have been described, in addition to one other fragment of the caudal extremity. Of these, the finest specimen was figured by Beyrich and Frischmann, loc. cit., in 1849, and the subsequent studies of Dr. Andreas Wagner resulted in its being separated from all other known species under the name of N. eximius.

The important fossil just referred to was obtained from the quarries of Eichstädt, and is complete with the exception of the tip of the tail: it indicates an original length of about nine feet, and exhibits a very definite outline, owing to the presence of plentifully scattered shagreen granules in the skin. The head is rounded and obtuse in front, and a considerable number of teeth are exhibited in the region of the mouth. The pectoral fins are evidently larger than the ventrals, and the anal is small compared with the dorsal; the latter is almost entirely in advance of the anal, although appearances may be deceptive owing to pressure during fossilization. But the most remarkable character displayed in this specimen is the presence of well-marked annular cartilages in the sheath of the notochord. These have been carefully studied by Dr. Hasse,¹ of Breslau, who has shown that they agree in microscopical structure with those of the living *Heptanchus*; and this Kimmeridgian form is thus the only fossil species hitherto discovered that it has been possible to refer to the correct subgenus. The vertebral rings in the caudal region are further apart than in the more anterior portions of the body.

The two other specimens of *Notidanus* from the Lithographic Stone are of small size, not exceeding $4\frac{1}{2}$ inches in length, and are regarded by Wagner as probably the young of the species under consideration. No figures have been published, but a plaster cast of one of these immature fishes is exhibited in the British Museum.

A group of the teeth of *N. eximius* are figured by Beyrich and Frischmann, and Wagner also represents a solitary example. The drawings of the Eichstädt fossil, however, do not appear to illustrate the variation of the dentition in different parts of the mouth, nor do the authors offer any particular observations upon this point. In

¹ C. Hasse, "Natürl. Syst. Elasm.-Besond. Theil," pp. 51, 52, pl. vii. figs. 23-25. DECADE III .--- VOL. III .--- NO. V. 14

the ordinary lateral teeth, the principal cone is destitute of serrations on its anterior border, and is followed by three (or sometimes four) much smaller cones. These teeth chiefly differ from *N. Münsteri* in the wider interspaces between the successive cones. They are also somewhat larger, and the apex of each cone occasionally exhibits a slightly hooked appearance.

Other teeth of the type just described are met with in the Upper Corallian beds of Schnaitheim, Würtemberg, and were originally figured by Quenstedt (loc. cit.) under the name of N. Münsteri. Wagner makes a brief allusion to these at the end of his description of \tilde{N} . eximius, and hints that they may possibly belong to his newly determined species. The National Collection contains a good series of specimens from the same deposit, which appear to leave no doubt of the correctness of this identification, and three of these form the subjects of Figs. 3-5. The teeth exhibit considerable variation in size-from one to two centimetres in length-and this may be due not only to age, but also to differences corresponding to the various parts of the jaw. All, however, are characterized by wider interspaces between the cones than is the case in N. Münsteri. In teeth that are probably from the front region of the mandible (Figs. 3, 4), the principal cone is relatively longer and less oblique than in those further back; while in anterior teeth of the upper jaw, the principal cone is still more prominent and placed erect upon the base. Fig. 5 represents one of the latter type, and the original of fig. 34, pl. 96, in Quenstedt's "Jura," is probably another from nearly the same situation. Of lower teeth, the other illustrations of Quenstedt are evidently characteristic examples, and Fig. 3 is a drawing of the largest tooth in the British Museum Collection; this specimen-like two others, Nos. 22489 and P. 4708-is remarkable on account of the oblique abrasion of the apex of the principal cone, which appears to have been produced during the life of the animal. The same figure also shows a slight crimping at the lower part of the anterior edge of the tooth; and fig. 33, pl. 96, of Quenstedt's "Jura," likewise exhibits this feature upon a greater extent of the border, but there is no definite denticulation.

It is interesting to add that Wagner further records a single tooth of N. eximits from Daiting, and another from the Lithographic Stone of Nusplingen, Swabia.

The upper tooth shown in Fig. 6 was also obtained from the Schnaitheim beds, but it appears scarcely referable to *N. eximius*, and must remain at present specifically undetermined.

4. N. WAGNERI, Agassiz, sp.

1843. Aellopos Wagneri, L. Agassiz, Rech. Poiss. Foss." vol. iii. p. 233.

1861. Notidanus Wagneri, A. Wagner, Abh. k. bayer. Akad. d. Wiss. cl. ix. vol. ix. pp. 296-299.

In the volume of the "Neues Jahrbuch" for 1836, p. 581, Count Münster briefly recorded a Selachian fossil from the Kelheim Lithographic Stone under the name of *Aellopos elongatus*. It exhibited nothing more than the hinder region of the body, and its affinities

were thus somewhat problematical, but the distinguished palacontologist just mentioned felt justified in regarding it as the type not only of a new species, but also of a new genus. Some years later, when preparing his classical work on Fossil Fishes, Agassiz confirmed Münster's original determination, and founded a second species of Aellopos-termed A. Wagneri-upon another specimen preserved in the Munich Museum. This likewise exhibited only the hinder region of the body, but the great relative size of what was then considered to be the second dorsal fin, and the distinctly calcified vertebral rings, were quite sufficient to separate it from all fossil sharks at that time known. No figures were published, however, and Agassiz' short notice embodied all available information until 1861, when Dr. Andreas Wagner was engaged in investigating the fish-fauna of the Solenhofen Stone, and succeeded in elucidating the problematical fossil by a reference to the magnificent specimen of Notidanus eximius, figured by Beyrich and Frischmann. His researches led to the conclusion that Münster's A. elongatus was really a Squatina (or an allied genus), and that Agassiz' A. Wagneri might be referred with equal certainty to the genus Notidanus. The considerable dimensions of the supposed "second" dorsal fin were thus no longer remarkable, and the comparatively advanced condition of the vertebral column was recognized as quite similar to that of the complete specimen just quoted. Some minor differences are sufficient to distinguish N. Wagneri from N. eximius, and among others, may be mentioned the relatively greater length of the dorsal fin: the vertebræ are also longer, and wide interspaces between them do not begin to appear before the middle of the tail, whereas in N. eximius this character is obvious quite at its commencement.

5. N. INTERMEDIUS, Wagner.

1861. N. intermedius, A. Wagner, loc. cit. p. 299, pl. iv. fig. 3.

A species founded upon a single tooth from the Lithographic Stone of Mühlheim, near Solenhofen, and characterized by the large size of the denticulations in front of the principal cone, which is thus placed not far in advance of the middle of the tooth. Behind the principal cone are five smaller ones.

As Wagner observes, this determination is merely provisional, for the dentition of *N. Wagneri* is at present wholly unknown, and the form of tooth in question may eventually prove to belong to the latter species.

6. N. HÜGELIÆ, Münster.

1843. N. Hügeliæ, Graf von Münster, "Beiträge zur Petrefaktenkunde," pt. vi. p. 54, pl. i. fig. 5.
1852. ,, ,, (?) F. A. Quenstedt, "Handbuch der Petrefaktenkunde," p. 167, pl. 13, figs. 5, 6.
1858. ,, ,, F. A. Quenstedt, "Der Jura," p. 519.

This species was founded by Münster upon a broken tooth from the Corallian of Gammelshausen, near Boll, Würtemberg. The specimen exhibited a large principal cone (without anterior serrations) followed by two small cones of about one-third the size of the first.

211

The originals of the figures in Quenstedt's "Handbuch" are very much smaller than the type specimen, and are characterized by the presence of anterior serrations; it is doubtful, indeed, whether they are truly referable to this form.

7. N. SERRATUS, Fraas. Pl. VI. Fig. 7.

1855. N. serratus, O. Fraas, Württemb. Jahresh. vol. ix. p. 98. 1858. ,, ,, F. A. Quenstedt, "Der Jura," p. 784, pl. 96, fig. 44.

This species was originally named by Fraas, but does not appear to have been completely defined before the publication of Quenstedt's work on the Jura. The last-mentioned palæontologist records a group of about 14 teeth, naturally associated, and figures one of the most typical forms. This, as a Jurassic type, is remarkable on account of the number of distinct cones that make up its crown, and the prominence of the sharp denticulations on the front edge of the principal cone; the latter is comparatively broad and long, and is succeeded by seven minor cones, of which the anterior is very much the largest. The species occurs in the Corallian of Nusplingen, Swabia.

A detached specimen in the British Museum (No. 35667), obtained by the late Mr. Bean from the Oxford Clay of Scarborough, agrees so closely with the tooth of this species figured by Quenstedt that it cannot be separated on present evidence. The fossil in question is shown of the natural size in Fig. 7, and is in an almost complete state of preservation. The principal cone of the crown is relatively very large, and is succeeded by five secondary cones, while at its base in front there occur three closely approximated denticles, the first being of considerable size. Of the secondary cones, the most anterior is directed sharply backwards and makes a wide angle with the posterior edge of the principal cone; it is nearly a third larger than that immediately following, and the remaining three are quite small. The base-line of the crown is arched, and the lower border of the root has a somewhat crimped appearance. This is evidently a tooth of the upper jaw, and the respects in which it differs from Quenstedt's figure are precisely those in which the upper teeth of living species differ from the lower.

8. N. DAVIESII, sp. nov. Pl. VI. Fig. 8.

1871. Hybodus polyprion, J. Phillips, "Geology of Oxford," p. 305, pl. xii. fig. 18.

The scarcity of remains of *Notidanus* in the Jurassic rocks of Britain appears somewhat remarkable when it is remembered how frequently they have been recorded on the Continent: and in addition to the Scarborough tooth already described, I have only succeeded in meeting with two other specimens.¹ These were erroneously referred to *Hybodus* by Professor Phillips, *op. cit.*, and they have been kindly pointed out to me by Mr. William Davies, who recog-

¹ Besides others already named, I have also to thank the following friends and correspondents who have kindly assisted me in the search for Jurassic Notidanida: — Mr. E. T. Newton, of Jermyn Street; Mr. T. Roberts, of the Woodwardian Museum, Cambridge; Mr. H. M. Platnauer, of the York Museum; Mr. H. J. Moale, of the Dorset County Museum; and Mr. H. E. Quilter, of Leicester. nized their true affinities some years ago when identifying fossil vertebrata in the Oxford Museum; I am also indebted to the kindness of Professor Prestwich for the opportunity of studying and publishing a further notice of the original teeth.

The specimens in question were obtained from the Oxford Clay of St. Clement's, near Oxford, and as they cannot be safely identified with any form at present known, I propose to apply to the most satisfactory tooth (Fig. 8) the provisional name of N. Daviesii : the second fossil (Fig. 9) may possibly be a variety of the same species, but this is at present uncertain. In the type specimen shown in Fig. 8, the principal cone is relatively large, both in breadth and height, and is destitute of serrations on its anterior border. This is followed by four rapidly diminishing secondary cones, and the crown terminates in a minute denticulation. The apices and edges of all the cones are remarkably sharp, and the base is short and thick compared with that of the majority of later species. The second tooth (Fig. 9) has a very peculiar form, and consists merely of two backwardly curved cusps, though other small ones may have been broken away behind. The lower part of the anterior edge of the principal cone is crimped, and the enamelled sides of the crown exhibit vertical wrinkles suggestive of those of Hybodus.

N. Daviesii appears to approach N. Munsteri more closely than any other, but it is easily distinguished from this species by the different relative proportions of the principal and secondary cones.

9. N. MICBODON, Agassiz. Pl. VI. Figs. 10-15.

1822.	Tooth of	Squalus? G. A. Mantell, "Fossils of South Downs," p. 227,
1843.	N. micro	pl. xxxii. fig. 22. don, L. Agassiz, '' Rech. Poiss. Foss.'' vol. iii. p. 221, pl. 27, fig. 1,
1843?	,, ,,	pl. 36, figs. 1, 2. H. B. Geinitz, "Schichten und Petrefakt. d. sächsischböhm.
1846.	,, ,,	Kreidegeb." p. 38, pl. 1x. fig. 2. A. E. Reuss, "Verstein. d. böhm. Kreideform." pt. ii. p. 98,
1850.	,, ,,	pl. xlii, fig. 8. F. Dixon, "Geol. and Foss. Sussex," pl. xxx. fig. 30.
1878.	»» »»	A. Fritsch, "Rept. u. Fische d. böhm. Kreideformation," p. 12 (woodcut).

Almost all the teeth of *Notidanus* met with in the Upper Cretaceous formations are referable to a single widely-spread species, N. *microdon*. This is a small form with a total number of five to nine distinct cones in its side teeth, each of these being slender and sharply pointed, and the principal cone usually much elongated compared with the remainder: there are also well-marked denticulations on the front edge of the crown.

On examining a large series of specimens, such as that available for study in the British Museum, considerable variations are at once apparent; but there are scarcely any discrepancies in size, and the presence of intermediate forms renders it quite impossible to recognize more than a single specific type. Some (Fig. 10) are obviously from the front of the upper jaw, and consist only of a single large cone, with one or two small denticles behind; while the short teeth, with prominent principal cone and 4-5 secondary cones (e.g. Figs. 11, 12) may be referred with almost equal certainty to situations in the upper jaw somewhat further back. The elongated teeth, which belong to the sides of the lower jaw—and perhaps partly to the upper—usually have the principal cone relatively prominent (Figs. 13—15), though in one or two examples such is not the case. The anterior serrations are mostly fine and numerous, but in a few instances (of upper teeth) they are reduced in number and increased in size.

Of British Cretaceous strata, the various divisions of the Chalk appear to yield the most abundant remains of N. microdon, although the Cambridge Greensand also affords a considerable number. The National Collection comprises specimens from Maidstone, Burham, and Charing in Kent; Lewes and other localities in Sussex; Guildford in Surrey; and Swaffham and Norwich in Norfolk.

10. N. LANCEOLATUS, sp. nov. Pl. VI. Fig. 16.

In the Egerton Collection of the British Museum there is a single upper tooth of *Notidanus* (P. 1227) from the Gault, which it appears impossible to identify with any species hitherto described. It is much larger than the corresponding teeth of *N. microdon*, and as its most conspicuous feature consists in the comparatively long and narrow form of the cones, I propose to distinguish this type of tooth by the provisional name of *N. lanceolatus*. The principal cone is relatively prominent, and is preceded by two very long denticles: there are three secondary cones, and the crown terminates in a minute denticulation. The great development of the anterior denticles renders it likely that the lower teeth were somewhat similar to those of *N. pectinatus*, Ag., but the latter is a much smaller species.

11. N. PECTINATUS, Agassiz.

1843. N. pectinatus, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 221, pl. 36, fig. 3.

A species founded upon a tooth from the Chalk, about the size of *N. microdon*, but especially differing from that form in the conversion of the anterior serrations of the crown into a series of distinct denticles. This type of tooth appears to be extremely rare, and I have not seen any examples.

12. N. DENTATUS, sp. nov. Pl. VI. Figs. 17, 18.

Among the Selachian remains in a collection of New Zealand fossils sent by Dr. Hector to the British Museum in 1876, there are two teeth from the Cretaceous of Amuri Bluff which are undoubtedly referable to the genus *Notidanus*. In several respects they differ from one another to a considerable extent, but an acquaintance with the dentition of living Notidanidæ can leave no doubt that they belong to a single specific type, and that the one is an upper tooth, while the other formed part of the mandibular series.

The lower tooth, which is shown of the natural size in Fig. 18, exhibits three small denticles in front of the principal cone, the first being the largest and having a recurved apex, the second slightly smaller with straight but backwardly-directed point, and the third very much more minute. Behind the principal cone, which is scarcely more robust than that immediately following, there are ranged three other cones, of gradually diminishing size; and posterior to these a minute denticulation is visible.

In the upper tooth (Fig. 17) the principal cone appears more definitely contrasted with the others. In front there are two distinct denticles, the first being three times the size of the second, and the principal cone itself is placed almost vertically with respect to the base-line of the crown, although its anterior edge has a much less abrupt slope than the posterior. Behind this, there are three other cones rapidly decreasing in dimensions; the first, somewhat inclined backwards and three-fourths the size of the principal cone; the second, backwardly directed at a corresponding angle, but only about one-third as large as the first; and the third, a minute, broad acuminate denticle. Though now imperfectly shown, the base-line of the crown was obviously arched, and the remains of the root indicate the usual configuration and robust proportions of an upper tooth.

On considering this assemblage of characters, the substitution of distinct denticles for the ordinary servations on the anterior edge of the principal cone in the lower tooth, is obviously the most striking feature; and hence it is proposed to distinguish the present modification under the specific name of N. dentatus. The only other fossil Notidanus that exhibits this peculiarity is the very rare N. pectinatus from the English Chalk, but this is a much smaller species, and differs in possessing a longer series of cones behind the principal. Among existing forms, however, one appears to be remarkable for its possession of the very same character.¹ This is the little N. pectorosus from the seas off the Patagonian coast, and Mr. Garman's description² of the lower tooth of this form agrees almost precisely with the particulars given above; he states that each tooth "has one" to two small, followed by four moderate-sized, cusps, the anterior of the four being little if any longer than the other three; and, in cases, there is also a small cusp on the posterior portion of the base." Indeed, in the absence of figures, \tilde{N} dentatus can only be distinguished from N. pectorosus by the presence of one more anterior denticle in its teeth, and by its relatively gigantic size-for the Patagonian species is only 16 inches in total length.

If subsequent researches tend to substantiate the latter statement, the fact becomes of unusual interest, since it was from the same deposit at Amuri Bluff that Mr. E. T. Newton, a few years ago,³ made known a tooth of Callorhynchus, differing only in minor points from C. antarcticus of the present southern seas. This living Chimæroid ranges through the same ichthyological province as Mr. Garman's new species of *Notidanus*, and the association of two extinct

http://iournals.cambridge.or@ownloaded: 22 Jul 2016

¹ The lower teeth of N. cinereus also exhibit some approach to this character.

² S. Garman, "A species of *Heptranchias* supposed to be new," Bull. Essex Institute, vol. xvi. (1884), pp. 56, 57. ³ E. T. Newton, "On Two Chimæroid Jaws from the Lower Greensand of New

Zealand," Q. J. Geol. Soc. vol. xxxii. (1876), pp. 329, 330, pl. xxi. figs. 6-9.

allies in a formation said to be of Cretaceous age in New Zealand is a very remarkable circumstance.¹

13. N. SERRATISSIMUS, Agassiz. Plate VI. Figs. 23-26.

1766.

Dens Squali, G. Brander, "Fossilia Hantoniensia," fig. 111. N. serratissimus, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 222, pl. 36, 1843. figs. 4, 5.

1870. F. Römer, "Geologie von Oberschlesien," p. 379, pl. 48, fig. 1.

This species was founded upon two teeth from the London Clay of Sheppey, said to be preserved in the collection of Dr. Bowerbank, but not now recognizable among the specimens acquired by the British Museum. The teeth are comparatively small-the largest I have examined not attaining a length of two centimetres-and the total number of cones appears to vary from five to ten, according to the situation in the mouth. The principal cone is only slightly longer than the first of those immediately following, but it is somewhat more robust and has its anterior edge much produced forwards and strongly indented with a series of regular serrations throughout half its length. The apices of all the cones are more or less blunt.

Fig. 23 represents a typical tooth of this species, such as was known to Agassiz. I have not succeeded in satisfactorily determining whether it appertains to the upper or the lower jaw; but in addition to this form the London Clay also yields a number of more elongated teeth, which are undoubtedly referable to the mandibular series. An adult specimen is preserved in the Museum of Practical Geology, and there are several immature examples in the British Museum. Three of the latter are shown in Figs. 24-26, and, except in size, they only differ from the adult in being either destitute of anterior serrations or exhibiting very delicate traces of them.

In England, N. serratissimus appears to be almost exclusively confined to the London Clay, rarely occurring in the Middle Eocenes of Barton and Bracklesham. On the Continent, however, Dr. Römer has described (loc. cit.) a similar tooth from the Lower Miocene of Zabrze, Silesia.

> 14. N. PRIMIGENIUS, Agassiz. Pl. VI. Figs. 19-22.

N. primigenius, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 218, pl. 27, 1843. figs. 4--8, 13-17.

- 1843.
- N. recurvus, L. Agassiz, ibid. p. 220, pl. 27, figs. 9-12. N. primigenius, R. W. Gibbes, Journ. Acad. Nat. Sci. Philad. ser. 2, vol. i. 1849. p. 195, p. 1. xx. fg. 95.
 A. Quenstedt, "Handb. Petrefakt." p. 167, pl. 13, fg. 3.
 J. Probst, Württb. Jahreshefte, vol. xiv. pp. 124-127.
 R. Lawley, Atti Soc. Toscana Sci. Nat. pp. 66-68, pl. i.
- 1852. ,, ,,
- 1858. ,, ,,
- 1877. ,, figs. 1-5.

1877. N. recurvus, R. Lawley, ibid. pp. 69, 70, pl. ii. fig. 1. 1879. ,, J. Probst, Württb. Jahresh. vol. xxxv. pp. 162, 163, pl. iii. figs. 12-17.

¹ In addition to Notidanus dentatus, the National Collection also comprises three teeth of *Oxyrhina* and one of *Odontaspis* from these beds; the former bear a very close resemblance to the common O. Mantelli of the European Cretaceous, though there are not sufficient materials to establish their identity; and the Odontaspis is indistinguishable from the well-known O. subulata of the same age.

1879. N. primigenius, J. Probst, ibid. pp. 158-162, pl. iii. figs. 1-5. 1885. ,, ,, F. Noetling, Abh. Geol. Specialk. Preussen u. Thüring. Staaten, vol. vi. pt. 3, pp. 17-19, pl. i. figs. 4, 5.

Among the fossil Notidanidæ, the dentition of N. primigenius appears to be more completely known than that of any other. Lawley in Italy, and Probst in Würtemberg, have both contributed to its elucidation, and though Agassiz stated that during his elaborate researches he had only succeeded in determining lower teeth, there can be little doubt now that he also figured some belonging to the upper series. It seems probable that fig. 13 of plate 27 in the "Poissons Fossiles" really represents a tooth of the upper jaw; and if the originals of figs. 4-8 are correctly associated with the others (which is perhaps questionable), these likewise must be referred to a similar situation : it is almost certain, too, that the so-called N. recurvus is an upper tooth of the same species.

In the mandibular teeth of N. primigenius (Fig. 22), the principal cone is only slightly longer and more robust than that immediately following, but the lower part of its anterior edge is much produced forwards and bears a number of small serrations, which decrease in size from above downwards. The secondary cones gradually diminish as they approach the hinder end of the crown, and of these there are usually five or six. The median lower tooth is not yet certainly known, although both Probst and Lawley venture to claim its discovery. The former figures it as having a median cone, while the latter represents it as possessing only lateral cones-so that as it is impossible for these to belong to the same species, neither determination can be accepted as correct until more satisfactory evidence of association is forthcoming.¹

(To be continued in our next Number.)

III.---NOTES ON JURASSIC BRACHIOPODA.

By S. S. BUCKMAN, F.G.S.

THE following notes relate to two Brachiopods—a Rhynchonella and a Terebratula-figured by the late Dr. Davidson in his last plates in the Palæontographical. Of the first a change of name is necessary; of the second, I consider that the identification needs revision, and that it deserves a separate name. Both species are from the Inferior Oolite.

RHYNCHONELLA LIOSTRACA, S. Buck.

1883. Rhynchonella bilobata, S. Buck., Brachiopoda Inf. Ool. Dorset, Nat. Hist.

Soc. Proc. vol. iv. p. 50. bilobata, Davidson, Appendix to Supplement Brachiopoda, Palæontographical Soc. Proc. vol. 38, plate 19, 1884. figs. 18, 19.

Having given the above references, there can exist no doubt as to the species intended; but having subsequently found that the name bilobata had been used for a species of Rhynchonella previous to my

¹ In his second paper (1879) Probst confirms his original determination (1858) and suggests that Lawley's fossil probably belongs to N. gigas or N. Meneghinii.