Abnormal Dentition in Sharks, Selachii

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Article II.—ABNORMAL DENTITION IN SHARKS, SELACHII

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INTRODUCTION

In working up the natural history of the frilled shark, *Chlamydoselachus anguineus*, for the Bashford Dean Memorial Volume, in collaboration with Dr. B. G. Smith, I chanced upon some interesting abnormalities in the teeth of three specimens. A little later, Captain W. E. Young presented me with a portion of the jaw of a tiger shark, *Galeocerdo tigrinus*, showing a dental deformity.

Incited by these finds, I made a careful examination of our shark-jaw material in the American Museum and brought to light other exceedingly interesting abnormalities. Others were found in the extensive collections of the U. S. National Museum. The history of still other material, which came to hand later, will be given further on. This material has been carefully figured and described herein and to these original figures and descriptions there have been added a few others from the widely scattered literature. These others, hidden in general works, have been unearthed only after considerable search, and just here it should be emphasized that not a single definite reference to dental abnormalities in sharks has been found. The names used are the commonly accepted ones, and the arrangement of the sharks is that found in Garman's 'Plagiostomia' (1913).

In an earlier paper (Gudger, 1933), I figured and described abnormal teeth in the rays (Batoidei) and therein I included some anomalous fossil teeth of myliobatid rays, with the teeth of modern forms of which I have some acquaintance. Although many variations are apparent, no fossil sharks' teeth will be included herein, since only an experienced paleichthyologist could distinguish between normal and abnormal ones.

DENTAL ABNORMALITIES IN SHARKS—SELACHII

Sharks do not have socketed teeth nor teeth directly ankylosed to the bones as in other fishes. On the contrary their teeth are set in rows on sheets of membrane forming tooth-pads extending from the rear surface of the jaws to their front edges. This mucous membrane grows at the rear throughout life, forming new teeth from tooth-buds situated at its inner (rear) edge. The teeth on the outer edge of the tooth-pad, attached to it by strong fibers which adhere tightly to the bony bases of the teeth, stand erect, and when these outer teeth are broken off the mucous membrane moves forward and outward, rolling over the rounded outer edge of the jaw, bringing new functional teeth upward and outward. At the same time new teeth are being formed in the embryonic tissue at the rear. Thus the supply is always equal to the need. Generally each functional tooth on the front of the pad described has in addition about four or five other teeth behind it and partly covered over by a "gum" or thecal fold. These matters will be made clear by reference to

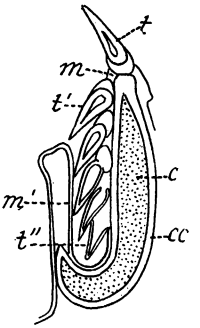

Fig. 1.—Transverse section through the jaw and teeth of *Carcharias* sp. *c*, cartilage of jaw; *cc*, calcified crust of jaw; *m*, mucous membrane covering jaw; *m'*, fold of mucous membrane (thecal fold) beneath which the young teeth develop; *t*, tooth in use; *t'*, its oldest successor; *t''*, youngest tooth of series.

After Ridewood, 1896, p. 385.

Fig. 1, which portrays a section through the jaws of a shark. This figure, copied from Ridewood,[1] is excellent. It, a macroscopic figure, cannot of course show the microscopic tooth-bud in the bottom of the furrow.

[1] Ridewood, W. G., 1896, 'The Teeth of Fishes.' Natural Science, VIII (Succession in shark's teeth, pp. 384–386, Fig. 9).

Chlamydoselachidae

This family is rated by Garman (1913) as the most primitive among the Selachii. It contains but one genus and one species—*Chlamydoselachus anguineus.* It is a relatively young family, as far as the record goes, the first fossil representative having been identified from teeth in the Pliocene of Orciano, Italy, whereas most "modern" families of sharks are known to date back to the Cretaceous and even to the Jurassic. The one present-day genus and species seems to have a quite restricted range. The fish was long thought to be peculiar to Japanese waters, but more recently it has been taken in the Eastern Atlantic from the Arctic waters of Norway to the semitropical shores of Morocco. It is found only at great depths.

Chlamydoselachus anguineus

The Frilled Shark

This archaic shark has the most remarkable dentition of any elasmobranch known to me. As may be seen in Fig. 2, each tooth consists of three backwardly directed briar-like fangs—a central and two lateral cusps of about equal size—and on each side of the central cusp two small inner cusps. Each compound tooth has a broad backwardly extended base inserted under the front base of the next tooth behind—thus the resistance of the tooth is stiffened against an outward pull.

These teeth, like those of all sharks, are set in rows five or six deep, but unlike other sharks the rows are separated by toothless spaces as wide as the tooth-rows. These rows are arranged bilaterally in both upper and lower jaws. A full description and discussion of these remarkable teeth and of their position in the jaws, counts of rows, etc., will be found in the paper by Professor Smith and myself, which appeared as Article V of the Dean Memorial Volume published by the American Museum in 1933. In the present paper only abnormalities in the dentition of *Chlamydoselachus* will be dealt with.

My first specimens of abnormal teeth are found in a fish now in our collections, and in a head in the zoological cabinet of Columbia University—both brought from Japan by Dr. Bashford Dean about 1905—and in a third fish brought from Japan in 1933 by Dr. Grace White. Then in the summer of 1936, long after Dr. Smith and I had published our paper on the 'Natural History of *Chlamydoselachus,*' after his paper on 'The Anatomy of the Frilled Shark' had gone to press, and even after the original draft of this paper had been typed, four other specimens came to light in the process of clearing out some long unopened

barrels of mixed and miscellaneous fish material. These four sharks were bought in and brought from Japan by Dr. Bashford Dean, 34 years ago. They have never been catalogued since it appears that they were his private "reservoir" from which he supplied specimens to many European students of this archaic shark—notably Dr. E. P. Allis, Jr. One of these fish had the teeth cut out and the other three have four abnormal tooth-rows of three distinct kinds.

Some slight departures from the normal—irregularities not abnormalities however—will first be pointed out.

At the symphysis of the halves of the lower jaw in all these specimens and in all the figures of jaws examined by me, there is a median row of teeth. Theoretically this row should be found squarely over the symphysis but in one of my specimens this median row is placed slightly to the left particularly in its hinder part. Another has this row displaced in front to the right with its hinder end extending diagonally back over the symphysis. Possibly these displacements have come about through unequal shrinking in the progress of formalin preservation.

Furthermore, Mrs. Hawkes (1907) found in all her specimens (two in the collections of the Liverpool University, and three in the British Museum) bilaterally symmetrical tooth-rows with no median row in the lower jaw. But she adds that "In every specimen examined, however, there was a torsion of the left front row of teeth toward the right side; and in one case this resulted in a median row of teeth." No figures and no description of these teeth are given, nor is there any count of the tooth-rows in each half-jaw.

None of the teeth noted above are abnormal, and these accounts are given here only to show thus early how very variable are the tooth-structures of this archaic shark.

At the symphysis of the upper jaw, there should be no row of teeth. But in some of my specimens, I have found some unusual rows of abnormal teeth. These will now be figured and described.

Fish No. I.—In this fish, now in the collections of the American Museum, there is found at the symphysis of the upper jaw a transverse row of very small teeth which are shown in Fig. 2, made from a photograph of the upper jaw in question. On the right of the center is a very small 3-cusped tooth which is about 0.4 the size of a normal tooth. To the left of this there is a single fang, next a pair and to the extreme left another pair. Furthermore, between the second and third rows of teeth on the right side of this upper jaw there is far toward the rear of

the gum a small 3-cusped tooth. Various other small and inconspicuous supernumerary teeth are found in this jaw. For all these the explanation may surely be offered that these are dermal denticles on the way to becoming teeth, but small in size and not in the normal positions.

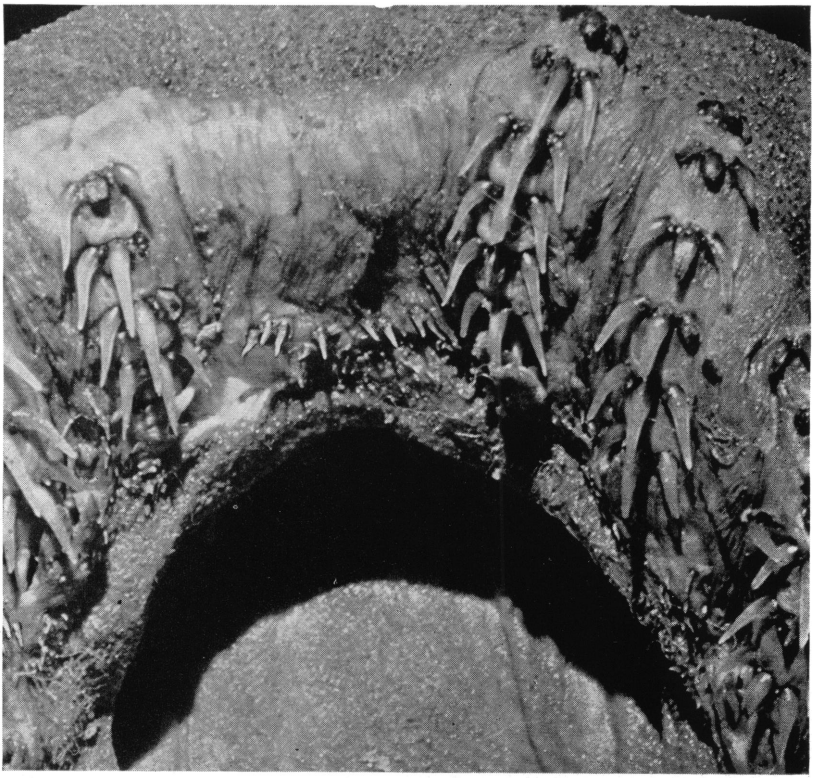

Fig. 2.—Center of upper jaw of a *Chlamydoselachus* from Japan. At symphysis note (right to left) a 3-cusped tooth, others with one and two cusps. Between right tooth-rows 2 and 3, is a small 3-cusped tooth.

Photograph of a specimen in American Museum

Fish. No. II.—This is a *Chlamydoselachus* brought from Japan in 1933 by Dr. Grace White, and now on deposit in the American Museum. Almost in the center of its upper jaw, but slightly to the right, it has a single row of abnormally small teeth. Lest this be thought to be the first right row displaced toward the center, it will be noted that each upper half-jaw has 11 rows of normally sized teeth. The row in question is composed of single small teeth as may be seen in Fig. 3.

These teeth are about half the size of normal teeth—2 mm. long instead of 4, the normal size in this jaw. The first two teeth of this row are represented only by broken-off stumps, the third has broken points, the others are intact. An abnormal or supernumerary tooth ANLAGE has

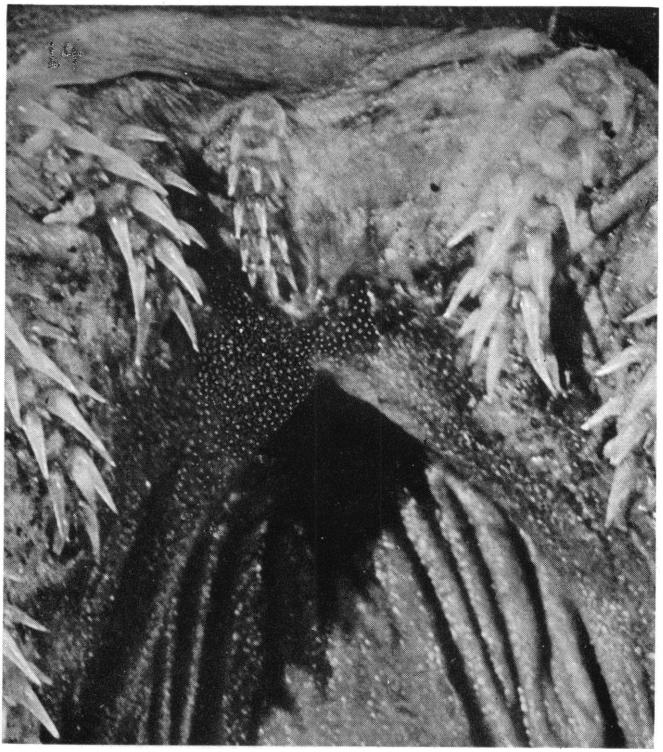

Fig. 3.—Symphysis of upper jaw of another *Chlamydoselachus* from Japan. Slightly to the right of the center of this jaw is a single row of half-sized teeth where none should be.

Photograph from a specimen belonging to Dr. E. Grace White.

here produced a single row of teeth half normal size. There is no external agent which can be alleged as the cause of this abnormal tooth-row. The origin must be in some internal disturbance.

Specimen No. III.—This fish from Doctor Dean's collection, has in the center of the upper jaw a single row of half-sized teeth practically identical with those just described. This row of minute teeth is flanked on each half-jaw by 13 rows of normally sized teeth. In this central

row, of the outer tooth the cusps are all gone, only the short stumps and the base are left. Of the second tooth, only the right lateral cusp is present, all others are gone. Teeth 3 and 4 have present 3 cusps each. Tooth 5 also has the 3 large cusps, but these are soft being imperfectly calcified. The cusps of teeth 3 and 4 are about 2 mm. long, while those of the normal right lateral row are 5 mm. long and those in the normal

Fig. 4.—Symphysis of upper jaw of a *Chlamydoselachus* from Japan. Slightly to the right of the center is a double row of half-sized teeth where none should be.
Photograph from a head at Columbia University.

row to the left are about 4 mm. long (worn?). This row of half-sized teeth is placed squarely in the center of the symphysis of the upper jaw—8 mm. from the central cusp of the two lateral teeth. For the presence of this second abnormal row of small teeth, one must conjecture that in some unknown way a tooth-germ arose in the epithelium of the tooth-pad tissue. But why it should give rise to half-sized teeth is inexplicable.

This median row of teeth is imperfect, and since the figure of the teeth (Fig. 3) in Dr. White's fish (No. II herein) is a much better one, this row will not be figured. It must be emphasized, however, that these single rows of half-sized teeth practically duplicate each other.

Specimen No. IV—This is a head brought from Japan by Doctor Dean and presented to the zoological cabinet of Columbia University. The upper jaw has 13 rows of teeth on each side, but in the normally vacant space at the symphysis there is a double row of half-sized teeth—Fig. 4. It is as if an abnormally developed tooth-bud, instead of producing a row of normal-sized teeth, had by a further abnormal development produced two rows of half-sized teeth. This double row of teeth is slightly displaced to the right—the distance between it and its right hand neighbor is 5 mm. while on the left the distance is 8 mm. This may possibly have resulted, however, from distortion produced in preserving the jaws in formalin. These teeth are very small, measuring (height or length of central cusp) 2.5 mm. in each row, while the perfect central cusps of the neighboring normal teeth measure 4.5 mm.

Two more specimens of *Chlamydoselachus*, with three sets of abnormal teeth between them, are now to be considered. Both came from Dr. Dean's private "reservoir."

Fish No. V.—From a double row of half-sized teeth we now turn to double rows of full-sized teeth. These were first noticed in this fish (No. V) which has in its lower jaw 13 rows of teeth on each side counting the double row as one row. In the left lower jaw of this specimen the teeth grade normally in size and spacing from front to back. However, the fifth row on the left is doubled. The rows of these double teeth are closely approximated at their inner edges, but manipulation of any tooth (of 3 cusps) shows that each row is a separate entity though the two rows stand on the same tooth-pad. The cusps of the teeth of the row in front of these "twins" are about 4 mm. long, those of the next row behind about 3 mm. long. The cusps of the twin row of teeth are *c.* 3.5 mm. long—measuring any central cusp. It is clear from this, that this is not a dwarf divided row but a full-grown doubled row. No figure of this double row of teeth is given, since the photograph of a precisely similar row in Fish No. VI is much better for reproduction.

Chlamydoselachus No. VI.—In this specimen there are 12 rows of teeth on each half of the upper jaw, but strange to say there is a double row on each half-jaw. The fifth upper left row is doubled (Fig. 5). The cusps of this double row of teeth measure *c.* 2.5 mm. in height, those

of the row in front are 3.5 mm. high and of the row behind the doubles *c.* 2 mm. long. Here, as in the preceding case, the teeth of the double row are fairly intermediate in size between those of the preceding and those of the succeeding row. In the three rear undisturbed teeth it is interesting to see that the inner teeth of each half-row are closely appressed. In front they apparently are a bit separated. Here, however, the point is obscured by the fact that some of the front teeth are broken off.

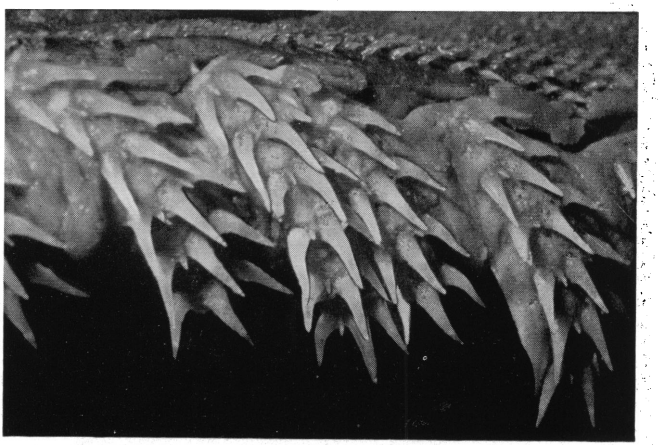

Fig. 5.—Section of upper left jaw of *Chlamydoselachus* in which the fifth row is composed of two sets of full-sized teeth. In this fish the eighth upper right row is also doubled.

Photograph from a specimen in American Museum.

In this shark the doubling of the fifth upper left row is of itself most unusual. But it is interesting to find in its mouth another double row of normal-sized teeth—the eighth row in the upper right jaw. These teeth are of normal size. The cusps of the row in front (seventh) measure 2.5 mm., those in the row behind (ninth) 1 mm., while those in the doubled row are 1.5 mm. high. Here again the doubled row maintains the gradation. These teeth are in no wise different (save in size) from those shown in Fig. 5, hence there is no point in figuring them herein.

As one looks at a jaw from symphysis to angle, the teeth are seen to become progressively smaller and the rows closer together. This is particularly true in the upper jaw, in the lower the rows are separated by wider spaces and are more distinct. But in the upper jaw under consideration these two sets of teeth, though small, form a double row on a

single tooth-pad. This is NOT a case of tooth-rows small and far back being crowded close together—tooth-rows 9 to 12 farther back are spaced normally.

As the figures show, and as manipulation demonstrates, each of these four double rows of teeth is found on a single tooth-pad. The origin of these double rows is a mystery. Some internal disturbance has split the tooth-germ, but instead of forming two double rows of half-sized teeth (as might have been expected from what has been seen above) each has given rise to a double row of entirely normal-sized teeth. Furthermore these double rows in the count of tooth-rows in each jaw COUNT AS ONE ROW.

No such abnormalities are found in our other three adult specimens of the Frilled Shark, nor in any published figures. Nevertheless, one dental abnormality in *Chlamydoselachus* has been reported by one author but unfortunately not figured. Thus Collett (1897) says of his huge fish from the Arctic coast of Norway, "In the present specimen the second side row of the left lower jaw is abnormal, being double (with two closely adjoining rows, all the teeth in them being somewhat smaller than normal teeth)." This is evidently an abnormality directly comparable with those above described. Collett has a fine lithographed figure showing the RIGHT side of the head and jaws instead of the one having this abnormality. Unfortunately Collett did not enumerate the number of rows of teeth in each half of the lower jaw.

Attention should be called to the fact that of 8 specimens of *Chlamydoselachus* (the ninth has the teeth cut out), 7 abnormal sets of teeth have been found in 6 fish. Here is additional proof of what Dr. Smith and I have found in our studies of this archaic shark—its fundamental tendency to vary.

HETERODONTIDAE

The sharks of this primitive family, also occupy a low position in the system. There are but four species—all found in the Pacific Ocean. They date back to the Jurassic, and so far as our knowledge of the fossil forms goes the present-day species differ comparatively little from their Mesozoic ancestors. They have remained comparatively stationary.

These sharks show a most extraordinary diversification of teeth from youth to maturity; and even in the jaws of a mature specimen there are more kinds of teeth than in any shark known to me. Hence the name *Heterodontus*, having heterodont, unlike or diversified teeth; teeth

varying in form and size in different parts of the mouth. However, this study will be confined to the unusual variations in the molars of a number of drawings examined. As Garman has shown (1913, plates 45, 46 and 47), the teeth of young specimens belonging to the various species of this genus, are all raptorial at first, the finely pointed cusps being suited for the capture of soft-bodied animals. Later the flat grinders develop, and it is in these that the considerable variation to be studied is found.

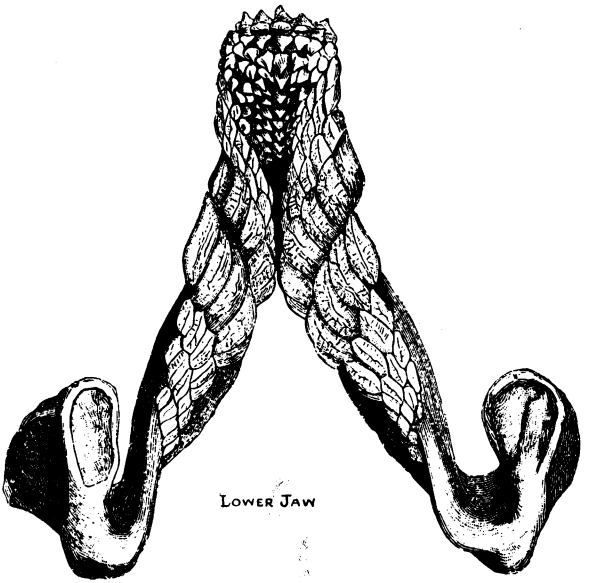

Fig. 6.—Lower jaw of *Heterodontus philippi* showing various abnormalities in the molar teeth.

After Zittel, 1887, p. 75.

Heterodontus (Cestracion) philippi

The Port Jackson Shark

This shark was discovered by Governor Arthur Phillip on his 'Voyage to Botany Bay' (Port Jackson). The fish and its jaws were figured and described in his book (1789, pp. 283–284, Figs.), but the teeth are perfectly normal. I have not been able to examine any jaws of this archaic fish and hence the literature must be relied on for figures of its abnormal dentition. A large number of the figures of the jaws of *Heterodontus* show abnormalities, but only three of the most characteristic of these will be reproduced.

Specimen No. I.—The oldest figure which I have found of abnormal dentition in this present-day shark is in Zittel's 'Palaeontologie' (1887, p. 75). This figure has been reproduced in Zittel's other works, and also by various other authors, without any reference, however, by either Zittel or his copiers, to the abnormalities. As may be seen in Fig. 6, a representation of the lower jaw, there are a few supernumerary teeth

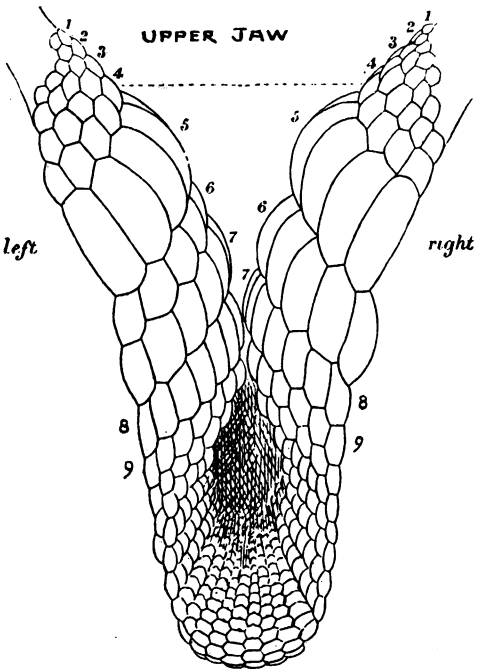

Fig. 7.—Upper jaw of *Heterodontus philippi* showing many variations in the molar teeth, particularly in rows 6, 7, 8 and 9.
After Bateson, 1894, p. 261.

at the rear of the right ramus. Disregarding these, we find a fair bilaterality (one cannot always be absolutely sure of the counts of relative rows of teeth) of great molars. But it should be noted that the teeth of right row number 3 (counting from the rear) are about 2 mm. longer than those on the left (11–9 mm.). On the other hand, the great molars of left row 4 vary from 19–16 mm. in length while the same on the right measure 16-15 mm. Again the fifth-row molars measure 16 mm. down to 7, while the corresponding teeth in the left fifth row measure

from 15 down to 7 mm. Then again on the left are two rows and a part of a row of teeth intermediate in size between the molars and the raptorial teeth, while on the right are three rows of these intermediate-sized teeth—the first row of which (row 6 from the rear) is as broad as the two complete rows on the left.

Specimen No. II.—So far as I know the next author to describe an abnormal (upper) jaw of *Heterodontus* was Bateson (1894, p. 261), whose figure is reproduced herein as No. 7. This is made from a specimen (No. 399) in the Museum of the College of Surgeons (Hunterian specimen). Here follows his description:

> On comparing the teeth of the two sides, it will be seen first that the rows do not correspond individually, and secondly that they do not at all readily correspond collectively. Assuming that the rows marked 4 on each side are in correspondence (which is not by any means certain) several difficulties remain; [right row 3 has 7 teeth, left row 3 has 5; right 4 has 6 teeth, left 4 but 5]; for right 5th is larger than left 5th, [as may be found by using dividers], but left 5th and 7th together are larger than right 6th; right 7th is about the same size as left [7th and] 8th, but right 8th is [smaller than left 8th and] larger than left 9th. The proportions in the figure were carefully copied from the specimen.

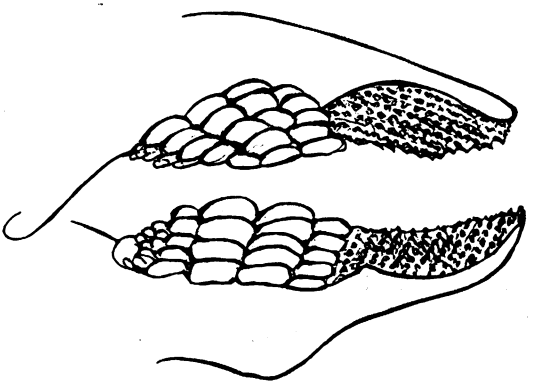

Fig. 8.—Abnormal teeth of *Heterodontus philippi*. The most striking departure from the normal is found in the third row of molars above with but three teeth. After Mummery, 1924, Pl. xi, Fig. 3.

Specimen No. III.—J. H. Mummery (1924) in his figure 3, Pl. xi, shows slight variations which, however, may be defects in drawing and in any case are rather too insignificant to notice. Not so, however, his figure 2 made from a specimen in the British Museum (Natural History). This, which is shown herein as Fig. 8, has very marked abnormalities in the rows of pavement or crushing teeth in the upper half of the figure.

Whether these are the right and left halves of the same jaw or are the halves of two jaws slightly twisted out of plane to make the teeth better visible, cannot be said. However, although the rows of small anterior teeth do not correspond, it seems quite likely that these are the halves of the lower jaw.

All the rows of molar teeth in the upper half of the figure are out of line owing to the fact that the third large row counting forward is incomplete—containing three teeth instead of 5—hence the upper rows do not correspond with those in the lower half. At the very rear the

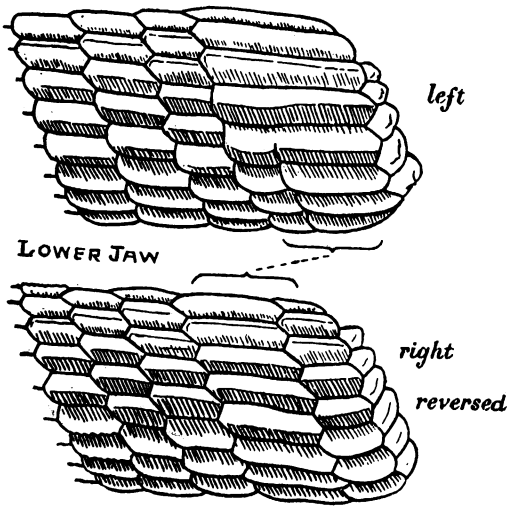

Fig. 9.—Portions of the hinder ends of the lower jaw of a *Gyropleurodus* (*Cestracion* or *Heterodontus*) sp., showing abnormalities particularly in the hindermost teeth of the left jaw.

After Bateson, 1894, p. 262.

two sets of small teeth do not correspond in size and number. The large molars of the first row above vary in size from 7 to 4 mm., while the corresponding measurements in the other half-jaw are from 5 to 4 mm. The second row of grinders above are five in number and are about 6 mm. long; the other jaw has four such teeth about 8 mm. long. Attention has been called to the three teeth of the third upper row. Compare them with the five 8-mm. teeth below. The teeth of the fourth upper and the similar lower row of molars differ not only in size but also in position. Lastly, the small anterior raptorial teeth above and below do not correspond. This, however, may be the result of poor drawing.

It should be noted that Mummery makes no mention whatever of the irregularities which I have pointed out, and it seems reasonable to suppose that he did not recognize them as abnormalities.

There is no external cause visible to account for any of these marked dental abnormalities. The causes must have arisen in the germinal epithelium from which the teeth were developed. Probably such variations are common in the teeth of this fish.

Gyropleurodus (Heterodontus, Cestracion) sp.

The Bull-headed Shark

In the Museum of the College of Surgeons, Bateson (1894, pp. 261–262, Fig. 71) found an abnormal selachian lower jaw labelled "*Cestracion* sp." This, however, he queries and labels his figure simply "The lower jaw of a Selachian, No. 400." In this (Fig. 9 herein) the lower half appears to be normal but in the upper is found a marked abnormality. The outer plates have partly divided, three completely but the fourth only partly, while four other rows show no signs of segmentation. The four teeth that show division have the outer sections large and the inner

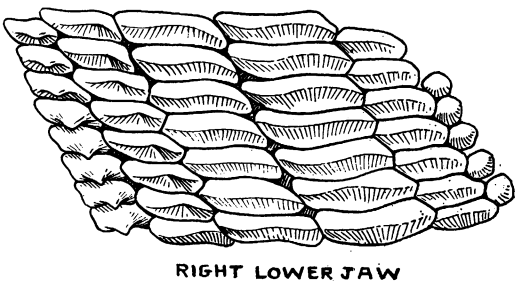

Fig. 10.—Teeth of the hinder part of right lower jaw of *Gyropleurodus* (*Heterodontus*, or *Cestracion*) *francisci*. This makes clear the source of the teeth shown in Fig. 8. From a specimen in the U. S. National Museum.

small, whereas the normal jaw has the smaller teeth to the outside and the larger inside. Also it is noticeable that these teeth do not fit with the teeth next to them in the excellent way found in the other parts of this jaw.

This figure completely puzzled me, for the very good reason that I had never seen the jaws themselves or even a good figure of these parts from such a shark or from any closely related form. However, among the valuable shark-jaw material which I examined at the U. S. National Museum were the complete mouth-parts of the bull-headed shark,

Gyropleurodus francisci, collected at Monterey, California, by the late Dr. D. S. Jordan. Fig. 10 shows the right half of the lower jaw of this specimen in which the teeth are all normal. This figure of normal teeth is introduced to clear up the doubt about the teeth shown in Fig. 9. While the teeth shown in this figure are possibly not from the same species of shark from which came the teeth of Fig. 9, they did come from a closely related form. In fact the relationship is so clear that no comment is necessary other than to say that possibly all the teeth shown in Bateson's figure are abnormal, there probably being supernumerary rows. No cause can be conjectured for this anomaly, which closely resembles what was found in a number of ray jaws (Gudger, 1933)

CARCHARHINIDAE

The sharks of this family have the teeth compressed, sub-triangular, some or all (generally the upper in any case) serrated, one series in function.[1]

Carcharhinus commersonii

The Cub Shark or Requiem

In the collection of sharks' jaws in the American Museum are two of about the same size, which have been provisionally identified by my colleague, Mr. John T. Nichols, as belonging to the above shark. No source is indicated for these jaws, but there is a good deal of internal evidence that, along with other material of like kind, they came from the Gulf of Aden and were presented by the late Dr. Alfred Ehrenreich.

Specimen No. I.—In the left upper jaw, the teeth of the seventh row (counting from the symphysis) are split into right and left segments approximately equal in size as may be seen in Fig. 11. Here it is impossible to measure the relative widths of the split teeth since the teeth lie so flat on each other that one cannot get the dividers to their inner bases. Nor is it possible accurately to compare the widths of the divided teeth counted as one row with those of the next row toward the

[1] In this division of this article there are numerous figures of the same kind, and, since it would be expensive to reproduce a whole half upper or lower jaw to show a single divided tooth-row or other abnormal tooth-structure, only sections of each quarter-jaw will be figured. To orient in the proper jaw the few tooth-rows figured in each section, the reader must look at the figure as the shark looks. The orientation will become clear if the reader will understand that the upper and lower quarter-jaws have been cut apart at the angles and symphyses and that each quarter-jaw was laid in its natural position on its outer surface so that the teeth on its inner surface might be photographed.

In the lower jaw seen thus from above and behind, the front teeth of any row will point upward and outward, the others inward and backward toward the jaw-cartilage and toward the reader. In the upper jaw seen from before but upside down, the front teeth point upward and backward toward the reader, all others forward toward the jaw-cartilage and away from the reader. Figured thus, right is right and left is left no matter in what quarter-jaw the divided teeth are found, and the teeth are seen as they occur in the mouth of the shark.

symphysis. Approximately these measurements are 23 mm. to 17 mm. or about one-third greater for the divided or double row.

The rear teeth of the double row were still covered over by the "gum" or thecal fold when I found the specimen. The jaw was soaked in warm water and the gum cut away as carefully as possible. These jaws had never been "cured," or hardened, in formalin, and the rear outer side of the jaw gave way in the process of dissection, but I am positive that no external disturbing factor was present to cause the split in the row of teeth. Whatever the disturbing agent was, it would seem to have been some internal defect in the tooth-bud for this row of teeth. This hurt must have been experienced long ago since all the teeth in this particular row (four in number— the unhardened teeth were torn out in removing the thecal fold) are divided.

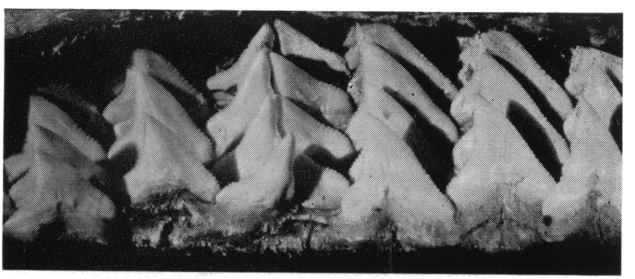

Fig. 11.—The seventh row of upper left teeth (counting from the symphysis) of *Carcharhinus commersonii* having all the teeth divided into approximately equal halves. Outer (lower) teeth broken off.

Specimen in American Museum.

Specimen No. II.—This set of jaws of *Carcharhinus commersonii* is of about the same size as the preceding. In its left upper jaw are found the curious abnormal (not divided) teeth in the sixth and seventh rows (counting from the symphysis) shown in Fig. 12. These two rows of teeth are widely separated from each other, and those of the sixth row have their left (outer) shoulders much reduced. The outermost tooth has unfortunately been broken off. We can only conjecture that its left base was defective, as is that of the next tooth behind, which lacks it entirely. The teeth of the seventh row have their right bases somewhat better developed than the left. But so far as bases are concerned, the teeth of this row are more nearly normal than are those of the sixth.

However, abnormal as these teeth are—and this is discernible at a glance—an added departure from the normal is found in the fact that

every tooth in each row (8 for the two rows) has the point bent backward and upward. This is done as neatly as one could with pliers bend a row of nails projecting from a board. However it was effected, the cause operated when the teeth were soft, "green," unhardened. Presumably the cause that operated to separate the two rows of teeth and to deform their bases somewhat has also brought about the backward and upward bending of the points of these teeth.

When these jaws were sent in, they had been merely "roughed out" (roughly cleaned) and dried. Hence in order to see the teeth clearly and get at the possible cause it was necessary to clear off the remnants of muscles from the cartilage and to cut out the thecal fold. Since the

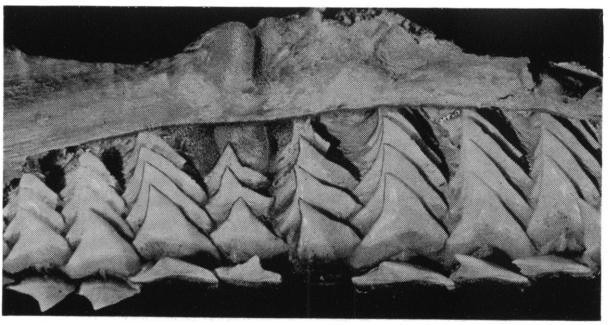

Fig. 12.—Sixth and seventh rows of teeth in the left upper jaw of *Carcharhinus commersonii* (specimen No. 2). Note that these three rows are widely separated and that the teeth are hooked backward. Note also the deformity of the jaw cartilage and the cartilaginous bulla under the hindmost teeth of the seventh row. Specimen in American Museum.

jaws had never been "cured" in formalin, this proved a difficult task, and the innermost soft teeth were destroyed in the process. In the pocket at the rear of the fold, but not embedded in "gum," was found what is apparently a fragment (8.5 mm. long) of the CENTRAL PART of a sting-ray's sting. It was resting somewhat in between the two rows of teeth shown, but it seemed merely to be there as a bit of débris. There was nothing to connect it with the hurt, as has been found for spines in other jaws to be studied later.

However, when the groove in the inner side of the jaw was cleared, slightly to the left of the line between tooth-rows 6 and 7, but about under the right of the median line of tooth-row 7, was found the curious bulla or rounded mass shown in Fig. 12. Evidently connected with this

is the curious grooved thickening or enlargement on the upper side of the left upper jaw cartilage. Whatever produced this must have produced the deformation of the teeth. What then could have produced these things? In the light of a definite cause presently to be described for other jaws, I thought of some inclusion in the bulla and in the high ridge on the left of the furrow. However, these when bored into proved to be as solid as are the other parts of the jaw cartilage. Inclusions being ruled out, I can think of but two other possible causes—the bite of another shark and the being caught on a shark hook.

But had a shark caught the jaw of this fish, it would have ripped out a whole section of a jaw, as has been done for a specimen in our collections—described by me elsewhere (Gudger, 1932). I can see no explanation other than that the shark was caught on a hook, the point of which hung on the inside of the jaw. The hook was probably pulled out, the point tearing a gash or furrow through the jaw-cartilage and skin and affecting the inner edges of the adjacent tooth-buds. The healing of this furrow produced the ridged mound on the upper surface of the jaw-cartilage and the bulla on the inside of the groove.

Carcharhinus limbatus

The Spotted-finned Shark

The jaws of this shark, now to be studied, were collected in the Gulf of Aden and were presented by the late Dr. Alfred Ehrenreich. They have been identified by Mr. Nichols as belonging to the shark whose name heads this paragraph. In another article (Gudger, 1932) I have shown that this particular individual shark had a marked fondness for the flesh of sting rays, inasmuch as 13 stings were found in and on its jaws. However, it is only two of these stings that are of interest just here.

This pair of jaws had merely been "roughed out" when they came into my hands; the grooves for the tooth-bands were filled with the "gum" or thecal fold and the cartilages of the jaws were covered with the remains of the adherent muscles. However, in the left lower jaw about two-thirds of the distance from the symphysis to the end of the tooth-band was seen the base of a broken-off sting-ray sting almost covered by the "gum." The jaws being well preserved were soaked in warm water and the gum and other tissues were carefully dissected away, whereupon this spine was clearly revealed (Fig. 13). This sting had been implanted with such vigor by the ray that it had penetrated the cartilage of the jaw and the point had come to the exterior in the middle

of the outer surface of the jaw in a vertical line about midway of the length of the jaw. In Fig. 13 is seen the sting embedded in the bottom of the tooth-groove, with the divided tooth-row above it.

Count of the teeth in this half of the lower left jaw shows that the thirteenth row of teeth has been divided into approximately equal

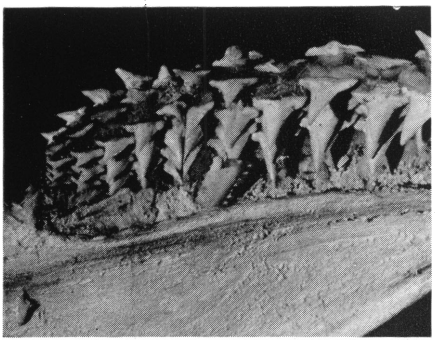

Fig. 13. A row of split teeth in the left lower jaw of a *Carcharhinus limbatus* from the Gulf of Aden. Here a sting-ray's sting embedded in the jaw has divided the fifth tooth-bud and the row of teeth developed therefrom.
Specimen in American Museum.

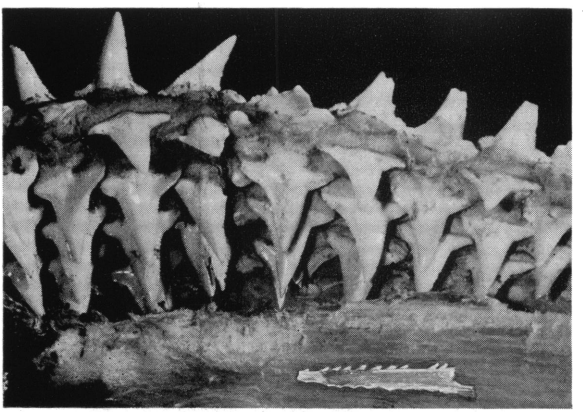

Fig. 14.—The fifth right lower row of teeth of *Carcharhinus limbatus* with the right bases separated from the teeth. This was caused by a sting embedded in the gum (but not in the jaw) between the fifth and sixth rows of teeth. The spine has been removed to show the clipped-off "shoulders" and is shown cemented to the inner side of the jaw-cartilage.
Specimen in American Museum.

halves, precisely as have the teeth in *Carcharhinus commersonii* shown in Fig. 11. However, here the cause is apparent—the sting-ray barb has evidently divided the tooth-germ into approximately equal halves. But as before, the two halves taken together are somewhat larger than the single tooth next to it on the right. The height of both sets of teeth is practically the same, but the width of the split tooth-row is greater than that of the normal tooth-row—13 mm. compared to 9.

But this is not the only implanted barb and divided tooth-row in this jaw. Between the fifth and six rows of teeth in the right lower jaw, I found a broken-off sting embedded in the gum but not penetrating the jaw cartilage. This spine has clipped off a bit of the right or outer side of the tooth-germ of the fifth row. The teeth (Fig. 14), instead of having a shoulder or basal projection on the right side as is found in the normal teeth, have the right side nearly straight from top to bottom, and the basal shoulders are seen as small tooth-fragments set off to the right. The split in the hindmost tooth is an artifact due to a slip of the knife when the leather-like tough "gum" was being cut out. The spine which did this damage when in place completely hid the cut-off right shoulder bases of the teeth. Hence it has been removed in order that these fragments may show in Fig. 14. It is represented in natural size affixed on the inner side of the jaw-cartilage. It may be noted just here that this last partial tooth-segmentation is an absolutely unique thing—all other divided teeth in sharks are approximately bilaterally symmetrical.

Carcharhinus sp.

In the U. S. National Museum there is a beautifully prepared pair of jaws (No. 26169) which cannot be identified further than the genus. These were collected at Clarion (Santa Rosa) Island in the Pacific Ocean southwest of the Revillagigedo Group, west of southern Mexico, by Dr. C. H. Townsend in 1889.

Each corner of this pair of jaws possesses an interesting abnormality. Counting the paired symphysial teeth, the upper jaw has 14 rows of teeth in each half. The thirteenth row in the upper right half is split into two rows of teeth as is shown in Fig. 15. There is nothing to show what caused this splitting, but it is plainly of long standing. The teeth of row 12, just to the left of this row, are 11 mm. wide and 8 high; while the combined width of the two sets of half-teeth of row 13 is 12 mm., but the height is only 6 mm.

Omitting reference to slight irregularities in the symphysial teeth

of the lower jaw, it is found that each ramus has apparently 14 rows of teeth, and that there are abnormalities at the outer ends of both left and right lower tooth-bands.

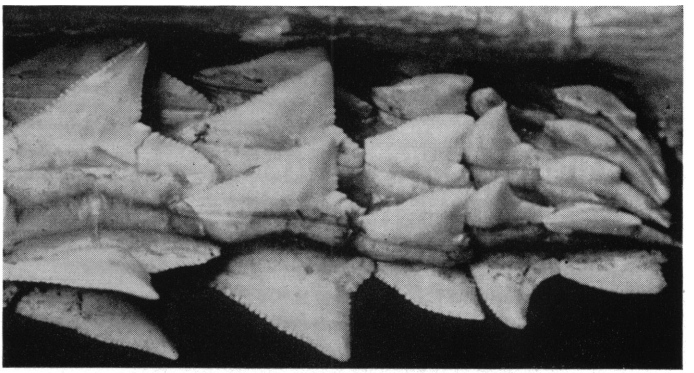

Fig. 15.—Divided teeth in the thirteenth row on the upper right jaw of an unknown *Carcharhinus* from Clarion Island, Pacific Ocean.
U. S. National Museum no. 26169.

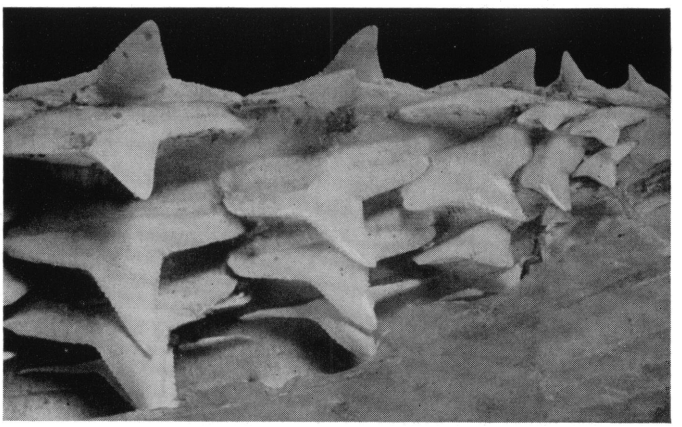

Fig. 16.—Divided teeth (row 12 from symphysis) at outer extremity of right lower jaw of *Carcharhinus* sp. from Clarion Island.
U. S. National Museum no. 26169.

In the right lower jaw is the remarkable condition shown in Fig. 16. Here there is a double row of small and closely crowded teeth, with short and overlapping bases as portrayed in the photograph. The tooth-row

count is the same (14) as that for each of the other three half-jaws (however, row 14 has only one tooth), but there is no such regular gradation in the size of the teeth going to the angle of the jaw as found in the other three rami of the jaws. The twelfth row is divided into two, but unequally so. The teeth to the left are large and observe the gradation from left to right but the teeth to the right are small, almost as small as the two of row 14. Note, however, that the material in double row 12 is almost equal to that in single row 11.

The twelfth row on the left lower jaw presents the condition which may be seen in Fig. 17. It will be noted that the inner basal shoulders of both rows of teeth are much shorter than the outer ones, whereas they should be about equal. It should be noted that rows 13 and 14 are

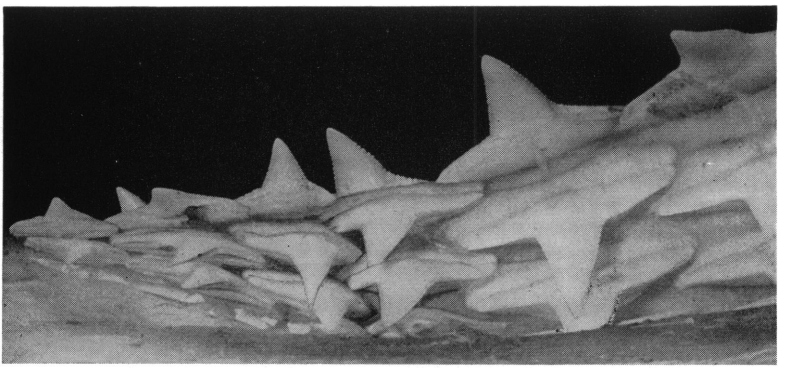

Fig. 17. Divided teeth (twelfth row from the symphysis) in left lower jaw of *Carcharhinus* sp. from Clarion Island.
U. S. National Museum no. 26169.

normal in decreasing size and also in position. I was long in doubt as to whether this is a case of divided or of crowded teeth. Since the teeth are not so closely set as in the divided teeth in the right upper jaw and since there is no visible cause for this abnormality, the smaller inner basal shoulders of both rows of teeth might be attributed to the crowding.

However, prolonged study of this specimen has finally left no doubt in my mind that this is a case of divided teeth, which are more widely separated than is normally the case. Counting these divided teeth as a pair, the count of tooth-rows—14—for this left lower jaw tallies exactly with that for the other three rami of these jaws.

This pair of jaws has more abnormalities (3) than any yet studied. In the right upper, it is a plain case of a divided tooth-row, the cause

being evidently an internal division of the tooth-germ. The abnormalities in the lower jaw are much more difficult to explain. On the supposition that there should be 14 rows of teeth in the lower as in the upper, then it may be conjectured that the abnormality on the lower right (Fig. 16) is a divided twelfth row of teeth with the divided teeth spread further apart than is usual, and that on the lower left (Fig. 17) what would have made a normal twelfth row has made two abnormal rows of about half-sized teeth. Here then are cases directly comparable with the second one figured for *Chlamydoselachus* (Fig. 4).

Particular attention should be called to the fact that these three anomalies are found at the outer end of each quarter-jaw; in the 13th row in the upper right, in the 12th row of the lower right, and in the 12th row of the lower left. Those in the two right half-jaws are almost in apposition—13th upper and 12th lower. No cause can be assigned for these curious facts, nor can any be alleged for the presence of these double rows of teeth.

Galeus galeus

Following Garman's arrangement of the plagiostomes (1913), this shark comes next in order. The phenomenon here is that of a pathologically altered jaw primarily and of teeth secondarily, and is directly comparable to what I have described for the second specimen of *Carcharhinus commersonii* above. The account abridged herein is taken from an article by Hilgendorf (1891) on the jaw of a shark to which he gives the above name.

This jaw had a healed wound extending diagonally across the right lower ramus. As a result of this hurt the 11 teeth toward the angle of the jaw had suffered peculiar deformation. Hilgendorf's description is detailed, but in the absence of figures, it is not clear to me just how these teeth were affected. They were somewhat smaller than normal and were bent and twisted. It is not clear whether the twisting was in the substance of the tooth or resulted from the way the tooth had been displaced on the jaw-cartilage. There was an excessive count in the number of rows in this right lower jaw, and our author queried whether a row of teeth might not have become divided. This is partially attested by the fact that between the eighth and ninth vertical rows of teeth there were "small diagonally placed tooth-rudiments," which might possibly have been separate pieces of the teeth of the ninth row. Apparently this is something like that found in the right lower jaw of *Carcharhinus limbatus*—Fig. 14. On the whole, however, Hilgendorf

seems to think that possibly in the beginning there may have been more rows of teeth on the right than on the left ramus.

Whatever the hurt was, it affected each of these rows of teeth from front to back—evidently the tooth-germ of each row was disturbed. It seems quite possible that this malformed jaw is in some degree comparable to that figured and described for *Lamna* in an earlier article (Gudger, 1932). If only Hilgendorf had figured this jaw, one could get a much clearer idea of the causes and results of the hurt. It can only be conjectured that this hurt came from a shark hook.

Galeocerdo tigrinus

The Tiger Shark

In *Chlamydoselachus anguineus*, the first shark studied, one was not surprised to find many tooth abnormalities since it is the most archaic shark alive today. But it is surprising to find so many examples (4) in

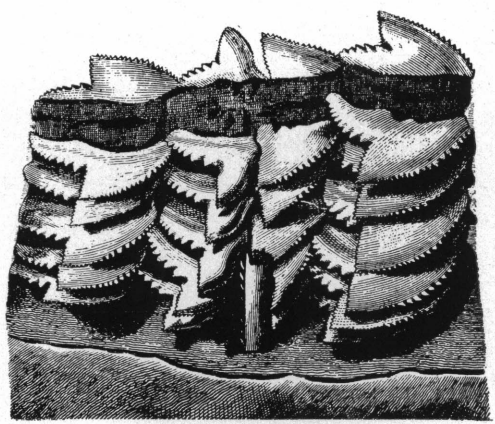

Fig. 18.—A divided tooth-row in left lower jaw of the tiger shark, *Galeocerdo tigrinus*. Here the embedded sting-ray spine has divided the tooth-germ into approximately equal parts.

After Andre, 1784, Pl. XIII.

the tiger shark which is relatively high in the scale and whose sickle-shaped teeth are certainly the most unsymmetrical and perhaps the most specialized of any belonging to the higher sharks. We will consider abnormalities from four sharks of this species for only one of which can a cause be assigned.

The Earliest Record.—In 1784 Andre published an article of which one section was devoted to "An Attempt to Prove that the Teeth of

Cartilaginous Fishes are Perpetually Renewed." This was illustrated by a beautifully drawn figure of a section of the lower left jaw of a tiger shark reproduced herein as Fig. 18. Here follows Andre's description in his own words:

> Being engaged in dissecting the jaws of a very large shark, I was surprised to find a portion of that sharp, bearded bone found in the tail of the fire-flaire, or sting ray, driven quite through the lower jaw among the posterior teeth, and fixed almost immoveably. How this happened must be obvious to every one. . . .
>
> The sharp bone of the sting ray was fixed in the lower jaw between two rows of teeth, and at their posterior part, where the first rudiments of the future teeth are formed, and it will be clear to everyone, particularly those who are conversant in such matters, that this could not have happened without producing a great deal of pain, swelling and disorder in the part where it was fixed. It is unnecessary to enumerate the different kinds of mischief this might occasion. Let it suffice to observe, that on account of the space taken up by this extraneous body, the teeth on each side of it, for want of room, could never be perfectly formed. The teeth on the left side wanting their angles to the right, and the teeth on the right side being destitute of their angles to the left.
>
> As it is certain that the anterior teeth were formerly posterior ones, and as the teeth in each row were all deficient in one angle, it follows, that they must have been formed posterior to the insertion of this extraneous body. Again, if we allow that before the accident the animal was in possession of perfect teeth, it follows also, that they were consumed and replaced by imperfect ones.

Andre then goes on to show that, since the undivided teeth are normal and the divided ones abnormal, the six pairs of half-teeth were formed after the sting was implanted in the jaw, as the normal teeth anterior to the sting were "consumed" or used up. Then he quaintly but correctly concludes thus: "I have endeavored to prove that a part of the inhabitants of the great deep retain, in the article of teeth, a perpetual juvenility, being apparently utter strangers to an edentulous old age."

Here then is a very definite cause for this row of divided teeth. The spine of the sting ray has divided the tooth-germ into almost equal parts, exactly as another spine has divided a tooth-row in *Carcharhinus limbatus* and as a second spine split off the right "shoulder" of each tooth in a whole row of teeth in the same shark.

Specimen No. II.—In a fragment of jaw of a tiger shark taken at Anegada Island in the British West Indies by Capt. W. E. Young, in 1930, and presented to me, is found the curious abnormality shown in Fig. 19. Here some agency has divided the tooth-bud into approximately equal halves. The teeth of these halves taken as a whole are slightly wider than those of a normal row. The five teeth in the row

to the left of the divided row measure each 24 mm. across the base. The breadths of the divided teeth from front to back are respectively 28, 29, 30, 27, 26 mm. The heights of the left halves of the divided teeth are practically identical with the heights of the teeth to the left—14 mm. The heights of the right halves of the divided teeth are slightly lower—13 mm. Since the whole tooth-band was not preserved, no cause can be found for this interesting phenomenon. The hurt, whatever it was, is evidently of long standing, for all the teeth including the outermost are divided.

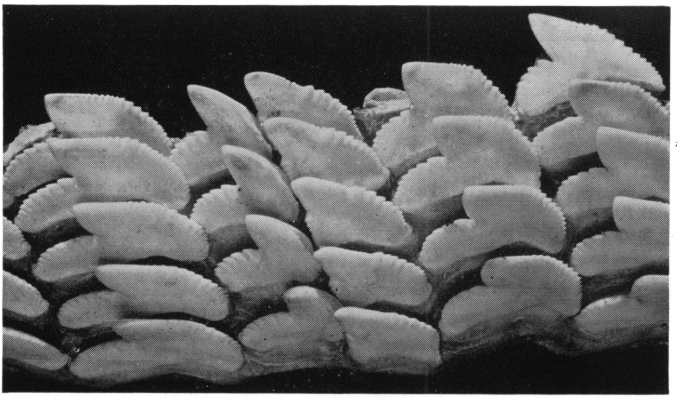

Fig. 19.—A divided tooth-row in the upper right jaw of a tiger shark (*Galeocerdo tigrinus*) from Anegada Island, B. W. I.
Presented by Capt. W. E. Young.

Since this tooth-band does not have on it the outer or functional teeth, and also lacks the inner not yet hardened teeth, it has been somewhat difficult to decide from what jaw it came. However, it does show on its lower edge (in the figure) that the outer teeth have been torn off and that the functional teeth have their points worn down, and it does possess the full number of rows of teeth (11) for a half-jaw, including a symphysial row. So it is plain that it is either the right upper or left lower tooth-band. Study of the symphysial teeth in a large number of tiger shark jaws in our collections demonstrates that it is the upper right tooth-band.

A careful examination of the 20 or more jaws of tiger sharks in the American Museum and of a larger number in the U. S. National Museum, brought to light no other dental anomalies.

Since the above was written, there have come to me two lots of tiger shark teeth far more unusual and unexplainable than those described above in this section, and indeed than any referred to in this paper. These are so extraordinary that each tooth will be separately figured and described. Since these teeth are detached from the jaws, they are portrayed as they would be seen on looking into the shark's mouth—i.e., the teeth from the right jaw are on the reader's left, those from the left jaw on his right.

Galeocerdo No. III.—In January 1935, Mr. E. M. Schuetz, at that time resident manager at Nassau, Bahamas, of The National Fisheries Corporation, sent me some abnormal tiger-shark teeth and wrote that "Deformed teeth, especially in the tiger shark in this region, are not uncommon." Then he spoke of a tiger shark with abnormal teeth which

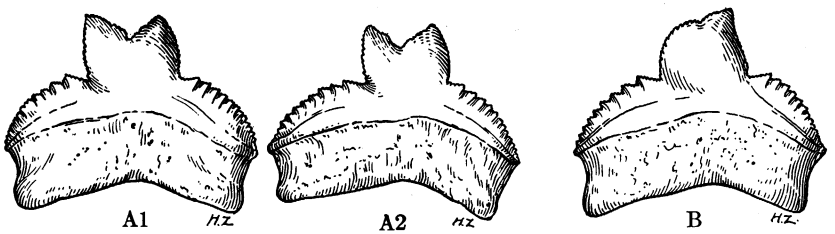

Fig. 20.—Three abnormal teeth (in front view) from the lower jaw of *Galeocerdo tigrinus* from the Bahamas. A1 and A2 with two cusps are from the right side of the symphysis of the lower jaw; B (having but one cusp) is from the left side.
Presented by Mr. E. M. Schuetz.

had been taken near Water and Barrow Cays some 85 miles N. by W. from Nassau, in June, 1932. The jaws of this shark were unfortunately destroyed, but Mr. Schuetz saved and sent to me three teeth. Of them he writes that "The deformed teeth were in the lower jaw on each side nearest the center of the jaw. Those on the left side were most deformed and those on the right side less so. There were 6 teeth in all—3 on each side in the row from front to back." In connection with this, it may be said just here that in various tiger-shark jaws I have found that teeth on either side nearest the symphysis show some slight departures from the typical form. This, however, is not an uncommon thing in the jaws of other sharks also.

These teeth are shown in Fig. 20 as one would see them in looking at the symphysis of the shark's lower jaw from the front (looking into its mouth). The peculiar serrate edges of the outer wings of these teeth are characteristic of tiger-shark teeth as may be seen in Figs. 18 and 19.

The normal sickle-shaped teeth in these figures are the most asymmetrical sharks' teeth known to me, whereas these abnormal teeth are, as Fig. 20 shows, almost bilaterally symmetrical—particularly teeth A1 and A2, less so tooth B. This latter tooth, from the left side of the symphysis has but one cusp which leans to the reader's right (the shark's left) as it should. Note the slight depression near the center—a possible forerunner of what will be seen in the other teeth. This point is undoubtedly the morphologized cusp of the normal tooth. It is sharply bent backward (i.e., into the fish's mouth).

Teeth A1 and A2 are from the right side of the shark's jaw, as indicated by their points leaning toward the reader's left. The central mass of each cusp is almost bilaterally produced into two cusps, the

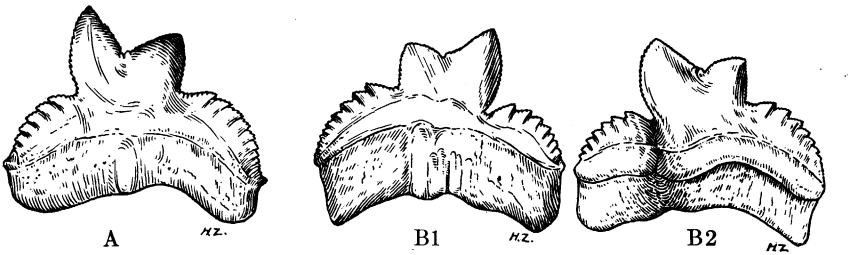

Fig. 21.—Two bicuspid teeth (in front view) from a *Galeocerdo tigrinus* taken off Sarasota, west coast of Florida. A is from the right side of the symphysis, B1 from the left side. B2 is a rear view of B1 showing a hurt inflicted on the left of the cusp.
Presented by Capt. W. E. Young.

outer one slightly the larger. In the tooth looked at edge-wise, the outer cusp lies almost exactly in the plane of the inside of the tooth, but the smaller cusp is bent backward (inward to the shark's mouth)—markedly so in tooth A1. In both teeth the bent cusps are those nearest the symphysis of the jaws. The hinder surfaces of these three teeth are entirely normal.

Specimen No. IV.—To "pile Pelion upon Ossa," in July, 1936, Capt. W. E. Young sent me a pair of very similar tiger shark teeth. These are to be seen in Fig. 21. Capt. Young wrote that these teeth were given him by a shark fisherman at Sarasota, west coast of Florida, who reported that "there were two pairs of teeth in each jaw and on both sides of the jaw, or 8 teeth in all." Presumably there were two pairs in each half-jaw upper and lower—a pair on each of four quarter-jaws.

As may be seen in Fig. 21, these are tiger-shark teeth showing the

same general type of deformity as those from the Bahamas. But it is clear that, coming from the same part of the lower jaw, these are from a larger and presumably older shark. The drawing shows the teeth with the larger points turned outward indicating that they come from opposite halves of the lower jaw. Comparing these teeth with normal ones in Figs. 18 and 19 there is no doubt that the central mass is the morphologized normal sickle-shaped cusp. The larger and higher point surely more nearly represents the point of the original cusp. Hence one concludes that the lower or secondary cusp is the more abnormal of the two. In tooth A the secondary cusp is bent sharply backward. In B1 the secondary cusp is almost in the same plane as the main point.

In rear view, tooth A is normal for itself—and like similar aspects of the teeth from the Bahamas. Not so, however, the rear of tooth B1 (Fig. 21, B2). Held horizontally with base to the eye it is seen to be much more convex on the front edge and more concave on the rear than tooth A. Inspection of B2 (Fig. 21) shows to what this sharp convexity is due. On the rear just outside of the outer cusp is a deep ravine as though the left lateral wing of the tooth had been bent sharply backward. The bending must have taken place when the tooth was as yet unhardened. The bending shows (but not so abruptly) in the base as well.

As to what caused these abnormalities (Figs. 20 and 21)—the most extraordinary ever reported in sharks' teeth—one can only wonder. Possibly, even probably, there were three factors. The first—whatever it was—produced the central mass, probably like that seen in 20B, which is the sickle-shaped cusp least changed. Then a second factor, a disturbance at the tip of the already abnormal tooth-bud, caused the bifurcation. Next a third factor led to a backward bending in each case of that cusp nearest the symphysis of the jaw. Had the entire jaws come to me, it might have been possible to find some explanation of these extraordinarily teratological teeth, but with the teeth only at hand, one is entirely at a loss as to the cause. However, it is interesting to note that these teeth seem to show some return to bilaterality—a condition common to most shark's teeth.

It is remarkable enough that the tiger shark should have the very abnormal teeth shown in Fig. 20, but much more remarkable that 300 miles away as the crow flies, with the great peninsula of Florida between, and some 425 miles as the fish swims to get around that peninsula, another tiger shark should be captured showing the same type of extraordinary tooth deformity (Fig. 21). The same essential cause must have functioned in the jaws of each shark. But what is it?

SUMMARY

The data on which this paper is based are set out briefly in the accompanying table.

Abnormalities in the Teeth of Sharks

Previously reported		Reported under		New reports	
Figs.	Descriptions	Name of Shark and No. of Specimens		Figs.	Descriptions
3	4	*Chlamydoselachus anguineus*	7	1	4
3	1	*Heterodontus philippi*	3	0	2
1	1	*Gyropleurodus* sp.	1	0	0
0	0	*Carcharhinus commersonii*	2	2	2
0	0	*Carcharhinus limbatus*	1	2	2
0	0	*Carcharhinus* sp.	1	3	3
0	1	*Galeus galeus*	1	0	0
1	1	*Galeocerdo tigrinus*	4	3	3
8	8	Totals—8 species	20	11	16

From this table it may be seen that in this research study has been made of the teeth of 20 specimens of 8 species of recent sharks. Of the 8 species studied, three are forms in which such variations have never before been reported, and in three others both old and new accounts are given, while in two only are abnormalities reported from the literature alone. The accounts of abnormal dentition in five forms are so deeply embedded in the literature that they have remained practically unknown.

In keeping with its position as the shark lowest in the series, the greatest number of abnormalities (8) has been found in *Chlamydoselachus anguineus.* In it I found seven in our specimens, and Collett (1897) had one. The archaic form, *Heterodontus,* also presents many abnormalities—three marked ones being figured and described. A *Carcharhinus* of unknown species from Clarion Island, Revillagigedo group, has the greatest number of abnormalities (three) in one set of jaws. And *Galeocerdo,* a shark relatively high in the scale, gives 4 jaws with abnormal teeth—3 previously undescribed. In all, 24 sets of abnormal teeth are described in more or less detail, 16 for the first time. Nineteen are figured, eleven for the first time.

Of all these 24 sets of abnormal teeth, definite causes can be found for but three. In 1784, Andre described a row of split teeth in the jaw of a *Galeocerdo tigrinus,* in which an embedded sting-ray sting had divided the tooth-bud into approximately equal halves (Fig. 18). In the jaws of a specimen of *Carcharhinus limbatus* in the American Museum, I have found two rows of malformed teeth due to the same cause.

In the lower left jaw a sting-ray spine embedded in the cartilage of the jaw has split the tooth-bud in halves (Fig. 12). In the right side of the same jaw another stingaree spine had clipped off the section of the base of the tooth-bud, the part producing the right shoulder of the tooth (Fig. 13).

For the other abnormal teeth no visible cause is at hand. These must have arisen from undetermined disturbances in the tooth-germs.

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