

mensions. Icebergs have been frequently met with which were from one to two miles in length and whose height reached 180 feet above sea level. In the region sailed over by the "Belgica" the voyagers sometimes saw as many as 110 at the same time in the circle of the horizon. About 40 per cent of these had the characteristic table-form, while the greater part resembled the Arctic icebergs, or mere modifications of the table-form. The larger icebergs were rare; those reaching 150 feet high were exceptional. The tabular icebergs were more frequently 90 to 120 feet in height. They only show the clear ice at the lower part, and this takes the form of alternating blue and white layers. The author could only examine this stratification near by in a single case, that of an iceberg imprisoned in a bank of ice; it was partly tilted over, and the strata were in an inclined position. The blue bands, as well as the white, were composed of ice having the characteristic glacier grain. The strata were not very sharply defined, and the only difference between the blue and white bands was that due to a porous structure in the white portion, the latter containing a much larger quantity of air bubbles. Both strata were, however, formed of compact ice. The supposition that tabular icebergs are formed of sea-ice is therefore quite erroneous. Besides, the mode of formation of sea-ice shows that its increase of thickness tends toward a limit, which Weyprecht supposes to be 22 feet at most, however low may be the mean winter temperature and however great the number of years of formation. The author thinks that for the Antarctic region this figure is even too high. Again, the continental origin of the Antarctic icebergs is beyond question, seeing that the bottom of the Antarctic Ocean is covered with sediment and erratic blocks which must have been deposited there by the successive melting of the icebergs. The most of the great glaciers of the Antarctic regions have a slope which is sufficiently small to produce the tabular icebergs; nevertheless, it is probable that the greater part of the ice-tables come, not from the glaciers proper, but from the great sheets of ice which form the *inlandjies* of the lowlands. The author considers that 150 feet is the maximum height of the table icebergs coming from the great ice-wall which extends to the east of Victoria Land as far as the 175th degree of west longitude, and which no doubt continues toward the east to the regions situated south and west of Alexander Land, as the observations made during the trip of the "Belgica" seem to have shown.

#### LIVING MILLSTONES.

By R. LYDEKKER.

THE mill-like action of their own upper and lower molar teeth upon one another may have been quite sufficient to suggest to our prehistoric parents the idea of opposing a pair of corrugated stones in such a manner that by mutual rotation or revolution they should be capable of reducing to powder hard substances placed between them. Indeed, the idea of millstones is such a simple and natural one that it is quite probable it may have occurred to the human mind without reference to any prototype in nature; and, in any case, if such a natural prototype is to be sought, it is not necessary to go further in search of it than our own dental organs. Excellent, however, for their special purpose as are these organs (when not subject to premature decay), there are other types of tooth-structure to be met with in the animal kingdom which present a much closer approximation to millstones, and might well have foreshadowed these instruments, had they only been accessible to the primeval savage. But since these natural millstones occur only in marine fishes, some of which inhabit distant seas, while others are met with only as fossils deeply buried in the rocks, it is evident that the idea of artificial millstones is not derived from these natural prototypes. In other words, to use an expression now fashionable in natural science, the development of artificial and natural millstones is a case of parallelism.

In spite of the fact that their early ancestors were provided with a good working set of sharply pointed dental organs, birds in these degenerate days manage to get along without teeth at all. A few mammals, too, like the South American anteaters, are in the same condition; and some people have thought that in a few more generations civilized man himself will be reduced to the same toothless state. The great majority of mammals, however, possess a more or less efficient set of teeth, varying in shape, size, and number according to the need of each particular species or group. But there is one feature common to these organs in mammals of all descriptions; and this is that they are strictly confined to the margins of the jaws, never extending either on to the palate, or to the space inclosed between the two branches of the lower jaw. In many reptiles, such as crocodiles and a large number of lizards, the same law of dental arrangement obtains. In some lizards, and still more markedly in certain extinct members of the reptile class, we find, however, a number of teeth developed on the palate, having flattened crowns, and thus tending to make the mouth act the part of one large millstone. But we must descend a stage further in the scale of animated nature before we come to structures which are strictly comparable with artificial millstones and crushing cylinders. And it is in the class of fishes that we meet with these organs in the full perfection of this type of development. Not that they occur by any means in all the groups of that class; the fact being that at the present day living millstones are going out of fashion, the great preponderance of modern fishes having their dental armature mainly restricted to the margin of the jaws, with or without a minor development of crushing teeth on the palate or the bones of the gullet. With the exception of a comparatively limited number of cases, showing a different type of development, to which it is not my present intention to allude, these dental millstones are confined at the present day to those hideous marine fishes commonly known as skates and rays, and to the singular Port Jackson shark and a few allied species inhabiting the Pacific and Malayan seas. On the other hand, the seas of the Cretaceous, Jurassic, and ante-

cedent epochs absolutely swarmed with numerous kinds of sharks, more or less nearly related to the Port Jackson species, whose mouths were filled with pavements of teeth showing marvelous variety of structure and beauty of ornamentation. The skates and rays, too, displayed types of dental millstones quite unlike any of those of the present day. And in addition to these, there were hosts of enamel-scaled fishes whose mouths were likewise crammed with beautiful crushing teeth, albeit of a totally different type of structure to that obtaining in either the sharks or the rays. Although well nigh extinct, these enamel-scaled fishes are still represented by the bony pike of the rivers of North America, and the bichir (remarkable for its fringed fins and the row of finlets down its back) of tropical Africa. But it is noteworthy that in neither of these survivors of an ancient group do we find the mouth furnished with an apparatus of millstones; while, as already said, among the host of sharks that infest the warmer seas of the globe it is only in the Port Jackson species and its three kindred that we find similar structures retained; all the other members of the group having developed cuspidate teeth adapted for seizing and tearing soft-fleshed prey, instead of for grinding up mail-clad food.

Clearly, then, there has been some general cause at work which has rendered crushing teeth, so to speak, unfashionable among the fishes of the present day and the immediately antecedent epochs. And in this connection it is important to notice that there has been an even more strongly marked tendency to the extinction of the enamel-scaled fishes, and their replacement by the ordinary soft-scaled fishes so abundant in the present seas. As the majority of these old mail-clad fishes, as well as a large proportion of the ancient sharks were provided with crushing teeth, it is a fair inference that their food consisted largely of shell-fish and crustaceans with a certain proportion of their own mail-clad relatives. When, however, the swift-swimming, soft-scaled fishes came to the fore, they would naturally offer a more tempting and nourishing diet to such sharks and other predaceous members of their own class as were swift enough in their movements to make them their prey. And consequently the old millstone-jawed sharks would tend to more or less completely disappear. On the other hand, the skates and rays, which are for the most part slow-moving creatures, flapping sluggishly along on the sea-bottom by means of their fan-like fins, would be quite unable to capture the modern type of swift-swimming fish. And they have thus had to content themselves with the old-fashioned diet of shell-fish and crabs, in consequence of which a large proportion of them have retained the dental millstones which have been so steadily going out of fashion among their more advanced relatives. Not that these rays and skates have by any means been content with the kind of molar machinery that did duty for their forefathers, since some of them, together with their Tertiary ancestors, have developed what appears to be absolutely perfect type of living mill, far superior to that which served the purpose of their predecessors. And it must always be remembered that these beautiful living millstones and cylinders (which are some of the most exquisite bony structures to be met with in the whole animal kingdom) excel their artificial substitutes in that they never wear out; being renewed either by the development of new teeth on the inner or hinder aspect of the cylinder, or by vertical successors replacing the individual teeth from below or above.

And now that the dental millstones of the rays have been mentioned, it will afford a convenient starting-point for a brief survey of some of the most remarkable types of structure presented by these curious organs.

The teeth of rays always form a pavement-like structure, of which the component elements are arranged in straight longitudinal rows, although they may likewise show a quincunxial mode of arrangement. The individual teeth are not replaced by vertical successors; but being in the form of a half-cylinder, as those in front become worn down, the whole series is pushed forward, and new teeth are developed on the hinder margin of the cylinder. The supreme development of a dental structure adapted for crushing in this group occurs in the family of the eagle-rays (*Myliobatidae*), in which the millstone of each jaw forms a perfect semi-cylinder or plate, made up of flat-crowned prismatic teeth united at their edges, often so as to constitute a mosaic-like pavement. No piece of modern machinery can be better adapted for crushing hard substances than are these beautiful ivory cylinders and plates, the crushing power of which, when worked by the strong jaws, must be enormous, and sufficient to grind the strongest shell that can be introduced between them to powder. Although in all cases pavement-like, the millstone differs considerably in the different species in its structure. As an illustration of the group we may take one of the millstones of the beaked eagle-rays (*Rhinoptera*). Here the millstone is in the form of a semi-cylinder, consisting of five or more rows of teeth; a very usual number being seven. Generally the teeth of the middle row are the widest; those of the rows on either side being considerably narrower; while the two or three marginal rows on each side may be compared to the tesserae in a mosaic pavement. A further development of the same type is exemplified by the typical eagle-rays (*Myliobatis*), in which the middle row of teeth in the millstone becomes still wider, while the three lateral rows on each side are reduced to the condition of hexagonal tesserae. Moreover, whereas in the species of *Rhinobatis* both millstones are in the form of half-cylinders, in *Myliobatis* the upper one alone retains this form, the lower being a flattened plate. The culmination of this type of structure is displayed in the rays belonging to the allied genus *Aetobatis*, in which both upper and lower millstones are flat and composed only of the middle row of teeth, which are of great width; the lateral rows having completely disappeared. The existing representative of this genus is not very large (for a ray), seldom if ever measuring more than about five feet across; but some of its extinct predecessors must have been monstrous fish, as the teeth measure five or six inches in diameter.

Quite a different type of dental armature is presented by the millstones of the beaked rays (*Rhinobatidae*). Here the teeth take the form of closely packed diamond-shaped knobs, arranged in an alternating manner, so that although they present longitudinal rows, yet they also show oblique series, so as to give rise to a quincunxial pattern. Then, again, the entire millstone in each jaw is thrown into a series of undulations, so that the upper one exhibits a large median boss, flanked by a pair of smaller undulations, which are received into corresponding depressions in the lower millstone. It is difficult to conceive a machine better adapted for crushing than is presented by the jaws of the beaked rays.

Of a much less powerful type are the millstones of the ordinary rays or skates (*Raidae*) of our own coasts; and among these the common thornback (*Raja clavata*) presents a very remarkable condition, since the individual teeth take the form of obtuse knobs in the female, whereas in the male the center of each of these knobs acquires a sharp recurved point. Since every thing in nature has a meaning, it would seem a fair inference that there must be some important difference between the food of the male and female thornback, but I have not come across any observations bearing upon the subject.

Among the fossils to be obtained occasionally from the workmen in large chalk-pits are teeth of a peculiar type. These teeth form convex quadrangular bosses, the marginal portion of which consists of a broad granular area, while the center is occupied by a variable number of bold ridges, or folds, between which are often irregular knobs. It is from these ridges that the fish take the name of *Ptychodus*. For a long time it was uncertain how these teeth were arranged, but careful comparison of a number of more or less incomplete series *in situ* has at length solved the problem. In the lower jaw the complete millstone was formed by a median row of large teeth similar to the one figured, on each side of which were six or seven other rows composed of teeth gradually decreasing in size from the center to the margin. In the upper jaw, on the other hand, there was a central row of small teeth, flanked on each side by a row of large ones, externally to which came a series of rows gradually diminishing in size. From this mode of arrangement it is inferred that *Ptychodus* was a ray; and the whole dental structure is as remarkable for its perfection as a crushing machine as it is for its intrinsic beauty.

Even more elegant from an æsthetic point of view are the "millstones" of the Port Jackson shark (*Cestracion*) and its allies. In place of forming a continuous plate across the palate after the fashion of the eagle-rays, the individual teeth in this group are arranged in oblique bands round the edges and inner sides of the jaw,\* showing in the hinder region a melon-shaped swelling of remarkable gracefulness, which would form an attractive ornament for the capital of a pillar. In this melon-like portion of the millstone the individual teeth form bluntly convex oblongs; those of one row being markedly larger than all the rest, while the rows in front of and behind this do not correspond with one another in size. Examined with a lens, each of these blunt teeth is seen to have a minutely pitted structure, while its median longitudinal line is marked by a narrow smooth streak. New teeth are being continuously produced on the margin of the series on the inner side of the jaw, and as the outer ones become worn away, the whole series is pushed over toward the edge of the jaw. Proceeding from the larger rows of teeth toward the front of the jaw, it will be seen that as the individual teeth become gradually shorter their smooth median line gains prominence, till it finally develops into the sharply pointed cusp surmounting each of the front teeth.

As already stated, the Port Jackson shark, and a few other nearly related species (all of which, by the way, feed on shell-fish and crustaceans) are the only sharks with millstones met with in our present seas. And it is fortunate that these have lived on, as otherwise we should never have gained a true idea of the dental armature of their extinct relatives which abounded in the seas of the Jurassic epoch. Visitors to Whitby must be familiar with certain black oblong fossils of about an inch and a half in length known to the quarrymen as "fossil leeches." These are the hinder teeth of an extinct shark (*Asteracanthus*) nearly allied to the Port Jackson species, but of much larger size; and although they are more rugose than pitted, they show the same smooth line on the summit. A beautiful specimen from Caen, in the British Museum, shows that the arrangement of these hinder teeth was almost exactly the same as in *Cestracion*, which may thus be regarded as a survivor from a long past epoch of the earth's history.

But there were other "millstone-mouthed" sharks at a still earlier period which appear to have been allied to *Cestracion*, although the degree of relationship is uncertain. In these Palæozoic sharks, as exemplified by *Cochliodus*, the series of hinder teeth seem to have had an arrangement very similar to that obtaining in *Cestracion*, but the individual teeth of several series were more or less completely fused into a single solid plate, the ridges on which mark the original lines of division between the component series. These sharks exhibit, therefore, one among many instances where the earlier forms of a group are in some respects more specialized than their descendants.

So much space has been taken up by the rays and sharks that only a few lines remain for the millstones of the enamel-scaled fishes. In none of these do the teeth, which are developed on most of the bones of both the upper and lower jaws, ever form continuous plates; and they are generally either spherical or kidney-bean-shaped, and arranged in more or less distinct longitudinal rows. Unlike those of the sharks and rays, these teeth, as in the familiar *Lepidotus* of the Wealden, are replaced by vertical successors; and their mode of development is so peculiar that in some cases the new tooth is placed wrong way up beneath the one it is destined to replace. In other instances, as in *Celodus*, from the Folkestone Gault, successional teeth have not been

\* Strictly speaking, the tooth-bearing cartilages of sharks are not true jaws.

observed, and the mode of renewal is consequently still unknown. Although within the limits of a single article in Knowledge it is impossible to do more than give the crudest sketch of a vast subject, yet what has been written may be sufficient to attract my readers' interest to an extremely fascinating branch of zoological study.

#### A REPORT CONCERNING THE CATTLE OF PORTO RICO.\*

PURSUANT to authorization from the honorable the Secretary of Agriculture and your instructions of March 27, 1899, to proceed to the island of Porto Rico for the purpose of making investigation concerning the existence of Texas fever infection and to note incidental observations of interest to the Bureau of Animal Industry, the following report is respectfully submitted:

On April 11 I arrived at San Juan, and since that date have visited practically all the cattle districts of

for export which averaged 950 pounds, and which had never received food other than that afforded by the native grass pastures. Older oxen far exceed the weight mentioned. They are all of the same general type, being descendants of the old Spanish stock with the infusion of African blood. The latest African importation was in the year 1834 and consisted of five Senegal bulls brought by Señor Casinus Laporte, of Ponce. It is said that two Swiss and four English cows were brought to this island in the year 1864, later data of which is unattainable. For at least during the past century the deleterious effects of inbreeding have obtained, and are decidedly in evidence in the cattle of the island.

Cattle are the universal burden carriers. They are hitched to immense two-wheeled carts by a crude yoke which rests on the poll and is lashed to the base of the horns. They haul all freight between the ports and the interior. Therefore, if the dangerous tick exists at all, the opportunity for the spread of infection is most favorable. The annual increase is 95 per cent of the sex-

or the selection of the best native individuals for breeding purposes. The steers have a staggy appearance, for it is the custom to allow all male animals to reach sexual maturity in the herd. In view of these facts there is no great wonder that the size of the cattle and the distribution of flesh on the animal frame do not approach the standard for beef breeds, or that the milk secretion is scanty. The ill effects of inbreeding and general injudicious handling must be in part counteracted by the natural favorable conditions of the island, which insure nutritious grasses and equable temperature throughout the year.

Judging from general appearance and from the fact that some 400 head of native cattle at the United States vaccine station, at Coama Baths, Porto Rico, were tested with tuberculin with but 1 per cent reacting, none of which were found upon post-mortem to be diseased, I conclude that there is but a small percentage of these cattle affected with tuberculosis. The bacilli of tetanus and blackleg have a general distribution. Deaths from these diseases occur annually in



STREET IN AIBONITO, PORTO RICO, SHOWING METHOD OF YOKING OXEN.



OXEN AND CART, NEAR AIBONITO, PORTO RICO, SHOWING METHOD OF YOKING OXEN.

the island of Porto Rico. From the most reliable information obtainable, I judge the number of cattle on the island to be 500,000, the majority of which are in the coast country, although there are small bunches and individual animals scattered throughout the mountainous interior. The predominant color is solid light yellow; some are black, others white and black, and but few roans and reds; many have dark muzzles, ear tips and legs. The hair is short and glossy; some are almost devoid of hair on the belly and inside of the thighs. The horns of many are inclined to unusual elevations and the ears droop. The color, the round, clean-cut straight limbs of many of the young animals and their well-rounded bodies with elevated heads and spike horns close together remind one of the antelope of our Western plains. The cattle of this island are usually in good flesh throughout the year. During April and May were seen numbers of four or five year old steers ready

\* By Rice P. Steddom, Inspector, Bureau of Animal Industry, Department of Agriculture, and forming part of the sixteenth annual report of the Bureau of Animal Industry.

usually mature females; and, as the island is free from wolves, coyotes, and allied foes of young live stock, the small percentage of loss is confined to the usual accidents incident to birth and to a large spider, the bite of which occasionally results in death.

Porto Rican cattle as a rule are very tractable, being accustomed to grazing at the end of a rope or otherwise handled by attendants. On the east coast I have seen more than a hundred head on a small tract of land where the grass, similar to Johnson grass, was higher than their backs, and so thick that it was with difficulty that our saddle ponies could make their way when away from the beaten paths. Each animal was tied to a bunch of grass by means of a rope about 25 feet long made of bark. This circle of 50 feet in diameter would suffice for many days' full rations. At no time of year are the cattle housed; except in a single instance, where there was a mere shed for protection from the sun, I found no pretense for cow-barn buildings.

But little attention is given to the matter of improving the stock, either by the introduction of new blood

different parts of the island. Minor surgical operations have been so frequently followed by tetanus that the use of the knife in castration has been discarded, and, as prevention against invasion by germs and annoyance by flies, a rather imperfect form of castration is accomplished, either by bruising the testicles or by rupturing the spermatic cord by torsion and tension without incising the skin.

From the reports of cattle owners it appears that exceptional conditions on this island produce annually a few well-marked cases of Texas fever. Ticks are the greatest enemies of these cattle. In all localities they were found infested with ticks, always apparently of the same species, numerous specimens of which were mailed to the Bureau of Animal Industry. If it is proven that this tick is capable of transmitting Texas fever, there can be no doubt that all Porto Rico teems with the contagion of Texas fever throughout the entire year, and that no cattle could depart from or be brought into the island without contact with such contagion.

I desire to acknowledge in this report the valuable