STEREOSCAN ELECTRON MICROSCOPE OBSERVATIONS ON OPISTHOBRANCH RADULAE AND SHELL-SCULPTURE

by

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Traditional methods of observation applied to the sculpture of tectibranch shells and to the radulae of gastropods in general, have yielded a great deal of information regarding the structure of these organs, which are so important in taxonomy. In the genus *Philine*, for instance, the numerous European species can be reliably distinguished only by means of radular formula and shell-sculpture. In other genera the structure of these organs is also of crucial importance for identification. In most opisthobranch families the structure of the radular teeth is a uniquely reliable feature.

Published descriptions of shell-sculpture in opisthobranchs have, however, not hitherto passed the hand-lens level of accuracy. The radula is customarily prepared for microscopic examination (following dissection, and cleaning in hot caustic soda or potash) by staining and mounting in balsam, or, more recently, in polyvinyl lactophenol (Thompson, 1958). These methods for the radula have the great disadvantage that it is necessary to squash the preparation considerably in order to examine the teeth. The results of squashing are somewhat unpredictable and, moreover, may distort or alter the natural relationships of the teeth, rendering difficult a functional interpretation of radular morphology.

The stereoscan electron microscope is a new tool for the investigation of shell and radular surface structure. With this microscope these organs can be examined and photographed, without elaborate preliminary preparation, without squashing or fragmentation, and with a depth of focus which the light microscope cannot attain. This is achieved within a great range of magnification, from ×20 to ×100,000; but it is in the lower part of this range that the value of the instrument is particularly relevant in studies of molluscan hard parts. It should not be assumed that, because this microscope is an expensive and relatively inaccessible piece of apparatus, it is valueless in routine identification of gastropods. Indeed, its chief value is that it enables so clear a picture of the shell sculpture or radular morphology to be obtained that more mundane methods of routine investigation are subsequently enlightened. The stereoscan microscope shows clearly features which are then easier to discern and understand with the hand-lens in the field.

Material for the stereoscan microscope is first dried, then coated with a thin layer of gold-palladium alloy. Direct observation is then possible, and suitable representative areas can be selected for photography. Photographic prints showing shell or radular surface morphology can be obtained the same day as the specimen was collected and killed, but long-dead specimens are equally suitable. Some of the photographs presented in Plate I were from material deposited in the British Museum (Natural History) over a century ago. The specimens are in no way damaged by the technique and may be preserved in spirit or formalin after examination.

The micrographs were taken with a stereoscan electron microscope produced by the Cambridge Instrument Company and purchased for Professor Hinton with a grant from the Science Research Council.

REFERENCES

THOMPSON, T. E., 1958: Observations on the radula of *Adalaria proxima* (A.&H.) (Gastropoda Opisthobranchia). Proc. malac. Soc. Lond. 33, pp. 49-56, pl. 6.

Plate I. Shell-sculpture in *Philine*.

A, *Philine catena* (Montagu, 1803), shell-length 4¼ mm, "Porcupine" collection, British Museum (N.H.) reg. no. 1885.11.5.4100. In this species chains of linked oval areas on the outside of the shell give specimens a delicate lacework appearance. The chains form spiralling rows, approximately 10 per mm.

B, *P. punctata* (Adams, 1800), shell-length 2 mm, Torbay, English Channel, British Museum (N.H.) reg.no. 1967551/1. The sculpture consists of spiral rows (approximately 16 per mm) of oval dots, which are usually separate from one another, as shown here, but occasionally fused in some areas of the shell.

C, *P. pruinosa* (Clark, 1827), shell-length 4½mm, Loch Fyne, British Museum (N.H.) reg.no. 1851.1.15.87. The sculpture consists of spiral and longitudinal rows of raised dots (approximately 20 rows per mm), which show a tendency towards fusion, varying in different individuals and on different parts of the shell. In some areas the dots run together to form raised lines.

D, *P. scabra* (Müller, 1776), shell-length 4½ mm, Cullercoats, Northumberland. The sculpture consists of spiral rows (approximately 12 per mm) of tiny oval dots; each dot consists of a raised oval platform, surrounded by a depressed "moat". Where one "moat" joins the next, a tiny kidney-shaped structure is placed, and the whole effect is very chain-like. At the anterior border of the outer lip of the shell the chain-like striae may, in some specimens, project irregularly in saw-tooth fashion.

E, as for C, but at a slightly lower magnification.

F, *P. quadrata* (Wood, 1839), shell-length 4 mm, Aberdeen, Scotland, British Museum (N.H.) reg.no. 1967552. The sculpture consists of spiral rows (approximately 20 per mm) of small indentations, linked together in a chain-like manner. Sometimes the rows of dots are alternately wide and narrow, as shown in this micrograph, but this is by no means always the case.

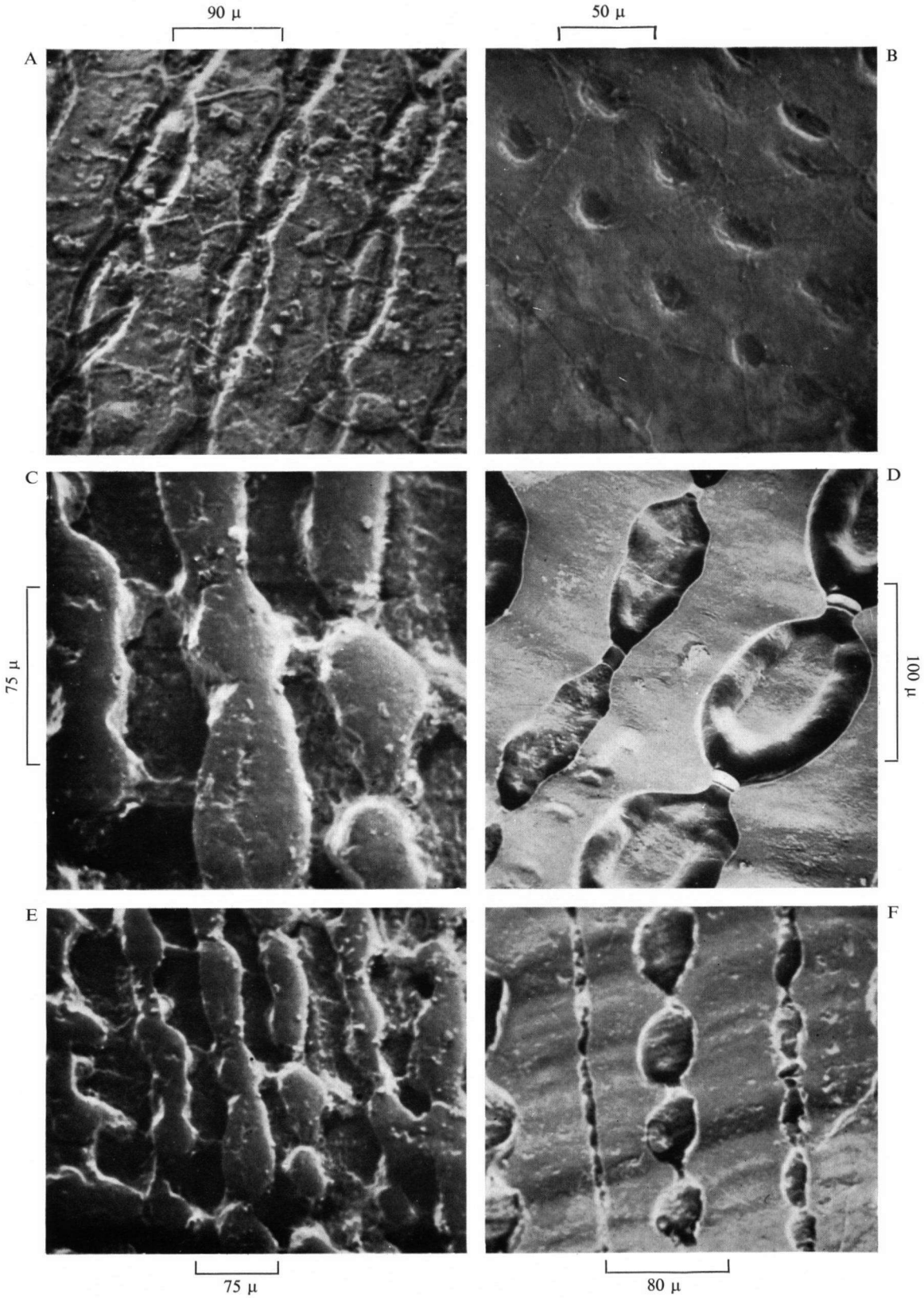

Plate I

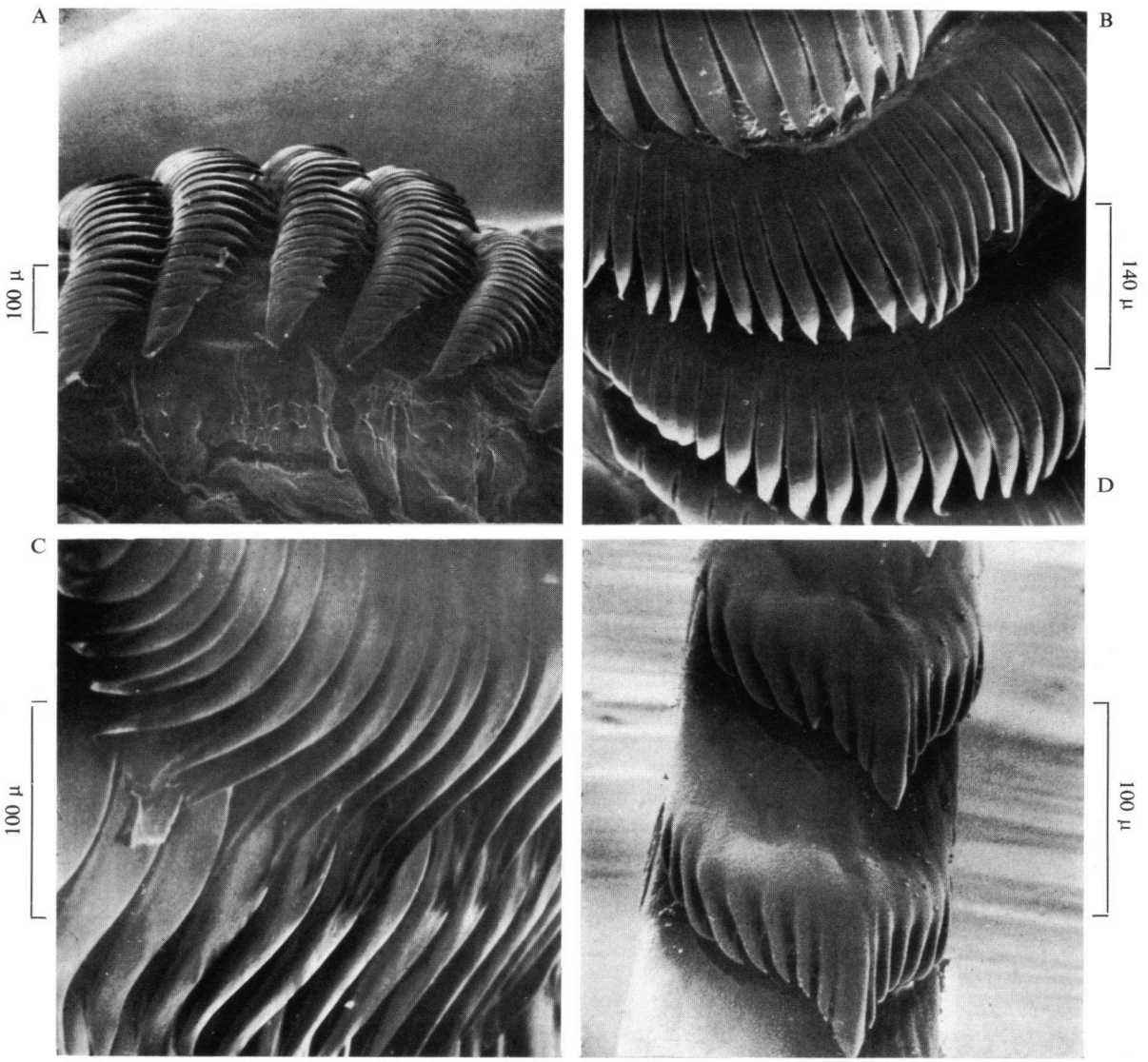

Plate II. Radulae of eolid nudibranchs.
A-C, *Aeolidia papillosa* (L., 1758), adult specimen from Falmouth, Cornwall, radular formula 25x0.1.0. In this species, which feeds upon sea-anemones, each tooth may be 1 mm across and bears up to 45 denticulations.
D, *Facelina auriculata* (Müller, 1776) var. *longicornis* (Montagu, 1808), adult body-length 30 mm, Lizard, Cornwall, radular formula 18x0.1.0. In this species, which is an active and voracious predator on gymnoblastic and calyptoblastic hydroids, each denticulate tooth measures up to 200 μ in width.

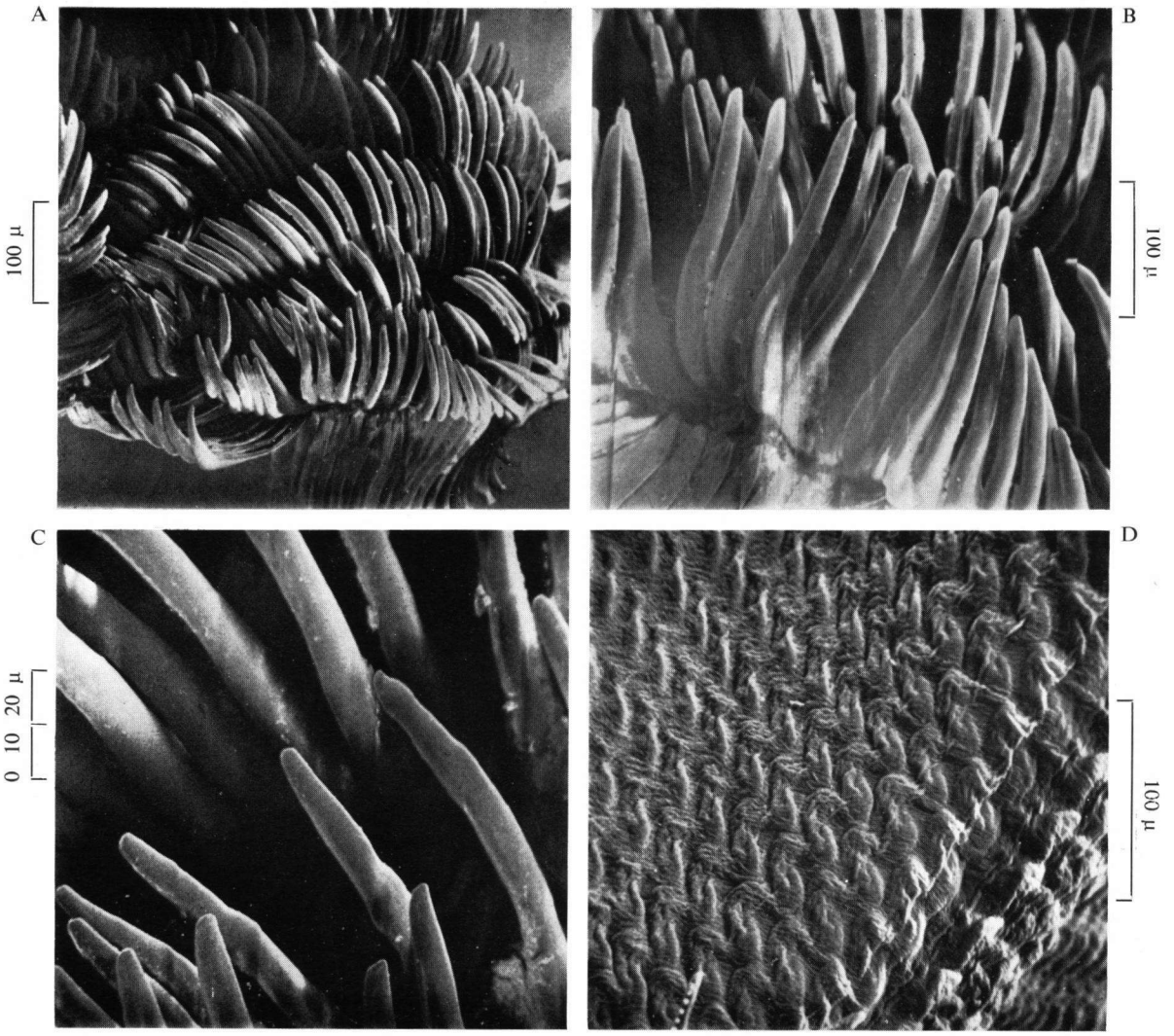

Plate III. Radulae of dorid nudibranchs.
A-C, *Archidoris stellifera* Vayssière, 1904, adult body-length 40 mm in spirit, Helford, Cornwall, radular formula 18x50.0.50 (including 5-7 rudimentary marginal teeth on each side of each transverse row). This species feeds upon encrusting siliceous sponges and the radula is adapted for scooping up shallow slices of the prey.
D, *Cadlina laevis* (L., 1767), adult body-length 14 mm in spirit, Cullercoats, Northumberland, radular formula 61x23.1.23. This micrograph shows the under-side of the radula and reveals details of the insertions of the bases of the teeth.

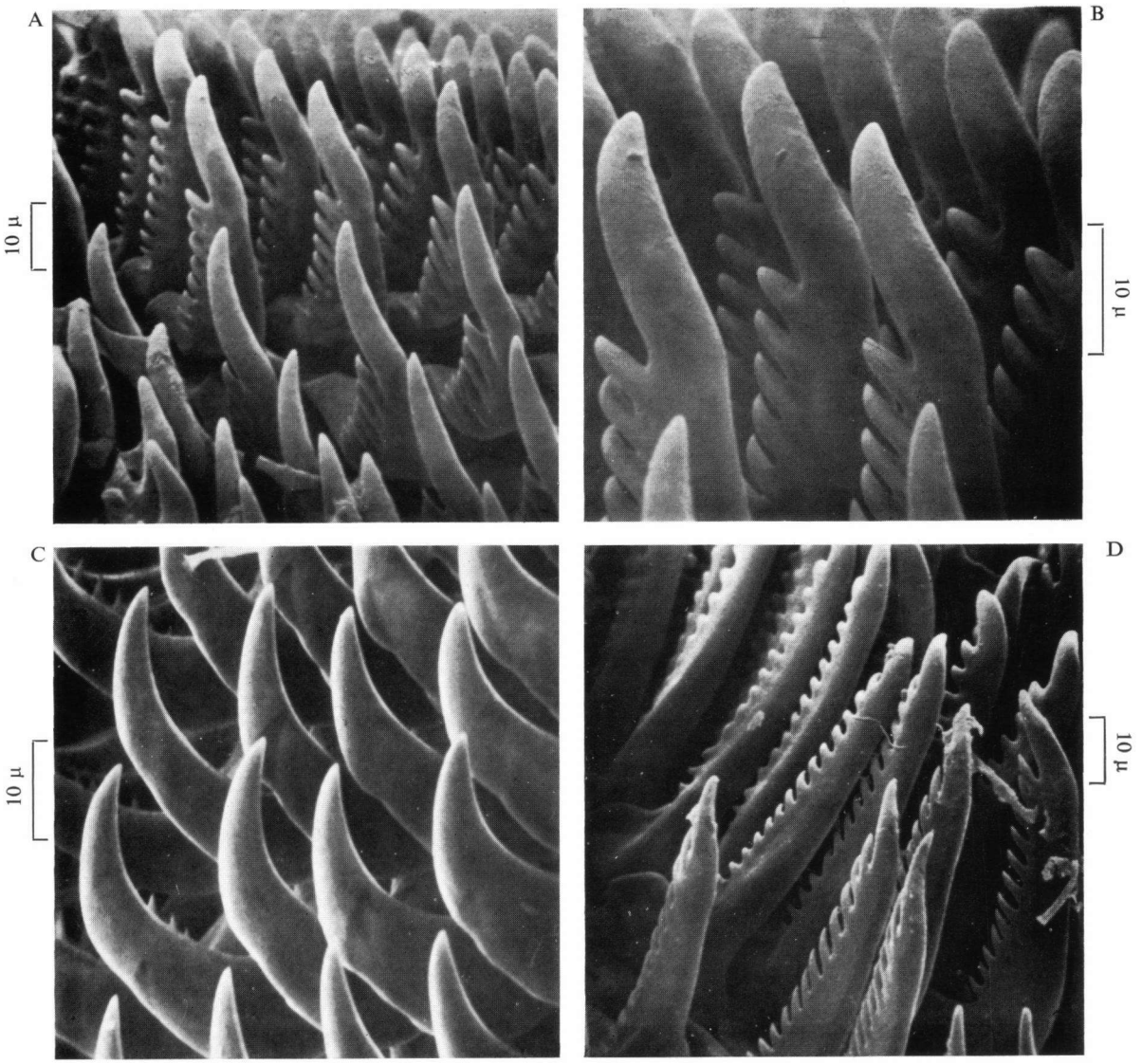

Plate IV. Radular teeth of *Cadlina laevis* (L., 1767).
A-C, teeth from near the centre of the radula.
D, teeth from the lateral extremity. Adult body-length 22 mm in spirit, Cullercoats, Northumberland, radular formula 67x24.1.24. This species is unusual among dorid nudibranchs in possessing a median tooth (not shown in the micrographs) and in having numerous denticulations on the lateral teeth, up to 20 per tooth, extending over ½-⅓ of the cutting cusp of teeth situated near the centre of the radula, but over the whole length of the cusp in teeth near the lateral margins. The normal diet consists of encrusting littoral siliceous sponges.