slightly raised in the centre and more so towards the aperture, which appears to be subcircular, with the inner lip strong and thickened. Surface of whorls ornamented by transverse, obliquely curved, regular, and equidistant lamellar ribs. Umbilicus small and apparently closed.

REMARKS.—This form certainly does not belong to the genus *Euomphalus*. Its whole appearance is trochiform, and it bears a close resemblance to *Trochus Stuxbergi* (Lindström),¹ but differs by the umbilical surface being flatter, by the marginal ridge being less developed, and by the greater strength and regularity of the growth-lamellæ on the surface. Its ornamentation is not so coarse as in *Tr. undulans* (Lindström),² but the shape of this species and its umbilical surface are very similar. The characters of the mouth and umbilical surface distinguish it from *Callonema obesum* (Lindström),³ with which at first sight it bears some resemblance in shape and ornamentation.

EXPLANATION OF PLATE VII.

FIG. 1.—*Phacops (Odontocheile) caudatus*, var. *corrugatus*, Salter. Head-shield (a 481), $\times 1\frac{1}{2}$. Woolhope Limestone, Littlehope.

FIG. 2.—Ditto. Pygidium (a 461), $\times 2$. Woolhope Limestone, Littlehope.

FIG. 3.—*Encrinurus multiplicatus*, Salter. Pygidium (a 226), $\times 3$. M. Bala, Barking, Dent.

FIG. 4.—*Trochus calyptræa*, Salter sp. (a 862), $\times 2$. Wenlock Limestone, Dudley.

FIG. 5.—*Subulites pupa*, Salter sp. (a 869), $\times 1\frac{1}{2}$. Wenlock Limestone, Dudley.

IV.—NOTES ON THE LOWER CARBONIFEROUS FISHES OF EASTERN FIFESHIRE.

By Dr. R. H. TRAQUAIR, F.R.S., F.G.S.

(Read before the Royal Physical Society of Edinburgh, January 16th, 1901.)

NOT much has as yet been done in the way of cataloguing the fossil fishes of the Lower Carboniferous rocks of Eastern Fifeshire. A few species and localities were noted by the late Rev. Thomas Brown in 1860⁴ and by Mr. Kirkby in 1880,⁵ and the late Mr. Robert Walker published a paper in 1872⁶ in which he described what he supposed to be a new species of *Amblypterus* (*A. anconoæchmodus*) from the Oil-shale works at Pitcorthy, near Anstruther. In this paper Mr. Walker drew attention to the abundance and variety of fish-remains in the oil-shale and ironstone worked at that locality, promising to describe them in detail afterwards—a promise which he was never able to fulfil. After his

¹ Sil. Gastr. Pter. Gotl., p. 147, pl. xiv, figs. 59–69 (especially fig. 62).

² Op. cit., p. 148, pl. xvi, figs. 8–10.

³ Op. cit., p. 189, pl. xv, fig. 27.

⁴ "Notes on the Mountain Limestone and Lower Carboniferous Rocks of the Fifeshire Coast from Burntisland to St. Andrews": Trans. Roy. Soc. Edinb., vol. xxii (1860), pp. 385–404.

⁵ "On the Zones of Marine Fossils in the Calciferous Sandstones of Fife": Quart. Journ. Geol. Soc., vol. xxxvi (1880), pp. 559–590.

⁶ "On a new species of *Amblypterus* and other Fossil Fish-remains from Pitcorthy, Fife": Trans. Geol. Soc. Edinb., vol. ii, pt. 1, pp. 119–124, with plate.

death in 1881, his important collection of fish-remains from this and other localities in East Fife was acquired by the Edinburgh Museum, and largely forms the basis of the present list. I myself have also done some collecting in this region; and a good many years ago the Museum acquired a number of specimens collected by Mr. W. T. Kinnear at Ardross, some of which are of great interest.

The district in question is comprised in sheets 41 and 49 of the Geological Survey Map of Scotland. All the species here noted are from Lower Carboniferous rocks, the horizons represented being the Upper part (Oil-shale group) of the Calciferous Sandstone Series and the Lower part of the Carboniferous Limestone Series. Here I may note that in 1890¹ I included the Teleostomi and Dipnoi of the region in a list of the fishes of these orders occurring in Fife and the Lothians, published by the Royal Society of Edinburgh. The present list, however, includes the Elasmobranchs as well, and also a few additional species now described as new.

CALCIFEROUS SANDSTONE SERIES.

ELASMOBRANCHII.

1. *Pleuracanthus horridulus*, Traq. Pitcorthy.
2. *Diploodus parvulus*, Traq. Pitcorthy.
3. *Cladodus unicuspidatus*, Traq., n.sp. Near Rock and Spindle.
4. *Callopristodus pectinatus* (Ag.). Rocks east of St. Andrews; Pitcorthy.
5. *Oracanthus armigerus*, Traq. Teeth, at Ardross.
6. *Gyracanthus*, sp. Rocks east of St. Andrews; Pittenweem. Not sufficiently well preserved for specific determination.
7. *Sphenacanthus serrulatus* (Ag.). Pitcorthy.
8. *Sphenacanthus Fifeensis*, n.sp. Rocks east of St. Andrews.
9. *Euphyacanthus semistriatus*, Traq. Ardross.
10. *Tristychius arcuatus*, Ag. Pitcorthy.
11. *Tristychius minor*, Portlock. Pitcorthy.
12. *Cynopodus crenulatus*, Traq. Pitcorthy.
13. *Acanthodes sulcatus*, Ag. Ardross.

TELEOSTOMI.

Crossopterygii.

14. *Rhizodus Hibberti* (Ag.). Rocks on shore east of St. Andrews; Pitcorthy.
15. *Rhizodus ornatus*, Traq. Pitcorthy; Pittenweem.
16. *Strepsodus striatulus*, Traq. Pittenweem.
17. *Strepsodus minor*, Traq. Pitcorthy.
18. *Cœlacanthopsis curta*, n. g. and sp.

Actinopterygii.

19. *Elonichthys Robisoni* (Hibbert). Pitcorthy.
20. *Elonichthys striatus* (Ag.). Pitcorthy.
21. *Elonichthys pectinatus*, Traq. Ardross.
22. *Rhadinichthys ornatissimus* (Ag.). Kiness Burn, near St. Andrews.
23. *Rhadinichthys carinatus* (Ag.). Pitcorthy; Corn Ceres, near Kilrenny.
24. *Rhadinichthys brevis*, Traq. Pitcorthy.
25. *Nematoptychius Greenocki* (Ag.). Pitcorthy.
26. *Gonatodus punctatus* (Ag.). Pitcorthy. This is the *Amblypterus anconoæchmodus* of R. Walker.
27. *Eurypterus crenatus*, Ag. Pittenweem; Pitcorthy; Corn Ceres; Kenly Mouth, east of St. Andrews.

¹ "List of the Fossil Ganoidei and Dipnoi of Fife and the Lothians": Proc. Roy. Soc. Edinb., vol. xvii (1890), pp. 385-400.

DIPNOI.

28. *Otenodus interruptus*, Barkas. Pittenweem.

INCERTA SEDIS.

29. *Eucentrurus paradoxus*, n. g. and sp. Ardross.

CARBONIFEROUS LIMESTONE SERIES.

ELASMOBRANCHII.

1. *Petalodus acuminatus*, Ag. Ladedda, near St. Andrews.
2. *Oracanthus armigerus*, Traq. Largo Ward.
3. *Sphenacanthus serrulatus*, Ag. Denhead Ironstone, Denhead, near St. Andrews.
4. *Acanthodes*, sp. Denhead.

TELEOSTOMI.

Crossopterygii.

5. *Rhizodus Hibberti* (Ag.). Denhead.
6. *Rhizodus ornatus*, Traq. Denhead.
7. *Megalichthys*, sp. Denhead.
8. *Elonichthys Robisoni* (Hibbert). Denhead.
9. *Elonichthys pectinatus*, Traq. Denhead.
10. *Eurynotus crenatus*, Ag. Denhead.

The above list contains all the species, thirty in number, which are contained in the Natural History Department of the Edinburgh Museum or in my own collection. Mr. Kirkby, however, records *Ctenacanthus*, sp., from near the Rock and Spindle, and *Pæcilodus obliquus*, Ag., from a marine limestone of Calciferos Sandstone age on the coast near Randerston Castle.

NOTES ON SPECIES.

Diplodus.—I have found small *Diplodus*-teeth in shales on the shore at Pittenweem, but which can hardly be safely identified with any known form or considered as new.

Cladodus unicuspidatus, n.sp.—Base flat below, depth from back to front about two-thirds the width from side to side, contour more convex in front than behind. A single slender pointed cusp arises from the middle of the front of the base, and is erect, straight when seen from the front, sigmoidally recurved when viewed laterally, covered with delicate raised ridges, which increase in number downwards by intercalation. No trace of lateral cusps. Height of cusp of most perfect specimen $\frac{5}{16}$ inch, width of base laterally about the same.

Under the term *Monocladodus*, Professor Claypole¹ has separated from *Cladodus*, Agassiz, two species from the Cleveland shale, on account of the apparent want of lateral cusps. Allied to *Cladodus*, and also possessing only one cusp, are *Lambdodus* and *Hybocladodus* of St. John and Worthen.² The present teeth, however, agree so closely with *Cladodus* in all respects, save the want of lateral cusps and the comparatively short lateral extent of the base, that I prefer leaving them with that genus for the present.

A cluster of these teeth was found by myself many years ago in a septarian nodule on the shore near the Rock and Spindle, east

¹ American Geologist, vol. xi (1893), p. 329.

² Geol. Surv. Illinois, vol. vi.

of St. Andrews. Owing to the hardness of the matrix it was impossible to work out the superficial configuration of the teeth, except in two instances where they happened to be covered by white carbonate of lime.

Sphenacanthus. Fifensis, n.sp. — Length of the largest specimen, $5\frac{3}{4}$ inches; greatest antero-posterior diameter, $\frac{3}{4}$ inch; implanted portion reaching up to $1\frac{3}{8}$ inches in front and $2\frac{3}{4}$ inches behind; form straight and tapering; posterior area slightly concave, its margins showing traces of abraded denticles; anterior margin of exerted portion formed by a sharp median ridge; sides ornamented by straight ribs or rounded ridges, which increase in number proximally by bifurcation, and are not nodose.

This spine, of which there are several specimens in the Walker Collection, Edinburgh Museum, differs from *Sph. serrulatus*, Ag., by the multiplication of the lateral ribs by bifurcation instead of intercalation. The want of nodosity of these ribs is of no consequence, as the greatest difference occurs in this respect in different individuals of *Sph. serrulatus*, and also of the closely allied Coal-measure form *Sph. hybodontoides* (Egerton). In a hard calcareous sandstone from the coast east of St. Andrews.

Cœlacanthopsis curta, n. g. and sp. — Of this interesting fish only one specimen has been obtained, and that one is unfortunately deficient at the caudal extremity. What remains measures 2 inches in length, and in this the length of the head is contained three times, being also equal to the greatest depth. The head bones are crushed and scarcely decipherable. Vertebral axis notochordal; abdominal region extending for $\frac{1}{2}$ inch behind shoulder-girdle; no ribs are seen, but there is distinct evidence of the ossified air-bladder characteristic of the Cœlacanthidæ. Neural arches united with the neural spines, which are long, very slender, and closely placed; hæmal arches and spines similar in condition and configuration. On the dorsal aspect and just above the termination of the abdominal cavity a set of slender interspinous bones commences, these being short at first but rapidly increasing in length, until they are as long as the neural spines, and then the fish suddenly breaks up about 2 inches from the tip of the snout. Attached to the distal extremities of these interspinous bones are fin-rays, very short anteriorly, and still short at the point of truncation of the specimen. It is probable that similar elements existed on the hæmal aspect of the skeleton, but have been lost. Paired fins not preserved, except a few imperfect rays where the ventrals ought to be. Indications of the presence of scales feeble.

Strikingly new as this little fish is specifically, a word or two must be said as to its family and generic relationships. The ossified air-bladder and the configuration of its neural and hæmal arches and spines at once indicate that its family position is in the Cœlacanthidæ, but its differences from any known genus of this family are very strongly marked. We have, firstly, the abbreviated form of the fish, which is certainly not entirely due to *post-mortem* shortening up, as the skeletal parts in front of the place where the specimen

is truncated lie nearly quite undisturbed; secondly, the great proportional length of the neural and hæmal spines; thirdly, the apparent absence of the two separate dorsal fins with their compound supporting 'axonosts,' characteristic of the *Cœlacanthidæ*. These *may* have been lost in the present specimen, but the tips of the neural spines come so close up to the dorsal margin that there would not have been room for the last-named elements if of the form prevalent in the genera of this family. Fourthly, the median fin which we see beginning just opposite the posterior termination of the abdominal cavity corresponds, in its relation to its supporting elements, to the caudal of *Cœlacanthus*, but is immensely further forward in its commencement. It is unfortunate that, owing to the truncation of the fish shortly after the commencement of this fin, we cannot see the extremity of the tail, but enough is shown in the specimen to prove its novelty, both specific and generic. The acquisition of more perfect specimens is, however, urgently to be desired, as it is clear that if the dorsal fins with their compound axonosts are really wanting in this form a change must be made in the received definition of the *Cœlacanthidæ*, as well as of the Actinistian group of the *Crossopterygii*.

From Ardross, collected by Mr. W. T. Kinnear, and now in the Edinburgh Museum.

Eucentrurus paradoxus, n. g. and sp.—This extraordinary little organism measures $2\frac{3}{4}$ inches in length, of which $\frac{1}{2}$ inch may be allotted to the head, $\frac{3}{4}$ inch to the body, and $1\frac{1}{4}$ inch to the tail. The head is a mass of calcareous matter, in which something suggestive of a broad curved mandible can be seen, but admits of no further description. The body, $\frac{3}{8}$ inch broad in front, is composed of a greyish film, which when examined by a strong lens is seen to consist entirely of minute, slender, slightly curved, and sharply pointed spinelets. The tail is tapering in form, consisting of amorphous-looking calcareous matter, but on each side (assuming that the creature is crushed vertically) is a conspicuous row of double spinelets arranged exactly opposite each other. From a common base arise two spinelets, which are placed close together and nearly parallel to each other; one of them, the anterior, being only half the length of the posterior one, which just behind the body may attain a length of $\frac{1}{16}$ inch, though towards the end of the tail they become smaller; both of the spinelets are slender, slightly curved, round in transverse section, smooth externally, sharply pointed, and traversed internally by a central tubular pulp cavity. No trace either of internal skeleton, or of limbs, or fins of any sort can be seen.

This strange organism is another of the problems of Palæozoic ichthyology, as it is scarcely possible to indicate its systematic position with any degree of certainty. The nature of its dermal armature would incline us to the belief that it is a Selachian, though all other evidence to that effect is wanting.

From Ardross, collected by Mr. W. T. Kinnear, and now in the Edinburgh Museum.