Annals and Magazine of Natural History: Series 6
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tnah12

VII.—Notes on the determination of the fossil teeth of Myliobatis, with a revision of the English Eocene species

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Published online: 12 Oct 2009.

To cite this article: A. Smith Woodward F.G.S. F.Z.S. (1888) VII.—Notes on the determination of the fossil teeth of Myliobatis, with a revision of the English Eocene species , Annals and Magazine of Natural History: Series 6, 1:1, 36-47, DOI: 10.1080/00222938809460670

To link to this article: http://dx.doi.org/10.1080/00222938809460670

EXPLANATION OF PLATE IV.

All the figures, with the exception of fig. 4, are from the living subject. Fig. 4 is from a preparation treated with 1 per-cent. acetic acid. Enlargement 400 diameters.

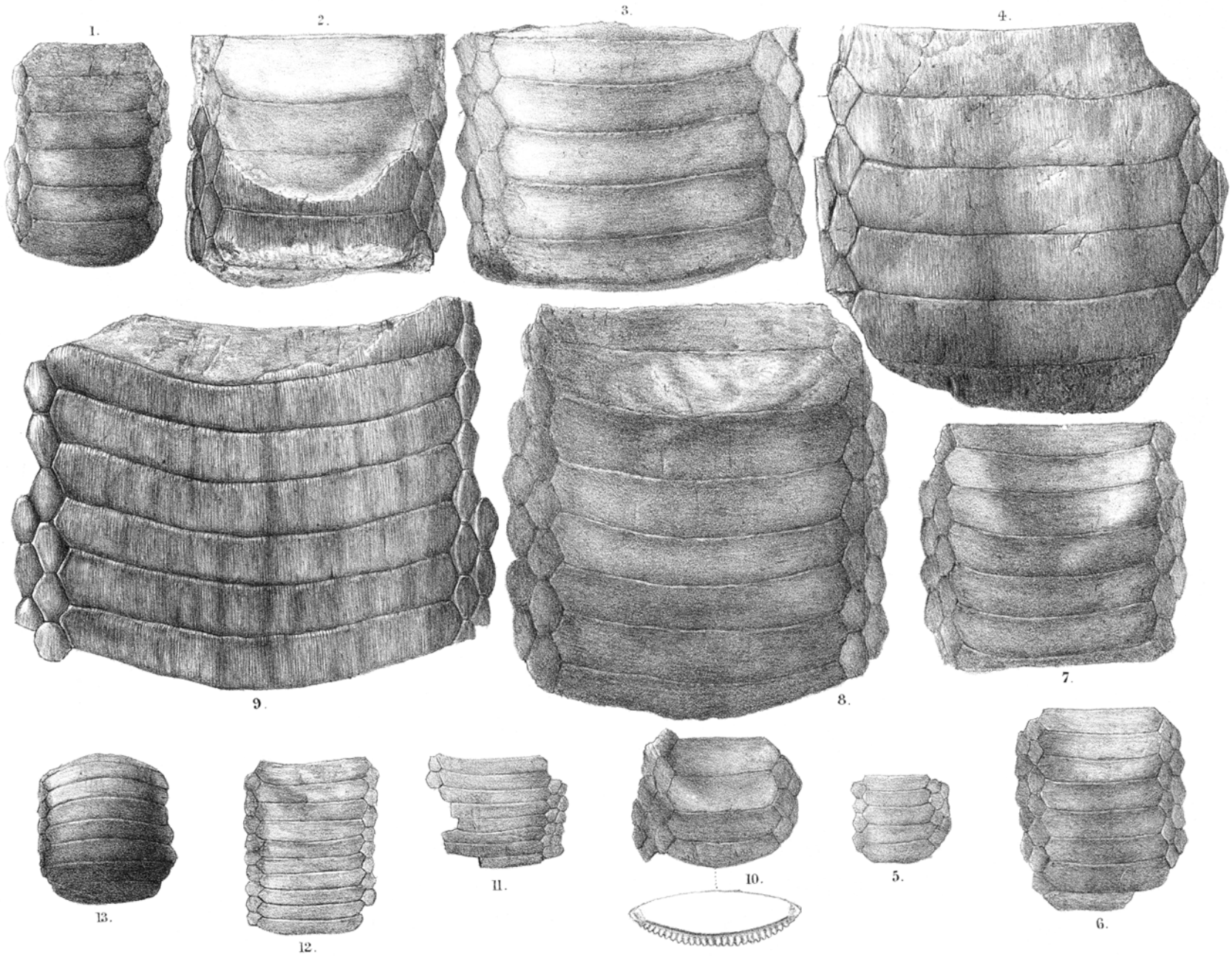
I. First individual (parent animal).
II. Second individual, produced by division from I.
n^1, nucleus of the first animal.
n^2, nucleus of the second animal.
CV, contractile vacuole.

Fig. 1. The plasma begins to withdraw itself from the animal II., produced by division from I. At the bottom of the shell it is still firmly attached and encloses the nucleus n^2, which is somewhat elongated.
Fig. 2. The process is further advanced, and the plasma is drawn out into a thin thread. The nucleus n^2 has again assumed its normal form.
Fig. 3. The thread is ruptured and the nucleus n^2 shows distinct reticular structure; it is dead.
Fig. 4. The expelled nucleus n^2 of another animal, after treatment with acetic acid of 1 per cent.
Fig. 5. The plasma is flowing again into shell II., and emits a pseudopodium towards the nucleus n^2.
Fig. 6. The pseudopodium has flowed round the nucleus n^2, and is drawing it back towards shell I.
Fig. 7. This process has further advanced.
Fig. 8. The nucleus n^2 has lost its structure, and appears as a strongly refractive irregular mass.
Fig. 9. The nucleus n^2 is again expelled.

VII.—*Notes on the Determination of the Fossil Teeth of* Myliobatis, *with a Revision of the English Eocene Species.* By A. Smith Woodward, F.G.S., F.Z.S., of the British Museum (Natural History).

[Plate I.]

Of all the numerous teeth of Selachian fishes met with in a fossil state none seem to have been studied with less satisfactory results than those of the well-known genus *Myliobatis*. Abundantly represented in nearly all the marine Tertiary formations, detached fragments of its dentition have been described under almost endless specific names from various parts of the world; and the most precise measurements have often been given, without the slightest reference to differences of age or even to variations in the individual jaw. Occasion-



Mintern Bros. del et lith.

DENTITION OF EOCENE SPECIES OF MYLIOBATIS

ally, moreover, the most distinguished naturalists have been led by imperfect specimens to enumerate as specific characters features that are wholly due to the effects of post-mortem abrasion; and other equally unreliable points have likewise been emphasized, owing to misapprehensions as to their significance and constancy.

Such mistakes are quite inevitable whenever materials are scarce and fragmentary, and especially when the observer has had but few recent specimens for comparative study. When, however, it is possible to examine and compare a large series of fossils from the same formation and locality, data are provided for much more certain and philosophical conclusions. And as the National Collection now comprises a very large number of the dental plates of *Myliobatis* from the London Clay of Sheppey and the Middle and Upper Eocenes of Bracklesham and Barton, the present seems a favourable opportunity for attempting some slight revision of the group. Here are preserved the type specimens of nearly all the species hitherto described from these formations, besides many other beautiful fossils from the cabinets of Mr. Frederic Dixon, Dr. Bowerbank, Sir Philip Egerton, and the late Earl of Enniskillen; and the whole are suggestive of some interesting considerations, which do not appear as yet to have been sufficiently recognized, at least by those who have examined the genus from a palæontological point of view. I therefore propose, in the present communication, to offer a few remarks upon the subject, based upon a careful study of the fossils I have recently been able to make; and the conclusions will lead to some slight reduction in the number of specific types supposed by previous authors to be represented.

Specific Characters afforded by Dentition.

Referring in the first place to the more general questions, it will be convenient to commence with a notice of the deceptive appearances due to post-mortem abrasion. To this may be added some remarks upon individual variations and differences in the teeth corresponding to differences of age. And the discussion will appear to result in determining at least three points of certain taxonomic value.

One of the most conspicuous of the accidental characters is the granular or punctate ornamentation produced by the removal of the superficial gano-dentine and the exposure of the vertical medullary tubes. There are several specimens in the British Museum demonstrating the process of wear and showing portions both of the original surface and that resulting

from its removal (*e. g.* no. 25658); and the circumstance has already been briefly noted by Le Hon *. Agassiz †, however, founded the species *M. punctatus* upon such an abraded fragment probably referable to the upper jaw of *M. striatus*, and Delfortrie ‡ and Issel § have more recently described fossils that appear to be similarly imperfect under the names of *M. microrhizus* and *M. granulosus*.

A less amount of abrasion of the grinding-surface often imparts to it a remarkable smoothness, which has also been occasionally relied upon as a specific character in determining dental plates. All the types of *M. Dixoni*, for example, are remarkably smooth; and though this feature was not especially alluded to in the original diagnoses of Agassiz and Dixon, the circumstance seems to have been sometimes regarded as an essential peculiarity of the species; fossils truly belonging to this form, but having the grinding-surface preserved, and thus showing striations, have been wrongly referred to *M. striatus*, as is proved by specimens in the National Collection. The specific name of *striatus* in fact might have been as appropriately applied to *M. Dixoni* and others as to the form that now bears it, if only unworn specimens had originally been available; though it so happens that other peculiarities in the species thus named render it nevertheless valid.

A further effect of post-mortem wear, or even perhaps of masticatory trituration, has led to the founding of still another species by Agassiz—the so-called *M. suturalis* ‖. This is described as possessing teeth in all respects similar to those of *M. toliapicus*, but united by jagged sutures rather than straight edges. Such a peculiarity is to be observed more or less in all the specific types when the dentition is deeply worn, as already hinted by Issel and Le Hon, and the fragment just referred to may undoubtedly be placed in the well-known species from Sheppey. Leidy's *M. serratus* ¶ may also be mentioned in this connexion, the chief character in the diagnosis being similarly misleading.

Among individual variations liable to be quoted as of

* H. le Hon, 'Préliminaires d'un Mémoire sur les Poissons Tertiaires de Belgique,' 1871, p. 13.

† L. Agassiz, Rech. Poiss. Foss. vol. iii. p. 322, pl. xlvii. figs. 11, 12.

‡ E. Delfortrie, "Les Broyeurs du Tertiaire Aquitanien," Actes Soc. Linn. Bordeaux, vol. xxviii. (1871), p. 225, pl. x. fig. 37.

§ A. Issel, "Cenni sui *Myliobates* fossili dei terreni terziarii Italiani," Ann. Mus. Civ. Stor. Nat. Genova, vol. x. (1877), p. 335.

‖ L. Agassiz, *tom. cit.* p. 322, pl. xlvi. figs. 12–16.

¶ J. Leidy, Journ. Acad. Nat. Sci. Philad. vol. viii. (1877), p. 239, pl. xxxii. fig. 5.

specific value the most striking perhaps is the variability sometimes so conspicuous in the antero-posterior measurements of the series of median teeth. This is a feature occasionally exhibited in every form, and there are good illustrations among the national fossils in dental plates of *M. Dixoni* and *M. toliapicus*, besides another specimen originally figured by Dixon under the name of *M. Edwardsii*. In the imperfect diagnosis of the latter species, however, the peculiarity is mentioned as one of the leading distinctive points *.

Equally inconstant are the small differences in the antero-posterior curvature of the median teeth, which are sometimes referred to with undue emphasis. In some species it is true there is a greater tendency towards the curvature of the plates than in others, and the present materials are insufficient to decide whether or not the sharp flexure of the extremities of the median teeth in certain forms is likewise a more or less fixed character; but it appears to be unsafe to rely upon the point when the specimens for study are few and fragmentary.

A prominent feature that seems to be entirely due to the effects of "overgrowth" has also been cited as the main characteristic of one other fossil form—the *M. irregularis* of Dixon †. In this species the median plates are slightly more than nine times as broad as long and very irregular both in their borders and surface-contour. But, as will be shown in the sequel, almost every gradation can be found between the type specimen, which forms an extreme, and the more normal teeth known as *M. striatus*; and there can thus be little hesitation in regarding this unique form as a very large variety of the latter—perhaps an unusually aged individual. The same irregularity, indeed, appears to exist in the teeth of overgrown examples of other species, e. g. *M. toliapicus*; for a single specimen probably referable to the last-named form, in which the ordinary adult ratio of length to breadth in the median series is about 1 : 6, exhibits a corresponding ratio of 1 : 7·5, and has all the inequalities of surface-contour presented by Dixon's fine fossil.

But the most fundamental consideration of all to be taken into account when determining the fossil dental plates of *Myliobatis* relates to their mode of growth; and this I have not found mentioned in any contribution to the palæontology of the genus, except that of Issel quoted above ‡. As

* F. Dixon, Foss. Suss. p. 199.
† F. Dixon, *op. cit.* p. 199, pl. xi. fig. 15.
‡ A. Issel, Ann. Mus. Genova, vol. x. (1877), p. 316.

already pointed out by Dr. Günther * there is no median series of larger teeth in very young individuals, all the plates being originally of nearly equal size and more or less regularly hexangular. But as growth proceeds the middle row begins to exhibit the familiar lateral elongation; and with the progressive increase in the size of the animal this peculiar character becomes more and more marked, until in the largest individuals—generally the most aged—there is the maximum ratio between length and breadth. In any one species, therefore, the median teeth have different relative dimensions at different ages, and in dealing with the fossils it is obviously necessary to take note of absolute size when stating these relative measurements for diagnostic purposes.

Another peculiarity which appears to be of equal importance to the last and can be employed with less restrictions is the form of the small dental plates arranged in the lateral rows. Species with broad lateral teeth seem to retain them correspondingly broad throughout life, and those in which they are narrow or small have them narrow and small at all ages; and when there is any prominent obliquity or irregularity this likewise exhibits but the slightest change as the successive plates follow one another during growth.

Lastly, the coronal surface-contour of the lower teeth may often be relied upon to a certain extent as a diagnostic character when the specimen is unabraded. The flatness or transversely arched form of the crown and its relative thickness are features of some specific value, though even in this respect I have found considerable variations in the young stages of one of the English species (*M. striatus*) described below.

Revision of English Eocene Species.

Applying the foregoing results to the revision of the English Eocene fossils it appears that as yet only four distinct species can be recognized with certainty, while three others remain incompletely defined and cannot at present be accepted. The well-marked types are *M. Dixoni*, *M. striatus*, *M. toliapicus*, and a hitherto undiscovered form which I propose to name *M. latidens*; and it will be convenient to treat of them in the order mentioned.

* A. Günther 'Catalogue of Fishes in the British Museum,' vol. viii. (1870), p. 489.

Myliobatis Dixoni, Agassiz. (Pl. I. figs. 1–4.)

1833–43. *Myliobatis Dixoni*, Agassiz, Poiss. Foss. vol. iii. p. 319.
1833–43. *Myliobatis heteropleurus*, Agassiz, *tom. cit.* p. 323, pl. xlvii. figs. 6–8.
1850. *Myliobatis Dixoni*, Dixon, Foss. Suss. p. 198, pl. x. figs. 1, 2, pl. xi. fig. 14, pl. xii. fig. 3.
1850. *Myliobatis contractus*, Dixon, *op. cit.* p. 200, pl. xi. fig. 17.
1850. *Myliobatis striatus*, Dixon (non Agass.), *op. cit.* pl. xii. fig. 2.

This species was named by Agassiz on inspecting the drawings of Mr. Dixon's fossils prepared for the well-known 'Geology and Fossils of Sussex,' all of which represented the upper jaw. Its main peculiarities were rightly noted as (i.) the strongly arched [upper] coronal surface, and (ii.) the great length of the median teeth compared with their breadth —the ratio rarely or never being more than 1 : 5. There are three rows of lateral dental plates on each side, which are all much elongated in shape.

The national specimens now render it possible to advance a step further, by indicating the changes in the relative dimensions of the median teeth resulting from differences of age (or absolute size), and the following series of measurements will show eight successive stages. In this table, as in each of the others, the numbers are expressed as decimal fractions of the metre, and the length in every case is approximately the average of three or more plates.

Upper Dentition of Myliobatis Dixoni.

No. of Specimen, Brit. Mus.	Breadth of Median Plate.	Length of Median Plate.
I. P. 1498 *a*	0·026	0·007
II. P. 3044 *a*	0·033	0·010
III. 25623	0·039	0·010
IV. P. 3044 *b*	0·044	0·011
V. 25621	0·047	0·012
VI. 25614	0·058	0·013
VII. 38839	0·066	0·014
VIII. P. 434	0·094	0·020

The lower dentition has not hitherto been recognized as such, although two or three examples have been figured under other specific names. There can be little doubt, however, that the following series of specimens is rightly so determined, and the measurements, it will be noticed, correspond very closely with those of the upper dental plates. Four of these specimens (nos. I., V., VII., and VIII.) are shown of the natural size in Pl. I. figs. 1–4, and a transverse section of

the largest is given in the accompanying woodcut, fig. 1.

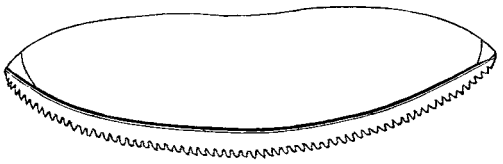


Fig. 1.

The crown is deep and the grinding-surface has a slightly arched contour, flattened in the middle.

Lower Dentition of Myliobatis Dixoni.

No. of Specimen, Brit. Mus.	Breadth of Median Plate.	Length of Median Plate.
I. P. 4457 *c*	0·023	0·0065
II. 25660	0·027	0·008
III. 25620	0·030	0·008
IV. 37758	0·035	0·010
V. P. 438	0·038	0·0105
VI. 25821	0·045	0·0105
VII. P. 1508 *a*	0·047	0·010
VIII. 25641	0·061	0·012
IX. P. 4458	0·078	0·012

Of these fossils the third was figured by Dixon as the type of a new species, *M. contractus*, while in the sixth the original surface is preserved—a fact which led the same author to refer it to *M. striatus*. The so-called *M. heteropleurus* may also be placed here with considerable certainty, the median teeth of the type specimen measuring 0·022 by 0·0065, and the lateral teeth, so far as preserved, likewise exhibiting the characters of those of *M. Dixoni*. I have seen no other fossils like this from Sheppey, and, as already stated by Agassiz, his determination of its being derived from the London Clay is hypothetical.

Range. Barton and Bracklesham Beds.

Myliobatis striatus, Agassiz. (Pl. I. figs. 5–9.)

1833–43. *Myliobatis striatus*, Agassiz, Poiss. Foss. vol. iii. p. 320.
1833–43. *Myliobatis punctatus*, Agassiz, *tom. cit.* p. 322, pl. xlvii. figs. 11, 12.
1837. *Myliobatis striatus*, Buckland, Geol. and Min. 2nd edit. vol. ii. pl. xxvii. *d*, fig. 14.
1850. *Myliobatis irregularis*, Dixon, Foss. Suss. p. 199, pl. xi. fig. 15.
1850. *Myliobatis Edwardsii*, Dixon, *op. cit.* p. 199, pl. xi. fig. 16.

A specimen of the lower dentition from the Barton Clay,

figured by Buckland in his 'Bridgewater Treatise,' was selected by Agassiz as the type of this species, and described as noteworthy for its superficial striation and the relatively considerable breadth of the median plates. The latter are shown to be six times as broad as long, and almost invariably exhibit a greater or less amount of antero-posterior curvature. The teeth of the first lateral series are somewhat longer than broad, though both these and those of the second series are not so elongate as in *M. Dixoni*. The coronal contour is flat in the adult, as shown in the accompanying woodcut (fig. 2), and almost so in the young.

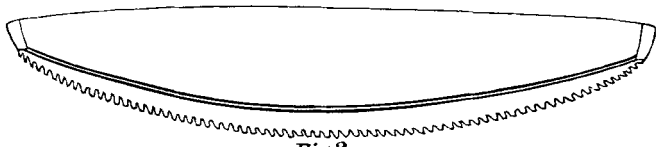


Fig. 2.

The following specimens of lower teeth seem to represent successive stages in the dentition of this specific type, and five (nos. I., II., IV., VI., IX.) are shown in Pl. I. figs. 5–9. Nos. IX. to XI. are unusually large, and may be certainly regarded as pertaining to overgrown individuals, although the last was described by Dixon as the type of a new species, *M. irregularis*.

Lower Dentition of Myliobatis striatus.

No. of Specimen, Brit. Mus.	Breadth of Median Plate.	Length of Median Plate.
I. P. 1507 *a*	0·013	0·003
II. P. 1507 *b*	0·023	0·0045
III. P. 1505 *a*	0·031	0·006
IV. P. 3049 *a*	0·038	0·007
V. P. 3043	0·042	0·0075
VI. 38838	0·054	0·009
VII. P. 3040	0·059	0·0085
VIII. 25666	0·065	0·009
IX. 40252	0·074	0·009
X. 25667	0·080	0·009
XI. P. 423	0·100	0·011

In the same series also we may evidently place the specimen figured by Dixon as *M. Edwardsii* (B. M. no. 25615), which is intermediate in size between nos. III. and IV., and has similar relative proportions. This fossil is very much abraded, and thus not so satisfactory as could be wished; but, like several others, it appears only to differ from the

most typical examples of the lower dentition of *M. striatus* in the straightness of the median plates—a character scarcely sufficient to justify specific separation. It is quite possible, of course, that it represents a form in which the successive stages of the dentition "run parallel," so to speak, with the earlier stages of *M. striatus*, and yet indicate an animal of much smaller dimensions when adult. But if so, it requires more than the present palæontological evidence to establish the fact, and *M. Edwardsii* must therefore be provisionally regarded as a synonym of the species under consideration.

More uncertain are the relationships of the fossil described by Agassiz as the type of *M. goniopleurus* *. This, there can be no doubt, is a fragment of a lower jaw. It is a much-rolled specimen from the London Clay of Sheppey, having approximately the dimensions of no. VII. of the foregoing list, but differing in the more raised contour of the crown; and it is noteworthy that the British Museum collection comprises no other corresponding fragment from the same formation and locality.

Of the upper dentition of *M. striatus* no particulars have hitherto been published, and, compared with the lower jaw, it appears to be represented by but few specimens in the National Collection. It is, however, impossible at present to distinguish with certainty the earlier stages of these teeth from the upper dentition of *M. toliapicus*, and we cannot venture to publish measurements of more than the following five specimens. It is not improbable also that the small fossil shown in Pl. I. fig. 10 may be placed in the same series; and, if this determination be correct, it is interesting as revealing the characters of all the three rows of lateral teeth.

Upper Dentition of Myliobatis striatus.

No. of Specimen, Brit. Mus.	Breadth of Median Plate.	Length of Median Plate.
I. 25659	0·033	0·0075
II. 40313	0·041	0·008
III. P. 1502	0·042	0·008
IV. 40312	0·065	0·010
V. P. 3047	0·068	0·009

Range. Barton and Bracklesham Beds; ? London Clay.

Myliobatis toliapicus, Agassiz.

1833–43. *Myliobatis toliapicus*, Agassiz, Poiss. Foss. vol. iii. p. 321, pl. xlvii. figs. 15–20.

* L. Agassiz, *tom. cit.* p. 319, pl. xlvii. figs. 9, 10.

1833–43. *Myliobatis suturalis*, Agassiz, *tom. cit.* p. 322, pl. xlvi. figs. 12–16.
1833–43. *Myliobatis nitidus*, Agassiz, *tom. cit.* p. 325.
1847. *Myliobatis striatus*, Owen, Ann. & Mag. Nat. Hist. [1] vol. xix. pp. 25–27, woodcut.

The well-known species of Sheppey is readily recognized by the flat, comparatively thin crown of the lower dentition and the broad, diamond-shaped lateral teeth; but there is little to add to the original descriptions of Agassiz, who made known both the upper and lower jaws. The following table, however, may be interesting, as illustrating some of the changes in the relative dimensions of the median teeth corresponding to an increase in absolute size. Specimen no. VII., as already mentioned (p. 39), exhibits irregularity of growth, and probably belongs to an unusually large individual.

Lower Dentition of Myliobatis toliapicus.

No. of Specimen, Brit. Mus.	Breadth of Median Plate.	Length of Median Plate.
I. P. 1507 *c*	0·016	0·0035
II. P. 1505	0·023	0·004
III. 38854	0·027	0·005
IV. P. 1505 *c*	0·029	0·005
V. 25669	0·032	0·005
VI. P. 3038 (type)	0·036	0·0055
VII. P. 3042	0·052	0·007

It may also be added that, so far as the type specimen of Agassiz, *M. nitidus*, will allow of determination, this fossil is referable to the upper jaw of the present species. The name, however, was published without definition, and so has not been employed in the nomenclature of other fossils. The specimen consists of a connected series of six upper median teeth, from the London Clay of Sheppey, and is now preserved in the British Museum in the Egerton Collection (no. P. 528). Each dental plate has a breadth of 0·024 and measures 0·0045 in length, and all the lateral teeth are destroyed.

Range. Barton and Bracklesham Beds; London Clay.

Myliobatis latidens, sp. nov. (Pl. I. figs. 11, 12.)

A hitherto unrecognized species appears to be indicated by some small examples of the lower dentition from Bracklesham, and with these may also be associated one or two series of upper median teeth from the same locality. The originals of figs. 11 and 12 may be regarded as typical, and they are

remarkable for the great relative breadth of their median teeth, as shown both by the figures and the following measurements :—

	Breadth.	Length.
I. P. 1507 *g*	0·020	0·002
II. 25630 *a*	0·020	0·0025–0·003

The lateral teeth are likewise comparatively broad and irregularly hexangular, and the coronal contour is flat.

A connected series of median teeth (no. P. 1506 *a*), of which each measures 0·040 by 0·0045, is also probably referable to this species, and testifies to the dimensions to which it sometimes attained; and the specimen shown in fig. 13, though somewhat fragmentary and belonging to the opposing dentition, may possibly be similarly determined.

The specific name of *latidens* suggests itself as appropriate for the form thus imperfectly recognizable ; and, so far as can be judged from teeth alone, it may be regarded as allied both to *M. toliapicus* and to the small fossil with narrower lateral teeth from the Upper Miocene of Aquitaine described by Delfortrie as *M. dimorphus* *.

Range. Bracklesham Beds.

With regard to the two species, *M. gyratus* and *M. jugalis*, ascribed by Agassiz † to the London Clay of Sheppey, I am unable to make any definite statement, not having examined the types. It appears, however, almost certain that the specimens are abraded fragments of the early dentition of one or other of the species defined above.

EXPLANATION OF PLATE I.

Fig. 1. Lower dentition of *Myliobatis Dixoni*. (No. P. 4457 *c*.)
Fig. 2. Ditto. (No. P. 438.)
Fig. 3. Ditto. (No. P. 1508 *a*.)
Fig. 4. Ditto. (No. 25641.)
Fig. 5. Lower dentition of *Myliobatis striatus*. (No. P. 1507 *a*.)
Fig. 6. Ditto. (No. P. 1507 *b*.)
Fig. 7. Ditto. (No. P. 3049 *a*.)

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* E. Delfortrie, Actes Soc. Linn. Bordeaux, vol. xxviii. (1871), p. 227, pl. xi. fig. 39.

† L. Agassiz, *op. cit.* vol. iii. pp. 323, 324, pl. xlvi. figs. 1–3, pl. xlvii. figs. 13, 14.

Fig. 8. Ditto. (No. 38838.)
Fig. 9. Ditto. (No. 40252.)
Fig. 10. Fragment probably of upper dentition of *Myliobatis striatus*, showing three series of lateral teeth. (No. 25671.)
Fig. 11. Lower dentition of *Myliobatis latidens*. (No. P. 1507 *g*.)
Fig. 12. Ditto. (No. 25630 *a*.)
Fig. 13. Fragment of upper dentition, probably of *Myliobatis latidens*. (No. 25656.)

All the figures are of the natural size. The original specimens are preserved in the British Museum, and the numbers refer to the Register of the Geological Department; all are from the Middle Eocene of Bracklesham Bay, Sussex.

VIII.—*On three extremely interesting new Moths of the Family* Chalcosiidæ *from Kilima-njaro and Natal.* By Arthur G. Butler, F.L.S., F.Z.S., &c.

Two of the following species were collected by Mr. F. J. Jackson near Kilima-njaro and were presented by him to the Museum.

It will be remembered that in the 'Annals' for 1884 I described a remarkable genus of moths under the name of *Pedoptila*; that in 1885 I referred to the allied genus *Doratopteryx* of Rogenhofer, and pointed out how it differed from *Pedoptila*; and, lastly, in 1887 I described a third genus of the same group under the name of *Semioptila*, all three genera being African.

Mr. Jackson has now brought to light a second species of *Doratopteryx*; and although every specimen has unfortunately arrived in a more or less broken condition, I am now in a position to point out certain inaccuracies which occur in Herr Rogenhofer's description of the genus.

The species figured and described by Herr Rogenhofer proves to be a female, not a male as he supposed; the males have distinctly pectinated antennæ.

The secondaries certainly have two veins as stated, but they have more than that; the subcostal vein passes down the tail; at the third fourth of its length the tail expands, and here the subcostal vein throws off a branch which terminates near the end of the expanded portion, whilst the main vein continues on to the point of the tail; the median vein, which is double, emits a short branch just before the tail, and ter-