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REPORT ON THE FISHES TAKEN IN MADEIRAN AND CANARIAN WATERS DURING THE SUMMER-AUTUMN CRUISES OF THE «DISCOVERY II» 1959 AND 1961

III. ORDER INIOMI I.

ON A TOOTHLESS, SEXUALLY MATURE *ANOTOPTERUS*

By G. E. MAUL

With 6 figures

SYNOPSIS

A blackish, toothless fish with ripe gonads referred to *Anotopterus pharao* is described in detail. Its identity is discussed and it is concluded that the different colouration and dentition are metamorphic characters connected with sexual development and migration to deep waters. The loss of teeth is suggested to be due to lack of vitamin D-containing food. Reasons are given why the present specimen was probably captured in great depth. The state of maturity is believed to be advanced but not complete on account of the presence of a considerable proportion of very small eggs among other apparently ripe ones.

It is suggested that the complete absence of ripe specimens of *Alepisaurus ferox* among the copious observed material taken in Madeiran waters at all seasons may be due to the fact that it behaves in a similar way to *Anotopterus* when reaching maturity.

At station 4740 the Isaacs-Kidd Midwater Trawl worked SSE of Funchal and due W of Bugio (the southernmost of the 3 Deserta Islands) over a bottom depth slightly more than 3000 m., the exact details of the haul being: — date 19.IX.61; depth (m.) 2500-(0); shot 0945; all out 1155; haul 1455; all in 1700; position 32°25'N, 16°40'W to 32°23 1/2'N, 16°51'W. When the net was placed on deck a long blackish fish was found lying across the opening of the bucket, which it had not entered because of its large size. Its state of preservation was perfect in spite

of the soft and delicate nature of its skin. Inside the bucket was a rich haul of 33 species of fish composed of *Vinciguerria poweriae*, *V. attenuata*, *Cyclothone pallida*, *C. microdon*, *C. braueri*, *Gonostoma bathyphilum*, *G. elongatum*, *Valenciennellus tripunctulatus*, *Argyropelecus hemigymnus*, *Sternoptyx diaphana*, *Chauliodus sloani*, *Eustomias obscurus*, *Grammatostomias* sp., *Idiacanthus fasciola*, *Lestidium affine*, *Hygophum reinhardti*, *H. macrochir*, *Diaphus* sp., *Notolychnus valdiviae*, *Lampadena* sp., *Lampanyctus photonotus*, *L. festivus*, *L. ater*, *Lepidophanes gausi*, *L. indicus?*, *Ceratoscopelus warmingi*, *Eupharynx* sp., *E. pelicanoides*, *Avocettina infans*, *Cyema atrum*, *Leptocephalus* sp., *Melamphaes* sp., *Edriolychnus schmidti*.

On closer examination it was found that the fish in question was undoubtedly an anotopterid, but because of a number of striking differences from known specimens of *Anotopterus pharao* was at first thought to be a different, new species. Further study, however, revealed that the specimen could not easily be separated from *A. pharao* and that the obvious differences observed could be due to metamorphosis.

Following, and before passing on to any further considerations, we shall describe the specimen in detail:

Material. One specimen with very large, ripe or close to ripe gonads, measuring 759mm. in standard length, MMF Reg. No. 20272.

All measurements are taken in a direct line between the reference points. The standard length is the distance between the point of the snout and the bases of the median caudal rays. The interorbital is the narrowest bony part of the roof of the head, between the eyes. The twin rays of the last basal bone of the anal are counted as one.

The specimen is in an extremely good state of preservation and was fixed in a stretched and completely straight position. Shrinkage of the muscles, as is often observed in unripe specimens of this fish, did not occur, so that none of the measurements run the risk of being incorrect through distortion of the body.

Total length (mm.)	ca.	787
Standard length (mm)		759

PROPORTIONAL DIMENSIONS IN PER MIL OF S. L.

Snout to adipose	892
Snout to pelvics	545
Snout to anal	887

Snout to anus	568
Snout to pectorals	200
Base of caudal to end of adipose base	73
Base of caudal to anal origin	116
Base of caudal to pelvic insertion	455
Ventral insertion to anal origin	341
Greatest depth of body	61
Least depth of caudal peduncle	21
Greatest depth of head	47
Head length	208
Snout to angle of gape	134
Snout	120
Postorbital length	73
Bony mandible	146
Eye to end of lower jaw (bone)	126
Least suborbital depth	9.0
Eye	18.4
Interorbital	14.5
Orbit to mandibular angle	22
Mandibular process	15.8
Eye to bridge between nostrils	14.5
Origin of pelvics to centre of anus	22
Width of head	26
Width of body	34
Width of caudal peduncle at middle of its length	13.4
Length of adipose fin	55
Base of adipose fin	37
Height of adipose fin	14.5
Length of anal fin	29
Base of anal fin	66
Height of anal fin	30
Base of pectoral fins	19
Length of pectoral fins	55
Width between insertion of pectoral fins	18.4
Base of pelvics	10.5
Width between end of base of pectorals	9.0
Length of pelvics	29

Width between insertion of pelvics	7.6
Width between end of base of pelvics	1.1

MERISTICS

Dorsal rays	0
Anal rays	14
Pectoral rays	14/14
Pelvic rays	10/10
Caudal rays (total)	45
Branchiostegals.	7/7
Lateral-line sections	73
Vertebrae (including hypural)	79

Body slender and compressed; its greatest depth 16.4 in standard length; head 4.8; snout to pelvics 1.8; snout to anal 1.1. The snout is 1.7 in head; eye 11.3; interorbital 14.4; snout to angle of gape 1.55; greatest depth of head 4.4; postorbital length 2.8; boney part of mandible 1.4; least depth of caudal peduncle 9.9; base of anal 3.2; length of pectorals 3.8. Pupils not wider than lense.

Teeth as well as gill-rakers or gill-raker-like structures on gill-arches completely lacking (See fig. 1). Segments of lateral line very long and narrow, those of middle of length with large pore in middle of upper and lower border, and sometimes one or more small pores between the two large ones.

In the abdominal cavity, reaching forward to the anteriormost part between the lobes of the liver, lie the two enormously enlarged ovaries (fig. 2), the left one measuring 210mm. and the right one 220mm. in length. They are both 26mm. in height and 12mm. in thickness. The diameter of the eggs varies from about 0.3mm. to 0.9mm. Dorsally, between the ovaries and of the same length as they, the two much thinner testes are clearly visible (fig. 3).

The alimentary canal is completely empty, very thin-walled and seems to be in a state of atrophy (fig. 4). The lobes of the liver are large and are clearly visible through the body wall.

The colour of the specimen after preservation in formalin, is pale brownish-yellowish on head and body, with the dorsal and opercular region slightly darker. The iris is black and the gill membranes are black-

ish brown. Field notes made immediately from the fresh specimen read as follows:—«Head and back blackish brown, belly silvery with black pigmentation. Iris deep black» (See fig. 5).

DISCUSSION AND CONCLUSIONS

Identity. Using for comparison proportions and meristic characters of the present specimen and of the greater part of material of *Anotopterus pharao* so far known there is nothing to distinguish it from the latter species. The ranges of variation given by Templeman (1970, table 3) for a large amount of material from 154mm. to 867mm. in standard length are considerable, particularly where proportions are concerned. However, anticipating any argument suggesting that a conclusion as to the identity of the present specimen has been made too easy by an exaggerated range of variation due to allometric growth-rates in this material, a comparison with a specimen of similar size shows only very small differences. Consequently we conclude that our specimen belongs to the species *Anotopterus pharao*, and we must, therefore, consider the important differences in dentition and colour metamorphic characters connected with sexual development.

Metamorphosis linked with vertical downward migration in larval or nearly full-grown stages, mostly connected with sexual development, is well-known in fishes. Ceratioids (Bertelsen, 1951 «Vertical distribution») and the berycoid fish *Anoplogaster cornutus* (Grey, 1955: 292-296) are good examples. However, in their cases the new acquired characters are, or can be imagined to be, a necessity to life in the new and different environment. The luminous appendages of the sluggish female angler-fishes may serve two ends: to attract animals for food, and species recognition for the males. *Anoplogaster cornutus* changes from grey to black during its journey to great depth (or perhaps after being there) and develops enormous fangs now needed for preying on much larger creatures it must feed on. While some advantage, as yet unknown to us, may be attached to black colouration for life in deeper waters, the complete loss of a previously formidable dentition in *Anotopterus* seems puzzling. Why should a fish shed its teeth, even if no longer indispensable, during the last, probably short stage of its life? And if, indeed, no advantage can be derived from this toothless state, what selective forces can have been at work to have evolved such a character?

It is, however, known that tooth succession, that is successive shedding of old teeth and their replacement by new ones which have formed gradually, goes on continuously in *Anotopterus* as in *Alepisaurus* (see Marshall, 1955: 318). Therefore, if replacement teeth cease to be produced, toothlessness will inevitably result, and if the process of succession is normally a fast one, this would happen within a short period. It could be caused by a physiological inability to grow these, due to lack of adequate food in the new environment.

Parr (1937: 27-28) suggested that a decrease in availability of vitamin D towards the depth may be responsible for the poor skeletal ossification in deep-sea vertebrates. In the same way it could completely impede the growth of new structures consisting largely of lime salts. The absence of teeth or any sharp excrescences to act as pincers would make it impossible to get a firm hold of the creatures of the depth that could serve as food. Toothlessness, therefore, in ripe specimens of the present species, may be a consequence of tooth succession combined with sinking to great depth rather than an evolutionary process. In this case there can be no relation with the reduction of maxillary dentition and complete disappearance of gill rakers, in adult *Luciosudis normani* and an undescribed scopolosaurid, reported by Krefft, 1968. This reduction of teeth (which may or may not result in total loss) and the complete disappearance of gill rakers are gradual, as expressed by the very meaning of the word reduction and the observation of the process of «melting down» of the gill rakers in 4 specimens. Other cases of total absence of gill rakers and teeth in iniomous fishes have been found in *Maulichthys harryi* (Maul, 1954 and 1955) and an unidentified paralepidid (Post, 1969), as well as in some large specimens of *Paralepis* sp. in the MMF collection. In none of these cases, however, is it known if they represent adult stages of species that normally have teeth or gill rakers when young.

Horizontal migration. Discussing the distribution of *Anotopterus pharao*, Templeman (1970) points out, without further comment, that the new records of the North Atlantic he presents are from within the area given for this species by Hubbs et al. and that there also is agreement in that most of the northern specimens are larger while most of the southern ones are small. Based on information communicated to him by us, Templeman considers the large ripe or almost ripe specimen here described as *Anotopterus pharao* and rightly sees in this record a

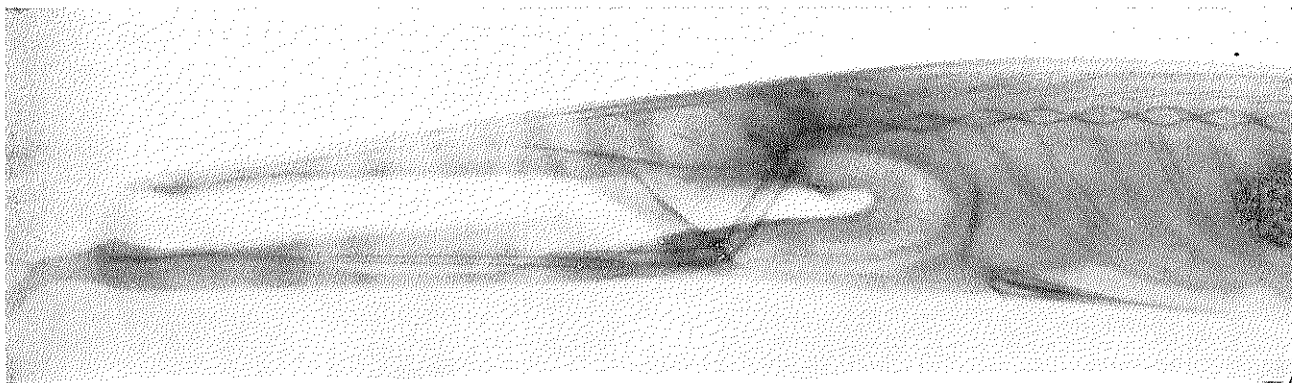


Fig. 1. — X-ray photograph. There is no sign of the functional or replacement teeth on the palatines

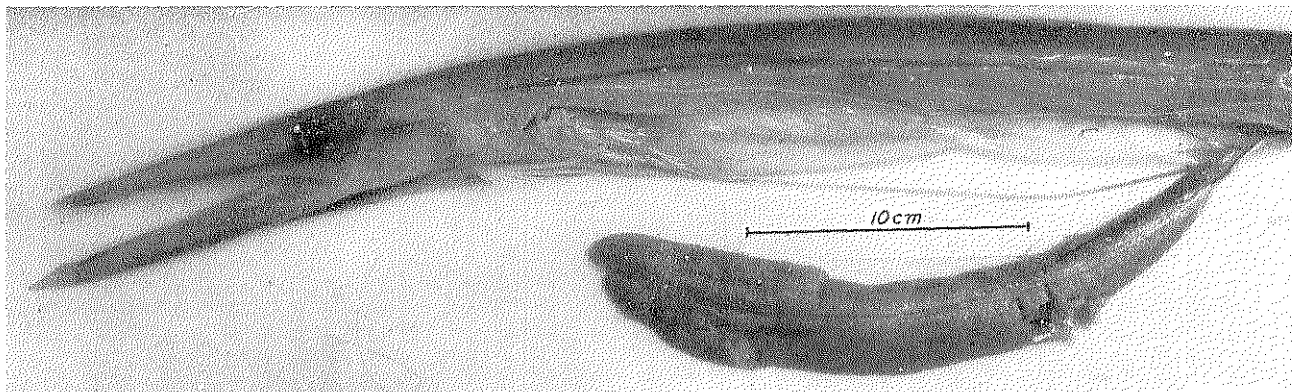


Fig. 2. — The abdominal wall has ruptured. The gonads, when lying straight in the cavity almost reach the end of the head

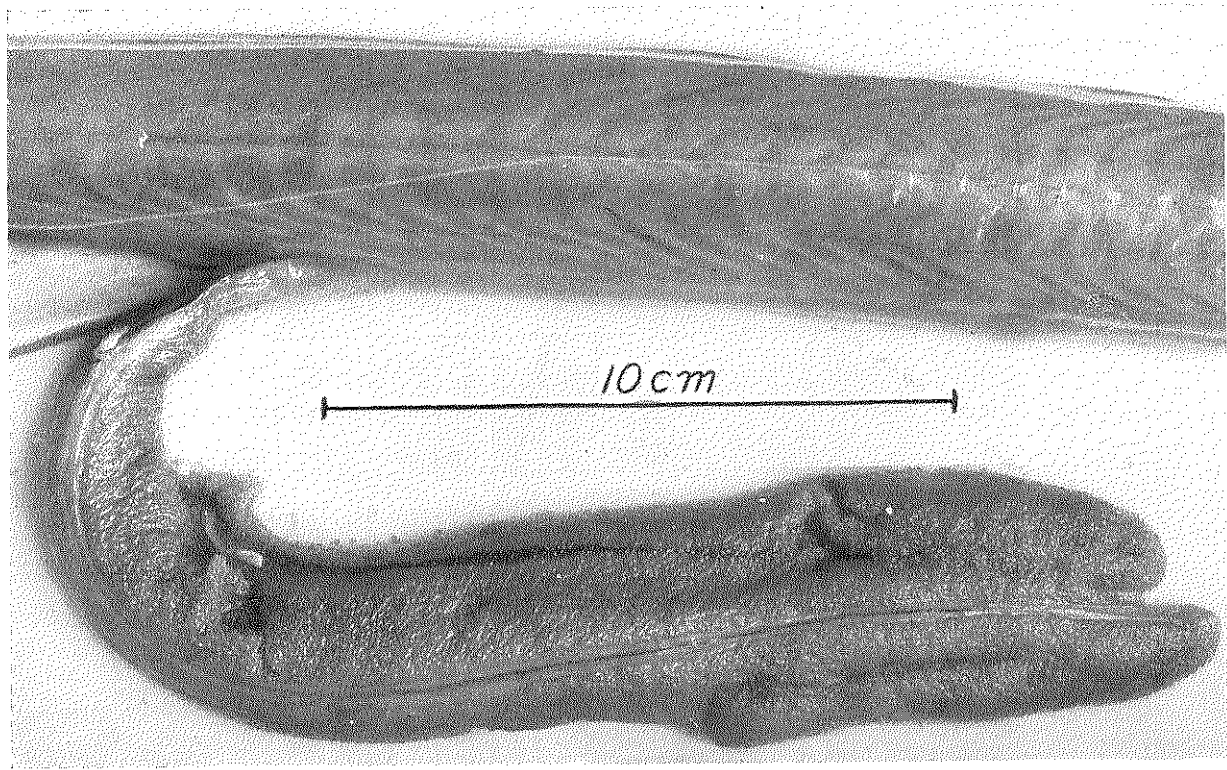


Fig. 3.—Dorsally, filling-in the groove formed by the two ovaries, the testes are clearly visible

further substantiation of the theory proposing a northward migration of this species with growth, within a depth of optimum temperature, postulated by Hubbs et al. (1953). We may suppose that this migration begins at a larval stage nearest the equator, ending with the largest specimens of nearly 1m. nearest the polar regions (see fig. 6). How near some of the ripe specimens, when returning to the regions of their birth, may penetrate into tropical waters, possibly at considerable depth, we cannot tell for lack of sufficient records. Nor does the lack of larval material from tropical waters have too much meaning so far. The records of very young specimens of less than about 100mm. standard length are extremely rare even at latitudes where the average of 15 to 30cm. specimens are relatively common. In fact, there are only 3 such records, viz. Nybelin (1948), 38°25' N, 14mm. S. L.; Maul (1952), Madeira, 47.5mm. S. L., Krefft (personal communication to Templeman, 1969: in Templeman, 1970), 29°23' N, 87.4mm. S. L. The comparison of *Anotopterus* material from the Atlantic and Pacific Ocean by Templeman (1970) showed that there is no specific distinction and it seems likely that the tropical belt is not an unsurmountable obstacle to *Anotopterus pharao*, whether in the form of ripe adults, current-born eggs or larvae.

Vertical migration. The distribution of *A. pharao* with regard to depth has been discussed by Hubbs et al. (1953) and Templeman (1970). Shape and colouration of the unripe specimens characterize them as pelagic fish of the upper, light penetrated layers of the oceans, a conception which is supported by the bulk of the records.

The haul in which the present specimen was taken was carried out with an IKMT without closing device. As the list of species (p. 2) shows, only very few can lay claim to having entered the net during its 3-hour horizontal passage at 2500m. Where our *Anotopterus* is concerned there is nothing to indicate at what depth it was taken. From experience we know that material which has been for prolonged hours inside the bucket of deep hauls is badly effected. Scaley fishes have often lost all their scales and show heavy damage to the tips of their fins, others are torn, and the usual entanglement of filamentous parts points to a whirling action within the bucket probably caused by the current of water at the opening. On the other hand, specimens that have for some reason become fastened to the meshes of the net—quite often by their teeth—usually are in much better condition. Thus the fact that the present specimen

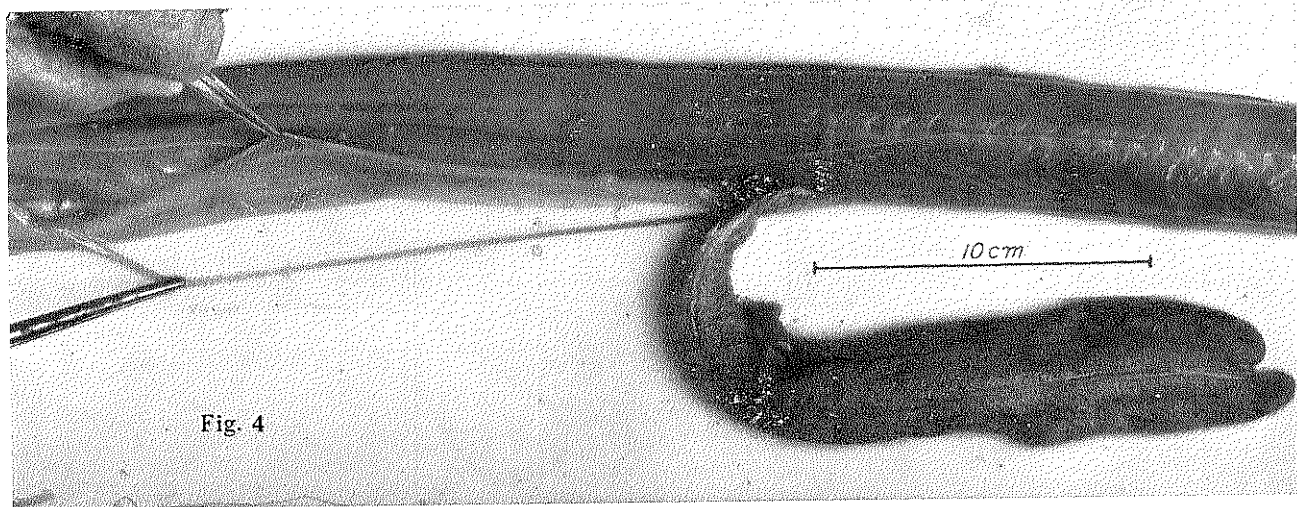


Fig. 4



Fig. 5

failed to enter the bucket and lay in an even curve at the very end of the net, with the middle of its body across the opening of the bucket may be the very reason for its excellent state of preservation which, therefore, need not necessarily be a sign of short permanence in the net. Its colouration is distinctly that of deep-living fishes, and the fact that no specimens in this condition have ever been taken in the infinitely more numerous hauls in lesser depth in the region of Madeira or its

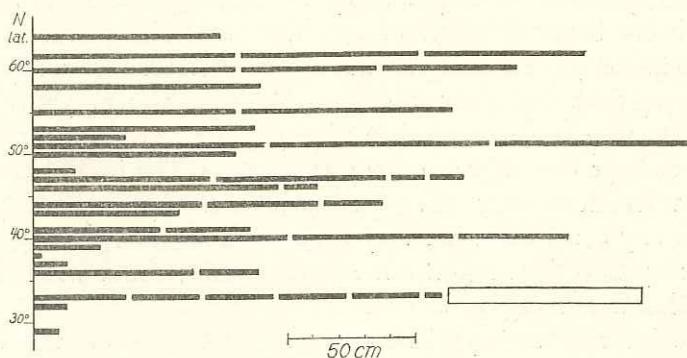


Fig. 6. — Sizes of known records of *Anotopterus pharao* in latitudinal distribution in the North Atlantic. (Lines = unripe specimens, box = ripe specimen)

approximate latitude give us further reason to believe that it came from deep waters. The present find, therefore, gives rise to the conception that the full-grown specimens of *Anotopterus* that have come to the end of their journey towards the poles and which quite obviously, as said above, must return to the more equatorial area where they spawn, do so in waters of considerable depth.

Sex. Where specimens of *Anotopterus* bear indications as to sex, in the current literature or personal communications, opinions are divided. Thus Thurow (1961), Postolaki (1962), Jow (1963), and Rofen (1966) consider their specimens males, while Templeman (1970) and Welander

Fig. 4. — The alimentary canal (held away with forceps) is but a thin-walled narrow, apparently functionless tube

Fig. 5. — Photograph of head taken not long after preservation and still showing the blackish colouring

(personal communication) consider their females. However, the condition of hermaphroditism discovered by Mead (1960) and Gibbs (1960) in *Alepisaurus* has since been found, by Gibbs and Silkstone (personal communication), to exist in all other known alepisauroid fishes which, of course, include *Anotopterus* (see fig. 3). Through personal communication we also know that, among numerous specimens of alepisauroids seen by that author, ripe adults have never come to hand. Easily close to 700 to 800 adult specimens of *Alepisaurus ferox* from Madeira must have passed through our hands at all seasons of the year. The presence of quite young specimens of less than 10 cm. in the stomachs of many indicate that spawning must take place in or near Madeiran waters, yet the gonads of the adults were never more than of negligible size. The same applies to numerous large *Omosudis* or other alepisauroids. The find of the present specimen with enormously developed gonads is therefore of particular interest, as any conclusions we may draw from its morphology and distribution may have bearing on other alepisauroids, about whose breeding habits we know nothing up to date.

State of maturity. The diameter of 10 eggs derived from our mature adult has been measured and compared with an equal number from each of 4 large specimens from near the Aleutian Islands. The largest and smallest eggs were selected as far as possible and the intermediate ones taken at random. The resulting values read as follows:

Specimen	Mature (Madeira)	Large immature (Near Aleutian Islands)			
		736	833	910	965
S. L. (mm.)	759				
Month of capture	Sept.	Aug.	June	June	July
Diameter in mm. (to the nearest μ)	0.325	0.050	0.081	0.075	0.075
	0.569	0.062	0.087	0.084	0.087
	0.587	0.069	0.087	0.084	0.100
	0.831	0.075	0.112	0.087	0.137
	0.850	0.077	0.112	0.102	0.150
	0.875	0.084	0.125	0.125	0.162
	0.887	0.087	0.125	0.144	0.171
	0.887	0.087	0.137	0.150	0.181
	0.912	0.094	0.137	0.162	0.187
	0.912	0.100	0.187	0.162	0.187

As can be seen, there is considerable difference in diameter of the eggs in each column, which is most pronounced in the mature specimen. This presence of a fair percentage of undeveloped eggs may mean that the moment of spawning would not have been reached for some time, and if the north to south movement had been continued a greater proximity to the equator would have been reached.

In the case of the present specimen, we mentioned above that the alimentary canal was completely empty and thin-walled (see fig. 4). The absence of any matter, such as mucus, or enteric parasites, usually present in functional guts, and the complete absence of teeth, are phenomena that strongly suggest that specimens in an advanced state of sexual development cease to feed.

It is most likely that spawning itself represents the final stage in the life history of *Anotopterus*. Fitch found 6 rings on the otoliths of a 1,017mm. specimen (Jow, 1963), and Thurow (1961) figures one of the scale-like structures of the lateral line of an 817mm. specimen in which 7 zones can be distinguished. If these rings or zones are in reality indicative of age, then the stage of sexual maturity is probably reached after about 8 or 9 years.

If the above tentative conclusions we have drawn from *Anotopterus* can be applied to *Alepisaurus*, that is cessation of feeding and downward migration during sexual maturity, we would have an explanation why ripe specimens of this common fish have apparently never been taken on the longlines or the various other devices used in the commercial fishery in depths to beyond 1000m. in the waters round Madeira.

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