

or regulating apparatus in connexion with the Albion. Doubtless it was intended to be used with his other invention, the Rectangulus, with which the relative positions of stars could be measured.

In the prefatory sentences to his treatise on this instrument, Richard tells us that he invented the Rectangulus in order to obviate the laborious and difficult use of the Armillary Sphere in determining the course and place of fixed stars and planets, and for other problems which were usually solved by the astrolabe and the torquetum. The fundamental principle of the instrument is based on the theorem of Euclid on the equality of the angles and lengths of equidistant lines between parallels.

The instrument consists of three superposed limbs or rules connected by hinges in such a manner that each limb may not only be opened out at varying angles like the blade of a pocket knife, but may also be rotated round a peg-pivot below its hinge. Above all is an alidade, or rule with perforated sight-vanes, which is so hinged to the third limb that it can be either elevated above it or be moved parallel with it. The hinges may all be clamped more or less tightly by wedges driven through slots in the pegs, like those used in astrolabes.

To complete the instrument six scales of bronze were prepared and graduated. Three of these are fixed to the sides of the three limbs; the other three are movable, being pivoted on the pegs under the limbs. The lowest scale was divided along the edges into 60 equal divisions called degrees or parts of chords, *gradus seu partes cordarum*, each of which might, in the case of a large instrument, be further subdivided into 60 parts, while the middle or intervening band was divided by a table of right and versed chords, *corde recte et verse*. This middle divided band is omitted in the five other scales. The division of the upper scale of chords, which are called right chords, are numbered from the peg to the end of the scale; the lower scale, called versed chord, is numbered from the end of the rule to the peg. The ends of the alidade and upper limbs are provided with plumb-lines.

In his second treatise on the use of the Rectangulus, Wallingford explains in ten chapters how various observations and calculations are to be made. In the first place the whole instrument must be adjusted for level by a plumb-line fixed near the surface of the base

pillar. The instrument is then ready for the first exercise, "To find the right and versed chord of a given arc less than a quarter of a circle and to find any arc from a given chord." The method in his own words, as translated by Sir John Findlay, is to

let the perpendicular of the second limb hang over the first limb at the given arc, the length between the peg and the string reckoned from the peg to the end of the limb is the right chord of the arc. The distance beyond the string, reckoning from the point of the limb, gives the versed chord of the same arc. The reverse process enables an arc to be found from its chord. Note that the plumb-line hangs at right angles when it falls on equal divisions of the scales on both sides of the limb, and this is chiefly why the scales of chords are double on all the scales. The right and versed sine of an arc greater than a quarter of a circle may be easily found from what has been said, for the right sine of an arc less than a quarter of a circle is the right sine of the arc of the rest of the circle. Further, the versed sine of an arc greater than the quarter of a circle but less than a semi-circle is greater than the semidiameter by the amount of the right chord of the angle by which the given arc is greater than a quarter of a circle, as is shown elsewhere.

Then follow chapters upon how "To find the meridian," "To find the altitude of a star above the horizon and its azimuth," "To find the latitude of a place by a star which does not set," "To find the latitude and longitude of a star from the equinoctial circle," "The declination of a star and its latitude in the ecliptic," "To find the true place of the sun from its aspect," "To find the true place of the moon in longitude and latitude," "The true place of fixed stars in latitude and longitude."

The treatise concludes with the sentence, "The Rectangulus was invented for the purposes which have been explained, and therefore, because what has been explained is sufficient for an apt pupil, the way is clear to everything that can be done by other instruments. Here I finish."

Wallingford died in 1335 at the age of forty-three. It is reported that the Abbot's house where he was sleeping was struck by lightning, and, weakened as he was by his disease, he did not survive the shock. His tomb is in the Abbey Sanctuary just east of the altar rails.

A Remarkable Suborder of Fishes.

DURING the Danish *Dana* Expeditions of 1920-1922 in the North Atlantic and the Gulf of Panama, under the leadership of Prof. Johs. Schmidt, a magnificent collection of ceratioid fishes was made, which forms the subject of a monograph by Mr. C. Tate Regan,¹ Keeper of Zoology in the British Museum (Natural History), from which the accompanying illustrations have been reproduced. Prior to the *Dana* Expeditions, and excluding the *Michael Sars* collection, as yet undescribed, only about sixty examples of this amazing suborder of fishes were known, so that the *Dana* addition of 220 specimens representing 39 species, many

of which were new to science, was of great biological value.

The Ceratioidea form part of the order Pediculata, that group of highly specialised fishes in which the first ray (illicium) of the spinous dorsal fin is placed on the head and modified into a 'line and bait.' Their characteristic features are evidently related to their conditions of life. They are inhabitants of the deeper parts of the ocean, the majority living in mid-water, probably from 500 to 1500 metres below the surface, where there is little or no light. Related to the absence of light is the structure of the 'bait,' or terminal expansion of the illicium, which is a luminous bulb; the outer skin of the bulb is generally transparent, and within is a glandular sac that opens to the exterior by a pore and has a luminous secretion; the lower, or

¹ "The Pediculate Fishes of the Suborder Ceratioidea." By C. Tate Regan. The Danish *Dana* Expeditions 1920-1922 in the North Atlantic and the Gulf of Panama. Oceanographical Reports edited by the *Dana* Committee, No. 2. (Copenhagen; Gyldendalske Boghandel. London: Wheldon and Wesley, Ltd., 1926.) 155.

sometimes the posterior part of the sac is pigmented, and this pigmented area, according to Brauer, is covered inside by a layer of cells which acts as a reflector. Externally the bulb may be furnished with papillæ, flaps or tentacle-like filaments. There are great differences in the length of the 'line' or first

Probably the chief interest in the ceratioids lies in the fact that they are unique among vertebrates in having the males dwarfed and parasitic on the females. The species in which males are known are *Photocorynus spiniceps* (male 10 mm. long attached to a female of 62 mm.), *Edriolychnus schmidti* (male 14 mm. long attached to a female of 62 mm.), and *Ceratias holboelli* (males of 80 and 85 mm. on a female of 1030 mm., and a male of 105 mm. on a female of 1000 mm.) (Fig. 3). The males resemble the females in general form, but differ from them in the development of structures for attachment, in the absence of the illicium, the reduction or absence of spines on the head, the absence of teeth, and the vestigial condition of the gut; the only organ of importance in the abdominal cavity is the large testis. The method of attachment to the female is of especial interest. In *Photocorynus* and *Ceratias*, upper and lower outgrowths of the anterior end of the

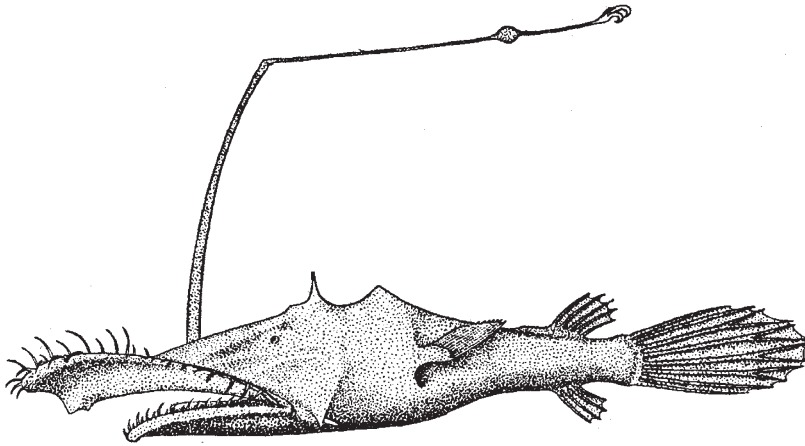


FIG. 1.—Lateral view of *Lasiognathus saccostoma*, Regan. Length 75 mm.

dorsal ray; from fishes in which the luminous bulb is sessile on the head, to those in which it is borne on a line several times as long as the fish itself. The line is articulated to the anterior end of a movable basal bone which as a rule lies in a trough on the upper side of the head. Those more highly specialised forms, in which the basal bone is slender and flexible and completely exerted, may be considered true anglers, for they have both rod and line, and *Lasiognathus* (Fig. 1), which is in addition provided with hooks, may well be termed a complete angler.

The majority of the ceratioids appear to be piscivorous, and have a large mouth and jaws furnished with slender acute teeth which are generally arranged in about three series. The teeth are depressible inwards, an arrangement which would make it very difficult for a ceratioid to release a fish it had seized, even if it wanted to. *Neoceratias* (Fig. 2), with teeth on top of the head that recall the spines of an echinoid, is perhaps the strangest of all. In some genera the

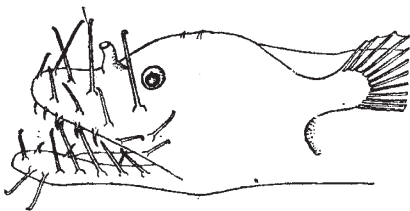


FIG. 2.—Head of *Neoceratias spinifer*, Pappenheim. Length to base of caudal fin, 25 mm. After Pappenheim, 1914.

stomach is extraordinarily distensible; thus a *Melanocetus* has been known to swallow a *Lampanyctus* three times its own length and many times its weight. Equally remarkable are the pincer-like jaws of *Rhynchoceratias*, and the forwardly directed telescopic eyes of *Aceratias*, indicating that the fishes of this genus have binocular vision.

head of the male unite in front of the mouth and fuse with a papilla-like projection from the skin of the female.

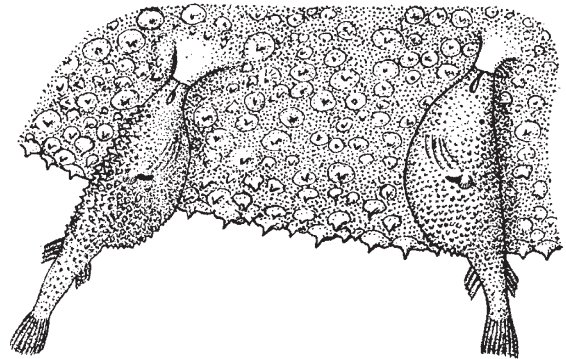


FIG. 3.—Two males of *Ceratias holboelli*. Half natural size. After Sæmundsson.

From his microscopic examination of sections of a strip of the tissue connecting the male and female *Ceratias*, Mr. Tate Regan is of the opinion that the male and female are completely blended, the highly vascular fibrous tissue of the outgrowths of the male being continuous with that of the papilla of the female, and he regards it as almost certain that the blood-systems of the two fishes are continuous. He does not favour the view that the attachment may be of the nature of a placenta, which implies that the two animals separate later on, but suggests that the males, soon after they are hatched, attach themselves to the females, if they are fortunate enough to meet them, and remain attached throughout life. In all probability the males are incapable of free development, and it is likely that the majority fail to find a female and perish, although another possibility has been suggested, namely, that the post-larval fishes that find and become attached to females develop into males, and those that do not, into females.