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(Read before the Society, November 8th, 1905).

PLATE VI.

VARIATION in the radula is by no means uncommon in Gastropods. This has been chiefly investigated in *Buccinum* and its allied genera, many species being easily obtainable. The organ in these cases is simple and large enough to be readily seen, consisting of a long ribbon bearing many rows of chitinous teeth. In the Buccinidæ, Fasciolariidæ, and others, there is a central plate and one lateral on each side, and these are divided into teeth, which are usually regular throughout the radula. It is the number of these teeth which varies very considerably, both in centrals and laterals, but in the former much more frequently than in the latter.

Bateson, in his "Materials for the Study of Variation," p. 262, draws attention to Friele's work on *Buccinum*, and also refers to information given him by the Rev. A. H. Cooke on this subject. Friele has worked thoroughly on the radula of the Norwegian species of the genus *Buccinum* (*Jahrb. Deutsch. Mal. Ges.*, vol. 6, p. 257, 1879). In a most elaborate paper he shows how enormously the radula of *Buccinum undatum* varies, and also, in a similar way, other species of the same genus. He regards the radula as of little value for the identification of species in comparison with external characters; closely-allied species, or what authorities have taken to be separate species, not presenting definite differences in the radula. Even in what we take to be distinct genera, we find sometimes that the forms of the radulæ merge into each other. For instance, the typical radula in *Buccinum undatum* has in each row a central plate bearing six teeth and a lateral plate on each side bearing four teeth. The typical form of *Neptunea antiqua* has a central plate bearing three teeth and a lateral plate on each side bearing three teeth. Now, Bateson gives in his notes above mentioned a figure of a radula of *Buccinum undatum*, from Labrador, from the collection of the Rev. A. H. Cooke, having three centrals and three laterals on each side throughout, these showing the same form as the typical *Neptunea antiqua*. This certainly is a very unusual specimen, although *Buccinum* is extremely variable.

Having had exceptional opportunities in the laboratory of Armstrong College, Newcastle-upon-Tyne, of examining the radulæ of *Buccinum undatum*, *Neptunea antiqua*, and (with fewer specimens) *Volutopsis norvegicus*, and *Buccinofusus berniciensis*, I think the results

may be of some interest, although they go over much the same ground that Friele has already investigated so thoroughly, both in the above-mentioned paper and in the "Norske Nordhavs Expedition," his illustrations in both papers being most profuse. I have not here figured any radulæ of the genus *Buccinum*.

As was to be expected, there appears to be no correlation of variation with regard to the shell and the radula. Forty-eight specimens of *Buccinum undatum* from the North Sea, eighty miles E. by N. of the river Tyne, were examined ; thirty female and eighteen male. Twenty-three of these had a normal radula (*i.e.*, laterals four, centrals six), seventeen of which were females. The other twenty-five varied as follows :—

Centrals.	Laterals.	Number of Specimens.
7	4	13 (4 ♂, 9 ♀).
$4\frac{1}{2}$	4	1 ♂.
$4\frac{1}{2}$ and 4	5 and 2	1 ♂.
7	4 and 3	1 ♂.
8	4	2 (1 ♂ and 1 ♀).
6	4 and 3 and a small lobe	1 ♂.
5	4	4 (2 ♂ and 2 ♀).
6	4 and 3	1 ♂.
5	5 and 4	1 ♂.
6	4 and 6	1 ♂.

Out of ninety-six specimens of *Buccinum undatum* from 120-130 miles E. by N. of the river Tyne, forty had a normal radula, seventeen of which were female. The remaining fifty-six varied as follows:

Centrals.	Laterals. Left.	Laterals. Right.	Number of Specimens.
7	4	4	28 (20 ♀, 8 ♂).
5	4	4	9 (5 ♀, 4 ♂).
8	4	4	4 (1 ♀, 3 ♂).
6	3	3	1 ♀.
7	6	6	1 ♀.
6	6	4	3 (1 ♀, 2 ♂).
7	5	5	3 (2 ♀, 1 ♂).
6	4	6	5 (2 ♀, 3 ♂).
3 (1 monstrous).	5	5	1 ♂.
7	5	4	1 ♂.

From these numbers it will be seen that about 43 per cent. only are normal. The females do not vary so much as the males, and chiefly only in the centrals. The most frequent variation is seven centrals instead of six ; indeed, so common is this that Gray regarded

this form as typical ("Guide to Mollusca," part 1). The females show more regularity, only three out of fifteen specimens with irregular laterals being female. Out of nine specimens with irregular laterals five varied on the right side and four on the left. The above results agree fairly well with Friele's numbers. I give one of his tables for comparison :

"In twenty-seven specimens from Hammerfest and Vardö, the teeth were as follows (*Jahrb. Deutsch. Mal. Ges.*, vol. 6, p. 257, 1879):

Central Plate.		Lateral Plate.		Cases.
5	-	4	-	8
6	-	4	-	12
7	-	4	-	2
6-8	-	4	-	1
9	-	4	-	1
6	-	3 and 4	-	1
7	-	3 and 4	-	1
8	-	4 and 5	-	1

It is thus seen that there may be as many as nine central teeth and as few as three; in the one case in which I found three centrals, one of the outside teeth was quite monstrous. There may be as many as six laterals and as few as two. In many cases these are small knobs showing a tendency to multiply lobes. In most cases the variation continues throughout the radula. Troschel ("Gebiss der Schnecken") expresses great surprise at a specimen having six central teeth in front and five at the back, and, as is seen from the above table, Friele found one from Hammerfest having six in front and eight at the back. Two of my specimens were irregular in this way; one had seven centrals throughout and four laterals on one side, but the other side had three teeth for thirty rows and then a very small fourth for three rows, then three again and so on very irregularly. In the second specimen the irregularity was in the centrals and in one side. On one side were five laterals throughout, and on the other there were two and a very small third for thirty-one rows and then only two. The centrals were four and a small knob for five rows, then only four for three rows and so on.

The variations in *Neptunea antiqua* were much the same as those found in *Buccinum undatum*. Thirty-two specimens from 120-130 miles E. by N. of the river Tyne were examined. They were all much alike, large, with thick shells, and deep yellow inside. Twenty-eight were female, and four male ; the females appear to congregate together. Fourteen radulæ, thirteen of which were female, were normal, that is to say, they had three laterals on each side and three centrals. The other eighteen varied as follows :—

Centrals.	Laterals. Left.	Laterals. Right.	Number of Specimens.
2	3	3	5 ♀.
4	3	3	3 ♀.
1	3	3	1 ♀.
3	4	3	2 (1 ♀, 1 ♂).
3	3	4	2 ♀.
3	3	6	1 ♀.
2	4	3	1 ♀.
2	3	4	1 ♂.
3	5	4	1 ♀.
3	3 (1 bilobed).	3	1 ♂.

In eight specimens, all female, from Berwick-on-Tweed, four were normal, the others varied thus :—

Centrals.	Laterals.	Number of Specimens.
5	3	2
2 (1 bilobed).	3	1
4	3	1

We see from these tables that although about 43 per cent. are normal, yet there is really more variation in this species than in *Buccinum undatum*, for if we counted as normal those specimens of *Buccinum* which have seven centrals, there would be a much smaller per-centage of variations. There may be as many as five centrals and as few as one in *Neptunea antiqua*, and there may be six laterals, but I have not found less than three. The same tendency to multiply lobes is found in this species, and although most are regular throughout, yet one shows a curious irregularity (fig. 6) ; it is normal all through except one tooth, which bears two minute extra lobes. Another (fig. 11) has very irregular laterals on the right side, near the front they are almost normal, with a small extra lobe, but gradually become monstrous with six irregular teeth. So far as can be seen from so few examples, the side variations are about equally distributed on the left and right side.

Ten specimens of *Volutopsis norvegicus* were examined. These were obtained with *Buccinum undatum* and *Neptunea antiqua* from the North Sea, 120-130 miles E. by N. of the river Tyne. There were eight female and two male ; seven females were alike in the radula, having two teeth to each lateral plate and four to the central. This we may suppose to be the typical form. One female and two males had five centrals, and one male had a small accessory tooth between the two normal teeth of the right lateral plate, and a bilobed fourth central on the left side, thus showing a tendency to increase the number of teeth, as in *Buccinum* and *Neptunea*.

Four specimens of *Buccinofusus berniciensis*, which were with the *Volutopsis*, were examined ; two male and two female, each radula was different, and varied in the following way :—

Centrals.	Laterals. Left.	Right.	Number of Specimens.
1	12	9	1 ♂.
1	13	11	1 ♀.
1 & 2 small lobes	7	6	1 ♀.
1	9	9	1 ♂.

Two radulæ, also from the North Sea, kindly lent me by Mr. Joseph Wright, of the Hancock Museum, Newcastle-upon-Tyne, were also examined ; they were as follows :—

Centrals.	Laterals.
1	8 right, 7 left.
1	9 left, 10 right.

From these numbers this species appears to be exceedingly irregular as to its radula, and it is impossible to say which is the normal form from so few examples. Only one has the laterals the same both sides. As this is one of our rare British shells, it is difficult to get many specimens ; even to find four together is unusual good fortune.

I have to thank Mr. A. Meek, M.Sc., for providing me with the excellent supply of specimens which enabled me to make these observations.

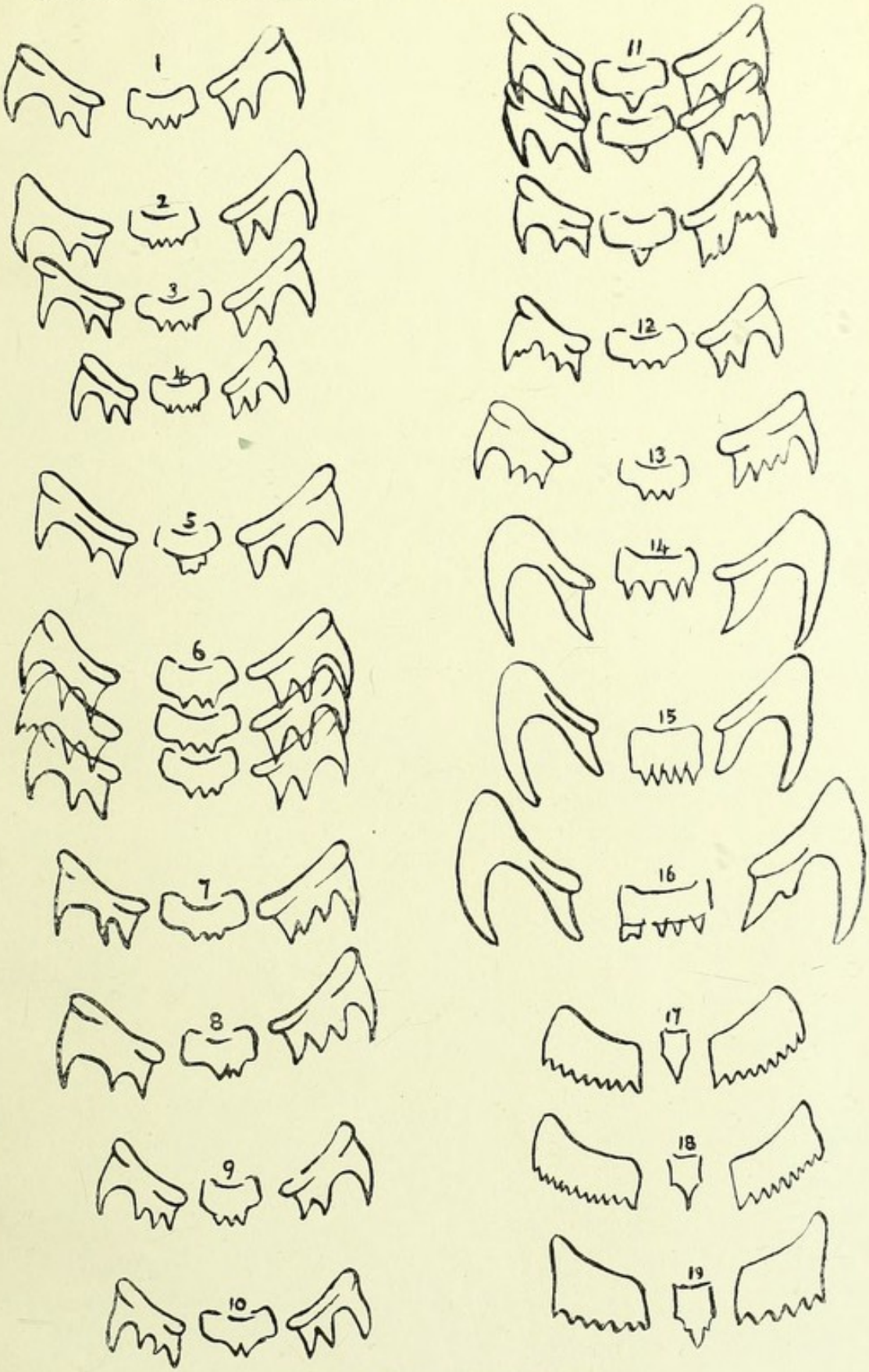
EXPLANATION OF PLATE 6.

The figures (with the exception of fig. 19) are tracings from photo-micrographs. Fig. 1 shows the normal radula of *Neptunea antiqua*, and fig. 14 that of *Volutopsis norvegicus* respectively. The rest are varieties.

Figs. 1 to 13.—*Neptunea antiqua.*

Figs. 14 to 16.—*Volutopsis norvegicus.*

Figs. 17 to 19.—*Buccinofusus berniciensis.*



RADULÆ OF BUCCINIDÆ.