

FISHERIES RESEARCH BOARD OF CANADA
Translation Series No. 1322

A comparative morphological study on the otoliths
of marine teleosts.

By Werner Schmidt

Original title: Vergleichend-morphologische Studie
über die Otolithen mariner Knochenfische.

From: Archiv für Fischereiwissenschaft, 19 (1): 5-66,
1968.

Translated by the Translation Bureau (MV)
Foreign Languages Division
Department of the Secretary of State of Canada

Fisheries Research Board of Canada
Biological Station
St. John's, Nfld

1969

175 pages typescript

DEPARTMENT OF THE SECRETARY OF STATE
TRANSLATION BUREAU
FOREIGN LANGUAGES DIVISION



FRB 1322
SECRETARIAT D'ÉTAT
BUREAU DES TRADUCTIONS
DIVISION DES LANGUES ÉTRANGÈRES

YOUR NO. VOTRE NO 769-18-14	DEPARTMENT MINISTÈRE Fisheries Research Board	DIVISION/BRANCH DIVISION/DIRECTION Mr.G.H. Winters, Biological Station	CITY VILLE St. John's
OUR NO. NOTRE NO 2476	LANGUAGE LANGUE German	TRANSLATOR (INITIALS) TRADUCTEUR (INITIALES) MV	DATE 10.9.1969

From Archiv für Fischereiwissenschaft, Volume 19, Supplement No.1,
pp.1-96, 1968

A comparative morphological study on the otoliths
of marine teleosts

By

Werner SCHMIDT

Federal Fisheries Research Establishment, Sea
Fisheries Institute

UNEDITED DRAFT TRANSLATION
Only for information
TRADUCTION NON REVISÉE
Information seulement



**FOREIGN LANGUAGES
DIVISION**

**DIVISION DES LANGUES
ÉTRANGÈRES**

TRANSLATED FROM - TRADUCTION DE German	INTO - EN English
--	-----------------------------

AUTHOR - AUTEUR
Werner SCHMIDT

TITLE IN ENGLISH - TITRE ANGLAIS
A comparative morphological study on the otoliths of marine teleosts
Vergleichend morphologische Studie über die Otolithen mariner Knochenfische

REFERENCE IN FOREIGN LANGUAGE (NAME OF BOOK OR PUBLICATION) IN FULL. TRANSLITERATE FOREIGN CHARACTERS.
RÉFÉRENCE EN LANGUE ÉTRANGÈRE (NOM DU LIVRE OU PUBLICATION), AU COMPLET. TRANSCRIRE EN CARACTÈRES PHONÉTIQUES.
Archiv für Fischereiwissenschaft

REFERENCE IN ENGLISH - RÉFÉRENCE EN ANGLAIS
Fisheries Archives

PUBLISHER - ÉDITEUR Westliche Berliner Verlags- gesellschaft Heenemann KG	DATE OF PUBLICATION DATE DE PUBLICATION			PAGE NUMBERS IN ORIGINAL NUMÉROS DES PAGES DANS L'ORIGINAL 1-96
	YEAR ANNÉE	VOLUME	ISSUE NO. NUMÉRO	
PLACE OF PUBLICATION LIEU DE PUBLICATION Berlin-Wilmersdorf, Germany	1968	19	1 (suppl.)	NUMBER OF TYPED PAGES NOMBRE DE PAGES DACTYLOGRAPHIÉES 175

REQUESTING DEPARTMENT / MINISTÈRE-CLIENT **Fisheries Research Board**

TRANSLATION BUREAU NO. / NOTRE DOSSIER NO. **2476**

BRANCH OR DIVISION / DIRECTION OU DIVISION **Biological Station, St. John's**

TRANSLATOR (INITIALS) / TRADUCTEUR (INITIALES) **MV**

PERSON REQUESTING / DEMANDE PAR **Mr. G.H. Winters**

DATE COMPLETED / ACHEVÉ LE **18.9.1969**

YOUR NUMBER / VOTRE DOSSIER NO. **769-18-14**

DATE OF REQUEST / DATE DE LA DEMANDE **15.8.1969**

UNEDITED DRAFT TRANSLATION
Only for information
TRADUCTION NON REVISÉE
Information seulement

List of Contents

	Original page No.
A. Introduction	5
B. Material	5
C. Comparative morphological description of the otoliths	6
Clupeiformes	7
Elopidae	7
Albulidae	7
Clupeidae	7
Engraulidae	8
Alepocephalidae	9
Argentinidae	9
Gonostomatidae	10
Scopeliformes	10
Synodontidae	10
Aulopidae	10
Anguilliformes	11
Muraenesocidae	11
Notacanthiformes	11
Notacanthidae	11
Beloniformes	11
Belonidae	11
Exocoetidae	12
Gadiformes	12
Moridae	12
Gadidae	14
Macrouriformes	20
Macrouridae	20
Beryciformes	24
Berycidae	24
Trachichthyidae	24
Diretmidae	25
Zeiformes	25
Zeidae	25
Caproidae	26
Mugiliformes	26
Sphyraenidae	26
Polynemiformes	27
Polynemidae	27
Perciformes	27
Serranidae	27
Priacanthidae	28
Apogonidae	29
Latilidae	29
Scombroidae	30
Carangidae	30
Emmelichthyidae	31
Lutjanidae	31
Gerridae	32

Pomadasyidae	33
Gasterisidae	34
Sciaenidae	34
Sparidae	37
Lethrinidae	39
Munidae	40
Mullidae	40
Ephippidae	40
Chirocentridae	41
Cepolidae	42
Pomacentridae	42
Labridae	42
Scaridae	43
Trachinidae	44
Bembropidae	45
Uranoscopidae	45
Anarhichadidae	46
Lumpenidae	48
Zoaridae	48
Brotulidae	49
Atomyxidae	49
Callionymidae	49
Acanthuridae	50
Trichuridae	51
Scorpaenidae	51
Stromateidae	52
Gobiidae	52
Scorpaenidae	53
Triglidae	54
Cottidae	56
Contususculidae	57
Agonidae	57
Cyclopteridae	58
Liparidae	58
Dactylopteriformes	59
Dactylopteridae	59
Pleuronectiformes	59
Bothidae	59
Pleuronectidae	60
Soleidae	63
Cynoglossidae	64
Batrachoidiformes	64
Batrachoididae	64
Lophiiformes	64
Lophiidae	64
Amemariidae	65
Chaunacidae	65
D. Summary	65
E. References	66
F. Appendix	67

A. Introduction

For a long time the otoliths of teleosts have been the subject of scientific study. They are an indispensable aid in determining the age of fish, and several papers have also dealt with their morphology. However, most publications have examined the otoliths of merely one single species, and articles studying the outer form of the otoliths of a larger number of fish species are unfortunately rare. Among the latter are "Recherches sur les Otolithes des Poissons" (Studies on the otoliths of fish) by J. CHAINE & DUVERGIER (1934-38, 1942, 1956-59) and "A comparative Study of the Otoliths of the neopterygian Fishes" by A. FROST (6). These authors describe the morphology of a number of otoliths, but they hardly ever compare related species with regard to similar or different characteristics. In my view, however, comparison is the most important task of such comprehensive studies, for the following reasons:

Repeatedly, otoliths have been found in the contents of fish stomachs and in the castings of sea birds which cannot be identified as to the species they belong to. Such an identification, however, might greatly contribute to our knowledge of the geographic range of fish species.

Comparative morphological studies are of interest from

a taxonomic viewpoint, too, because as a rule the otoliths within a genus or an entire family show very characteristic, similar features which underline the relationship among the species. Thus, otoliths might be used as another determining character.

In this article, on the basis of relatively extensive, systematically organized test material, I have attempted to give a review of the many otolithic forms in existence.

I have also tried, by means of brief comparative descriptions of otolith morphology, by giving the ratio of length:width:thickness, and with the help of drawings and photographs, to contribute to an easier identification of some fish species.

The suggestion for these studies came from my venerated teacher, Professor Dr. R. KÄNDLER, Director of the Department of Fish Biology, Kiel Institute of Oceanography. I would like to take this opportunity to express my gratitude to him.

I am also greatly indebted to Dr. G. KREFFT from the Sea Fisheries Institute of the Federal Fisheries Research Establishment in Hamburg for his untiring assistance in identifying tropical fish species which it was difficult to determine, and in classifying them taxonomically; and to Dr. H. SCHULZ, also from the Sea Fisheries Institute in Hamburg, for many valuable ideas for the practical implementation of my work.

B. Material

The material I examined included a total of 186 fish species from the North and Baltic Seas, and from the northern and tropical Atlantic.

I examined only those species of which at least two complete pairs of otoliths, i.e. four otoliths, were available. Because of the frequently great variety of shape and size it is impossible, **in the case** of a small number of species, to describe the otolithic forms and features typical for them.

I collected the material on numerous voyages on the fisheries research steamers "Anton Dohrn" and "Walther Herwig", on commercial fishing steamers and luggers, and during my participation in the "Guinean Trawling Survey" (GTS) in 1964 in the Gulf of Guinea. I did not deliberately choose the species to be examined, but selected them at random because I had at my disposal only the material I had collected on my voyages. This is the reason why in this study several relatively rare species are included, while some very common species are absent.

For description, the following characters were examined:

1. General form of otolith
2. Type and extent of curvature of inner and outer sides

3. Depth and distinctiveness of incisure
4. Size and shape of rostrum and antirostrum
5. Location, form and depth of sulcus
6. Extension and depth of area
7. Shape and structure of margins
8. Ratio of length:width:thickness (length = 1)
9. Average length of fish in cm and average length of their otoliths in mm
10. Ratio of otolith length:fish length (otolith length = 1)

The Figures, arranged on 25 Plates, are appended to the text. By means of a schematic sketch, Plate 1, Fig.1 illustrates the various otolithic characters.

C. Comparative morphological description of the otoliths

To ensure the greatest possible uniformity in the taxonomic classification of the species, the "System of recent and fossil fish-like animals and fishes" by L.S. BERG (1) was used as a reference basis, supplemented by "Poissons de Mer du Sénégal" by J. CADENAT (2) and "Poissons" by M. POLL (12).

The drawings represent one pair of otoliths each. The inner side of the left otolith is on the left, a cross-section in the middle, and the outer side of the right otolith on the right.

The repeatedly occurring designations were abbreviated as follows:

Material	= M	Sulcus	= S
Locality	= L	Rostrum	= R
Depth	= D	Antirostrum	= AR
Fish length	= FL	Incisure	= Inc.
Otolith	= O	Dorsal margin	= D-margin
Otolith length	= OL	Ventral margin	= V-margin
Otolith width	= OW	Inner side	= I-side
Otolith thickness	= OT	Outer side	= O-side

Unless stated otherwise, the scale applied to the photographs on Plates 14-25 is always 0.5 cm.

Order Clupeiformes

7

Family Elopidae Plate 14

Elops lacerta VAL. Plate 1, Fig.2

M: 14 specimens L: Gulf of Guinea D: 30 m

FL in cm: 30 44

OL in mm: 8.01 9.02

OL:OW:OT approx. 1:0.55:0.15

OL:OF1 approx. 1:43

Otolith elongate, posteriorly broad and rounded, anteriorly

pointed, with slight outward curvature. S broad, deep. Cauda long, straight, terminates unbroken. Ostium broadens anteriorly, open. R long, strong, acute, AR hardly recognizable. Inc. weak, I-side and O-side slightly convex. D-margin coarsely sinuous or serrate, V-margin sharp-edged, finely sinuous or serrate.

Family Albulidae Plate 14

Albula vulpes (L.) Plate 1, Fig.3

M: 12 specimens L: Gulf of Guinea D: 20 m

FL in cm: 36 40

OL in mm: 13.06 14.07

OL:OW:OT: approx. 1:0.45:0.26

OL:FL approx. 1:28

Otolith compact, elongate, V-margin more curved than D-margin. Caudal end acute, R short, blunted, curved slightly outward, AR and Inc. missing. I-side strongly convex, O-side lightly convex. At the posterior end of otolith, S forms a deep pit, rises as far as the D-margin, bends, becomes more shallow and terminates open. Margins smooth or gently sinuous, V-margin often finely serrate in older specimens.

Family Clupeidae Plate 14

Otoliths form a very uniform group. Close relation between species is obvious. All otoliths are relatively small, OL:FL is

approx. 1:42 to 1:72.

I-side and O-side little curved, V margin always more sinuous or serrate than D-margin. Inc. always broad, not very deep. R and AR well developed. S in all species broad, very deep anteriorly.

Ilisha africana (BLOCH) Plate 1, Fig.4

M: 16 specimens L: Gulf of Guinea D: 20 m

FL in cm: 18 20 22

OL in mm: 4.28 4.86 5.43

OL:OW:OT approx. 1:0.56:0.16

OL:FL approx. 1:41

Otolith flat, caudal end broad and rounded. I-side slightly convex, O-side gently concave. Inc. well developed and sharply crenate. R broad, terminating in a thin, long point. AR broad and short. S deep, extending from last quarter of otolith to tip of R. D-margin almost smooth, V-margin coarsely serrate.

Basic form little varied, number of teeth in V-margin increases with age, varying between 2 and 10.

Clupea harengus L. Herring Plate 1, Fig.5

M: 20 specimens L: North Sea D: 30-100 m

FL in cm: 27 29

OL in mm: 4.32 4.91

OL:OW:OT approx. 1:0.46:0.17

OL:FL approx. 1:61

Otolith elongate, caudal end crenate. I-side gently convex, O-side concave to the same extent. R long and strong, mostly slightly rounded anteriorly. AR broad, not long, Inc. sharply crenate. S deep, extending across entire otolith, narrowing posteriorly to a small duct which opens into the notch of the margin. Ostium and cauda not defined from each other. Ventral and dorsal cristae arched ridge-like. D-margin irregularly strongly sinuous, V-margin deeply serrate.

Sardina pilchardus (WALB.) Sardine Plate 1, Fig.6

M: 6 specimens L: Central North Sea D: 40 m

FL in cm: 22 24

OL in mm: 3.48 3.61

OL:OW:OT approx. 1:0.50:0.16

OL:FL approx. 1:65

Otolith similar to that of herring, but can be easily distinguished from the latter. O-side not concave as in herring, but plane or gently convex. Caudal end always without notch, R blunted anteriorly, slightly more slender, S terminating unbroken posteriorly. Flat area may be developed. D-margin smooth or slightly serrate, V-margin strongly and irregularly serrate.

Family Engraulidae Plate 14Engraulis encrasicolus (L.) Anchovy Plate 1, Fig.8

M: 4 specimens L: Southern North Sea D: 35 m

FL in cm: 15

OL in mm: 3.91

OL:OW:OT approx. 1:0.39:0.13

OL:FL approx. 1:38

Otolith lanceolate. I-side gently convex, O-side plane or gently convex. Inc. sharp, R and AR strong and pointed. S flat and broad, with straight outlines, terminating unbroken posteriorly, opening anteriorly. D-margin slightly wavy, V-margin smooth, with the exception of a few isolated small and mostly acute teeth.

Family Alepocephalidae Plate 14Alepocephalus bairdii GOODE & BEAN Plate 1, Fig.9

M: 10 specimens L: SW Iceland D: 810 m

FL in cm: 56 66 71

OL in mm: 6.40 6.87 7.03

OL:OW:OT approx. 1:0.65:0.15

OL:FL 1:95

Otolith very flat, almost triangular. I-side almost plane, O-side arched like a hill in the centre, sloping off evenly towards

the sides. Inc. frequently sharp, but very often only poorly developed. R broad, moderately long, rounded. AR mostly strong, not very long, rounded, but frequently only outlined, in which case the triangular shape is particularly obvious. S deep, straight, not very broad, open anteriorly and posteriorly. Ventral crista hardly visible, dorsal crista, as a high ridge, partly hiding the dorsal portion of the sulcus. D-margin with several deep notches, V-margin serrate. In the centre of the caudal end of otolith mostly a single hump-like protuberance.

Family Argentinidae Plate 14

Argentina silus (ASCAN.) Greater silver smelt Plate 1, Fig.10

M: 40 specimens L: North Norway D: 300 m

FL in cm: 21 34 44 49

OL in mm: 5.37 7.95 9.93 11.26

OL:OW:OT approx. 1:0.67:0.14 (adult specimens)

" 1:0.61:0.13 (young specimens, ca. 20 cm long)

OL:FL approx. 1:42

Otolith broad and flat, rounded posteriorly, acutely pointed anteriorly. I-side slightly convex, O-side gently concave. Inc. insignificant, AR small, rounded, superposed on the dorsal side of R. R broad, long, terminating in a sharp point. D-margin of rostrum smooth, V-margin strongly sinuous or serrate, or sharply defined

from the margin of the otolithic body. S not very broad but long, deep, straight; open anteriorly and posteriorly. V-margin wavy, in older specimens often sharply and deeply serrated anteriorly, D-margin strongly sinuous or wavy.

Argentina sphyraena L. Lesser silver smelt Plate 1, Fig.11

M: 30 specimens L: Northwestern North Sea D: 100 m

FL in cm: 22 24

OL in mm: 5.88 6.30

OL:OW:OT approx. 1:0.64:0.15

OL:FL approx. 1:38

Otolith almost identical with that of young A. silus, with only a few differences.

1. V-margin of rostrum merges almost straight into the margin of the otolithic body.

2. V-margin of rostrum smooth, at best gently wavy.

3. In young A. silus the smooth D-margin of R and the sinuous D-margin of the otolithic body form an almost straight line, in A. sphyraena the D-margin of the otolith mostly bends sharply upward at the base of R.

4. In A. silus the V-margin is wavy, in A. sphyraena almost smooth.

Family Gonostomatidae Plate 1410Maurolicus muelleri GMEL. Müller's pearlsides

M: 10 specimens L: North Sea D: 150 m

FL in cm: 6.5

OL in mm: 2.10

OL:OW:OT approx. 1:0.67:0.19

OL:FL approx. 1:31

Otolith somewhat triangular, I-side plane, O-side unusually strongly convex. Inc. and AR hardly recognizable. R broad, terminating in a fine, sharply defined point. S straight, horizontal, ostium terminating openly. Cauda terminating closed in the last quarter of the otolith. Ventral crista ridge-shaped, extending to the outermost tip of R, dorsal crista terminates at the beginning of R. Margins very irregular, irregularly sinuous, partly deeply divided.

*

Order ScopeliformesFamily Synodontidae Plate 14Saurida parri NORMAN Plate 1, Fig.13

M: 20 specimens L: Gulf of Guinea D: 70 m

FL in cm: 13 15

OL in mm: 4.48 4.89

OL:OW:OT approx. 1:0.39:0.13

OL:FL approx. 1:30

Otolith slightly lanceolate. V-margin more curved than D-margin, caudal end blunt or rounded. I-side and O-side slightly convex. Inc. and AR absent, R well developed, with sharp point. S moderately broad, deeply incised in the middle, terminating gradually anteriorly and posteriorly. Cauda terminating closed, ostium broadening only slightly, terminating open. With the exception of the always smooth posterior quarter, D-margin strongly sinuous. V-margin with sharp edges, almost smooth except in the anterior third which is mostly slightly sinuous. Caudal margin with one or several notches.

Trachinocephalus myops SCHNEIDER Plate 1, Fig.14

M: 20 specimens L: Gulf of Guinea D: 200 m

FL in cm: 26

OL in mm: 9.10

OL:OW:OT approx. 1:0.59:0.22

OL:FL approx. 1:29

Otolith massive, slightly oval, acutely pointed anteriorly. I-side convex, O-side gently concave. Inc. and AR small, frequently absent. R short with sharp tip. S lying far dorsad. Ostium short, anteriorly terminating open, narrowing rearward and merging into the long cauda terminating closed at the caudal margin. V-margin

almost smooth, sometimes gently sinuous, D-margin irregularly wavy or sinuous. Caudal margin mostly smooth, with a notch lying far dorsad, end of sulcus in front of that notch. Notch and end of S may be connected by a thin furrow.

Family Aulopidae Plate 14

Aulopus cadenati POLL Plate 2, Fig.15

M: 10 specimens L: Gulf of Guinea D: 200 m

FL in cm: 20 23

OL in mm: 5.63 6.28

OL:OW:OT approx. 1:0.48:0.22

OL:FL approx. 1:36

Otolith slightly kidney-shaped, I-side gently convex, O-side slightly concave. Inc. and AR absent. R short, rounded, slightly curved outward and lying far dorsad. S lying closely below D-margin. Ostium short, funnel-shaped, terminating open at dorsal side of otolith tip. Cauda long, narrow, curved slightly ventrad in the last third, terminating closed. D-margin broad, wavy, with several hump-shaped protuberances. A particularly well developed hump mostly lying close to the opening of the ostium. V-margin with sharp edges, with an almost semi-circular curvature, almost smooth.

Little variation of basic form, in exceptional cases R may be pointed.

Order AnguilliformesFamily Muraenesocidae Plate 15Phyllogramma regani PELL. Plate 2, Fig.16

M: 10 specimens L: Gulf of Guinea D: 70 m

FL in cm: 69 108

OL in mm: 12.56 14.79

OL:OW:OT approx. 1:0.55:0.17

OL:FL approx. 1:64

Otolith compact, elliptic to oval, blunted posteriorly. I-side moderately convex, O-side slightly concave. S broad, shallow, straight, mostly filled by colliculum. Terminating closed anteriorly and posteriorly. Perpendicular to the anterior end of S, a fine canal frequently extends as far as the margin of the otolith. V-margin smooth, D-margin slightly wavy or sinuous, caudal margin smooth, frequently slightly curved inward, sometimes straight so that otolith appears to have been cut off.

*

Order NotacanthiformesFamily Notacanthidae Plate 15Notacanthus phasganorus GOODE Plate 2, Fig.17

M: 12 specimens L: SW Iceland D: 500 m

FL in cm: 90

OL in mm: 2.77

OL:OW:OT approx. 1:1.04:0.43

OL:FL approx. 1:320

Otolith very thick, almost circular. I-side and O-side convex. Ventrally with an edge, dorsally I-side and O-side, evenly rounded, merge with each other. S broad and deep, ostium as long as the pit-like cauda terminating closed. V-margin mostly gently sinuous. Remarks: Basic form variable. Some otoliths resemble an amorphous lump with serrated edges.

*

Order Beloniformes

Family Belonidae Plate 15

Belone belone (L.) Garfish Plate 2, Fig.18

M: 4 specimens L: Irish Sea D: 30 m

FL in cm: 71

OL in mm: 5.16

OL:OW:OT approx. 1:0.56:0.17

OL:FL approx. 1:73

Otolith slightly oval, acutely pointed anteriorly, broad and rounded posteriorly. I-side slightly convex, O-side concave in anterior third, the thicker, caudal end convex. Inc. and AR insignificant or absent, R terminating in a short sharp point.

S straight, closed posteriorly shortly before the margin, open anteriorly, ostium and cauda hardly defined from each other.

V-margin slightly wavy, D-margin varyingly sinuous.

Family Exocoetidae Plate 15

Cypselurus pinnatibarbatus (BENNET) Plate 2, Fig.19

M: 4 specimens L: Gulf of Guinea D: 1m

FL in cm: 31

OL in mm: 9.15

OL:OW:OT approx. 1:0.51:0.24

OL:FL approx. 1:34

Otolith massive, elongate, blunted posteriorly, acutely pointed anteriorly. I-side moderately convex, O-side slightly concave. Irc. and AR absent, R short, broad, with sharp tip. S broad, very deep, closed anteriorly and posteriorly. Cauda and ostium not defined from each other. In the posterior half of the otolith, below the ventral crista, there is a well-developed area. V-margin with sharp edges, slightly wavy, D-margin broad, with a smooth edge facing the I-side and a deeply crenate and sinuous edge facing the O-side.

*

Order GadiformesFamily Moridae Plate 15

Although within this family otolithic shape is by no means uniform, it is nevertheless so characteristic that we may speak of a "morid type". All otoliths are large, extraordinarily thick, the ratio of their length to the fish length varies between 1:22 and 1:30. The anterior part is always broader than the posterior part, some species have otoliths that are almost axe-shaped. In most species the narrowing caudal end is forked. Inc. and AR are always absent, the I-side is plane, the O-side convex and thickened by dome-shaped growths. D-margin and V-margin almost smooth in all species. The sulcus is also very typical. It is clearly divided into ostium and cauda, the short ostium, completely filled with a colliculum, always terminates closed, the deep long cauda terminates open and is divided into two parts by a longitudinal high and sharp ridge.

Mora mora (RISSO) Plate 2, Fig.20

M: 4 specimens L: Iceland D: 800 m

FL in cm: 57

OL in mm: 18.55

OL:OW:OT approx. 1:0.66:0.23

OL:FL approx. 1:30

Otolith massive, approximately axe-shaped. Blunt anteriorly,

caudal end also blunt, appearing broken off, mostly forked. V-margin with sharp edges, D-margin broad and rounded. I-side almost plane, O-side thickened by flat, dome-shaped elevations. Inc. absent. S flat, far dorsad. Cauda straight, long, considerably 13 broadening and deepening rearward, terminating open. Ostium clearly defined from cauda, almost twice as broad, filled by colliculum, terminating closed near the anterior margin. Colliculum extending in the centre of the cauda to the end of the latter as a narrow, high ridge. V-margin smooth, anterior and D-margin slightly sinuous or serrate.

Halargyreus affinis COLLETT Plate 2, Fig.21

M: 6 specimens L: Iceland D: 800 m

FL in cm: 20 24

OL in mm: 8.37 9.74

OL:OW:OT approx. 1:0.46:0.22

OL:FL approx. 1:25

Otolith very similar to that of Mora mora, but its posterior part is longer, its anterior part more slender and rounded. I-side almost plane, Inc. absent, S as in Mora, but ostium not as broad. D- margin and V-margin smooth, anterior margin strongly sinuous.

Lepidion eques (GÜNTHER) Plate 2, Fig.22

M: 10 specimens L: Iceland D: 600 m

FL in cm: 16 20 29 33
 OL in mm: 8.12 9.60 12.18 14.12

Otolith elongate. Anterior part rounded, only little broader than deeply forked posterior part. Thus it differs considerably from the previous species, but the relationship is still very obvious. I-side plane, O-side strongly convex, thickened by several humps. Inc. and AR present only in isolated cases. S as in the previous species, again the deep cauda is divided into half by a longitudinal ridge. In contrast to the other species, a well-developed area above the dorsal crista. V-margin smooth or gently wavy, D-margin more strongly wavy.

Laemonema laureysi POLL Plate 2, Fig.23

M: 20 specimens L: Gulf of Guinea D: 400 m

FL in cm: 22 24 26
 OL in mm: 8.90 8.94 9.28

OL:OW:OT approx. 1:0.36:0.33 } *
 OL:FL approx. 1:27 }
 OL:OW:OT approx. 1:0.42:0.29 } *
 OL:FL approx. 1:22 }

Otolith as in Lepidion,^{but} broader, rounded anteriorly, narrowing

*

Translator's note: Either of these pairs of data belongs to Lepidion eques above.

considerably rearward, terminating in a sharply pointed tip. Therefore it cannot be taken for the otolith of Lepidion. V-margin straight, with razor-sharp edge, D-margin rounded, without edge. The otolith is so thick that a second ventral edge has developed on the O-side. Thus, in addition to the plane I-side and the O-side which has several hump-shaped elevations, it has a third surface, the ventral side. The posterior end of the latter always has a spoon-shaped depression. S similar to that of the previous species, but cauda curved and considerably longer. One long and deep area each dorsally and ventrally. In this otolith, too, a sharp ridge runs along the entire cauda longitudinally.

Uraleptus maraldi (RISSO) Plate 2, Fig.24

14

M: 14 specimens L: Gulf of Guinea D: 400 m

FL in cm: 17 18

OL in mm: 6.40 6.42

OL:OW:OT approx. 1:0.25:0.27

OL:FL approx. 1:27

Otolith similar to that of Laemonema, but more slender and much more delicate. Anteriorly acute, not rounded. Ventral side present, but without the spoon-shaped depression typical for Laemonema. S slightly more slender, straight, cauda very deep, with paper-thin, very high longitudinal ridge. Dorsal and ventral areas present, both narrow and flat.

Family Gadidae Plates 15/16

With regard to the morphology of their otoliths, the species of this family do not present a uniform picture. The "typical" gadid otolith is compact, more or less elongate, the broader end always points forward, the tapering end rearward. I-side strongly arched, anterior and posterior ends mostly with slight outward curvature. Inc. and AR absent. S of almost the same width throughout, closed anteriorly and posteriorly, ostium may have an open outward connection in the form of a narrow canal. Other characteristics of gadid otoliths are a strongly plicate surface and hump-like elevations on the O-side. Several species differ considerably from this standard form; details will be given in the description of those species.

Subfamily Gadinae

Gadus morhua L. Cod Plate 2, Fig.25

M: 100 specimens L: North Norway and North Sea D: 70 - 150 m

FL in cm: 15 76 105

OL in mm: 6.72 17.25 21.50

OL:OW:OT approx. 1:0.48:0.19

OL:FL approx. 1:46

Otolith in young specimens approx. lanceolate, in adult specimens approx. triangular, with the longest side of the triangle

at the bottom, the shortest side anteriorly on top. I-side strongly convex, O-side moderately concave. Surface of otolith strongly plicate. This structure is particularly distinct on the O-side, which in addition to the folds has numerous hump-like growths. Inc. and AR absent. S straight, of constant width, filled by colliculum. Terminating closed near margin anteriorly and posteriorly. In its anterior third S is constricted by ventral crista and thus divided into cauda and shorter ostium. From ostium a fine groove frequently extends to margin of otolith. Margins deeply notched.

Melanogrammus aeglefinus (L.) Haddock Plate 2, Fig.26

M: 12 specimens L: North Sea D: 30 - 40 m

FL in cm: 21 45 70

OL in mm: 10.00 17.58 21.09

OL:OW:OT approx. 1:0.33:0.16

OL:FL approx. 1:27

Otolith almost trapezoid. More slender than that of codfish. D-margin thin and sharp-edged, V-margin substantially thicker. I-side convex, O-side slightly concave. S filled by colliculum, closed anteriorly and posteriorly. Ostium distinctly defined from longer cauda by constriction by ventral crista. Groove from ostium to otolith margin rare. Plicate surface and humps well developed particularly in younger specimens, they flatten with increasing age. Margins sinuous, gently wavy in old specimens.

Pollachius pollachius (L.) Pollack Plate 2, Fig.27

M: 18 specimens L: Norway D: 100-150 m

FL in cm: 51 75 90

OL in mm: 15.47 19.29 20.61

OL:OW:OT approx. 1:0.40:0.20

OL:FL approx. 1:38

Otolith cannot be distinguished with certainty from that of haddock. Somewhat broader and thicker than ⁱⁿ previous species, D-margin also mostly thicker, bending ventrad anteriorly, irregularly sinuous. I-side more convex than in haddock, O-side moderately concave, S closed anteriorly and posteriorly, distinct constriction by ventral crista. Folds on surface distinctly developed, humps on O-side not very big. Margins only gently and irregularly sinuous.

Pollachius virens (L.) Coalfish Plate 2, Fig.28

M: 12 specimens L: Iceland D: 110 m

FL in cm: 42 61 73 88

OL in mm: 13.16 15.14 17.26 18.67

OL:OW:OT approx. 1:0.32:0.16

OL:FL approx. 1:40

Otolith very similar to that of haddock, but much smaller in relation to fish length and slightly more slender. I-side moderately convex, O-side slightly concave. S straight, closed

anteriorly and posteriorly. Folds on surface distinct, humps mostly small. D-margin and V-margin sinuous.

Merlangius merlangus (L.) Whiting Plate 3, Fig.29

M: 30 specimens L: Central North Sea D: 30-50 m

FL in cm: 21 37 51

OL in mm: 12.04 20.09 27.60

OL:OW:OT approx. 1:0.28:0.09

OL:FL approx. 1:18

Otolith elongate, flat, anterior end broad and more or less rounded; posterior end gradually tapering, terminating in a long drawn out tip. D-margin thin and sharp-edged, V-margin thicker and slightly rounded. I-side only slightly convex, O-side gently concave. Inc. and AR absent. S as in codfish and haddock, a fine groove frequently extending from ostium to otolith margin. Long cauda extending to the very end of tip. Folds and humps distinct, but not as distinct as in codfish. V-margin slightly wavy or sinuous, D-margin thin and - particularly in otoliths of young specimens - very regularly sinuous.

Remarks: Anterior margin of otolith varies greatly. It may be evenly rounded, but often is sloping or sinuous.

Trisopterus minutus (MÜLLER) Plate 3, Fig.30

M: 30 specimens L: Central North Sea D: 30 m

FL in cm: 15 17 20
 OL in mm: 7.31 7.78 8.96
 OL:OW:OT approx. 1:0.48:0.31
 OL:FL approx. 1:22

Otolith thick, drop-shaped, posteriorly terminating in a sharp, slightly outward-curving tip. O-side strongly convex, I-side slightly convex. Inc. and AR absent. S gently curved, closed anteriorly and posteriorly. Ostium and cauda defined from each other by constricting cristae, but not as well as in other species; also, both cristae are involved. A narrow groove may extend from ostium to margin. Folds on surface and humps on O-side very distinct. D-margin and V-margin strongly sinuous.

Trisopterus esmarkii (NILSSON) Plate 3, Fig.31

M: 30 specimens L: Northern North Sea D: 75 m
 FL in cm: 18 23
 OL in mm: 7.43 8.75
 OL:OW:OT approx. 1:0.42:0.24
 OL:FL approx. 1:25

Otolith difficult to distinguish from that of Tr. minutus. More slender, thinner, humps and sinuosity of margins less well developed. Tip also sharply pointed, but only slightly curved. O-side not as strongly convex as in Tr. minutus, S also constricted

from both sides, ostium always with a narrow opening in otolith margin in the form of a groove or notch.

Trisopterus luscus (L.) Plate 3, Fig.32

M: 14 specimens L: Central North Sea D: 30 m

FL in cm: 22 24 26

OL in mm: 9.56 10.23 10.56

OL:OW:OT approx. 1:0.45:0.29

OL:FL approx. 1:23

Otolith differs from that of Tr. minutus in only a few features:

1. No open groove from ostium to otolith margin.
2. S constricted only by ventral crista; dorsal crista continues straight.

Remarks: Hardly any flattening of folds and humps on O-side even in otoliths of older specimens.

Micromesistius poutassou (RISSO) Blue whiting Plate 3, Fig.33

M: 20 specimens L: Norway T: 200 m

FL in cm: 31 35 42

OL in mm: 13.46 15.55 17.63

OL:OW:OT approx. 1:0.30:0.14

OL:FL approx. 1:23

Otolith elongate, approx. lanceolate, rounded anteriorly. V-margin and D-margin terminating with slight curvature into posterior tip. I-side slightly convex, O-side slightly concave. Inc. and AR absent, S straight, closed anteriorly and posteriorly. Constriction by cristae not observed. Colliculum not completely filling S so that the latter is visible as distinct depression. 17
 Folds poorly developed, I-side and O-side appearing almost smooth. No humps on outer surface. Margins almost smooth, only posterior portion of D-margin, bending slightly ventrad, regularly sinuous. In very old specimens even this portion becomes smooth.

Boreogadus saida (LEPECHIN) Arctic cod Plate 3, Fig.34

M: 16 specimens L: Spitzbergen D: 350 m

FL in cm: 14 16 18

OL in mm: 5.53 6.49 7.83

OL:OW:OT approx. 1:0.44:0.15

OL:FL approx. 1:24

Otolith somewhat lanceolate, not curved in contrast to all previous species. Again, the anterior end is broader. I-side only very slightly convex, O-side concave to the same extent. In contrast to other gadids, a sharp Inc. in the centre of the anterior otolith margin, therefore AR well developed. The latter as long as the short R which is only slightly broader. Both rounded anteriorly, with completely smooth margins. S shallow, straight, slightly constricted

in centre, cauda closed mostly far away from otolith margin, ostium open. Folds slightly visible only at margins of I-side, O-side completely smooth, appears polished. No humps. Margins shallowly sinuous, D-margin mostly more sinuous than V-margin.

Remarks: Some otoliths lack Inc. completely, thus also AR. S may sometimes terminate open into notch of caudal margin of otolith.

Gadiculus thori SCHMIDT Plate 3, Fig.35

M: 14 specimens L: Norway D: 250 m

FL in cm: 16 18

OL in mm: 7.46 8.47

OL:OW:OT approx. 1:0.67:0.20

OL:FL approx. 1:21

Otolith not very similar to those of other Gadinae. Approx. oval, both sides slightly convex, O-side mostly more arched than I-side. Inc. and AR usually absent. S moderately deep, slightly curved, open both anteriorly and posteriorly. Constriction by cristae very weak or completely absent, colliculum poorly developed. Folds blurred, frequently hardly recognizable. Margins slightly and irregularly sinuous or wavy.

Remarks: Otolith may be deeply notched anteriorly, posteriorly, or on both ends. Into these notches S opens, the depth of which also varies greatly. It may be a deep furrow, but not infrequently it

is very shallow and hardly recognizable.

Subfamily Lotinae

Urophycis blennioides (BRÜNNICH) Plate 3, Fig.36

M: 20 specimens L: Norway D: 100-150 m

FL in cm: 35 45 58

OL in mm: 14.26 14.83 18.12

OL:OW:OT approx. 1:0.38:0.21

OL:FL approx. 1:30

Basic form resembling a parallelogram. Anterior half of otolith considerably thicker than posterior half, caudal end slightly curved outward. V-margin more curved outward than D-margin, posterior part of otolith therefore appearing ventrally sloping outward. Otolith tapering rearward, but terminating rounded. I-side moderately convex, Inc. and AR absent. S long, fairly broad, horizontally straight, filled by colliculum. Slightly constricted by dorsal crista only at far anterior end, short ostium tapering shortly before terminating, terminating closed directly at margin, more or less pointed. Frequently, however, a notch or groove forming an open connection outward. Cauda long, narrowing at the far posterior end to approx. half its original width, terminating closed directly at caudal margin of otolith. A groove not quite half as wide as S extending directly below the latter; it is also

bordered by "cristae", so that the impression of two sulci, one above the other, is created. Numerous transverse folds extending across this pseudo-sulcus, making it particularly conspicuous. Folds and humps poorly developed, margins slightly and irregularly sinuous. Central portion of V-margin may be sharply serrate.

Molva molva (L.) Ling Plate 3, Fig.37

M: 22 specimens L: Norway D: 100-200 m

FL in cm: 72 119 130

OL in mm: 11.87 16.95 21.20

OL:OW:OT approx. 1:0.38:0.12

OL:FL approx. 1:64

Shape resembling a slightly curved \sim . I-side moderately convex, O-side slightly concave. D-margin bending sharply outward at far anterior end, V-margin approx. in centre, thus forming an oblique bend in otolith which becomes more and more pronounced with increasing age of specimens. Its shape differing from that of the other species, the bend, and its thinness give the ling otolith its characteristic appearance. In otoliths of younger specimens up to approx. 70 cm long, sharp Inc., broad, moderately long R, and short, pointed AR are frequent. In older specimens R growing under AR, the latter remaining visible only as very small tip lying on R; Inc. disappearing almost completely. S broad, ^{very}not/deep. Greatly constricted by both cristae approx. in centre. Cauda closed,

the almost equally long ostium terminating open. Folds distinctly visible in small otoliths, greatly blurred in older ones, humps slightly visible on O-side only in young otoliths. Flat, but distinct area above dorsal crista. Margins in small otoliths irregularly sinuous, becoming smoother with increasing age.

Remarks: Basic form greatly variable. Curved form frequently obliterated, R not infrequently straight even in old specimens, which keeps Inc. distinctly visible.

Molva dypterygia (PENNANT) Blue ling Plate 3, Fig.38

M: 16 specimens L: Norway D: 200-250 m

FL in cm: 67 105 121

OL in mm: 12.73 19.79 22.56

OL:OW:OT approx. 1:0.40:0.11

OL:FL approx. 1:53

Otolith similar to that of ling, but clearly distinct from it. Not curved, but rather shaped like a parallelogram. Bend in otolith also present, although not as pronounced, but not oblique, rather across centre of otolith. I-side moderately convex, O-side slightly concave. Inc. and AR were not observed, but it is possible that, as in the ling, they exist in younger specimens. The smallest otoliths available for this species came from specimens 67 cm long. S moderately deep, partially filled by colliculum; as in the ling, constricted centrally by both cristae, cauda closed already some

distance from otolith margin, ostium terminating open. Area mostly absent. Folds distinct, particularly in younger specimens, humps poorly developed. V-margin only slightly wavy, D-margin strongly sinuous, frequently sharply serrated.

Brosme brosme (ASCAN.) Torsk Plate 3, Fig.39

M: 12 specimens L: Norway D: 150 m

FL in cm: 50 59 85

OL in mm: 10.71 11.38 14.25

OL:OW:OT approx. 1:0.53:0.17

OL:FL approx. 1:53

Otolith much more compact than that of blue ling, like in the latter bent slightly in the centre. Curved form of ling otolith still faintly recognizable. I-side moderately convex, O-side slightly concave. Inc. and AR absent, outlined only in young specimens. S very shallow, strongly constricted by both cristae in centre. At the latter point S frequently completely filled^{by}/colliculum, which separates ostium and cauda completely from each other. Cauda terminating closed a good distance from otolith margin, widening rapidly, ostium broadening into funnel, terminating open. Folds on D-margin faintly visible, humps on outer surface absent. Margins sinuous or irregularly crenate, often deeply furrowed or serrated in otoliths of old specimens.

Enchelyopus cimbrius (L.) Fourbeard rockling Plate 3, Fig.40

M: 22 specimens L: North Sea D: 30-40 m

FL in cm: 18 25 30

OL in mm: 2.92 4.29 4.69

OL:OW:OT approx. 1:0.54:0.20

OL:FL approx. 1:61

Otolith shaped almost like an isosceles triangle the hypotenuse of which is formed by the V-margin. Slightly curved outward. I-side gently convex, O-side gently concave, Inc. and AR absent. S deep, straight. Cauda terminating closed, tapering conically as far as centre of otolith, where dorsal and ventral cristae meet and close S entirely. Ostium, in this manner completely separated from cauda, also conical, terminating open. Folds poorly developed, humps absent on outer surface. Margins only slightly wavy.

Gaidropsarus argentatus (REINHARDT) Plate 3, Fig.41

M: 10 specimens L: Northern Iceland D: 500-800 m

FL in cm: 16 18 24

OL in mm: 2.53 3.11 3.95

OL:OW:OT approx. 1:0.51:0.19

OL:FL approx. 1:60

Otolith almost identical with that of Enchelyopus,

distinction possible only by two characteristics:

1. In Enchelyopus, otolith curved slightly outward, in Gaidropsarus, always straight.

2. In Enchelyopus, I-side slightly convex, in Gaidropsarus, 20
almost plane.

All other examined features are identical in both species.

Subfamily Merlucciinae

Merluccius merluccius (L.) Hake Plate 3, Fig.42

M: 14 specimens L: North Sea D: 110-150 m

FL in cm: 48 60 74

OL in mm: 18.85 23.73 29.10

OL:OW:OT approx. 1:0.37:0.09

OL:FL approx. 1:25

Otolith elongate, very flat, somewhat resembling that of whiting. Anteriorly blunted, posteriorly tapering, terminating in a pointed tip which as a rule is not as long and as pointed as in whiting. I-side slightly convex, O-side almost plane, Inc. and AR absent. S broad, only partially filled by colliculum, sharply constricted by ventral crista in anterior third. Contrary to whiting, dorsal crista, too, sinuous at this point, thus contributing essentially to the sharp constriction. Cauda closed, a narrow groove remaining as connection between almost closed ostium and otolith

margin. Folds very distinct, in otoliths of younger specimens D-margin coarsely and deeply sinuous, V-margin regularly and much more finely sinuous. With increasing age, V-margin becoming almost smooth, D-margin, on the other hand, becoming more deeply and sharply sinuous, often deeply divided especially in caudal portion. Humps poorly developed or altogether absent.

Merluccius polli CADENAT Plate 4, Fig.43

M: 20 specimens L: Gulf of Guinea D: 400 m

FL in cm: 31 38 50

OL in mm: 12.79 15.16 18.39

OL:OW:OT approx. 1:0.38:0.09

OL:FL approx. 1:25

Otoliths differing distinctly from that of previous species in several features. Not gradually tapering rearward, but forming a short, rounded tip which hardly differs from anterior end of otolith. I-side gently convex, O-side almost plane. Im. and Ar absent. S broad and shallow, sharply constricted approx. in centre by both cristae. Cauda closed, ostium may also be closed, not infrequently an open outward connection remains in the form of a groove; ostium may even terminate completely open. Development of surface folds varying greatly, independent of age. Accordingly, margins also varyingly sinuous. Central portion of V-margin, however, always smooth. No humps.

Order MacrouriformesFamily Macrouridae Plate 17

They definitely show a certain resemblance to Gadidae. Otoliths compact, relatively large, in several species anterior end broader. Folds mostly distinct, humps on O-side usually present, although not very well developed. Form of S, too, similar to that of previous family.

Contrary to Gadidae, otoliths in Macrouridae very compact, 21 in one species even a little wider than long. I-side almost plane in almost all species, O-side always convex, sometimes very strongly so. Coryphaenoides is the only exception.

Coryphaenoides rupestris GUNN. Rock grenadier Plate 4, Fig.44

M: 14 specimens L: North Norway D: 500-750 m

FL in cm: 35 61 84

OL in mm: 10.25 16.61 21.97

OL:OW:OT approx. 1:0.43:0.14 (in specimens over 50 cm long)

approx. 1:0.50:0.14 (in specimens up to 50 cm long)

OL:FL approx. 1:36

In young specimens, otolith approx. triangular as in Gadidae. With increasing size otolith becoming approx. bean-shaped, rounded anteriorly and posteriorly. I-side moderately convex, O-side slightly concave, Inc. and AR may be indicated, but are mostly absent.

S broad, not deep, extending parallel to V-margin, terminating open anteriorly and posteriorly. In young specimens median, in older specimens closely below D-margin. Slightly constricted by ventral crista in centre. Folds distinctly visible, in young otoliths especially at D-margin. In older specimens, clearly developed folds typical only for Coryphaenoides present on O-side, running transversely across otolith. Number of these folds usually varying between 4-8. In young otoliths D-margin strongly sinuous, V-margin smooth or slightly wavy. In older otoliths D-margin and V-margin differently sinuous, often sharply serrate.

Remarks: Cauda may be closed; ostium also sometimes terminating almost closed. In that case, however, a narrow open connection to the margin remains in the form of a groove.

Coelorhynchus coelorhynchus (RISSO) Plate 4, Fig.45

M: 20 specimens L: Norway and Gulf of Guinea D: 300-500 m

FL in cm: 16 26 35

OL in mm: 7.51 9.60 12.88

OL:OW:OT approx. 1:0.64:0.23

OL:FL approx. 1:25

Otolith compact, broad end with very short tip/^{is}the anterior end, tapering rounded end/_{is the}posterior end. I-side and O-side slightly convex, Inc. and AR absent. S broad, comparatively deep. As in Coryphaenoides, extending in dorsal part of otolith, only slightly

constricted by ventral crista. Ostium open, the slightly longer cauda mostly closed, sometimes a narrow open connection with the margin remaining in the form of a groove. Colliculum absent in otoliths of West African fish, always well developed in otoliths of fishes from Norwegian waters. Folds, too, hardly recognizable in tropical specimens, but very distinct in specimens from arctic waters. Humps on O-side always well developed, mostly in the form of a large single hump in centre of otolith, from the tip of which the surface slopes down evenly on all sides. Boreal fishes may have one or two other humps. V-margin always almost smooth, D-margin more or less strongly sinuous.

Malacocephalus laevis (GÜNTHER) Plate 4, Fig.46

22

M: 26 specimens L: Gulf of Guinea D: 400 m

FL in cm: 28 37

OL in mm: 8.04 13.35

OL:OW:OT approx. 1:0.57:0.17

OL:FL approx. 1:31

Otolith flat, mostly with short blunt tip anteriorly and posteriorly. I-side almost plane, O-side slightly convex. S shallow, in dorsal part of otolith, usually open anteriorly and posteriorly, moderately constricted by ventral crista in centre. Colliculum mostly filling only parts of S. Folds very well developed, particularly in young specimens, therefore margins deeply sinuous, too. Humps

frequently present, may also be absent.

Remarks: Basic form highly variable. Anterior and posterior ends may be evenly rounded, sometimes bearing one strong, sharp tip each. Margins not infrequently deeply and irregularly grooved or crenate.

Malacocephalus occidentalis GOODE & BEAN Plate 4, Fig.47

M: 18 specimens L: Gulf of Guinea D: 200 m

FL in cm: 21 23

OL in mm: 7.88 8.26

OL:OW:OT approx. 1:0.60:0.18

OL:FL approx. 1:27

Can hardly be confused with previous species. The broader anterior part bears a short but pointed tip, the slightly more elongate posterior part, slightly tapering, is rounded. I-side almost plane, O-side gently convex. Small Inc. and very short rounded AR mostly present. S broad, moderately deep, straight, slightly rising dorsad from rear to front, constricted by ventral crista twice near centre at short intervals, not only once as in M. laevis. Dorsal crista also slightly contributing to this constriction. In contrast to previous species, cauda and ostium closed, a narrow groove frequently extending from ostium to margin of otolith. Colliculum poorly developed, folds very indistinct. No humps on

O-side. V-margin very gently sinuous, D-margin strongly sinuous. Centre of D-margin mostly with broad notch, another notch almost always in caudal margin.

Nezumia aequalis (GÜNTHER) Plate 4, Fig.48

M: 4 specimens L: Iceland D: 600 m

FL in cm: approx. 25

OL in mm: 7.55

OL:OW:OT approx. 1:0.64:0.21

OL:FL approx. 1:33

Otolith compact, anterior end broad with very short, slightly rounded tip, posterior end tapering, terminating rounded. I-side plane, O-side slightly convex. Inc. and AR absent. S shallow, slightly constricted in centre by ventral crista, cauda closed, ostium open. Folds poorly developed, humps absent. V-margin almost smooth, gently sinuous in caudal part, D-margin more strongly, irregularly sinuous. In the centre of margin particularly pronounced curvature.

Hymenocephalus italicus GIGLIOLI Plate 4, Fig.49

M: 14 specimens L: Gulf of Guinea D: 200 m

FL in cm: 17

OL in mm: 5.73

OL:OW:OT approx. 1:1.01:0.31

OL:FL approx. 1:30

Otolith length equal to its width. As an exception, strong short tip not anteriorly or posteriorly, but on top. I-side plane, O-side convex, Inc. and AR absent. S broad, moderately deep, centrally expanded in the shape of a bottle. Strongly tapering foreward and rearward, terminating open. Not constricted by cristae. Colliculum mostly absent. Folds and humps were not observed; evenly arched outer surface completely smooth. V-margin smooth, D-margin gently and irregularly wavy. Mostly one more or less deep notch in anterior half.

Trachyrinchus murrayi GÜNTHER Plate 4, Fig.50

M: 6 specimens L: Iceland D: 500 m

FL in cm: 16 20

OL in mm: 5.57 6.30

OL:OW:OT approx. 1:0.81:0.31

OL:FL approx. 1:30

Basic form similar to that of previous species, but D-margin deeply divided, consisting merely of several teeth of different length. I-side plane, O-side unusually strongly convex, giving the impression of a flat pyramid. S narrow and shallow, closed posteriorly, narrowing to a narrow groove immediately before its anterior end, terminating open. Not constricted by cristae, colliculum absent. Folds on O-side coarsely and irregularly developed, humps poorly developed, V-margin gently wavy.

Trachyrinchus trachyrhynchus (RISSO) Plate 4, Fig.51

M: 12 specimens L: Iceland D: 600 m

FL in cm: 43 51

OL in mm: 16.11 17.28

OL:OW:OT approx. 1:0.80:0.24

OL:FL approx. 1:28

Basic form similar to that of Tr. murrayi, but much flatter, I-side, unlike the previous species, slightly convex. S very broad, not constricted. Closed posteriorly, bending slightly upward anteriorly, terminating almost closed. Open connection in the form of a groove remains, however. Colliculum poorly developed, dorsal crista arched forming a high ridge. Folds hardly visible, several small humps may be present on O-side, but they are mostly absent. Instead, a shallow groove almost always extending from centre of V-margin upward at a right angle, tapering, terminating above centre of otolith. V-margin smooth or very slightly wavy, D-margin, as in previous species, sharply serrate or grooved. In older otoliths, however, these teeth disappear, with the exception of a few very prominent ones.

Bathygadus goethemi Poll Plate 4, Fig.52

M: 4 specimens L: Gulf of Guinea D: 400 m

FL in cm: 31

OL in mm: 10.10

OL:OW:OT approx. 1:0.59:0.19

OL:FL approx. 1:30

Otolith approximately elliptical, but this basic form is varied by the strongly sinuous D-margin. Otolith rounded anteriorly and posteriorly. I-side plane, O-side gently convex. S broad, almost straight, twice slightly constricted by ventral crista which divides S into three almost equally long parts. S closed posteriorly, open anteriorly. Folds poorly visible only at D-margin, humps absent. V-margin almost smooth, D-margin very strongly, irregularly grooved or sinuous.

*

Order Beryciformes

Family Berycidae Plate 17

Beryx decadactylus CUV. & VAL. Plate 4, Fig.53

M: 4 specimens L: Western Iceland D: 400 m

FL in cm: 56

OL in mm: 21.40

OL:OW:OT approx. 1:0.67:0.15

OL:FL approx. 1:26

Otolith broad, flat, slightly curved outward. Anteriorly broad, posteriorly tapering, terminating rounded. I-side slightly

convex, outer surface sloping obliquely downward on all sides from raised centre to sharp margins. Inc. poorly developed, AR only indicated, R short with sharp tip pointing straight upward. S shallow, slightly curved; divided into short narrow cauda terminating open posteriorly into V-margin, and longer, also open ostium which, on account of the ventral crista bending sharply downward and extending in a curve to the tip of R, is approx. twice as wide as cauda. Dorsal crista arched forming sharp ridge, above it sometimes flat area. D-margin coarsely and irregularly wavy and serrate, V-margin finely and sharply serrate.

Family Trachichthyidae Plate 17

Hoplostethus atlanticus COLLETT Plate 4, Fig.54

M: 12 specimens L: Gulf of Guinea D: 400 m

FL in cm: 12 16

OL in mm: 4.78 6.10

OL:OW:OT approx. 1:0.53:0.15

OL:FL approx. 1:26

Otolith elongate, mostly forked posteriorly, slightly broader anteriorly, bent obliquely upward with short, rounded tip. Two conspicuous long needle-like growths on V-margin which stand at right angles to the latter. Anterior growth at the point where V-margin bends upward, posterior growth approx. in centre of

horizontal portion. I-side plane, O-side slightly convex, Exc. and AR absent. S shallow, following the curvature of V-margin; closed posteriorly, open anteriorly, almost entirely filled by colliculum. Margins slightly wavy, mostly a deep notch in centre of D-margin.

Hoplostethus mediterraneum VAL. Plate 4, Fig.55

M: 4 specimens L: Iceland D: 500 m

FL in cm: 17

OL in mm: 10.45

OL:OW:OT approx. 1:0.73:0.20

OL:FL approx. 1:16

Otolith broader than in H. atlanticus, also bent upward anteriorly, with two growths on V-margin which, however, are broad and short, the anterior one sometimes only a slight protrusion of the margin. I-side plane, O-side convex. S curved as in previous species, but distinctly constricted by ventral crista. Cauda short and closed, ostium terminating open in anterior quarter of D-margin. Colliculum poorly developed. V-margin almost smooth, with the exception of the two growths, D-margin deeply grooved and lobed; a particularly deep indentation in centre, as in H. atlanticus.

Gephyroberyx darwini (JOHNSON) Plate 4, Fig.56

M: 10 specimens L: Gulf of Guinea D: 200 m

FL in cm: 10 20
 OL in mm: 5.34 8.95
 OL:OW:OT approx. 1:0.71:0.15
 OL:FL approx. 1:20

Otolith very delicate, I-side plane, O-side slightly convex. No longer distinctly curved as in previous species, but the broad R also points straight upward with its short tip. Inc. and AR, lying far behind R, present. S broad, extending obliquely upward from rear to front; slightly constricted by ventral crista which then curves downward, extending in a curve as far as tip of R. Cauda terminating open into notch in V-margin, broader ostium also terminating open into Inc. Colliculum poorly developed. V-margin slightly and irregularly sinuous, D-margin strongly sinuous and crenate. Anterior margin of R finely and regularly serrate.

Family Diretmidae Plate 17

Diretmus argenteus (JOHNSON) Plate 4, Fig.57

M: 4 specimens L: Gulf of Guinea D: 400 m

FL in cm: 12
 OL in mm: 6.39
 OL:OW:OT approx. 1:1.30:0.23
 OL:FL approx. 1:19

Otolith resembles an isosceles triangle. Tip formed by two equal sides pointing forward. Caudal end of otolith appearing truncate, thus slightly distorting the triangular form. All three margins very sharp. Inc. appearing as very small, shallow notch, AR as insignificant short tip. S slightly curved, open anteriorly and posteriorly. Ostium broad, distinctly defined from the much longer cauda by sharply bent ventral crista. Colliculum poorly developed, but forming a raised ridge in ostium which extends as far as opening. D-margin slightly and irregularly sinuous, anterior margin, in particular its lower half, strongly sinuous. Ventral, round caudal end and posterior margin sharply serrate.

*

Order Zeiformes

Family Zeidae Plate 18

Zeus faber L. Dory Plate 4, Fig.58

M: 8 specimens L: Southern North Sea D: 40 m

FL in cm: 45

OL in mm: 3.76

OL:OW:OT approx. 1:0.70:0.27

OL:FL approx. 1:120

Otolith very small and strangely shaped; resembling a three-cornered star. Two relatively narrow corners forming the ventral part,

one pointing forward, the other rearward; the third corner forming the dorsal part, not exactly perpendicular, but slightly tilted backward, widening upward. On I-side, in a horizontal direction across the ventral corners, a ridge dividing the dorsal and ventral parts of otolith. This ridge shorter, but higher than lower arms, its ends curved slightly upward. S broad, very short and shallow, hardly recognizable, extending above ridge at lower end of dorsal corner, terminating open anteriorly and posteriorly. Ostium and cauda not defined from each other, colliculum absent. All margins almost smooth.

Zenopsis conchifer (LOWE) Plate 5, Fig.59

M: 6 specimens L: Gulf of Guinea D: 40 m

FL in cm: 63

OL in mm: 2.87

OL:OW:OT approx. 1:0.93:0.26

OL:FL approx. 1:220

Otolith almost identical with that of previous species, but dorsal corner mostly vertical, ventral corners tilted obliquely downward, not almost horizontal as in Zeus. Thus angles between corners almost identical. Anterior corner mostly broader than posterior one, often with a small, downward-oriented hook- or horn-shaped preeminence near the tip.

Family Caproidae Plate 18Antigonia capros LOWE Plate 5, Fig.60

M: 24 specimens L: Gulf of Guinea D: 100 m

FL in cm: 7

OL in mm: 3.89

OL:OW:OT approx. 1:1.44:0.27

OL:FL approx. 1:19

Otolith somewhat oval, more pointed end turned downward. I-side and O-side slightly convex, Inc. appearing as sharp notch in centre of anterior margin, R and AR short, pointed, of equal width. S closed posteriorly, open anteriorly. Ostium broad, sharply defined from longer cauda by sinuous ventral crista. Margins wavy, partly serrate, D-margin mostly with strongly protruding tip above cauda.

*

Order MugiliformesFamily Sphyraenidae Plate 18Sphyraena dubia BLEEKER Plate 5, Fig.61

M: 16 specimens L: Gulf of Guinea D: 40 m

FL in cm: 28 39 49

OL in mm: 8.95 10.91 11.53

OL:OW:OT approx. 1:0.33:0.15

OL:FL approx. 1:36

Otolith slender, pointed anteriorly, blunt posteriorly. I-side convex, O-side slightly concave. Inc. short, AR small, R long and pointed. S deep, straight, closed posteriorly, ostium terminating open and cup-shaped. Narrow area above dorsal crista. O-side and I-side smooth, margins gently wavy.

Sphyraena piscatorum CADENAT Plate 5, Fig.62

M: 4 specimens L: Gulf of Guinea D: 20 m

FL in cm: 101

OL in mm: 15.30

OL:OW:OT approx. 1:0.36:0.15

OL:FL approx. 1:66

Otolith almost identical with that of preceding species, but much more curved outward, posterior end of cauda distinctly broadening, area absent.

*

Order Polynemiformes

Family Polynemidae Plate 18

Pentanemus quinquarius (L.) Plate 5, Fig.63

M: 26 specimens L: Gulf of Guinea D: 30 m

FL in cm: 19 22

OL in mm: 6.26 6.66

OL:OW:OT approx. 1:0.55:0.14

OL:FL approx. 1:32

Otolith flat, somewhat oval. I-side slightly convex, O-side almost plane. Inc. and AR only indicated, very often absent. R moderately long, broad, slightly rounded. S long, curved downward posteriorly, cauda closed, ostium short, cup-shaped, terminating open. Outer and inner surfaces smooth, V-margin slightly sinuous, D-margin coarsely and unevenly sinuous or serrate.

Galeoides decadactylus (BLOCH) Plate 5, Fig.64

M: 30 specimens L: Gulf of Guinea D: 40 m

FL in cm: 27 36 40

OL in mm: 7.26 9.59 10.03

OL:OW:OT approx. 1:0.55:0.19

OL:FL approx. 1:38

Otolith slightly vitreous, anteriorly broadened and blunt, posteriorly rounded. Strongly curved, I-side moderately convex, O-side concave. Inc. and AR poorly developed, R short, without tip. S broad, wavy. Cauda long, slightly broadened posteriorly, terminating apparently closed, but groove continues to margin of otolith. Ostium short, funnel-shaped, terminating open. Margins deeply and irregularly serrate, V-margin sometimes almost smooth.

Order PerciformesFamily Serranidae Plate 18Anthias anthias (L.) Plate 5, Fig.65

M: 24 specimens L: Gulf of Guinea D: 100 m

FL in cm: 13 16

OL in mm: 5.65 5.82

OL:OW:OT approx. 1:0.54:0.19

OL:FL approx. 1:25

Otolith almost oval, Exc. and AR mostly absent, R strong, short, slightly rounded. S deep, slightly curved, distinctly constricted by ventral crista in anterior third. Cauda closed, ostium funnel-shaped, terminating open. D-margin strongly wavy or deeply sinuous. V-margin in young specimens slightly sinuous, in old specimens almost smooth.

Neanthias accraensis NORMAN Plate 5, Fig.66

M: 4 specimens L: Gulf of Guinea D: 50 m

FL in cm: 13 17

OL in mm: 6.91 8.50

OL:OW:OT approx. 1:0.57:0.22

OL:FL approx. 1:20

Otolith very similar to that of Anthias, but can easily be distinguished from the latter. Terminating pointed anteriorly and

posteriorly, I-side moderately convex, O-side only gently concave. Inc. shallow, AR blunt, very short, R broad, rounded, curved upward in a hook-like manner. S deep, cauda turned downward posteriorly, closed, ostium distinctly defined by sharp recession of ventral crista, flatter than cauda. Margins slightly wavy, sometimes isolated, more prominent protuberances on D-margin.

Epinephelus aeneus GEOFF.ST.-HIL. Plate 5, Fig.67

M: 4 specimens L: Gulf of Guinea D: 70 m

FL in cm: 88

OL in mm: 26.65

OL:OW:OT approx. 1:0.52:0.14

OL:FL approx. 1:33

Otolith oval, caudal end broad and rounded, pointed anteriorly, strongly curved outward. I-side convex, O-side moderately concave. Inc. small but distinct, AR short and pointed, R strong and slightly rounded. S deep, cauda turned downward posteriorly, closed; ostium broader and more clearly defined by respective upward and downward bends of cristae. Margins irregularly serrate, dorsal margin usually more than ventral margin.

Family Priacanthidae Plate 18

Priacanthus arenatus CUV. Plate 5, Fig.68

M: 26 specimens L: Gulf of Guinea D: 70 m

FL in cm: 14
 OL in mm: 1.63
 OL:OW:OT approx. 1:1.10:0.35
 OL:FL approx. 1:85

Otolith peculiarly shaped; wider than long, caudal end evenly rounded, sometimes with deep notch in centre, V-margin forming a pointed hook anteriorly. Dorsal part thick, margin broad, ventral part thin, margin with sharp edge. I-side and O-side convex. S straight, anteriorly moderately deep and terminating open, becoming more shallow rearward and recognizable only by the cristae which rise like two walls above the level of the surface and extend close to the caudal margin of the otolith. They terminate abruptly without combining posteriorly. Thus S open posteriorly, too. Margins slightly wavy, V-margin frequently sinuous.

29

Family Apogonidae Plate 18

Synagrops microlepis NORMAN Plate 5, Fig.69

M: 10 specimens L: Gulf of Guinea D: 200 m

FL in cm: 12
 OL in mm: 7.31
 OL:OW:OT approx. 1:0.50:0.11
 OL:FL approx. 1:16

Otolith flat, broadest in centre, posteriorly rounded,

anteriorly acutely pointed. I-side slightly convex, O-side plane, Inc. and AR only indicated, R short, very broad. S straight, cauda closed, ostium long, cup-shaped, terminating open. Margins smooth, sometimes slightly wavy, caudal margin frequently sinuous.

Epigonus telescopus (RISSO) Plate 5, Fig.70

M: 24 specimens L: Iceland, Gulf of Guinea D: 300-400 m

FL in cm: 20 23 32

OL in mm: 10.25 11.41 12.85

OL:OW;OT approx. 1:0.70:0.17

OL:FL approx. 1:22

Otolith compact, angular, frequently rhomboid, anterior end slightly curved outward. I-side gently convex, O-side almost plane. Inc. small and shallow, AR short, mostly pointed, R also with sharp, slightly upturned tip. S broad, deep, straight, cauda terminating closed. Ostium approx. equally long, but considerably wider/on account of bent ventral crista. D-margin slightly wavy, V-margin finely serrate or sinuous.

Remarks: The otoliths of Icelandic fishes are not pronouncedly rhomboid, but almost triangular. Inc. more deeply incised, AR longer than in West African specimens. However, since tropical specimens were available to a length of only 23 cm, while Icelandic specimens were available only from a length of 30 cm upwards, it cannot be precluded that the features change with

increasing age.

Family Latilidae Plate 18

Latilus semifasciatus NORMAN Plate 5, Fig.71

M: 12 specimens L: Gulf of Guinea D: 70 m

FL in cm: 23 41

OL in mm: 7.57 12.29

OL:OW:OT approx. 1:0.65:0.19

OL:FL approx. 1:32

Otolith approx. oval, rounded posteriorly, acutely pointed anteriorly. I-side slightly convex, O-side concave. Inc. short, AR small and blunt, R broad, moderately long, pointed. S deep, anteriorly and posteriorly open in older specimens, cauda terminating closed shortly before otolith margin in younger specimens. Ostium only slightly broadening. Dorsal crista arched, forming a sharp ridge, particularly in otoliths of older specimens. O-side strongly folded, margins sinuous, often deeply divided.

Family Scombropidae Plate 18

Hypoclydonia bella GOODE & BEAN Plate 5, Fig.72

M: 18 specimens L: Gulf of Guinea D: 200 m

FL in cm: 15 18 21

OL in mm: 5.17 5.98 6.57

OL:OW:OT approx. 1:0.65:0.20

OL:FL approx. 1:30

Otolith almost conical, rounded posteriorly, acutely pointed anteriorly. I-side slightly convex, O-side slightly concave. Inc. and AR absent. S peculiarly shaped; cauda long, deep, posteriorly bent ventrad at a right angle, becoming narrower forward. Ostium short, greatly broadened, partly filled by colliculum; curves out slightly rearward so that part of ostium appears to lie on cauda. Margins slightly wavy, anterior part of D-margin often sharply serrate.

Family Carangidae Plate 19

The otolith type of this family is very uniform in the species examined. It is elongate, the caudal end is more or less rounded. A long, strong, slightly outward-curved R and a small, pointed AR lying far dorsad are always developed. In all species the I-side is slightly convex, the O-side concave.

Particularly characteristic for this family is the very deep sulcus which anteriorly broadens only slightly and always terminates open; but in the caudal part bends ventrad and terminates closed. Dorsal area is always developed. Other typical features are the finely serrate or sinuous V-margin and the coarsely sinuous or serrate D-margin.

Trachurus trachurus (L.) Horse mackerel Plate 5, Fig.73

M: 30 specimens L: North Sea D: 30-50 m

FL in cm: 27 29 35

OL in mm: 8.64 9.54 12.04

OL:OW:OT approx. 1:0.45:0.15

OL:FL approx. 1:30

Otolith elongate, acutely pointed anteriorly, rounded posteriorly. I-side moderately convex, O-side slightly concave. Inc. short, very sharp, AR small and pointed, R long, very strong, also very pointed. S long, deep, posteriorly slightly curved downwards. Ostium not defined from cauda. Cristae arched into ridges, a distinct area extending across dorsal crista as far as into AR. V-margin gently wavy or serrate, D-margin sharply serrate or coarsely sinuous.

Caranx ronchus GEOFF.ST.-HIL. Plate 5, Fig.74

M: 12 specimens L: Gulf of Guinea D: 40 m

FL in cm: 29

OL in mm: 7.92

OL:OW:OT approx. 1:0.51:0.15

OL:FL approx. 1:37

Otolith very similar to that of Trachurus, but posterior end of S bending much more sharply. Also, in this downward-oriented

part the dorsal margin is remarkably oblique, while in Trachurus both margins of S are almost vertical. Here too, area distinctly developed, but shorter than in preceding species, does not extend as far as AR. V-margin evenly and finely serrate, D-margin unevenly sinuous or serrate.

Scyris alexandrinus (GEOFF.ST.-HIL.) Plate 6, Fig.75

M: 14 specimens L: Gulf of Guinea D: 30 m

FL in cm: 29 38 60

OL in mm: 5.10 5.84 7.92

OL:OW:OT approx. 1:0.51:0.16

OL:FL approx. 1:65

Otolith elongate, I-side slightly convex, O-side slightly concave. Inc. short, very sharp, AR broad, mostly with fine long tip, R long, strong, but terminating blunt. S as in preceding species, area only flat and narrow. V-margin finely and regularly sinuous, D-margin more coarsely, irregularly sinuous.

Vomer setapinnis (MITCHILL) Plate 6, Fig.76

M: 18 specimens L: Gulf of Guinea D: 30 m

FL in cm: 21 23 25

OL in mm: 4.57 5.12 5.73

OL:OW:OT approx. 1:0.54:0.18

OL:FL approx. 1:45

Otolith almost rectangular, I-side moderately convex, O-side slightly concave. Inc. narrow, deep, AR strong, pointed. R long, very massive, with short tip lying far dorsad. Upper margin of R horizontal, represents an elongation of the dorsal edge of the otolith. S deep, also bending ventrad posteriorly. Ostium short, only slightly broadened. Dorsal crista highly arched, above it a well-developed area. Margins sinuous or serrate at differing degrees.

Family Emmelichthyidae Plate 19

Erythrocles monodi POLL & CADENAT Plate 6, Fig.77

M: 18 specimens L: Gulf of Guinea T: 70 m

FL in cm: 21 24

OL in mm: 7.01 8.29

OL:OW:OT approx. 1:0.45:0.14

OL:FL approx. 1:29

Otolith thin, fragile, sloping posteriorly, acutely pointed anteriorly. I-side slightly convex, O-side slightly concave. Inc. deep and narrow, sometimes partly overgrown so that only short notch remains visible. AR not long but strong and pointed, R broad, mostly slightly rounded. S deep, posteriorly bending slightly ventrad. Cauda long, closed, ostium short, broadened in cup-shaped manner, terminating open. Dorsal crista highly arching, above it a narrow,

flat area. V-margin finely and regularly serrate or sinuous, D-margin deeply and irregularly.

Family Lutjanidae Plate 19

Apsilus fuscus VAL. Plate 6, Fig.78

M: 12 specimens L: Gulf of Guinea D: 50 m

FL in cm: 21 28 ~~36~~

OL in mm: 5.99 7.75 9.48

OL:OW:OT approx. 1:0.48:0.17

OL:FL approx. 1:36

Otolith thin and fragile, shape similar to that of Erythrocles, but rounded anteriorly, curved outward. Inc. narrow, sometimes partly overgrown, but always remaining visible as sharp notch. AR strong and pointed, R broad and rounded. S long, rather deep, posteriorly bending ventrad. Cauda terminating closed, ostium short, distinctly defined, broadening in cup-shaped manner, terminating open. Area absent. V-margin only shallowly sinuous or serrate, D-margin coarsely sinuous, often deeply divided.

Lutjanus goreensis VAL. Plate 6, Fig.79

M: 6 specimens L: Gulf of Guinea D: 40 m

FL in cm: 53 79

OL in mm: 15.80 19.05

OL:OW:OT approx. 1:0.57:0.17

OL:FL approx. 1:37

Otolith massive, rounded anteriorly, blunt posteriorly; bending sharply in centre, both ends pointing outward. D-margin lying like a roof above straight V-margin. I-side strongly convex, O-side strongly concave. Inc. short and sharp, AR small but very pointed, R broad and rounded. S deep, comparatively short. Cauda sharply bending downward, terminating closed directly above ventral margin of otolith. Ostium distinctly defined, broadening greatly, terminating open. Margins irregularly and finely serrate, caudal end of V-margin mostly sharply serrate.

Lutjanus fulgens VAL. Plate 6, Fig.80

M: 14 specimens L: Gulf of Guinea D: 40 m

FL in cm: 36

OL in mm: 14.83

OL:OW:OT approx. 1:0.55:0.17

OL:FL approx. 1:24

Otolith similar to that of preceding species, but can easily be distinguished from it. Rounded anteriorly, more pointed posteriorly than in L. goreensis. Strongly curved, but not sharply bent. I-side strongly convex, O-side moderately concave. Inc. and AR only indicated, frequently absent, R broad and rounded. S deep, curving ventrad

much more posteriorly than in L. goreensis. Ostium short, cup-shaped, terminating open. D-margin irregularly serrate or sinuous, V-margin slightly wavy, sometimes serrate at caudal end.

Family Gerridae Plate 19

Eucinostomus melanopterus (BLEEKER) Plate 6, Fig.81

M: 18 specimens L: Gulf of Guinea D: 20 m

FL in cm: 15

OL in mm: 4.76

OL:OW:OT approx. 1:0.70:0.21

OL:FL approx. 1:32

Otolith compact, hyaline, strongly curved, V-margin sinuated downward. Inc. short, AR small, very pointed, lying far dorsad. R short, fairly broad, mostly rounded. S bending ventrad posteriorly, cauda deep and closed, ostium flat, funnel-shaped, terminating open. Margins strongly but irregularly sinuous, serrate or grooved.

Family Pomadasyidae Plate 19

The examined species of this family have compact, fairly uniformly shaped otoliths. The ratio otolith length:fish length varies between 1:21 and 1:26. The otoliths are compactly oval, anteriorly acute. I-side in all species strongly convex, O-side

concave, only in Brachydeuterus slightly convex. AR always very small or absent. Another characteristic is the sulcus which very distinctly is divided into a short broad ostium terminating open and a long narrow closed cauda bending ventrad posteriorly.

Pomadasys jubelini (CUV.) Plate 6, Fig.82

M: 30 specimens L: Gulf of Guinea D: 40 m

FL in cm: 27 34 41

OL in mm: 12.22 17.12 20.50

OL:OW:OT approx. 1:0.70:0.24 (older specimens)

" 1:0.64:0.27 (younger specimens)

OL:FL approx. 1:21

Otolith compact, anteriorly acute, posteriorly rounded. Anterior part of O-side often with sharp-edged crystalline deposits which may be rising acutely or column-shaped. I-side very strongly convex, O-side very strongly concave, Inc. and AR absent. R broad with short tip. S moderately deep; cauda narrow, bending vertically downward in centre, terminating closed, ostium flatter, approx. twice as broad, lying far dorsad, not broadening, terminating open. Margins almost smooth, only posterior half of D-margin sometimes deeply grooved or serrate.

Remarks: The otoliths of younger specimens up to approx. 35 cm long differ essentially from those of old specimens. They are more slender, almost oval, R longer, with sharp tip, Inc. and AR small but

distinctly recognizable. I-side strongly convex, O-side only slightly concave and always without crystalline deposits. V-margin smooth, D-margin slightly wavy.

Pomadasys incisus (BOWDICH) Plate 6, Fig.83

M: 14 specimens L: Gulf of Guinea D: 40 m

FL in cm: 19 24

OL in mm: 9.12 9.93

OL:OW:OT approx. 1:0.68:0.24

OL:FL approx. 1:22

Otolith closely resembling that of preceding species, but R slightly shorter and rounded, O-side only moderately concave. Inc. and AR small, becoming shallower with increasing age, but always present. However, since only specimens with a maximum total length of 24 cm were available, nothing can be said about the shape of older otoliths. S not as strongly curved as in P. jubelini. V-margin finely serrate, with increasing otolith size almost smooth, D-margin irregularly sinuous.

Pomadasys suillus (VAL.) Plate 6, Fig.84

M: 4 specimens L: Gulf of Guinea D: 30 m

FL in cm: 22 27

OL in mm: 8.14 10.60

OL:OW:OT approx. 1:0.67:0.26

OL:FL approx. 1:26

Otolith so similar to those of preceding species that it cannot with certainty be distinguished from them. Comparatively smaller than otolith in P. jubelini, O-side strongly concave already in small otoliths, Inc. and AR small, frequently absent, R slightly rounded. Ostium broader and slightly shorter than in P. jubelini. V-margin finely serrate, D-margin more coarsely serrate or sinuous.

Brachydeuterus auritus (VAL.) Plate 6, Fig.85

M: 26 specimens L: Gulf of Guinea D: 20-40 m

FL in cm: 15 18

OL in mm: 7.54 8.21

OL:OW:OT approx. 1:0.76:0.23

OL:FL approx. 1:21

Otolith compact, anteriorly with short, mostly slightly rounded tip, caudal end blunt and angular. I-side strongly convex, O-side slightly convex. Inc. and AR only indicated, often absent, R short, fairly broad, mostly rounded. S deep, slightly bent ventrad very far posteriorly. Cauda closed, ostium short, broad, terminating open. V-margin serrate or strongly sinuous, D-margin slightly sinuous, mostly almost smooth.

Family Gaterinidae Plate 19Gaterin mediterraneus (GUICHENOT) Plate 6, Fig.86

M: 6 specimens L: Gulf of Guinea D: 30 m

FL in cm: 38 47

OL in mm: 13.68 14.88

OL:OW:OT approx. 1:0.54:0.17

OL:FL approx. 1:30

Otolith elongate, comparatively thin, strongly curved; anteriorly and posteriorly tapering into short, not very sharp tip. I-side strongly convex, O-side moderately concave. Inc. short, AR small and pointed, R very broad, long, slightly rounded. S deep, not very long. Cauda posteriorly bent ventrad, closed, ostium flatter, funnel-shaped, terminating open. Short area above dorsal crista. O-side on dorsal half of otolith distinctly folded. V-margin finely and irregularly serrate, D-margin deeply sinuous and grooved.

Family Sciaenidae Plate 19

The otoliths of this family agree in so many characteristic features that we can speak of a "sciaenid type". They are large, extraordinarily compact, and often appear rather shapeless. The ratio otolith length:fish length varies between 1:18 and 1:28, the ratio length:thickness may be as high as 1:0.45. Other typical features are the almost smooth margins, the smooth, never folded inner

surface, the complete absence of Inc. and AR, humps on the O-side, and the development of the sulcus, the long and deep cauda of which terminates far posteriorly, above the V-margin, rises as far as below the D-margin, and there bends forward. The ostium is very flat, unusually broad, mostly vesicular, narrows posteriorly into a narrow canal, and terminates open.

Pseudotolithus typus BLEEKER Plate 6, Fig.87

35

M: 26 specimens L: Gulf of Guinea D: 30-50 m

FL in cm: 37 50 65

OL in mm: 17.17 23.42 25.67

OL:OW:OT approx. 1:0.47:0.23

OL:FL approx. 1:23

Otolith anteriorly and posteriorly approx. equally broad, evenly rounded and often razor-sharp anteriorly, increasing wedge-like in thickness posteriorly. D-margin increasingly curving inward, approx. from centre of otolith extending as high sharp ridge to caudal end. Above D-margin on posterior part of otolith numerous humps which are intergrown and in older specimens may often form loops and rings. I-side strongly convex, O-side plane, Inc. and AR absent. S very peculiarly shaped. Cauda deep, terminating closed far posteriorly, directly above V-margin; rising vertically upward, gradually becoming horizontal and extending directly below the inward-arched D-margin; narrowing somewhat and terminating,

apparently closed, in anterior half of otolith. Only a hair-thin groove extending farther forward under D-margin, terminating open. Below this groove a shallow, vesicular depression which is sinuated rearward, occupies approx. three quarters of the width of the otolith, narrows considerably anteriorly, and opens far dorsad into fine marginal notch together with groove. EZIUZO (1963) regards only the narrow groove as the ostium, but presumably the vesicular depression must be included. In the following species a development series becomes clearly recognizable in the course of which the cauda anteriorly becomes gradually more shallow and merges into the vesicular depression increasingly more harmoniously. This transition moves from the D-margin closer to the centre, the depression becomes smaller from species to species, and finally attains the known form of a strongly broadened ostium. The narrow, slightly depressed groove always remains as dorsal boundary of the ostium.

Pseudotolithus brachygnathus BLEEKER Plate 6, Fig.88

M: 4 specimens L: Gulf of Guinea D: 40 m

FL in cm: 83

OL in mm: 29.90

OL:OW:OT approx. 1:0.58:0.34

OL:FL approx. 1:28

Otolith closely resembling that of preceding species, but broader and strongly curved outward. D-margin bending sharply in

centre of otolith before merging into curved anterior margin, arching inward only in posterior half of otolith. Hump-like growths on O-side particularly well developed.

Pseudotolithus elongatus (BOWDICH) Plate 7, Fig.89

M: 16 specimens L: Gulf of Guinea D: 20 m

FL in cm: 39

OL in mm: 21.45

OL:OW:OT approx. 1:0.58:0.35

OL:FL approx. 1:18

Otolith not sharply conical as in P. typus, posteriorly considerably thicker than the latter. D-margin highly arched, not merging into anterior margin without transition but terminating abruptly, thus forming a shallow notch into which the ostium opens. S deep, cauda longer than in preceding species, ostium as in Pseudotolithus. Thickened growths on O-side coalesced into one.

36

Larimus peli BLEEKER Plate 7, Fig.90

M: 18 specimens L: Gulf of Guinea D: 30-40 m

FL in cm: 13 18

OL in mm: 7.36 9.91

OL:OW:OT approx. 1:0.83:0.42

OL:FL approx. 1:18

Otolith very compact, conical, anterior margin razor-sharp. D-margin only slightly arched inward, V-margin straight, forming a sharp corner with caudal margin. I-side and O-side convex. S as in Corvina, but the vesicular ostium already considerably smaller. Thickenings on O-side relatively poorly developed.

Umbrina canariensis VAL. Plate 7, Fig.91

M: 22 specimens L: Gulf of Guinea D: 70 m

FL in cm: 20 27 33

OL in mm: 8.26 10.44 12.72

OL:OW:OT approx. 1:0.76:0.45

OL:FL approx. 1:25

Otolith resembling that of Larimus, but easily distinguished from it. Basic form approx. oval, posteriorly broader, dorsal and caudal margins meeting at acute angle, forming a corner which in contrast to Larimus lies on top. Otolith thickening very rapidly only from centre onwards so that conical form is not distinct. On O-side mostly only 1-4 isolated high humps. D-margin not arched inward. S moderately deep, cauda curved, tapering anteriorly, becoming more shallow and protruding slightly into ostium which shows heart-shaped widening and terminates far dorsally through a fine notch. Margins almost smooth.

Sciaena mbizi POLL. Plate 7, Fig.92

M: 22 specimens L: Gulf of Guinea D: 70 m

FL in cm: 19 22 26

OL in mm: 9.66 10.54 11.81

OL:OW:OT approx. 1:0.66:0.35

OL:FL approx. 1:21

Otolith closely resembling that of Umbrina, but can be distinguished from it with certainty. I-side only slightly convex, often almost plane; in Umbrina very strongly convex. Cauda not tapering, but merging into heart-shaped, anteriorly pointed ostium without narrowing. Thickenings on O-side consisting of few humps which mostly are very flat. Margins smooth, D-margin sometimes slightly wavy.

Sciaena angolensis NORMAN

Otolith resembles that of S. mbizi so closely that distinction is impossible.

Family Sparidae Plate 20

The otoliths of this family form a very uniform group with very characteristic similarities. They are compact, with sloping caudal end. The broad, short, frequently slightly upward-pointing rostrum mostly acutely pointed, but it may also be long

and rounded, as e.g. in Spondyliosoma. Antirostrum always very small or altogether absent. I-side always convex, anterior and posterior ends of otolith curved outward. Characteristic features are above all the deeply sinuous and serrate D-margin, the much more finely sinuous or serrate V-margin, the folded surface, and the deep sulcus. Cauda deep, curved ventrad posteriorly; the equally deep, distinctly defined ostium becoming funnel-shaped, terminating open. Dorsal crista always highly arched, above it an area in all species.

Dentex angolensis POLL & MAUL Plate 7, Fig.93

M: 24 specimens L: Gulf of Guinea D: 50 m

FL in cm: 14 16

OL in mm: 7.02 7.81

OL:OW:OT approx. 1:0.77:0.25

OL:FL approx. 1:20

Otolith compact, anteriorly with short, outward-curved tip, posteriorly blunt or rounded. I-side moderately convex, O-side gently convex, often plane. Inc. indicated, AR small, mostly blunt, sometimes absent. R broad with short tip pointing upward. S deep, turned slightly downward posteriorly, closed; ostium cup-shaped. Well-developed area above arched dorsal crista. D-margin deeply and irregularly sinuous, V-margin slightly sinuous.

Dentex congoensis POLL Plate 7, Fig.94

M: 24 specimens L: Gulf of Guinea D: 50 m

FL in cm: 19 21

OL in mm: 9.01 9.79

OL:OW:OT approx. 1:0.78:0.25

OL:FL approx. 1:21

Otolith very similar to that of preceding species, but O-side always slightly convex. Inc. sharp, AR broader and more pointed, ventral crista of ostium sometimes wavy. O-side deeply folded, in D. angolensis only gently folded, margins deeply sinuous, often sharply serrate.

Dentex filusus VAL. Plate 7, Fig.95

M: 8 specimens L: Gulf of Guinea D: 70 m

FL in cm: 44 47

OL in mm: 14.32 14.92

OL:OW:OT approx. 1:0.59:0.16

OL:FL approx. 1:31

Otolith clearly distinct from those of previous species. More elongate, oval, with long tip which is not turned upward. I-side convex, O-side moderately concave. Inc. small, sharp, AR short and pointed, both may be absent. S deep, curved obliquely downward posteriorly, funnel-shaped anteriorly. Area above dorsal

crista well developed, distinct folds on O-side. V-margin finely serrate or sinuous, D-margin and caudal margin deeply and sharply serrate and grooved.

Pagrus pagrus-(L.) Plate 7, Fig.96

M: 4 specimens L: Gulf of Guinea D: 100 m

FL in cm: 47

OL in mm: 14.26

OL:OW:OT approx. 1:0.53:0.23

OL:FL approx. 1:33

Basic form and size as in D. filusus, but most of the other features are different. Otolith considerably thicker, strongly curved outward. I-side convex, O-side moderately concave. Inc. and AR poorly developed, R strong, short, mostly slightly rounded. S unusually deep, curved posteriorly, closed shortly above V-margin. Slightly more shallow, horizontal continuation of cauda extending as far as posterior margin of otolith. Ostium funnel-shaped, also extraordinarily deep. Dorsal crista highly arched, above it a well-developed area. Folds distinct. D-margin very typical; sharp-edged, deeply serrate, appearing broken off. V-margin strongly serrate. Caudal margin irregularly serrate, often appearing fringed.

Pagrus gibbiceps (VAL.) Plate 7, Fig.97

M: 12 specimens L: Gulf of Guinea D: 70 m

FL in cm: 29 33
 OL in mm: 10.13 11.48
 OL:OW:OT approx. 1:0.65:0.22
 OL:FL approx. 1:29

Otolith compact, thinner and less curved than in P. pagrus. I-side strongly convex, O-side moderately concave. Inc. and AR indicated, frequently absent. R strong, short, mostly pointed. S very deep, cauda long, bending obliquely downward, ostium short and funnel-shaped. Deep area above horizontal part of cauda. Surface of O-side deeply folded. D-margin deeply divided and serrate, V-margin irregularly serrate.

Pagrus ehrenbergi VAL. Plate 7, Fig.98

M: 22 specimens L: Gulf of Guinea D: 40 m
 FL in cm: 29 37 57
 OL in mm: 10.06 11.73 16.22
 OL:OW:OT approx. 1:0.72:0.22
 OL:FL approx. 1:32

Otolith more compact than in P. gibbiceps, strongly curved. I-side strongly convex, O-side moderately concave. Inc. and AR sometimes indicated, mostly absent. R broad, short, rounded. S more shallow than in preceding species, downward-curved end of cauda shorter. Distinct area above dorsal crista. Folds on O-side

clearly visible, especially in older specimens. D-margin sharply and irregularly serrated or notched, V-margin more finely so, but also sharply.

Pagellus coupei DIEUZEIDE Plate 7, Fig.99

M: 26 specimens L: Gulf of Guinea D: 50-100 m

FL in cm: 16 21 30

OL in mm: 7.57 9.05 11.85

OL:OW:OT approx. 1:0.66:0.22

OL:FL approx. 1:23

Otolith rounded posteriorly, anteriorly with short tip which is slightly curved outward. I-side only moderately convex, O-side very slightly concave. Inc. and AR small and hardly visible, R broad, moderately long, with mostly sharp tip **pointing upward**. S deep, posterior end slightly bending ventrad, ostium funnel-shaped. 39 Distinct area above dorsal crista. Surface of O-side only gently folded. D-margin strongly sinuous, but never sharply serrate and divided as in the two preceding species, V-margin wavy or more finely sinuous.

Boops boops (L.) Plate 7, Fig.100

M: 16 specimens L: Gulf of Guinea D: 70 m

FL in cm: 12 14

OL in mm: 4.92 5.28

OL:OW:OT approx. 1:0.57:0.22

OL:FL approx. 1:25

Otolith slightly oval, posteriorly rounded, anteriorly with slightly outward-turned tip. I-side moderately convex, O-side slightly concave. Inc. short and sharp, AR small, strong, and pointed like the broad R. S deep, cauda bending ventrad, ostium funnel-shaped. A flat and insignificant area above central portion of dorsal crista. Folds on surface poorly developed. V-margin almost smooth, D-margin irregularly sinuous.

Spondyliosoma cantharus (L.) Plate 7, Fig.101

M: 20 specimens L: Southern North Sea D: 40-80 m

FL in cm: 16 37 41

OL in mm: 5.58 12.52 13.60

OL:OW:OT approx. 1:0.52:0.15

OL:FL approx. 1:30

Otolith elongate, strongly curved. I-side strongly convex, O-side concave. Inc. mostly short and sharp, AR small, broad and pointed. R for this family extremely long, slender and rounded. S as in preceding species: cauda bending ventrad, ostium cup-shaped, dorsal crista highly arched, above it a deep area. Surface of O-side distinctly folded. D-margin deeply divided and serrate, V-margin, particularly its caudal portion, strongly serrate and sinuous.

Remarks: Basic form very variable. R sometimes only short and blunt, frequently Inc. and Ar are well developed in one otolith of a pair while they are altogether absent in the other one.

Family Lethrinidae Plate 20

Lethrinus atlanticus VAL. Plate 7, Fig.102

M: 10 specimens L: Gulf of Guinea D: 30-40 m

FL in cm: 28

OL in mm: 8.88

OL:OW:OT approx. 1:0.69:0.27

OL:FL approx. 1:32

Otolith approx. oval, anteriorly slightly rounded; blunt caudal end with remarkably deeply and sharply serrate margin is typical. I-side strongly convex, O-side concave. Otolith strongly curved. Inc. mostly narrow, deep, lying far dorsad, AR small and pointed, R very broad, rounded. S deep, **cauda** horizontal in anterior half, posterior half bending ventrad. Ostium funnel-shaped, approx. as long as cauda. Well-developed narrow area above dorsal crista. Folds on surface gentle, V-margin and D-margin moderately sinuous and serrate.

Family Maenidae Plate 2040Smaris macrophthalmus CADENAT Plate 7, Fig.103

M: 22 specimens L: Gulf of Guinea D: 50 m

FL in cm: 17 19 21

OL in mm: 6.77 7.12 7.59

OL:OW:OT approx. 1:0.75:0.22

OL:FL approx. 1:27

Otolith resembling those of Sparidae. Compact, slightly curved outward, anteriorly with very short tip. I-side moderately convex, O-side gently concave. Inc. and AR insignificant, R short, very broad, slightly rounded. S deep, differing from Sparidae by terminal end of cauda bending only slightly ventrad. Ostium funnel-shaped, well-developed area above highly arched dorsal crista. D-margin deeply grooved, often sharply serrate, V-margin finely serrate.

Family Mullidae Plate 20Mullus surmuletus L. Red mullet Plate 7, Fig.104

M: 4 specimens L: Southern North Sea D: 40 m

FL in cm: 26

OL in mm: 3.75

OL:OW:OT approx. 1:0.70:0.20

OL:FL approx. 1:70

Otolith compact, anteriorly slightly tapering, caudal end broad, sloping or rounded. I-side moderately convex, O-side concave. Inc. frequently broad and deep, not infrequently absent altogether. AR broad and pointed, sometimes absent too. R broad and rounded. S deep, cauda greatly broadened posteriorly by bending of ventral crista, terminating closed, ostium unusually deep, cup-shaped, terminating open. Poorly developed colliculum frequently recognizable in S. Dorsal crista arched into ridge, above it a narrow but particularly deep area. Margins strongly and irregularly sinuous and wavy.

Pseudupeneus prayensis (CUV.) Plate 8, Fig.105

M: 14 specimens L: Gulf of Guinea D: 20 m

FL in cm: 20 23

OL in mm: 3.60 4.17

OL:OW:OT approx. 1:0.72:0.21

OL:FL approx. 1:55

Otolith very similar to that of Mullus. I-side convex, O-side slightly concave. Inc. mostly sharp, AR strong and pointed, R broad and rounded. S almost identical with that in Mullus, ostium usually less broadened. Deep area immediately above dorsal crista. V-margin deeply grooved, often sharply serrate, D-margin only slightly sinuous.

Remarks: Very often Inc. filled with hyaline otolith material, apparently disappearing. R and AR no longer defined from each other, but under the microscope, under transmitted light, still clearly recognizable.

Family Ehippidae . Plate 20

Drepane africana OSORIO Plate 8, Fig.106

M: 16 specimens L: Gulf of Guinea D: 20 m

FL in cm: 24 27 31

OL in mm: 10.17 10.28 12.40

OL:OW:OT approx. 1:0.76:0.17

OL:FL approx. 1:25

Otolith flat, fragile, slightly curved. Of approx. equal width anteriorly and posteriorly, rounded on both ends. I-side moderately convex, O-side moderately concave. Inc. small but distinct, AR short, broad, not very pointed. R also short, fairly broad, mostly rounded, not infrequently with small tip which turns upward like a hook. S narrow and deep in centre, cauda broadening rearward, becoming shallow at the same time and terminating closed. Frequently becoming so shallow at the end that it appears to merge into margin open. Ostium cup-shaped, terminating open. Not very deep area over dorsal crista. D-margin deeply divided and sharply serrate, V-margin more finely, but also strongly serrate.

Chaetodipterus goreensis (CUV.) Plate 8, Fig.107

M: 16 specimens L: Gulf of Guinea D: 20 m

FL in cm: 24 27

OL in mm: 6.90 7.57

OL:OW:OT approx. 1:062:0.22

OL:FL approx. 1:35

Otolith approx. oval, strongly curved, more elongate and relatively much smaller than the otolith of Drepane. I-side strongly convex, O-side moderately concave. Inc. small but not very sharp. AR short, mostly blunt. R similar to that of preceding species; broad, mostly rounded, sometimes with short tip bent upward like a hook. S as in Drepane - narrow in centre, widening in both directions, cauda bending ventrad. Flat area above dorsal crista. D-margin coarsely sinuous or serrate, V-margin finely serrate or sinuous.

Family Chaetodontidae Plate 20Chaetodon luciae ROCHERBRUNE Plate 8, Fig.108

M: 12 specimens L: Gulf of Guinea D: 30 m

FL in cm: 11 15 19

OL in mm: 5.07 6.52 7.82

OL:OW:OT approx. 1:0.54:0.21

OL:FL approx. 1:23

Otolith elongate, anteriorly more or less pointed, posteriorly rounded. I-side convex, O-side slightly concave. Inc. and AR poorly developed, R broad, moderately long, mostly slightly rounded, but sometimes acutely pointed. S not very deep, extending obliquely across otolith. Posterior end of cauda curving ventrad, terminating closed. Ostium short, funnel-shaped, terminating open far dorsally. D-margin strongly sinuous, often sharply serrate, V-margin gently wavy or finely serrate.

Chaetodon hoefleri STEINDACHNER

Otolith cannot be distinguished from that of C. luciae. In both species, all features are completely identical.

Chaetodon marcellae POLL Plate 8, Fig.109

M: 4 specimens L: Gulf of Guinea D: 70 m

FL in cm: 11 12

OL in mm: 4.91 4.94

OL:OW:OT approx. 1:0.51:0.24

OL:FL approx. 1:23

Otolith distinctly different from that of the two preceding species. Thicker, more elongate, I-side moderately convex, O-side almost plane. Inc. small but distinct, AR short, broad, rounded like R. S not deep, curved downward posteriorly, ostium only slightly

broadened, terminating open. D-margin slightly wavy, with characteristic strong indentation in centre, V-margin gently sinuous or serrate.

Family Cepolidae Plate 20

Cepola pauciradiata CADENAT Plate 8, Fig.110

M: 4 specimens L: Gulf of Guinea D: 100 m

FL in cm: 25 31

OL in mm: 5.87 6.15

OL:OW:OT approx. 1:0.52:0.18

OL:FL approx. 1:45

Otolith elongate, anteriorly pointed, posteriorly mostly rounded, sometimes also pointed. I-side slightly convex, O-side plane. Inc. and AR only dimly indicated, R strong, with sharp tip slightly turned upward. S moderately deep, greatly constricted by both cristae; cauda short, closed, ostium approx. twice the length of cauda, extending upward in a gentle curve, hardly broadening, terminating open. Well-developed colliculum visible at constricted point. Margins almost smooth.

Family Pomacentridae Plate 21

Chromis lineatus CADENAT Plate 8, Fig.111

M: 20 specimens L: Gulf of Guinea D: 70 m

FL in cm: 12 16
 OL in mm: 5.36 6.60
 OL:OW:OT approx. 1:0.57:0.22
 OL:FL approx. 1:23

Otolith approx. oval, I-side moderately convex, O-side slightly concave. Inc. short, mostly sharply incised, AR small and pointed, R broad and strong. S deep, cauda curving obliquely downward posteriorly, ostium funnel-shaped, deeper and only slightly shorter than cauda. V-margin finely serrate or sinuous, D-margin coarsely so.

Family Labridae Plate 21

The otoliths of this family vary so greatly in shape and features that it is impossible to give a characteristic description valid for the entire family. Here we are far from a "typical" labrid otolith.

Ctenolabrus rupestris (L.) Plate 8, Fig.112

M: 4 specimens L: Western Baltic Sea D: 10 m

FL in cm: 11
 OL in mm: 2.16
 OL:OW:OT approx. 1:0.65:0.23
 OL:FL approx. 1:50

Otolith compact, pointed anteriorly and posteriorly, D-margin much more strongly curved than V-margin. I-side slightly convex, O-side plane. Inc. long and sharp, AR broad, acutely pointed, R very strong, slightly rounded anteriorly. S straight, horizontal, in the centre very narrow and shallow, broadening and deepening evenly forward and rearward, ostium always terminating open. Margins thick, only gently wavy.

Coris julis L. Plate 8, Fig.113

M: 12 specimens L: Gulf of Guinea D: 20 m

FL in cm: 21

OL in mm: 4.10

OL:OW:OT approx. 1:0.56:0.22

OL:FL approx. 1:50

Otolith approx. triangular, longest side at bottom, shortest side at top anteriorly. I-side moderately convex, O-side plane. Inc. poorly developed, AR broad, blunt, very short, R strong, moderately long, slightly rounded. S deep, straight, cauda long and closed, ostium short, funnel-shaped, terminating open. V-margin slightly serrate, D-margin almost smooth.

Hemipteronotus novacula (L.) Plate 8, Fig.114

M: 12 specimens L: Gulf of Guinea D: 20 m

FL in cm: 18

OL in mm: 4.18

OL:OW:OT approx. 1:0.85:0.27

OL:FL approx. 1:43

Otolith almost round, I-side strongly convex, O-side plane. Small Inc. and short pointed AR sometimes present, but mostly absent. S deep, straight, of even width, closed posteriorly, open anteriorly. Sometimes not median, but in dorsal half of otolith. Margins slightly and irregularly sinuous.

Pseudolepidaplois scrofa (VAL.) Plate 8, Fig. 115

M: 4 specimens L: Gulf of Guinea D: 40 m

FL in cm: 55

OL in mm: 8.01

OL:OW:OT approx. 1:0.46:0.16

OL:FL approx. 1:70

Otolith elongate, anteriorly blunt, posteriorly sloping and pointed. I-side moderately convex, O-side almost plane as in preceding species. Inc. indistinct, R and AR visible only as two small, almost equally long growths. S very broad, unusually deep, straight, horizontal; narrow in centre, somewhat more shallow, broadening forward and rearward. Cauda closed, ostium open. D-margin coarsely serrate, V-margin more finely, irregularly serrate.

Family Scaridae Plate 21Scarus hoefleri (STEINDACHNER) Plate 8, Fig.116

M: 14 specimens L: Gulf of Guinea D: 30 m

FL in cm: 22

OL in mm: 3.63

OL:OW:OT approx. 1:0.61:0.18

OL:FL approx. 1:60

Otolith thin and fragile, glassily transparent, rectangular to trapezoid. I-side slightly convex, O-side slightly concave. Inc. mostly very deep, R long, blunt, fairly broad, AR only slightly shorter, rounded. S straight, comparatively narrow and shallow in centre, broadening and deepening forward and rearward, cauda and ostium terminating open. Dorsal crista highly arched, above it a deep area. Surface of O-side, particularly in ventral part of otolith, strongly folded. V-margin deeply grooved and serrate, D-margin slightly sinuous or wavy.

Remarks: In some cases Inc. only flat, then R and AR appear correspondingly shorter.

Family Trachinidae Plate 21

Otoliths vary from species to species, but the relationship among them is clearly recognizable. Otolith oval to lanceolate, Inc. and AR indicated or altogether absent, R always well developed.

The sulcus is the most important characteristic of the family. It is comparatively narrow, filled by colliculum, ostium and cauda hardly defined from each other. Cauda terminating closed at a long distance from posterior margin of otolith, ostium hardly broadening, terminating open. S frequently located in dorsal half of otolith. Margins only slightly sinuous or wavy, often almost smooth.

Trachinus draco (L.) Greater weever Plate 8, Fig.117

M: 4 specimens L: Southern North Sea D: 35 m

FL in cm: 32

OL in mm: 9.48

OL:OW:OT approx. 1:0.41:0.14

OL:FL approx. 1:34

Otolith elongate, posteriorly rounded, ventral part acutely pointed anteriorly. I-side slightly convex, O-side plane. Inc. almost rectangular on account of perpendicular bend in D-margin, AR blunt and not prominent, R long, slightly curved upward anteriorly, rounded. S straight, filled by colliculum; often not median, but in dorsal part of otolith. Cauda closed, ostium hardly broadened, terminating open. D-margin slightly sinuous, V-margin almost smooth.

Trachinus vipera CUV. Lesser weever Plate 8, Fig.118

M: 24 specimens L: Southern North Sea D: 25-35 m

FL in cm: 12 14

OL in mm: 5.26 6.12

OL:OW:OT approx. 1:0.41:0.22

OL:FL approx. 1:23

Otolith approx. lanceolate, anteriorly with long and sharp tip, posteriorly with short tip lying far ventrad. I-side moderately convex, O-side slightly convex. Inc. and AR dimly indicated, mostly altogether absent. R long, with slightly upturned tip. S lying far dorsad, cauda closed, ostium hardly broadened, slightly curved upward, terminating open. D-margin and V-margin smooth or gently wavy.

Trachinus armatus SCHLEGEL Plate 9, Fig.119

45

M: 10 specimens L: Gulf of Guinea D: 50 m

FL in cm: 17 20

OL in mm: 7.50 8.33

OL:OW:OT approx. 1:0.53:0.21

OL:FL approx. 1:24

Otolith more compact than in preceding species, posteriorly rounded, anteriorly pointed. I-side moderately convex, O-side almost plane. Inc. and AR absent, R broad, with sharp, not curved tip. S lying dorsad, filled by colliculum, cauda closed, ostium not broadened, open. Margins very slightly sinuous or wavy.

Trachinus radiatus CUV. Plate 9, Fig.120

M: 4 specimens L: Gulf of Guinea D: 70 m

FL in cm: 33
 OL in mm: 11.80
 OL:OW:OT approx. 1:0.46:0.16
 OL:FL approx. 1:28

Otolith very different from previous ones. Elongate, tapering anteriorly, terminating in a not very sharp tip. Caudal end blunt and sloping, posterior margin divided and serrate. I-side moderately convex, O-side slightly concave. Inc. and AR merely indicated, R very short, slightly rounded. S median, cauda only partly filled by colliculum, ostium mostly slightly narrowing, terminating open. Long, deep area above dorsal crista, extending anteriorly as far as the AR. Anterior portion of D-margin strongly serrate and sinuous, for the rest the margins - except the caudal one - are only slightly and unevenly wavy.

Family Bembropidae Plate 21

Bembrops heterurus (MIRANDA RIBEIRO) Plate 9, Fig.121

M: 4 specimens L: Gulf of Guinea D: 200 m

FL in cm: 19
 OL in mm: 6.04
 OL:OW:OT approx. 1:0.53:0.21
 OL:FL approx. 1:31

Otolith elongate, anteriorly pointed, posteriorly rounded, often sloping. Ventral part thick, becoming thinner upward, finally forming a sharp dorsal edge. I-side and O-side slightly convex. Inc. short and sharp, AR small and pointed, R strong, slightly curved upward. S straight and short. Cauda filled by colliculum, closed. Ostium fairly deep, sharply defined by constriction of ventral crista, not broadened, terminating open. Short deep area above dorsal crista, directly below D-margin. D-margin coarsely and irregularly wavy or sinuous, V-margin gently wavy.

Family Uranoscopidae Plate 21

The otoliths of the three examined species are very similar. All of them are very massive, elongate-round, pronounced AR absent, margins only slightly wavy or sinuous. S closed anteriorly and posteriorly, moderately deep, always extraordinarily short. Above it mostly an area, but it may be absent.

Uranoscopus albesca REGAN Plate 9, Fig.122

M: 6 specimens L: Gulf of Guinea D: 70 m

FL in cm: 18

OL in mm: 7.63

OL:OW:OT approx. 1:0.59:0.31

OL:FL approx. 1:25

Otolith massive, posteriorly rounded or blunt, anteriorly sometimes with short tip, mostly also blunt. Margins wide and rounded, only anterior, sloping part of D-margin forming sharp edge. I-side slightly convex, O-side strongly convex, Inc. and AR sometimes indicated, mostly absent altogether. R short, broad, blunt, only rarely with short tip. S an elongated pit which is deepest and widest in the centre and becomes more shallow and narrower forward and rearward. Mostly a distinct area above dorsal crista. Margins slightly wavy, anterior portion of D-margin slightly sinuous.

Uranoscopus polli CADENAT Plate 9, Fig.123

M: 24 specimens L: Gulf of Guinea D: 70 m

FL in cm: 17 22 26

OL in mm: 6.18 9.18 9.43

OL:OW:OT approx. 1:0.57:0.28

OL:FL approx. 1:26

Otolith cannot with certainty be distinguished from that of U. albesca. O-side not as strongly convex as in the preceding species, R sometimes rounded, frequently with short tip. S mostly somewhat narrower, area usually distinct, but often only poorly developed. Margins irregularly wavy.

Remarks: On account of the relatively wide variability of the otolith form within a single species, these slight differences are not sufficient for clear distinction.

Uranoscopus cadenati POLL Plate 9, Fig.124

M: 12 specimens L: Gulf of Guinea D: 70 m

FL in cm: 17

OL in mm: 6.33

OL:OW:OT approx. 1:057:0.25

OL:FL approx. 1:27

Otolith very similar to that of preceding species, but distinction nevertheless easy. It is thinner and more slender, I-side only slightly convex, O-side plane or slightly concave. Inc. and AR sometimes indicated, mostly absent. R longer and more slender than in U. albesca, S somewhat narrower and more shallow. Area above dorsal crista mostly distinct, but may be absent. D-margin irregularly sinuous, V-margin smooth or gently wavy.

Family Anarhichadidae Plate 21

The otoliths of the three examined species are very similar. They are very small, the ratio OL:FL varies between 1:145 and 1:210. I-side always plane, O-side convex, V-margin long and slightly curved, D-margin short and very strongly curved. Caudal end rounded. The very long, pointed, ventrad-lying R and the short, rounded AR are typical; also characteristic are the deep S which is divided into a short, crater-shaped cauda and a longer, broadening, open ostium. O-side folded, with numerous small protuberances which

give the surface a roughened appearance.

Anarhichas lupus L. Atlantic wolffish Plate 9, Fig.125

47

M: 30 specimens L: Norway D: 80-140 m

FL in cm: 23 57 77

OL in mm: 2.60 3.34 4.74

OL:OW:OT approx. 1:0.60:0.27

OL:FL approx. 1:165

Otolith posteriorly rounded, I-side plane, O-side moderately convex. Inc. not long, AR short, broad, rounded, R extraordinarily long, strong, pointed. S deep, straight. Cauda short, crater-shaped, terminating closed a long distance before posterior margin of otolith. Ostium longer, broadening forward, terminating open. Ventral crista extending into the tip of R, arching highly, dorsal crista forming a high ridge only in its anterior portion. Above this part a short area, below the entire ventral crista a deep, ditch-like area. Surface of O-side deeply folded, often densely covered with short round protuberances which extend as far as the V-margin. O-side therefore appearing rough and prickly. D-margin deeply and coarsely sinuous, V-margin more finely so.

Remarks: Basic form changing with increasing age. Otoliths of young specimens mostly with smooth surface, without folds and protuberances, margins smooth, R short, AR and Inc. hardly visible.

However, otoliths of some young specimens 20-30 cm long already as well developed as otoliths of adult specimens.

Anarhichas minor OLAFSEN Spotted wolffish Plate 9, Fig.126

M: 18 specimens L: North Norway D: 240-300 m

FL in cm: 87

OL in mm: 6.01

OL:OW:OT approx. 1:0.61:0.33

OL:FL approx. 1:145

Otolith very similar to that of A. lupus, but can be distinguished from it with certainty. In relation to fish length larger and considerably thicker than that of preceding species, I-side appearing smoother since cristae are only slightly arched and the areae flatter. O-side very strongly convex. S in A. lupus a groove open in its entire length, in A. minor dorsal and ventral cristae from AR and R approach each other at an acute angle and merge. This results in a barrier which separates the funnel-shaped ostium completely from the short cauda which is hardly recognizable. Folds gentler, but protuberances distinct. Margins only slightly sinuous or wavy.

Anarhichas denticulatus KRØYER Northern wolffish Plate 9, Fig.127

M: 20 specimens L: Iceland D: 300-500 m

FL in cm: 97 119
 OL in mm: 4.45 5.61
 OL:OW:OT approx. 1:0.55:0.29
 OL:FL approx. 1:210

Otolith thick, I-side plane, O-side strongly convex. Inc. mostly not deep, AR rounded, only slightly prominent. R differing distinctly from that of the two preceding species; it is also long, but comparatively narrow, frequently divided once longitudinally, the result being a short ventral tip and above it a considerably longer, often round protuberance which represents the actual tip of R. S similar to that in A. minor, but cristae mostly not merging, only touching each other, so that ostium and cauda remain connected. Dorsal area flat, ventral area mostly absent. Protuberances on O-side short, often coalesced, therefore surface only slightly roughened. Folds poorly developed, margins slightly sinuous or wavy.

Family Lumpenidae Plate 22

48

Lumpenus lampretæformis (WALB.) Snake blenny Plate 9, Fig.128

M: 18 specimens L: Norway D: 100-150 m

FL in cm: 20 21 24
 OL in mm: 2.47 2.51 2.89
 OL:OW:OT approx. 1:0.54:0.28
 OL:FL approx. 1:83

Otolith approx. elliptical, V-margin only slightly curved. I-side plane, often slightly indented in centre, sometimes slightly convex. O-side slightly convex. Inc. short, mostly sharply notched, sometimes very shallow. AR small, broad, rounded, R only slightly longer, also rounded, frequently somewhat narrower than AR. S short, narrow, conical. Margins almost smooth, sometimes gently sinuous.

Family Zoarcidae Plate 22

Zoarces viviparus L. Eelpout Plate 9, Fig.129

M: 4 specimens L: North Sea, western Baltic Sea D: 20-50 m

FL in cm: 36

OL in mm: 2.88

OL:OW:OT approx. 1:0.54:0.24

OL:FL approx. 1:125

Otolith elongate, posteriorly rounded, anteriorly sloping, V-margin almost straight. I-side plane, O-side slightly convex, with small depressions. Inc. short, AR small, broad, rounded, R slightly longer, also broad and mostly rounded. S shallow, narrow in centre, broadening forward and rearward. Partly covered by ventral crista. Cauda closed, deeper ostium terminating open. Margins slightly and irregularly sinuous.

Lycodes vahlii gracilis SARS Vahl's eelpout Plate 9, Fig.130

M: 16 specimens L: Norway D: 250 m

FL in cm: 24 31 33

OL in mm: 4.19 4.54 4.86

OL:OW:OT approx. 1:0.70:0.29

OL:FL approx. 1:65

Otolith compact, approx. triangular, becoming much thinner towards D-margin. I-side plane, O-side moderately convex. Inc. shallow, AR hardly prominent, R short, broad, mostly rounded. S shallow, narrow, straight. Cauda short, closed, ostium approx. twice as long, distinctly defined by slight constriction by ventral crista, slightly broadened far forward, terminating open. Broad, not very deep dorsal area and narrow, shallow ventral area developed. Margins slightly and irregularly sinuous.

Lycodes esmarki COLLETT Esmark's eelpout Plate 9, Fig.131

M: 4 specimens L: Barents Sea D: 300 m

FL in cm: 39

OL in mm: 5.49

OL:OW:OT approx. 1:0.75:0.30

OL:FL approx. 1:70

Otolith difficult to distinguish from that of preceding species. Inc. and AR only dimly indicated, R even shorter than in

L. vahlii. Ostium more sharply defined from cauda since both cristae contribute to constriction. Margins slightly wavy or sinuous.

Family Brotulidae Plate 22

Brotula barbata (SCHNEIDER) Plate 9, Fig.132

M: 22 specimens L: Gulf of Guinea D: 70 m

FL in cm: 26 35 48

OL in mm: 16.46 19.80 28.10

OL:OW:OT approx. 1:0.26:0.17

OL:FL approx. 1:17

Otolith unusually long and narrow. Broadest in first third, then D-margin obliquely sloping forward and rearward as far as horizontal V-margin. Thus otolith pointed anteriorly and posteriorly. I-side convex, O-side almost plane, Inc. and AR absent. S moderately broad, completely filled by colliculum, extending closely below D-margin. Cauda somewhat tapering posteriorly, terminating open. Ostium shorter, somewhat broader by slight bending of ventral crista, narrowing to canal at tip of R, terminating open. D-margin always smooth, V-margin slightly wavy or sinuous, in young specimens sometimes sharply serrate.

Family Ammodytidae Plate 22Hyperoplus lanceolatus (LESAUVAGE) Plate 10, Fig.133

M: 10 specimens L: Irish Sea D: 30 m

FL in cm: 30 33 37

OL in mm: 4.80 5.44 5.87

OL:OW:OT approx. 1:0.43:0.18

OL:FL approx. 1:63

Otolith resembling a grain of rice. Anteriorly pointed, posteriorly rounded. I-side slightly convex, O-side plane, with shallow indentation in centre. Inc. small, almost rectangular, AR small, rounded, lying far dorsad, R short, broad, mostly also slightly rounded. S short, cauda very flat, straight, closed. Ostium somewhat longer, considerably deeper, distinctly defined by slight constriction by cristae; hardly broadening, terminating open. Margins smooth or slightly wavy.

Ammodytes tobianus L. Plate 10, Fig.134

M: 4 specimens L: Central North Sea D: 30 m

FL in cm: 15

OL in mm: 1.94

OL:OW:OT approx. 1:0.44:0.23

OL:FL approx. 1:77

Otolith distinctly different from that of preceding species.

Also elongate, but anteriorly only slightly tapering and blunt. I-side and O-side slightly convex. Inc. deeper, AR strong, short, R only little longer and thicker, both rounded anteriorly. S even shorter, cauda terminating already shortly behind centre of otolith. Margins slightly wavy or sinuous.

Family Callionymidae Plate 22

Callionymus lyra L. Plate 10, Fig.135

M: 14 specimens L: North Sea D: 30-40 m

FL in cm: 18

OL in mm: 2.74

OL:OW:OT approx. 1:0.50:0.20

OL:FL approx. 1:65

Otolith shaped like an isosceles triangle whose hypotenuse forms the V-margin and whose upper corner is rounded. Both tips slightly curved outward, I-side moderately convex, O-side slightly concave. Inc. short, mostly sharp, AR small, strong, slightly rounded. R substantially longer, broad, mostly pointed. S deep and short. Cauda closed, ostium distinctly defined by constriction by ventral crista, twice as long, only slightly broadened, terminating open. Cristae highly arched, dorsal area broad, deep, extending into AR, ventral area narrow, also deep, extending into R. Margins slightly wavy or sinuous.

Callionymus maculatus RAFINESQUE Plate 10, Fig.136

M: 6 specimens L: Southern North Sea D: 45 m

FL in cm: 14

OL in mm: 2.25

OL:OW:OT approx. 1:0.60:0.28

OL:FL approx. 1:62

Otolith distinctly different from that of C. lyra. Thicker, anterior tip short, posteriorly rounded. I-side and caudal part of O-side moderately convex, anterior part slightly concave. Inc. only indicated, AR small, rounded, R shorter than in C. lyra, also slightly rounded. S as in preceding species, dorsal area and ventral area only poorly developed. V-margin almost smooth, D-margin strongly sinuous.

Callionymus phaeton GÜNTHER Plate 10, Fig.137

M: 4 specimens L: Gulf of Guinea D: 200 m

FL in cm: 14

OL in mm: 3.47

OL:OW:OT approx. 1:0.55:0.27

OL:FL approx. 1:40

Otolith similar to that of C. lyra, but with distinct differences. Approx. triangular, very thick below, becoming thinner above. I-side convex, O-side almost plane. Inc. rounded cavity,

AR small, broad, rounded, R moderately long, hollowed like a spoon, strongly curved upward. S broad, very deep. Cauda closed, ostium not broadened, terminating open. Dorsal crista highly arched, above it a long deep area which extends as far as AR. Ventral area shallow, narrow and insignificant. V-margin smooth, D-margin strongly and irregularly serrate.

Family Acanthuridae Plate 22

Acanthurus monroviae STEINDACHNER Plate 10, Fig.138

M: 4 specimens L: Gulf of Guinea D: 40 m

FL in cm: 41

OL in mm: 8.19

OL:OW:OT approx. 1:0.59:0.24

OL:FL approx. 1:50

Otolith elongate, anteriorly pointed, posteriorly blunt, appearing broken off. I-side strongly convex, O-side strongly concave. Inc. sharp, AR short, slightly rounded, R long, broad, with sharp, slightly upturned tip. S deep, posteriorly bending downward at right angles, terminating closed; ostium gradually widening, terminating open. Shallow, insignificant area above dorsal crista. V-margin anteriorly finely sinuous or serrate, posteriorly smooth, D-margin slightly sinuous.

Family Trichiuridae Plate 22Trichiurus lepturus L. Cutlass fish Plate 10, Fig.139

M: 26 specimens L: Gulf of Guinea D: 100-200 m

FL in cm: 42 90

OL in mm: 4.00 7.07

OL:OW:OT approx. 1:0.42:0.18

OL:FL approx. 1:115

Otolith resembling a flat isosceles triangle, its hypotenuse forming the V-margin. Characteristic a sharp bend in longitudinal axis so that D-margin and V-margin point outward. Inc. and AR insignificant, R short, fairly broad, more or less pointed. S moderately deep, straight, of almost constant width, posteriorly closed, anteriorly open. Margins slightly serrate or sinuous.

Aphanopus carbo LOWE Black scabbardfish Plate 10, Fig.140

M: 10 specimens L: Iceland D: 300-400 m

FL in cm: 95

OL in mm: 7.01

OL:OW:OT approx. 1:0.43:0.14

OL:FL approx. 1:135

In spite of certain similarities, otolith distinctly different from that of Trichiurus. It is elongate, anteriorly pointed, posteriorly blunt, not curved longitudinally. I-side

slightly convex, O-side plane or slightly concave. Inc. and AR poorly developed, frequently absent, R broad and pointed. S as in preceding species, but becoming more shallow rearward and forward. V-margin finely serrate or sinuous, D-margin more coarsely so.

Family Scombridae Plate 22

Scomber scombrus L. Mackerel Plate 10, Fig.141

M: 16 specimens L: North Sea D: 35 m

FL in cm: 34

OL in mm: 4.41

OL:OW:OT approx. 1:0.35:0.12

OL:FL approx. 1:77

Otolith slender, posteriorly sloping, anteriorly very acute and slightly curved outward. I-side slightly convex, O-side slightly concave. Inc. sharp and deep, AR strong, mostly pointed, R very long, slender, horizontal, tapering evenly, terminating in sharp tip. S long, broad, deep, bending ventrad far posteriorly, terminating closed. Ostium short, hardly defined from cauda, widening into funnel, terminating open. Margins sinuous or serrate in different degrees.

Family Stromateidae Plate 22

Stromateus fiatola L. Plate 10, Fig.142

M: 18 specimens L: Gulf of Guinea D: 50 m

FL in cm: 27
OL in mm: 6.35
OL:OW:OT approx. 1:0.46:0.10
OL:FL approx. 1:44

Otolith elongate, flat, fragile, posteriorly more or less rounded or sloping, anteriorly acutely pointed. Both ends slightly curved outward. I-side slightly convex, O-side slightly concave. Inc. mostly short and sharp, AR not large but broad and pointed. R long and strong, with sharp, slightly upturned tip. S deep, cauda long, slightly curved downward far posteriorly, closed. Ostium considerably shorter, distinctly defined by ventral crista curving downward. Widening into cup, terminating open. Margins deeply sinuous, often sharply serrate.

Remarks: Length of R varies considerably, Inc. sometimes extending to beginning of cauda as deep narrow notch.

Paracubiceps multisquamis MARCHAL Plate 10, Fig.143

M: 18 specimens L: Gulf of Guinea D: 70-100 m

FL in cm: 17
OL in mm: 5.00
OL:OW:OT approx. 1:0.49:0.10
OL:FL approx. 1:34

In spite of great similarities, otolith distinctly different from that of Stromateus. It is more compact, posteriorly evenly rounded. I-side slightly convex, O-side slightly concave. Inc. short, mostly slightly rounded, AR only small, blunt, R broad, very long and pointed; anteriorly frequently curved upward like a hook, but sometimes horizontal. S deep, narrower than in Stromateus, both cristae highly arched. Ostium open, cauda bending ventrad, becoming much more shallow, terminating closed directly above margin of otolith. Margins deeply sinuous.

Paracubiceps ledanoisi BELLOC Plate 10, Fig.144

M: 14 specimens L: Gulf of Guinea D: 70-100 m

FL in cm: 15 17

OL in mm: 4.43 4.75

OL:OW:OT approx. 1:0.55:0.14

OL:FL approx. 1:35

Otolith very similar to that of preceding species, but somewhat broader and thicker. Inc. mostly deeper and sharper, AR strong and pointed. R long, also curved upward, but in contrast to P. multisquamis anteriorly blunt or rounded. S deep, cauda bending ventrad posteriorly, becoming only a little more shallow. V-margin and D-margin strongly sinuous or serrate.

Family Gobiidae (no photograph)Pomatoschistus minutus (PALLAS) Plate 10, Fig.145

M: 12 specimens L: Central North Sea D: 5 m

FL in cm: 6.8 7.0

OL in mm: 1.79 1.90

OL:OW:OT approx. 1:0.89:0.30

OL:FL approx. 1:38

Otolith thick, approx. square to rectangular, deeply notched anteriorly and posteriorly. V-margin always straight, D-margin sometimes strongly curved. I-side plane, O-side moderately convex. Inc., AR and R not clearly recognizable. S very short, slightly sloping downward from rear to front, filled by colliculum. Cauda narrow, ostium club-shaped, somewhat broader and longer, both closed. V-margin completely smooth, D-margin sinuated 3-6 times.

53Family Scorpaenidae Plates 22/23

In spite of numerous superficial similarities, the otoliths of this family do not represent a uniform group because all essential features vary considerably from species to species. The only trait all species have in common is their relative size (OL:FL varies between 1:16 and 1:33), the I-side is always convex, the O-side concave.

Sebastes marinus (L.) Rosefish Plate 10, Fig.146

M: 24 specimens L: Newfoundland D: 250-400 m

FL in cm: 38 50 73

OL in mm: 13.21 17.00 17.64

OL:OW:OT approx. 1:0.58:0.15

OL:FL approx. 1:33

Basic form approx. elliptical, but considerably distorted with increasing age. I-side moderately convex, O-side slightly concave. Inc. broad, sharp, deep, AR strong, sometimes pointed, often rounded. R long, unusually massive, with mostly sharp tip. S moderately deep, cauda short and closed, ostium somewhat longer, filled by colliculum, funnel-shaped, terminating open. Ventral crista arched, below it mostly a flat area. V-margin fairly regularly serrate, D-margin strongly sinuous or serrate, deeply divided particularly in old specimens.

Sebastes viviparus KRØYER Plate 11, Fig.147

M: 26 specimens L: Norway D: 100-150 m

FL in cm: 22 25 28

OL in mm: 9.00 10.79 12.39

OL:OW:OT approx. 1:0.66:0.19

OL:FL approx. 1:23

Otolith very similar to that of S. marinus; more compact,

Inc. mostly shorter and narrower, AR somewhat smaller and blunt, sometimes merely indicated. S as in preceding species, ostium only partly filled by colliculum. Small shallow area below arched ventral crista. V-margin only slightly sinuous, not serrate, D-margin wavy, never divided or serrate.

Helicolenus dactylopterus DELAROCHE Blackbelly rosefish

Plate 11, Fig. 148

M: 10 specimens L: Norwegian Deep D: 200 m

FL in cm: 24 28 36

OL in mm: 9.51 9.62 12.50

OL:OW:OT approx. 1:0.53:0.15

OL:FL approx. 1:28

In spite of great similarities, otolith can be distinguished from that of previous species. It is more elongate, Inc. much less developed, AR small, always rounded. S very deeply incised, colliculum only indicated. Ostium hardly defined from cauda, only slightly widening, becoming slightly more shallow anteriorly, not terminating into Inc., but farther ventrad directly above tip of R; terminating open. Dorsal, not ventral, crista highly arched, above it a well-developed area. V-margin irregularly sinuous or serrate, D-margin strongly sinuous.

Pontinus accraensis NORMAN Plate 11, Fig.149

M: 22 specimens L: Gulf of Guinea D: 70 m

FL in cm: 17 20 22

OL in mm: 9.58 10.75 11.17

OL:OW:OT approx. 1:0.52:0.20

OL:FL approx. 1:20.

Otolith very similar to that of Helicolenus. I-side moderately convex, O-side slightly concave. Inc. and AR merely indicated, often absent. R broad, not very long, sometimes with pointed tip, often rounded. S very deep, straight, in contrast to Helicolenus distinctly constricted by cristae. Cauda short, closed; ostium long, slightly widening forward, terminating open. Broad area above dorsal crista always present. Margins sometimes strongly sinuous or serrate, not infrequently only slightly wavy or almost smooth.

Scorpaena normani CADENAT Plate 11, Fig.150

M: 8 specimens L: Gulf of Guinea D: 100 m

FL in cm: 12

OL in mm: 7.30

OL:OW:OT approx. 1:0.54:0.24

OL:FL approx. 1:16

Otolith distinctly different from those of previous species. Approx. elliptical, anteriorly acutely pointed, posteriorly slightly

rounded. I-side strongly convex, O-side moderately concave. Inc. short, very varyingly developed. Often sharply notched, sometimes broad and rounded, not infrequently merely indicated. AR short, strong, pointed, sometimes only slightly prominent. R long, fairly broad, with sharp, slightly upturned tip. S deep, cauda bending ventrad posteriorly. Ostium short, distinctly defined, broadening and becoming slightly more shallow forward. Well-developed area above dorsal crista. D-margin finely and sharply serrate, V-margin almost smooth.

Scorpaena angolensis NORMAN Plate 11, Fig.151

M: 10 specimens L: Gulf of Guinea D: 70 m

FL in cm: 14 16

OL in mm: 6.03 7.31

OL:OW:OT approx. 1:0.43:0.17

OL:FL approx. 1:23

Otolith slightly glassy. Similar to that of S. normani, but more slender and thinner, Inc. and AR mostly only indicated, R shorter and rounded. S deep, downward-turned part of cauda longer, terminating farther ventrad. Area above dorsal crista hardly recognizable. D-margin finely sinuous, not serrate, V-margin also sinuous, sometimes finely and sharply serrate, never smooth.

Family Triglidae Plate 23Subfamily Triglinae

The examined species have compact, approx. triangular otoliths of very characteristic appearance. I-side convex, O-side concave. AR always extraordinarily strong, only slightly shorter but mostly broader than R. S in all species broad and very deep, greatly constricted in centre, except in Trigla lyra. Cauda closed, ostium open, colliculum always absent. Margins finely serrate or sinuous.

55

Trigla gurnardus L. Gurnard Plate 11, Fig.152

M: 26 specimens L: North Sea D: 30-50 m

FL in cm: 24 39

OL in mm: 3.68 5.30

OL:OW:OT approx. 1:0.71:0.24

OL:FL approx. 1:70

Otolith triangular, I-side slightly convex, O-side slightly concave. Inc. deep and sharp, AR very strong, slightly rounded, R broad, moderately long, acutely pointed. S extraordinarily deep, constricted by ventral crista in centre. Cauda club-shaped, ostium only slightly widening. Deep area above dorsal crista. Margins finely sinuous, sometimes serrate.

Trigla corax BONAPARTE Red gurnard Plate 11, Fig.153

M: 24 specimens L: Southern North Sea D: 30-40 m

FL in cm: 30 38

OL in mm: 4.27 5.11

OL:OW:OT approx. 1:0.80:0.31

OL:FL approx. 1:72

In spite of great similarities, otolith can easily be distinguished from that of T. gurnardus. It is thicker, I-side more strongly convex, O-side slightly more concave. Inc. deep and sharp, AR very massive, mostly slightly rounded, as long^{as} and often broader than the moderately pointed R. S again very deep, but considerably varying in form and depth. Constriction by ventral crista distinctly stronger than in preceding species. Area above dorsal crista very shallow, frequently altogether absent. Margins irregularly sinuous or serrate.

Trigla lyra L. Plate 11, Fig.154

M: 22 specimens L: Gulf of Guinea D: 400 m

FL in cm: 21 25

OL in mm: 5.04 5.23

OL:OW:OT approx. 1:0.67:0.22

OL:FL approx. 1:45

Corners of otolith more rounded. I-side moderately convex,

O-side only slightly concave. Inc. short, not sharply notched but rounded or blunted inside. S more shallow, cauda slightly widened, not extending as far as margin of otolith. Constricted by both cristae, but less so than in the two previous species. AR broad, only short, R comparatively narrow, acutely pointed. Area substantially deeper than in T. corax, but always more shallow than in T. gurnardus. Margins finely serrate.

Trigla gabonensis POLL & ROUX Plate 11, Fig.155

M: 10 specimens L: Gulf of Guinea D: 40 m

FL in cm: 20 22

OL in mm: 3.75 3.89

OL:OW:OT approx. 1:0.77:0.29

OL:FL approx. 1:55

I-side of otolith strongly convex, O-side moderately 56
concave. Inc. shallow and rounded as in T. lyra. AR short, considerably broader than the slightly upturned, mostly pointed and slightly longer R. S particularly deep, greatly constricted by both cristae in centre. Cauda club-shaped, ostium only slightly broadened. Area poorly developed, as in T. corax. Margins sharply serrate.

Subfamily Peristediinae

Peristedion cataphractum (L.) Plate 11, Fig.156

M: 20 specimens L: Gulf of Guinea D: 200 m

FL in cm: 13

OL in mm: 3.48

OL:OW:OT approx. 1:0.63:0.22

OL:FL approx. 1:37

Otolith resembling those of the Triglinae only little. It is compact, anteriorly terminating in a short tip, posteriorly in a slightly longer and sharper tip. I-side moderately convex, O-side slightly concave. Inc. and AR hardly recognizable, R short, broad, slightly rounded. S shallow, greatly constricted by ventral crista. Cauda club-shaped as in the Triglinae, ostium slightly longer, only slightly widening. Well-developed area above dorsal crista. Margins only slightly wavy or sinuous.

Family Cottidae Plate 23

The otoliths of the four examined genera represent two very different types: the otoliths of Myoxocephalus and Taurulus resemble closely those of several Scorpaenidae, particularly Helicolenus. They have a long, strong R, a short but well-developed AR, and sinuous or wavy margins.

The otoliths of Triglops and Artidiellus have a short, rounded R, a very poorly developed AR, and almost smooth margins.

Features common to all 4 species are the elongate shape

and the short sulcus. The cauda terminates closed long before reaching the posterior margin of the otolith, ostium hardly defined, only slightly broadening, terminating open.

Myoxocephalus scorpius (L.) Shorthorn sculpin Plate 11, Fig.157

M: 22 specimens L: Western Baltic Sea D: 10 m

FL in cm: 19 23

OL in mm: 5.87 6.62

OL:OW:OT approx. 1:0.53:0.20

OL:FL approx. 1:34

Otolith elongate, anteriorly pointed, posteriorly rounded, often deeply notched. I-side slightly convex, O-side slightly concave. Inc. short and sharp, AR broad, rounded, R long, strong, mostly pointed. S short, moderately deep, posteriorly closed long before margin of otolith, anteriorly open. Broad, very shallow area above dorsal crista. V-margin slightly and irregularly sinuous, D-margin more strongly and regularly so.

Taurulus bubalis (EUPHRASEN) Plate 11, Fig.158

M: 18 specimens L: Western Baltic Sea D: 10 m

FL in cm: 12.5

OL in mm: 3.21

OL:OW:OT approx. 1:0.46:0.20

OL:FL approx. 1:40

In spite of great similarity, otolith can be distinguished with certainty from that of previous species. Mostly it is even more elongate, caudal part more produced. I-side slightly convex, O-side slightly concave. S, in contrast to M. scorpius, curved, extending approx. parallel to D-margin. Area absent. Margins irregularly sinuous or wavy.

Triglops murrayi GÜNTHER Plate 11, Fig.159

M: 10 specimens L: North Norway D: 200 m

FL in cm: 9.5 10.5

OL in mm: 3.44 3.76

OL:OW:OT approx. 1:0.48:0.24

OL:FL approx. 1:28

Otolith bearing only little resemblance to the otoliths of preceding species. Approx. oval. I-side moderately convex, O-side plane. Inc. and AR indicated or absent. R broad, moderately long, rounded. S short, shallow, slightly curved, cauda closed, ostium hardly broadened, terminating open. Ventral crista highly arched, dorsal crista flat. V-margin almost smooth, D-margin slightly wavy.

Artediellus atlanticus JORDAN & EVERMANN Plate 11, Fig.160

M: 4 specimens L: Norway D: 100 m

FL in cm: 10

OL in mm: 3.80

OL:OW:OT approx. 1:0.58:0.29

OL:FL approx. 1:26

Certain similarity with otolith of Triglops. I-side and O-side slightly convex, Inc. short, almost rectangular, AR small, curved inward, R broad and short. Both evenly rounded. S deep, straight, cauda closed, ostium hardly broadened, open. Broad and shallow area above dorsal crista. Margins smooth or very slightly wavy.

Family Cottunculidae Plate 23

Cottunculus microps COLLETT Plate 12, Fig.161

M: 4 specimens L: Norway D: 250 m

FL in cm: 13

OL in mm: 4.81

OL:OW:OT approx. 1:0.76:0.29

OL:FL approx. 1:27

Otolith compact. I-side plane, O-side slightly convex. Inc. short and sharp, AR and R broad, rounded, little prominent. S short and shallow. Cauda small, basin-shaped, lying approx. in centre of otolith, ostium extending obliquely upward as narrow groove, open. Caudal and V-margin smooth, D-margin moderately sinuous.

Family Agonidae Plate 23Agonus cataphractus Bullhead Plate 12, Fig.162

M: 10 specimens L: North Sea D: 30 m

FL in cm: 9 10.5 12

OL in mm: 3.57 3.86 4.55

OL:OW:OT approx. 1:0.43:0.19

OL:FL approx. 1:26

Otolith slender, caudal end often drawn out into long tip. 58
 I-side slightly convex, O-side slightly concave. Inc. and AR mostly absent, R short and rounded. S shallow, sometimes posteriorly bent slightly ventrad. Cauda short and closed, ostium longer, distinctly defined by constriction by ventral crista; hardly broadening, seemingly terminating also closed, but narrow groove extending to margin of otolith. V-margin slightly wavy or smooth, D-margin varyingly sinuous.

Leptagonus decagonus (SCHNEIDER) Plate 12, Fig.163

M: 12 specimens L: North Norway D: 180-300 m

FL in cm: 12 18 19

OL in mm: 3.04 3.95 4.48

OL:OW:OT approx. 1:0.63:0.28

OL:FL approx. 1:42

Otolith bearing only little resemblance to that of previous

species. Thicker, more compact, I-side plane, O-side convex. Inc. mostly shallow, AR and R broad, short, rounded. S narrow, moderately deep. Cauda closed far from posterior otolith margin, ostium only little broadening, terminating open. V-margin slightly wavy, D-margin coarsely and irregularly sinuous.

Family Cyclopteridae Plate 23

Cyclopterus lumpus L. Lump sucker Plate 12, Fig. 164

M: 6 specimens L: North Sea D: 30 m

FL in cm: 29 50

OL in mm: 1.45 1.75

OL:OW:OT approx. 1:0.60:0.30

OL:FL approx. 1:260

Otolith very small, compact, anteriorly and posteriorly more or less blunt. I-side plane, O-side moderately convex. Inc. shallow, AR and R approx. equally broad, short, rounded. S short, moderately deep, conical; closed posteriorly, broadening evenly and terminating open anteriorly. Broad area above dorsal crista; another, deeper, pit-shaped area below highly arched ventral crista. Therefore surface of I-side appearing plicate and grooved. V-margin smooth, D-margin slightly wavy.

Family Liparidae Plate 23Careproctus reinhardtii KRØYER Plate 12, Fig.165

M: 10 specimens L: Norway D: 150 m

FL in cm: 12

OL in mm: 1.95

OL:OW:OT approx. 1:0.97:0.40

OL:FL approx. 1:65

Otolith thick, almost circular. I-side plane, O-side strongly convex. Inc. mostly shallow, sometimes deeply notched. AR and R very broad, short, rounded, R hardly longer, but frequently slightly narrower than AR. S short, moderately deep, slightly curved upward. Cauda resembling a small basin in centre of otolith, ostium longer, distinctly defined by constriction, not broadening, terminating open. Ventral crista arched and thickened into a ridge below cauda. Area absent, margins gently wavy or sinuous.

*

Order Dactylopteriformes

59

Family DactylopteridaeDactylopterus volitans (L.) Plate 12, Fig.166

M: 14 specimens L: Gulf of Guinea D: 30 m

FL in cm: 24 29

OL in mm: 2.52 3.12

OL:OW:OT approx. 1:0.71:0.27 (adult specimens)

" 1:0.84:0.37 (young specimens)

OL:FL approx. 1:95

Otolith compact, in young specimens almost round. I-side very strongly convex, O-side plane or slightly concave. Inc. deep, broad, sharp, AR strong, long, pointed, R also broad, only slightly longer, with obliquely upturned tip. S unusually broad and deep, strongly constricted by ventral crista in centre where it is distinctly more shallow. Cauda closed, ostium terminating open. Well-developed area above dorsal crista which arches into a ridge. D-margin strongly sinuous and serrate, V-margin finely and strongly serrate. Serration becoming sharper with age.

*

Order Pleuronectiformes

Family Bothidae Plate 24

The otoliths of the examined species show such great agreement in appearance and individual features that we can speak of a "bothid type of otolith". They are comparatively flat, compact, sometimes almost oval, caudal end broader and mostly blunt. Inc. and AR mostly present, but inconspicuous. The most important family characteristic is the sulcus; its cauda is short and closed, its ostium is considerably longer and always terminates open.

Psetta maxima (L.) Turbot Plate 12, Fig.167

M: 20 specimens L: North Sea D: 30-60 m

FL in cm: 51 64

OL in mm: 8.50 12.00

OL:OW:OT approx. 1:0.70:0.20

OL:FL approx. 1:57

Basic form very variable. Compact, anteriorly with short tip, caudal end broad and blunt, often appearing broken off. D-margin bent in centre, V-margin moderately curved. Right and left otolith of one fish almost always different, without certain features being specific only for right or left otoliths, respectively. I-side moderately convex, O-side slightly concave. Inc. and AR merely indicated, may both be absent, particularly in right otolith. R broad, not long, rounded. S moderately deep, cauda short, sometimes circular, often oval or elongate, ostium distinctly defined, very elongate, slightly tapering anteriorly, terminating open. Sometimes distinct area above dorsal crista, but frequently it is absent. Margins sinuous or serrate to differing degrees.

Scophthalmus rhombus (L.) Plate 12, Fig.168

M: 12 specimens L: North Sea D: 30-50 m

FL in cm: 36 57

OL in mm: 8.03 8.95

OL:OW:OT approx. 1:0.66:0.18

OL:FL approx. 1:52

Basic form variable, caudal end also broad, anterior end tapering and sloping. Differences between otoliths of a pair slighter than in Psetta. I-side moderately convex, O-side slightly concave. Inc. and AR inconspicuous, only rarely Inc. deeply notched, in which case AR is broad and rounded. R short, strong, rounded. S of different depths. Cauda short, always elongate, ostium mostly slightly broader, often turned slightly upward. Frequently an area above dorsal crista, but sometimes it is absent. Margins gently sinuous; serrated or grooved margins were not observed.

Lipidorhombus whiffiagonis (WALB.) Whiff Plate 12, Fig.169

M: 16 specimens L: North Sea D: 150 m

FL in cm: 35 48

OL in mm: 6.23 7.89

OL:OW:OT approx. 1:0.61:0.15 (right)

" 1:0.59:0.18 (left)

OL:FL approx. 1:59

Right and left otoliths differ considerably. Left otolith distinctly club-shaped, with anterior tip, blunt caudal end, and almost smooth margins. Right otolith thinner, D-margin strongly curved, deeply grooved or sinous, often divided. V-margin gently

wavy. Inc. in left otolith merely indicated, AR hardly visible, R short, broad, mostly slightly rounded. Inc. in right otolith well developed, almost rectangular, AR broad and blunt, R also broad and mostly slightly rounded. S moderately deep, straight, slightly rising dorsad. Cauda short and closed, ostium distinctly defined, not broadening, terminating open.

Family Pleuronectidae Plate 24

The otoliths of individual species are by no means uniformly shaped, but several important features are characteristic of almost the entire family. Otolith compactly oval, caudal end blunt. In contrast to Bothidae, Inc. and AR absent, ostium of mostly short S terminating closed, far from otolith margin. However, some examined species do not fit this pattern: The otolith of Hippoglossus hippoglossus has an indicated AR, and the S extends as far as the anterior margin of the otolith, sometimes with a narrow open outward connection. In this respect it represents a transitional form to the Bothidae. The otoliths of Microstomus and Reinhardtius are very different and bear only little resemblance to the other species of the family.

Hippoglossus hippoglossus (L.) Halibut Plate 12, Fig.170

M: 28 specimens L: Northern North Sea, Norway D: 90-150 m

FL in cm: 50 86 108
 OL in mm: 8.34 12.04 13.63
 OL:OW:OT approx. 1:0.61:0.13
 OL:FL approx. 1:76

Otolith flat, approx. oval, anteriorly narrow, posteriorly blunt or rounded, sometimes notched or indented. I-side slightly convex, O-side slightly concave. Inc. and AR indicated, R short, strong, rounded. S **straight**, moderately deep. Cauda short, closed, ostium approx. twice as long, distinctly defined by constriction, sometimes bending slightly dorsad far anteriorly, terminating open into Inc., frequently, however, continuing straight, terminating closed below Inc. In that case, one or two fine grooves not infrequently extending from anterior end of ostium to Inc.; thus all transitions between open and closed ostium can be observed here. Margins gently wavy or sinuous.

Pleuronectes platessa L. Plaice Plate 12, Fig.171

M: 22 specimens L: North Sea D: 20-50 m

FL in cm: 27 36 40
 OL in mm: 6.14 7.25 8.90
 OL:OW:OT approx. 1:0.61:0.16
 OL:FL approx. 1:46

Otolith approx. oval, posteriorly blunt, D-margin much less

curved than V-margin forming a sharp corner with caudal margin. No differences between right and left otoliths were observed. I-side slightly convex, O-side plane or slightly concave. Inc. and AR absent, R broad, evenly rounded. S straight, closed anteriorly and posteriorly, short cauda distinctly defined from considerably longer, slightly broader ostium by slight constriction. Margins gently sinuous or wavy.

Platichthys flesus (L.) Flounder Plate 12, Fig.172

M: 8 specimens L: Western North Sea D: 20 m

FL in cm: 27

OL in mm: 5.48

OL:OW:OT approx. 1:0.65:0.17

OL:FL approx. 1:50

Otolith form almost identical with that of plaice. The corner formed by caudal and D-margins even more pronounced. I-side slightly convex, O-side slightly concave. Inc. and AR absent, R broad and rounded. S as in P. platessa, mostly even shorter. Unlike preceding species, margins sharply and fairly regularly serrate.

Limanda limanda (L.) Dab Plate 12, Fig.173

M: 32 specimens L: North Sea D: 30-50 m

FL in cm: 23 30

OL in mm: 4.74 6.00

OL:OW:OT approx. 1:0.64:0.18

OL:FL approx. 1:50

Otolith very similar to that of plaice, but more angular. I-side almost plane, O-side slightly convex or also plane. Inc. and AR absent, R broad and rounded. S slightly shorter, broader and deeper than in P. platessa, a shallow but distinct area above dorsal crista. Margins gently and irregularly wavy.

Remarks: Caudal margin very variable. Sometimes evenly curved, not infrequently straight, so that otolith appears broken off; it may even be curved inward, forming a sharp corner each with V-margin and D-margin.

Hippoglossoides platessoides (FABRICIUS) American plaice

62

Plate 12, Fig.174

M: 26 specimens L: North Sea D: 60-90 m

FL in cm: 18 24 36

OL in mm: 4.12 4.80 7.99

OL:OW:OT approx. 1:0.73:0.21

OL:FL approx. 1:46

Otolith more compact and thicker than in preceding species, anteriorly only slightly tapering, posteriorly terminating blunt. I-side plane, sometimes slightly convex, O-side mostly slightly convex, not infrequently plane or slightly concave. Inc. and AR absent,

R very broad, evenly rounded. S fairly short, cauda and ostium distinctly defined from each other by often sharp constriction. Margins gently wavy or sinuous.

Glyptocephalus cynoglossus (L.) Gray sole Plate 13, Fig.175

M: 36 specimens L: Northern North Sea D: 100-150 m

FL in cm: 33 39 42

OL in mm: 6.10 6.94 7.20

OL:OW:OT approx. 1:0.90:0.23

OL:FL approx. 1:56

Otolith almost circular, dorsal part flattened since D-margin always horizontally straight. I-side plane or, like O-side, slightly convex. Inc. and AR absent. S very short, moderately deep, ostium longer and broader than cauda. Sometimes shallow area above dorsal crista. Margins gently wavy, V-margin not infrequently sinuous.

Reinhardtius hippoglossoides (WALB.) Greenland halibut

Plate 13, Fig.176

M: 32 specimens L: Eastern Greenland D: 250-450 m

FL in cm: 40 52 68

OL in mm: 7.68 9.40 11.56

OL:OW:OT approx. 1:0.79:0.13 (right)

" 1:0.68:0.13 (left)

OL:FL approx. 1:56

Since the right otolith hardly resembles the left otolith, it seems logical to describe them separately.

Right otolith: Posteriorly rounded, anterior part narrow and so deeply sinuous that it loses its uniform shape. In the centre remains a slightly raised shaft from which numerous obliquely forward-pointing branches originate dorsally and ventrally. The dorsal branches are shorter and less distinctly developed than the ventral ones. S long, straight, filled by colliculum, lying on shaft, posteriorly terminating closed, anteriorly open or closed. Caudal margin of otolith always smooth.

Left otolith: Apart from its size, it hardly resembles the right otolith. Basic form very variable; anteriorly broad, blunt, posteriorly tapering, rounded. I-side plane or slightly concave, with hill-shaped protuberances in centre, O-side also plane or slightly convex. Inc., AR and R not distinctly developed. S appearing merely as short, pit-like depression immediately behind centre of otolith. Margins in anterior part deeply divided, in caudal part wavy or gently sinuous.

Microstomus kitt (WALB) Plate 13, Fig.177

M: 40 specimens L: North Sea D: 30-80 m

FL in cm: 31 43

OL in mm: 2.80 3.28

OL:OW:OT approx. 1:0.61:0.22

OL:FL approx. 1:120

Otolith compact, in relation to FL fairly small, anteriorly and posteriorly approx. equally broad and blunt, in isolated cases anteriorly pointed. I-side plane or slightly convex, O-side slightly convex. Inc. broad, of different depth, may be absent. AR short, strong, rounded or acute, sometimes altogether absent. R short, broad, slightly rounded. S very different from that of preceding species; straight, cauda short, closed, ostium long, distinctly defined, often funnel-shaped, sometimes of constant width, always terminating open. Mostly a narrow but distinct area above dorsal crista. Margins smooth or gently wavy.

Family Soleidae Plate 24

The otoliths of the three examined species show several very typical family characteristics: almost round shape, considerable thickness, complete absence of Inc. and AR, smooth margins, and short S closed anteriorly and posteriorly. S always surrounded by narrow, horseshoe-shaped area.

Solea solea (L.) Sole Plate 13, Fig.178

M: 18 specimens L: North Sea D: 20-30 m

FL in cm: 18 30 37
 OL in mm: 2.60 3.98 4.73
 CL:OW:OT approx. 1:0.86:0.27
 OL:FL approx. 1:75

Otolith anteriorly blunt or rounded, V-margin strongly curved, D-margin only slightly curved. The caudal margin which is almost always curved inward is typical. I-side moderately convex, O-side slightly concave. S moderately deep, closed anteriorly and posteriorly, distinctly divided by strong ventral constriction into short cauda and longer ostium; surrounded by narrow, horseshoe-shaped area. Margins almost smooth.

Dicologlossa cuneata (MOREAU) Plate 13, Fig.179

M: 6 specimens L: Gulf of Guinea D: 40 m
 FL in cm: 23
 OL in mm: 4.20
 OL:OW:OT approx. 1:0.79:0.26
 OL:FL approx. 1:55

Otolith very similar to that of sole, but caudal margin slightly curved outward. I-side plane, O-side slightly convex. S shorter than in Solea, only slight ventral constriction. Horseshoe-shaped area and almost smooth margins as in preceding species.

Buglossidium luteum (RISSO) Plate 13, Fig.180

M: 8 specimens L: Southern North Sea D: 30 m

FL in cm: 10

OL in mm: 2.33

OL:OW:OT approx. 1:0.90:0.31

OL:FL approx. 1:43

Otolith almost circular, fairly thick. I-side moderately convex, O-side plane or slightly convex. S shallow, slight constriction as in Dicologlossa, ostium extending almost as far as anterior margin of otolith. Again horseshoe-shaped area and smooth margins.

Family Cynoglossidae Plate 24Cynoglossus canariensis STEINDACHNER Plate 13, Fig.181

M: 20 specimens L: Gulf of Guinea D: 100 m

FL in cm: 32 37

OL in mm: 5.11 5.81

OL:OW:OT approx. 1:0.76:0.26

OL:FL approx. 1:64

Otolith compact, anteriorly rounded, posteriorly appearing broken off obliquely. I-side slightly convex, O-side slightly concave. Inc. and AR absent. S very shallow, extending obliquely

upward, closed anteriorly and posteriorly; narrow in centre, ostium widening into club, terminating directly at otolith margin, cauda slightly shorter, widening greatly upward and downward. Margins smooth or gently wavy.

*

Order Batrachoidiformes

Family Batrachoididae Plate 25

Batrachoides didactylus (SCHNEIDER) Plate 13, Fig.182

M: 22 specimens L: Gulf of Guinea D: 40 m

FL in cm: 13 18

OL in mm: 5.09 6.37

OL:OW:OT approx. 1:0.58:0.24

OL:FL approx. 1:27

Otolith elongate, anteriorly broad and rounded, posteriorly mostly acutely pointed, rarely rounded. Strongly curved, anterior and posterior ends pointing outward. I-side strongly convex, O-side moderately concave. Inc. and AR indicated, often absent, R short, broad, rounded. S moderately deep, strongly constricted in centre. Cauda short and closed, ostium slightly broadened, terminating open. Broad area above dorsal crista. Margins varyingly sinuous.

*

Order LophiiformesFamily Lophiidae Plate 25Lophius piscatorius L. Monk Plate 13, Fig.183

M: 40 specimens L: Northern North Sea, Norway D: 60-150 m

FL in cm: 31 63 88

OL in mm: 4.25 6.94 7.90

OL:OW:OT approx. 1:0.75:0.23

OL:FL approx. 1:100

Otolith compact, ventral part thick, rapidly becoming thinner upward. Lower half of I-side in older specimens still further thickened by ridge, in that case transition into thin dorsal part very abrupt. I-side mostly slightly convex, O-side plane. Inc. and AR absent, R short and rounded. S short, pit-shaped, closed anteriorly and posteriorly. V-margin slightly and irregularly wavy, D-margin strongly sinuous, in older specimens often divided and lobed.

Remarks: Basic form highly variable, otolith may be almost elliptical or oval.

Family Antennariidae Plate 25Antennarius scaber CUV. Plate 13, Fig.184

M: 12 specimens L: Gulf of Guinea D: 30 m

FL in cm: 7 10
 OL in mm: 3.00 3.43
 OL:OW:OT approx. 1:0.61:0.20
 OL:FL approx. 1:25

Otolith approx. oval, anterior end slightly narrower. I-side slightly convex, O-side plane. Inc. and AR absent, R short, broad, rounded. S short, straight, not very deep, extending obliquely upward, terminating closed posteriorly and anteriorly. Margins gently wavy.

Family Chaunacidae Plate 25

Chaunax pictus LOWE Plate 13, Fig. 185

M: 18 specimens L: Gulf of Guinea D: 400 m

FL in cm: 11 12 13
 OL in mm: 4.84 5.25 5.35
 OL:OW:OT approx. 1:0.75:0.25
 OL:FL approx. 1:23

Otolith compact, anteriorly broad and rounded, posteriorly slightly tapering. D-margin much more curved than V-margin. I-side and O-side slightly convex, Inc. and AR absent. S shallow, short, of constant width, closed anteriorly and posteriorly. V-margin smooth or gently wavy, D-margin 2 to 8 times strongly sinuated.

D. Summary

Several otolith pairs each were examined for a total of 186 marine fish species from 75 families. A morphological comparison of their appearance and individual regions shows that within an entire family, certain features are frequently identical or very similar, even if e.g. the shape of the otolith varies considerably between species. In this manner otoliths can usually be assigned to their proper families. The sulcus in particular is a very valuable aid in this respect, because its shape and size are mostly characteristic of an entire family.

The outward appearance of otoliths frequently varies between individuals within one and the same species. Nevertheless, almost always certain characters within one species are constant, and differ from those of a closely related species in a characteristic manner. Here again the sulcus is highly significant. Although it characterizes entire families, its size and shape undergo highly species-specific modifications. Thus, with few exceptions, a fish species can be clearly identified on the basis of its otoliths alone. However, definite identification requires the use, not only of outward appearance, but also of all other features, including the ratio length:width:thickness.

E. References

- (1) BERG, L. S.: System der rezenten und fossilen Fischartigen und Fische. - VEB Deutscher Verlag der Wissenschaften, Berlin 1958
- (2) CADENAT, J.: Poissons de Mer du Sénégal - I.F.A.N., Dakar 1950
- (3) CHAÏNI, J.: Recherches sur les otolithes de poissons, étude descriptive et comparative de la sagitta des téléostéens. - Bull. du C.E.R.S., T1, Fasc. 2 et 4, Biarritz 1956/57; T2 Fasc. 2, Biarritz 1958
- (4) EZIHO, E. N. C.: The identification of otoliths from West African demersal Fish. - Bull. de l'I.F.A.N. T. XXV, sér. A, no 2, 1963
- (5) FARKAS, B.: Zur Kenntnis der Struktur und Funktion der Otolithen. - Zool. Anz. 21. Suppl., Leipzig 1958
- (6) FROST, A.: A comparative study of the otoliths of the neopterygian fishes. - Ann. Mag. Nat. Hist., ser. 9, vol. XV, 1925; ser. 10, vol. IV, 1929
- (7) FRYD, C.: Die Otolithen der Fische in bezug auf ihre Bedeutung für Systematik und Altersbestimmung. - Inaugural-Dissertation, Kiel 1901
- (8) HILMPF, G.: Zum Wachstum der Otolithen bei Jungheringen. - Helgol. Wiss. Meeresunters. Bd. 6, H 3, S. 241-259, List 1959
- (9) IMMERMANN, F.: Beiträge zur Altersbestimmung der Fische II. - Wiss. Meeresunters. Abt. Helgol. Bd. 8, H 2, S. 129-176. 1908
- (10) LISSNER, H.: Die Altersbestimmung beim Hering mit Hilfe der Otolithen. - Ber. D.W.K., N. F. Bd. 1. 1919-1923
- (11) MARTINI, E.: Otolithen in Gewöllen der Raubseeschwalbe (*Hydroprogne caspia*). - Bonner Zool. Nachr., Heft 1/2, 15/1964
- (12) POLL, M.: Poissons. Expédition Océanographique Belge dans les Eaux Côtières Africaines de l'Atlantique Sud. - 1948-1949
- (13) SAHRHAGE, D.: Über die Verbreitung der Fischarten in der Nordsee. - Ber. DWK. N.F., Bd. XVII, Heft 3. 1964

Translation of non-English entries:

1. System of recent and fossil fish-like animals and fishes.
2. Marine fishes of Senegal.
3. Research into fish otoliths; a descriptive and comparative essay on the sagitta of teleosteans.
5. On the structure and function of otoliths.
7. Fish otoliths with regard to their significance for taxonomy and age determination. Inaugural dissertation
8. On the growth of otoliths in young herring.

9. Contributions to the age determination in fish.II.
10. Age determination in herring on the basis of otoliths.
11. Otoliths in the castings of Hydroprogne caspia.
12. Fishes. The Belgian oceanographic expedition into the African coastal waters of the South Atlantic.
13. On the range of fish species in the North Sea.

A P P E N D I X

Anhang

Plate 1

Fig. 1-14

Explanation of
otolith regions

- | | |
|--|---|
| 1. <i>Albula vulpes</i> (L.) | 2. <i>Elops lacerta</i> VAL. |
| 3. <i>Clupea harengus</i> L. | 4. <i>Hlisha africana</i> (BLOCH) |
| 5. <i>Sprattus sprattus</i> (L.) | 6. <i>Sardina pilchardus</i> (WALB.) |
| 7. <i>Alepocephalus bairdii</i> G. et BEAN | 8. <i>Engraulis encrasicolus</i> (L.) |
| 9. <i>Argentina sphyraena</i> L. | 10. <i>Argentina silus</i> (ASCAN.) |
| 11. <i>Saurida parri</i> NORMAN | 12. <i>Maurollicus muelleri</i> GMEL. |
| | 13. <i>Trachinocephalus myops</i> SCHNEIDER |

Plate 2

Fig. 15-28

- | | |
|--|--|
| 15. <i>Aulopus cadenati</i> POLL | 16. <i>Phyllogramma regani</i> PELL. |
| 17. <i>Notacanthus phasganorus</i> GOODE | 18. <i>Belone belone</i> (L.) |
| 19. <i>Cypselurus pinnatibarbus</i> (BENNET) | 20. <i>Mora mora</i> (Risso) |
| 21. <i>Halargyreus affinis</i> COLLETT | 22. <i>Lepidion eques</i> (GÜNTHER) |
| 23. <i>Laemonema laureysi</i> POLL | 24. <i>Uraleptus maraldi</i> (Risso) |
| 25. <i>Gadus morhua</i> L. | 26. <i>Melanogrammus aeglefinus</i> (L.) |
| 27. <i>Polladius polladius</i> (L.) | 28. <i>Polladius virens</i> (L.) |

Plate 3

Fig. 29-42

- | | |
|--|---|
| 29. <i>Merlangius merlangus</i> (L.) | 30. <i>Trisopterus minutus</i> (MÜLLER) |
| 31. <i>Trisopterus esmarkii</i> (NILSSON) | 32. <i>Trisopterus luscus</i> (L.) |
| 33. <i>Micromesistius poutassou</i> (Risso) | 34. <i>Boreogadus saida</i> (LEPECHIN) |
| 35. <i>Gadiculus thori</i> SCHMIDT | 36. <i>Urophycis blennioides</i> (BRÜNN.) |
| 37. <i>Molva molva</i> (L.) | 38. <i>Molva dypterygia</i> (PENNANT) |
| 39. <i>Brosme brosme</i> (ASCAN.) | 40. <i>Enchelyopus cimbrius</i> (L.) |
| 41. <i>Gaidropsarus argentatus</i> (REINHARDT) | 42. <i>Merluccius merluccius</i> (L.) |

Plate 4

Fig. 43-58

- | | |
|---|--|
| 43. <i>Merluccius polli</i> CADENAT | 44. <i>Coryphaenoides rupestris</i> GUNNERUS |
| 45. <i>Coelorhynchus coelorhynchus</i> (Risso) | 46. <i>Malacocephalus laevis</i> (GÜNTHER) |
| 47. <i>Malacocephalus occidentalis</i> G. et BEAN | 48. <i>Nezumia aequalis</i> (GÜNTHER) |
| 49. <i>Hymenocephalus italicus</i> GIGLIOLI | 50. <i>Trachyrinchus murrayi</i> GÜNTHER |
| 51. <i>Trachyrinchus trachyrhynchus</i> (Risso) | 52. <i>Bathygadus goethemi</i> POLL |
| 53. <i>Beryx decadactylus</i> CUV. et VAL. | 54. <i>Hoplostethus atlanticus</i> COLLETT |
| 55. <i>Hoplostethus mediterraneum</i> VAL. | 56. <i>Gephyroberyx darwini</i> (JOHNSON) |
| 57. <i>Dirctmus argenteus</i> (JOHNSON) | 58. <i>Zeus faber</i> L. |

Plate 5

Fig. 59-74

- | | |
|--|---|
| 59. <i>Zenopsis condifer</i> (LOWE) | 60. <i>Antigonia capros</i> LOWE |
| 61. <i>Sphyraena dubia</i> BLEEKER | 62. <i>Sphyraena piscatorum</i> CADENAT |
| 63. <i>Pentanemus quinquarius</i> (L.) | 64. <i>Galeoides decadactylus</i> (BLOCH) |
| 65. <i>Anthias anthias</i> (L.) | 66. <i>Neanthias accraensis</i> NORMAN |
| 67. <i>Epinephelus aeneus</i> GEOF. ST. HIL. | 68. <i>Priacanthus arenatus</i> CUV. |
| 69. <i>Synagrops microlepis</i> NORMAN | 70. <i>Epigonus telescopus</i> (Risso) |
| 71. <i>Latilus semifasciatus</i> NORMAN | 72. <i>Hypoclydonia bella</i> GOODE et BEAN |
| 73. <i>Trachurus trachurus</i> (L.) | 74. <i>Caranx ronchus</i> GEOF. ST. HIL. |

Plate 6

Fig. 75-88

- | | |
|---|---|
| 75. <i>Scyris alexandrinus</i> (GEOF. ST. HIL.) | 76. <i>Vomer setapinnis</i> (MITCHILL) |
| 77. <i>Erythrodes monodi</i> POLL et CADENAT | 78. <i>Apsilus fuscus</i> VAL. |
| 79. <i>Lutjanus goreensis</i> VAL. | 80. <i>Lutjanus fulgens</i> (VAL.) |
| 81. <i>Eucinostomus melanopterus</i> (BLEEKER) | 82. <i>Pomadasys jubelini</i> (CUV.) |
| 83. <i>Pomadasys incisus</i> (BOWDICH) | 84. <i>Pomadasys suillus</i> (VAL.) |
| 85. <i>Brachydeuterus auritus</i> (VAL.) | 86. <i>Gaterin' mediterraneus</i> (GUICHENOT) |
| 87. <i>Pseudotolithus typus</i> BLEEKER | 88. <i>Pseudotolithus brachygnathus</i> BLEEKER |

Plate 7

Fig. 89-104

- | | |
|---|---------------------------------------|
| 89. <i>Pseudotolithus elongatus</i> (BOWDICH) | 90. <i>Larimus peli</i> BLEEKER |
| 91. <i>Umbrina canariensis</i> VAL. | 92. <i>Sciaena mbizi</i> POLL |
| 93. <i>Dentex angolensis</i> POLL et MAUL | 94. <i>Dentex congoensis</i> POLL |
| 95. <i>Dentex filiosus</i> VAL. | 96. <i>Pagrus pagrus</i> (L.) |
| 97. <i>Pagrus gibbiceps</i> (VAL.) | 98. <i>Pagrus ehrenbergi</i> VAL. |
| 99. <i>Pagellus coupei</i> DIEUZEIDE | 100. <i>Boops boops</i> (L.) |
| 101. <i>Spondylisoma cantharus</i> (L.) | 102. <i>Lethrinus atlanticus</i> VAL. |
| 103. <i>Smaris macrophthalmus</i> CADENAT | 104. <i>Mullus surmuletus</i> L. |

Plate 8

Fig. 105-118

- | | |
|---|--|
| 105. <i>Pseudupeneus prayensis</i> (CUV.) | 106. <i>Drepane africana</i> OSORIO |
| 107. <i>Chaetodipterus goreensis</i> (CUV.) | 108. <i>Chaetodon luciae</i> ROCHEBRUNE |
| 109. <i>Chaetodon marcellae</i> POLL | 110. <i>Cepola pauciradiata</i> CADENAT |
| 111. <i>Chromis lineatus</i> CADENAT | 112. <i>Ctenolabrus rupestris</i> (L.) |
| 113. <i>Coris julis</i> L. | 114. <i>Hemipteronotus novacula</i> (L.) |
| 115. <i>Pseudolepidaplois scrofa</i> (VAL.) | 116. <i>Scarus hoefleri</i> (STEINDACHNER) |
| 117. <i>Trachinus draco</i> L. | 118. <i>Trachinus vipera</i> CUV. |

Plate 9

Fig. 119-132

- | | |
|--|--|
| 119. <i>Trachinus armatus</i> SCHLEGEL | 120. <i>Trachinus radiatus</i> CUV. |
| 121. <i>Bembrops heterurus</i> MIRANDA RIBEIRO | 122. <i>Uranoscopus albesca</i> REGAN |
| 123. <i>Uranoscopus polli</i> CADENAT | 124. <i>Uranoscopus cadenati</i> POLL |
| 125. <i>Anarhichas lupus</i> L. | 126. <i>Anarhichas minor</i> OLAFSEN |
| 127. <i>Anarhichas denticulatus</i> KRØYER | 128. <i>Lumpenus lamprataeformis</i> (WALB.) |
| 129. <i>Zoarcetes viviparus</i> L. | 130. <i>Lycdes vahlii gracilis</i> SARS |
| 131. <i>Lycodes esmarki</i> COLLETT | 132. <i>Brotula barbata</i> (SCHNEIDER) |

Plate 10

Fig. 133-146

- | | |
|--|--|
| 133. <i>Hyperoplus lanceolatus</i> (LESAUVAGE) | 134. <i>Ammodytes tobianus</i> L. |
| 135. <i>Callionymus lyra</i> L. | 136. <i>Callionymus macularus</i> RAFINESQUE |
| 137. <i>Callionymus phacton</i> GÜNTHER | 138. <i>Acanthurus monroviae</i> STEIND. |
| 139. <i>Trichiurus lepturus</i> L. | 140. <i>Aphanopus carbo</i> LOWE |
| 141. <i>Scomber scombrus</i> L. | 142. <i>Stromateus fiatola</i> L. |
| 143. <i>Paracubiceps multisquamis</i> MARCHAL | 144. <i>Paracubiceps ledanoisi</i> BELLOC |
| 145. <i>Pomatoschistus minutus</i> (PALLAS) | 146. <i>Sebastes marinus</i> (L.) |

Plate 11

Fig. 147-160

- | | |
|--|---|
| 147. <i>Sebastes viviparus</i> KRØYER | 148. <i>Helicolenus dactylopterus</i> DELAROCHE |
| 149. <i>Pontinus accraensis</i> NORMAN | 150. <i>Scorpaena normani</i> CADENAT |
| 151. <i>Scorpaena angolensis</i> NORMAN | 152. <i>Trigla gurnardus</i> L. |
| 153. <i>Trigla corax</i> BONAPARTE | 154. <i>Trigla lyra</i> L. |
| 155. <i>Trigla gabonensis</i> POLL et ROUX | 156. <i>Peristedion cataphractum</i> (L.) |
| 157. <i>Myoxocephalus scorpius</i> (L.) | 158. <i>Taurulus bubalis</i> (EUPHRASEN) |
| 159. <i>Triglops murrayi</i> GÜNTHER | 160. <i>Artediellus atlanticus</i> JORDAN et Everm. |

Plate 12

Fig. 161-174

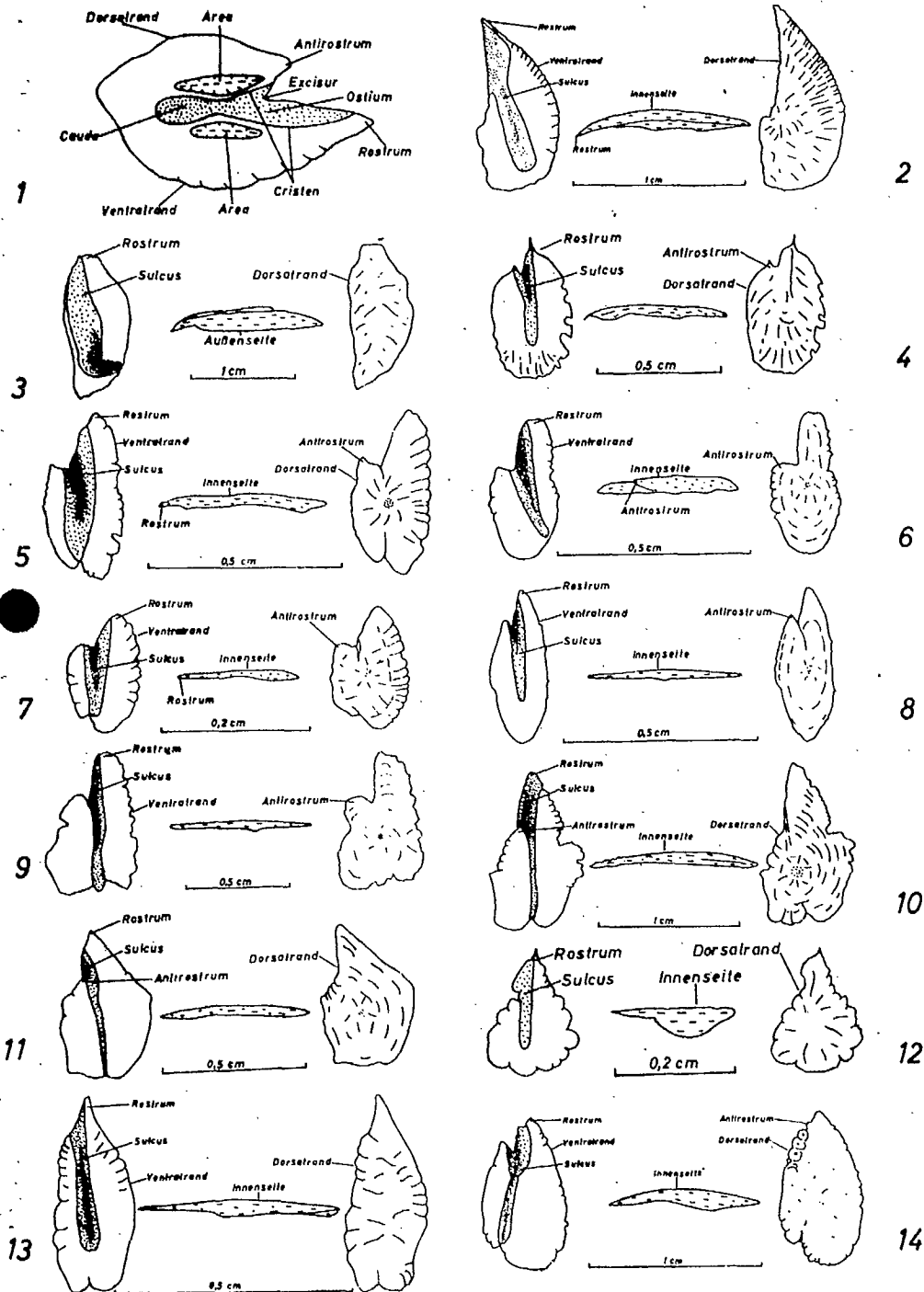
- | | |
|--|--|
| 161. <i>Cottunculus microps</i> COLLETT | 162. <i>Agonus cataphractus</i> L. |
| 163. <i>Leptagonus decagonus</i> (SCHNEIDER) | 164. <i>Cyclopterus lumpus</i> L. |
| 165. <i>Careproctus reinhardtii</i> KRØYER | 166. <i>Dactylopterus volitans</i> (L.) |
| 167. <i>Psetta maxima</i> (L.) | 168. <i>Scophthalmus rhombus</i> (L.) |
| 169. <i>Lepidorhombus whiffiagonis</i> (WALB.) | 170. <i>Hippoglossus hippoglossus</i> (L.) |
| 171. <i>Pleuronectes platessa</i> L. | 172. <i>Platichthys flesus</i> (L.) |
| 173. <i>Limanda limanda</i> (L.) | 174. <i>Hippoglossoides platessoides</i> (Fabricius) |

Plate 13

Fig. 175-185

- | | |
|---|--|
| 175. <i>Glyptocephalus cynoglossus</i> (L.) | 176. <i>Reinhardtius hippoglossoides</i> (WALB.) |
| 177. <i>Microstomus kitt</i> (WALB.) | 178. <i>Solea solea</i> (L.) |
| 179. <i>Dicologlossa cuneata</i> (MOREAU) | 180. <i>Buglossidium luteum</i> (Risso) |
| 181. <i>Cynoglossus canariensis</i> STEIND. | 182. <i>Batrachoides didactylus</i> (SCHNEIDER) |
| 183. <i>Lophius piscatorius</i> L. | 184. <i>Antennarius scaber</i> CUV. |
| 185. <i>Chaunax pictus</i> LOWE | |

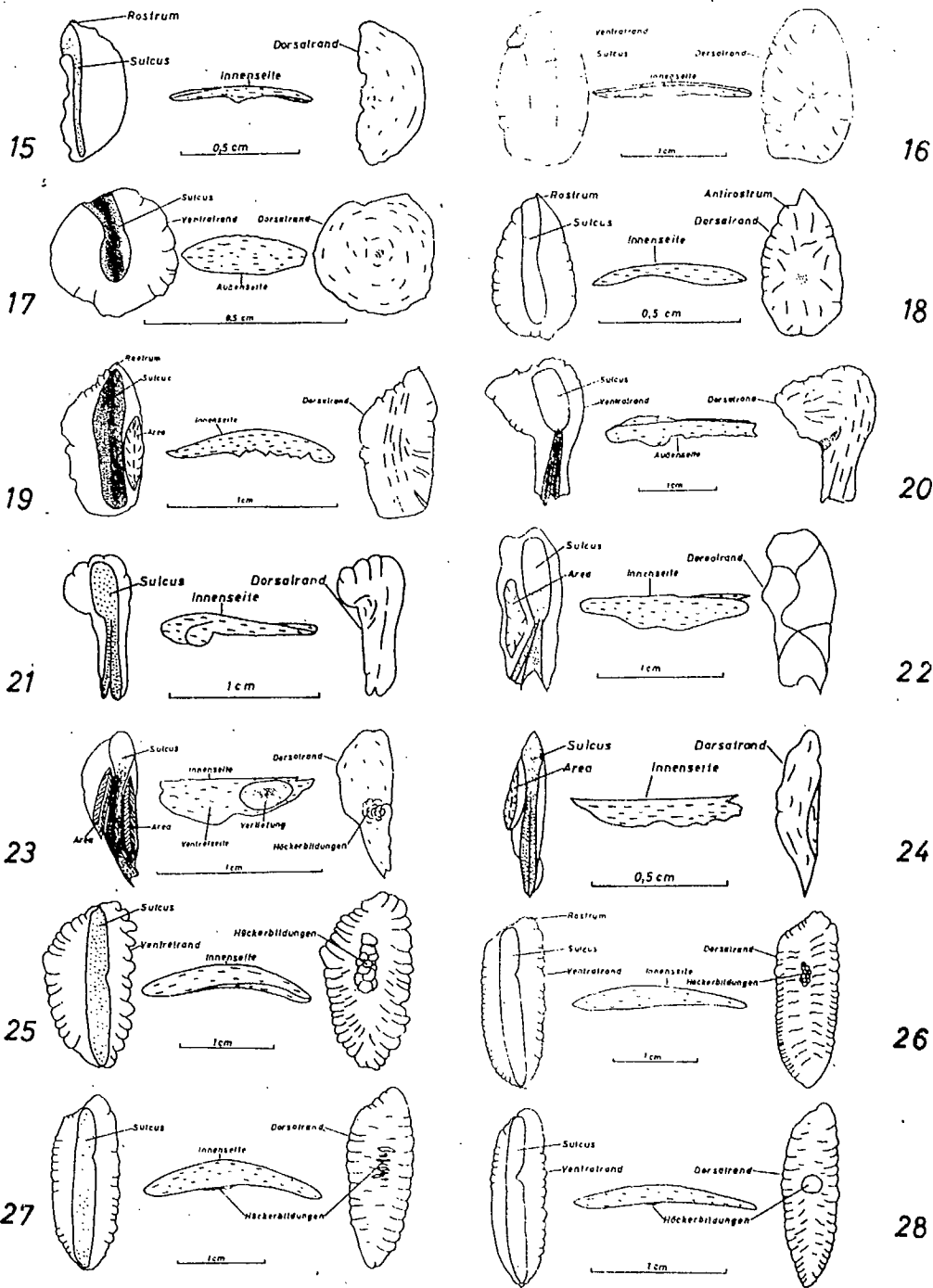
Plate 1.



Teil 1

Dorsalrand - dorsal margin
 Excisur - incisure
 Ventralrand - ventral margin

Cristen - cristae
 Innenseite - inner side
 Außenseite - outer side

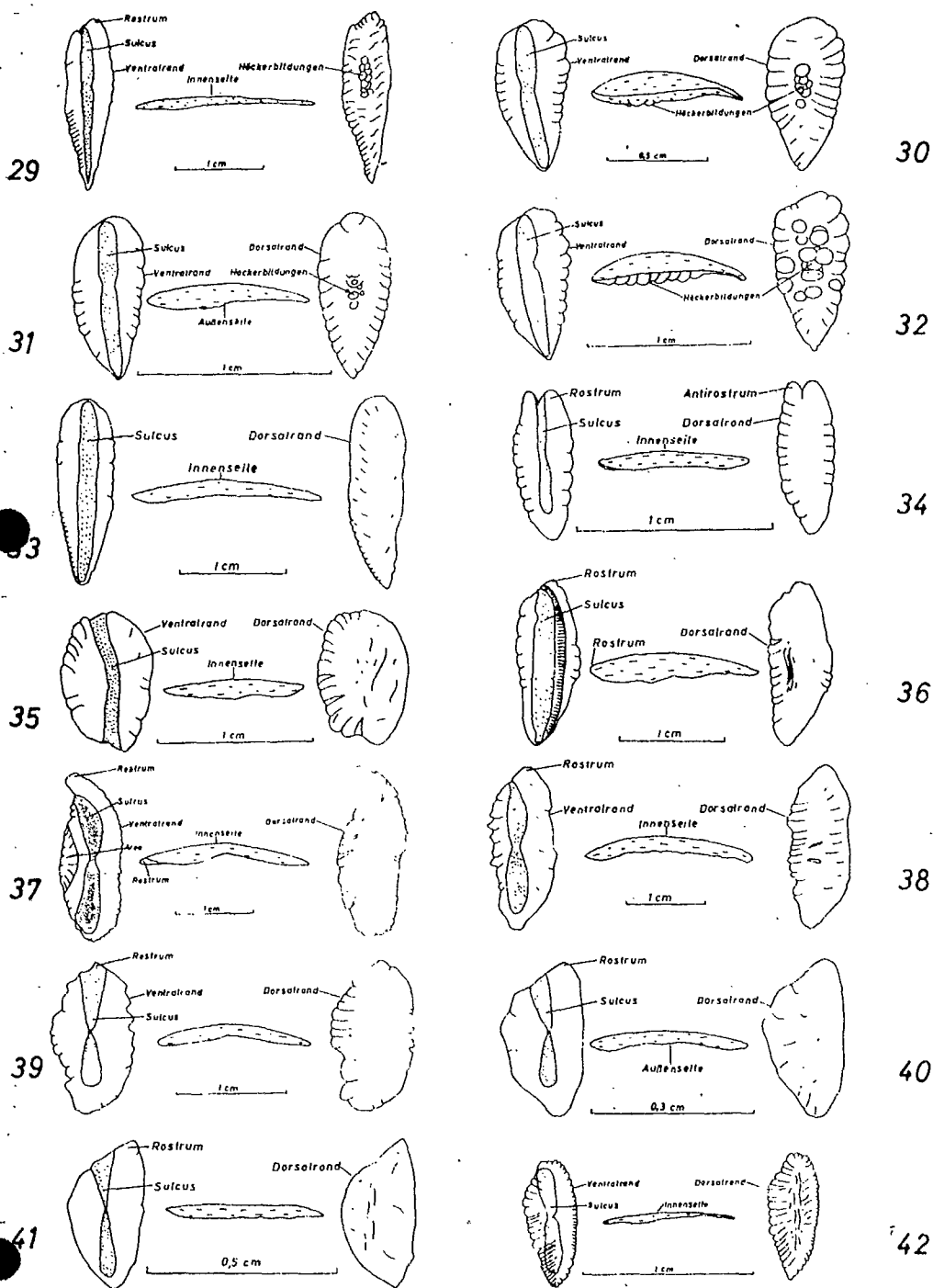


Tafel 2

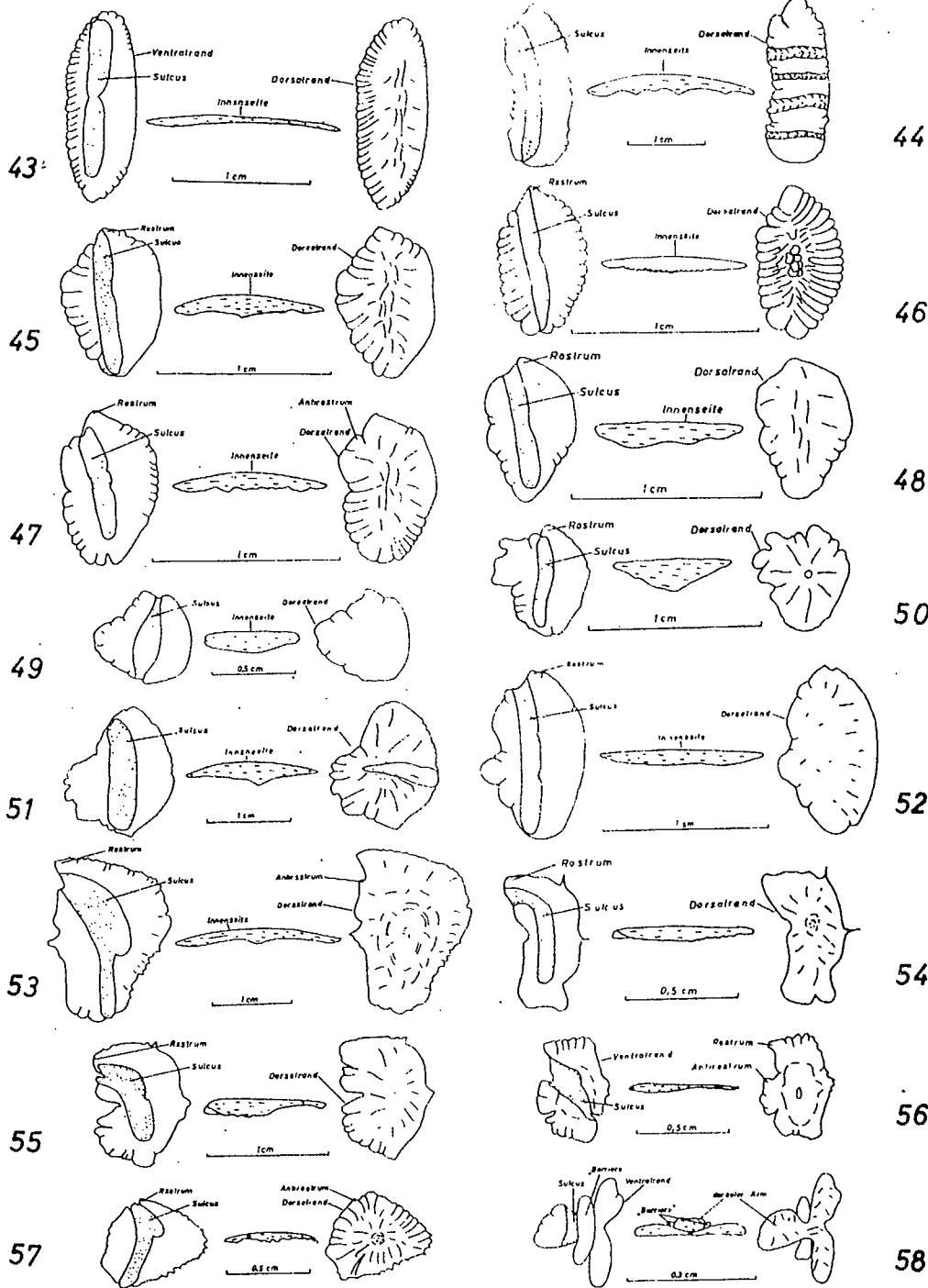
Dorsalrand - dorsal margin
 Innenseite - inner side
 Vertiefung - depression
 Höckerbildungen - humps

Ventralrand - ventral margin
 Außenseite - outer side

Plate 3.



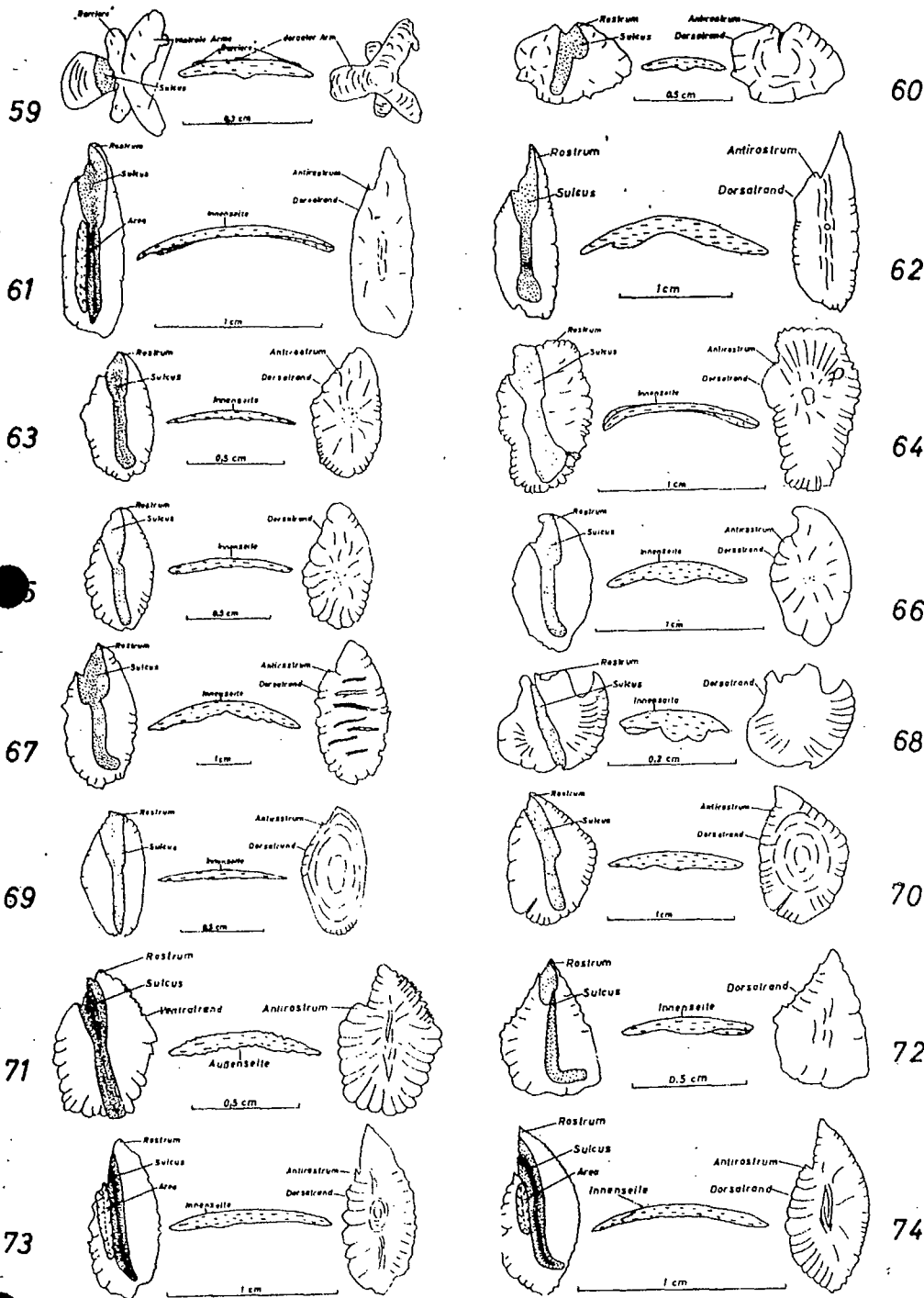
Tafel 3 Innenseite - inner side Höckerbildungen - humps
 Dorsalrand - dorsal margin Außenseite - outer side
 Ventralrand - ventral margin



Tafel 4
 Ventralrand - ventral margin
 Innenseite - inner side
 dorsaler Arm - dorsal corner

Dorsalrand - dorsal margin
 Barriere - barrier

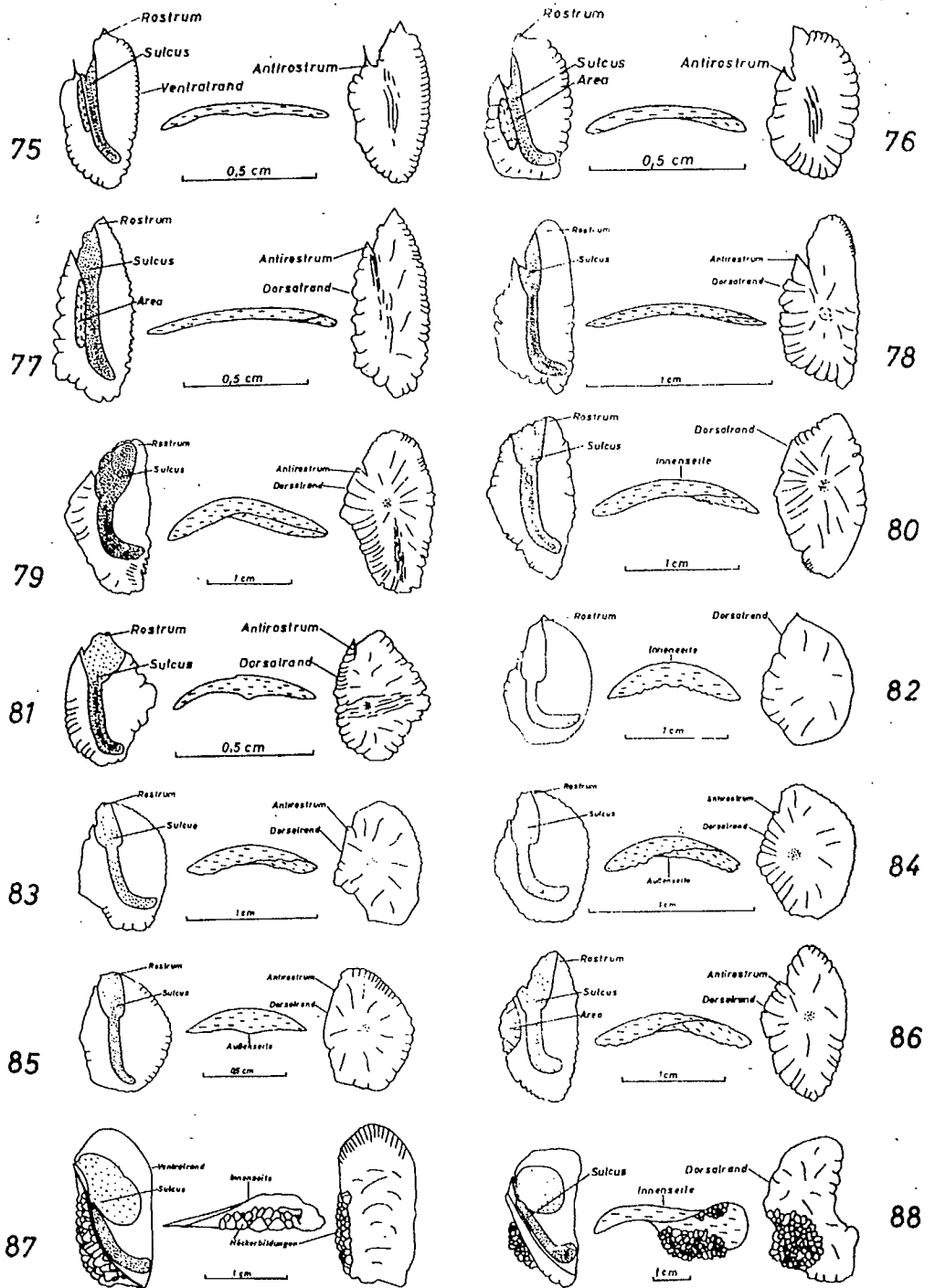
Plate 5.



Tafel 5

dorsaler Arm - dorsal corner
 Dorsalrand - dorsal margin
 Ventralrand - ventral margin

ventrale Arme - ventral corners
 Innenseite - inner side
 Außenseite - outer side

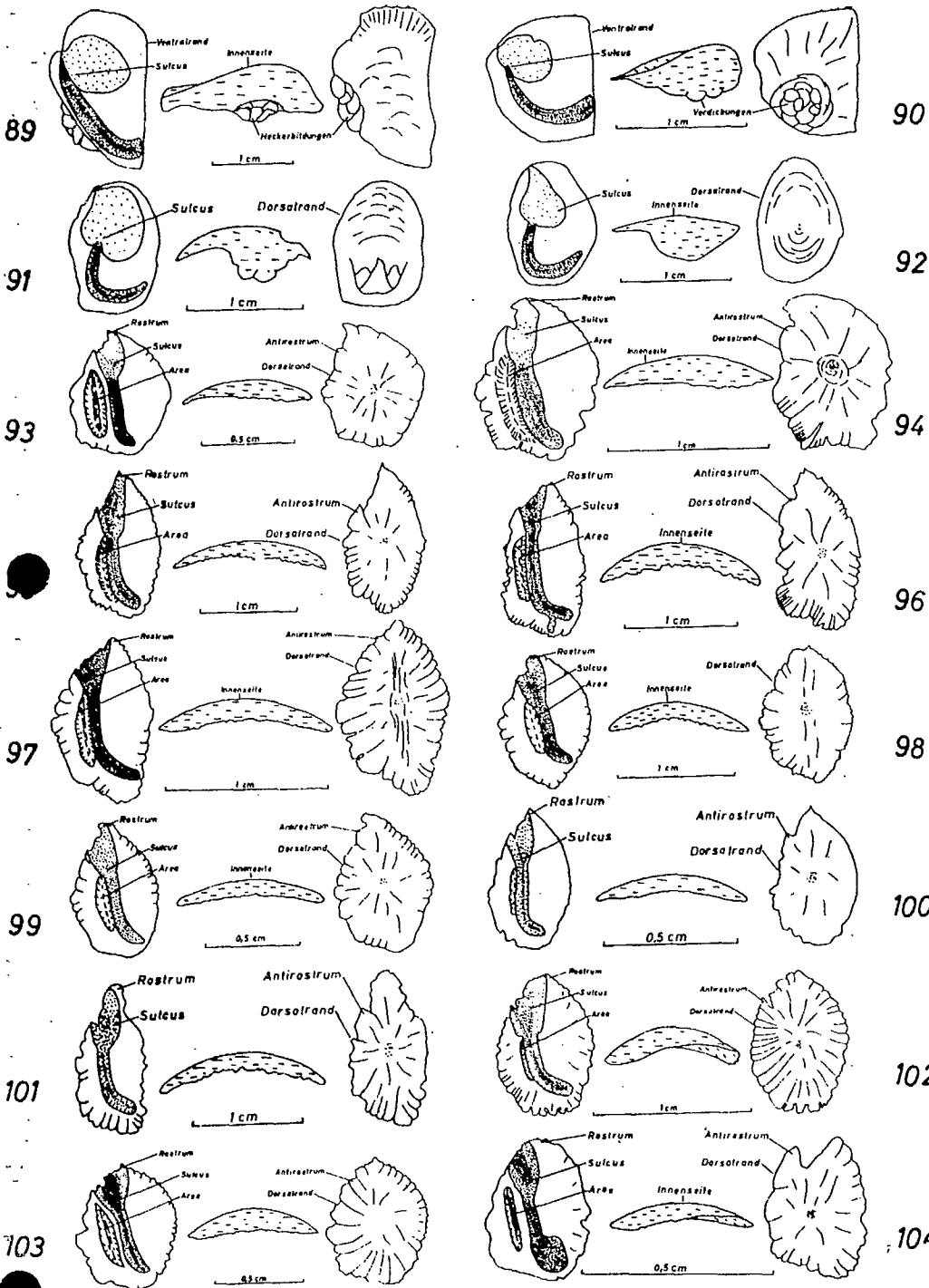


Tafel 6

Ventralrand - ventral margin.
 Außenseite - outer side
 Höckerbildungen - humps

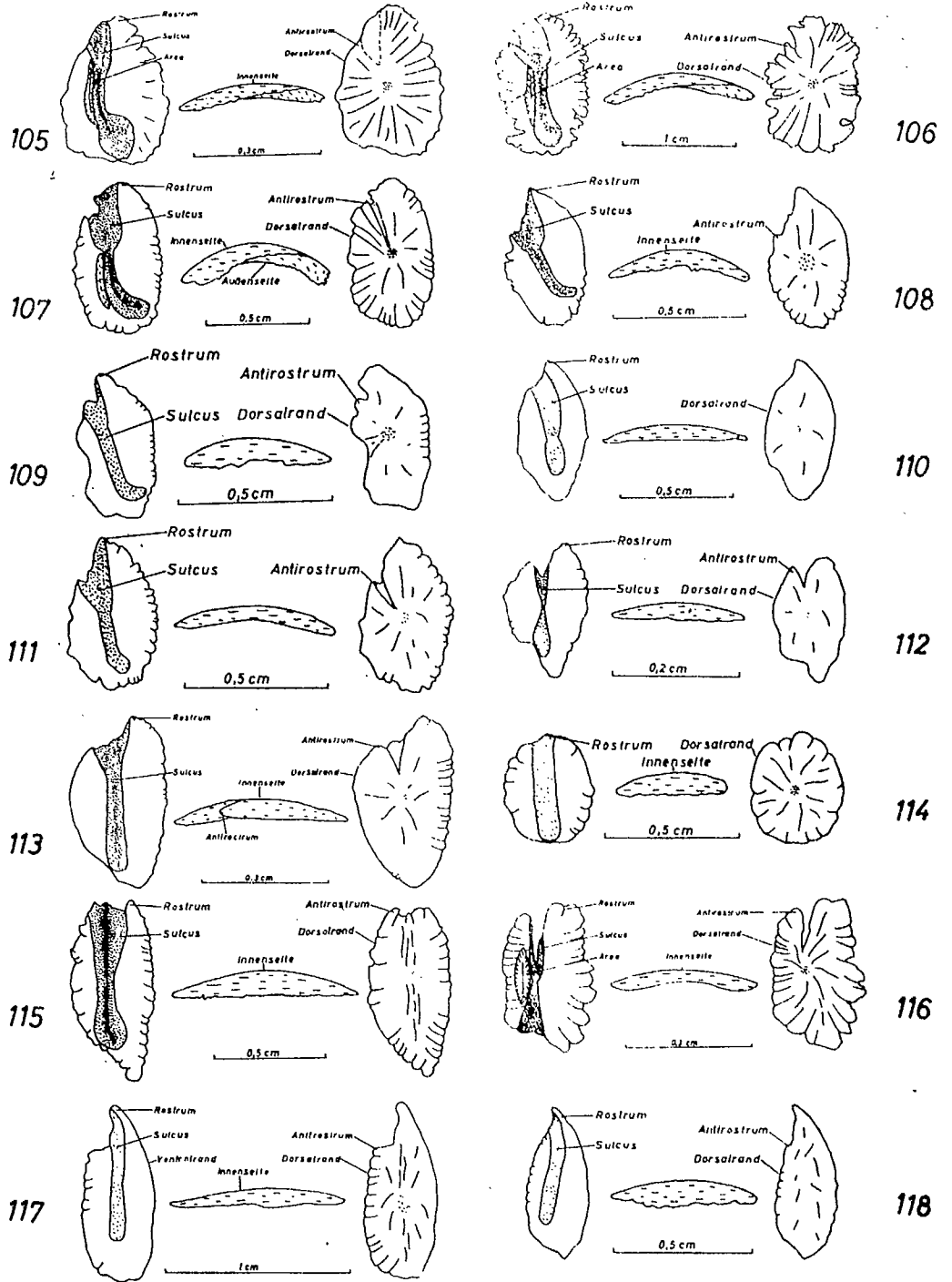
Dorsalrand - dorsal margin
 Innenseite - inner side

Plate 7.



Tafel 7 Ventralrand - ventral margin Innenseite - inner side
 Höckerbildungen - humps Dorsalrand - dorsal margin
 Verdickungen - thickenings

Plate 8.

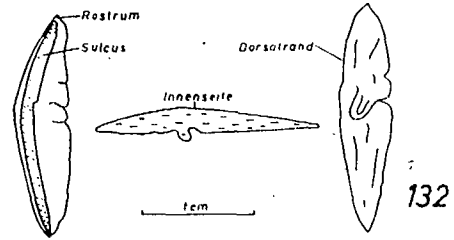
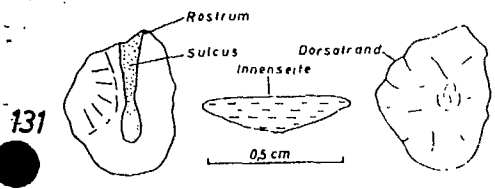
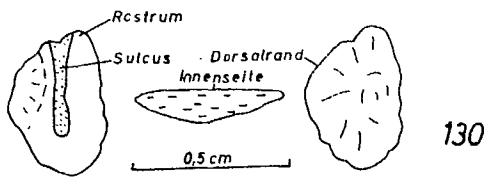
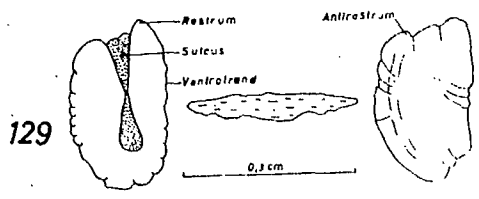
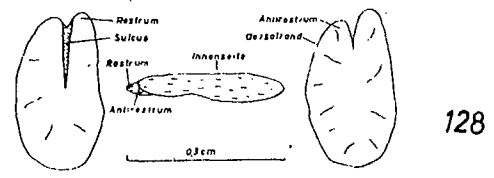
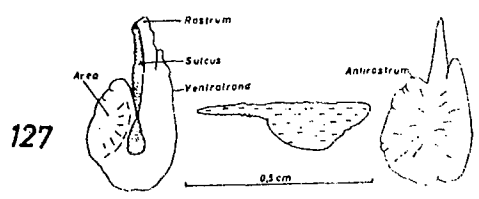
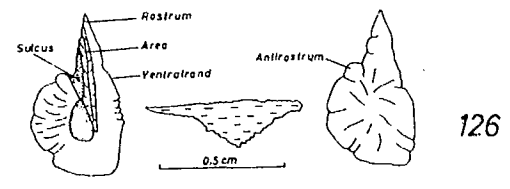
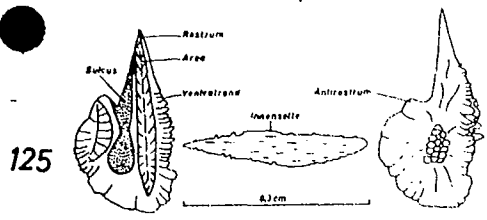
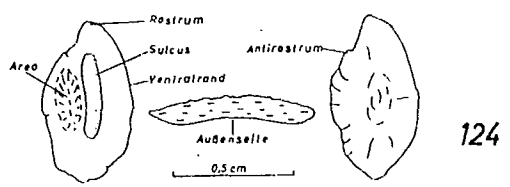
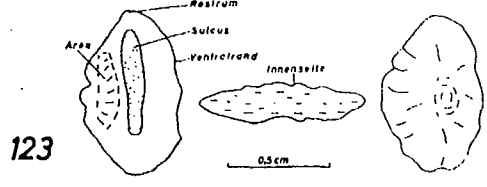
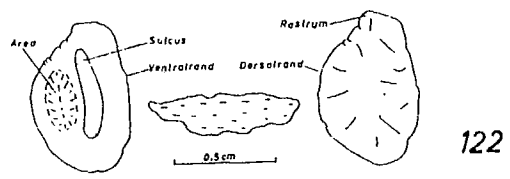
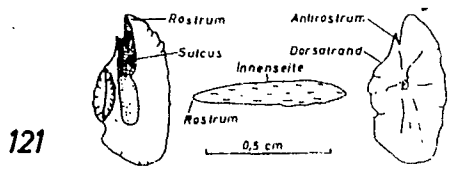
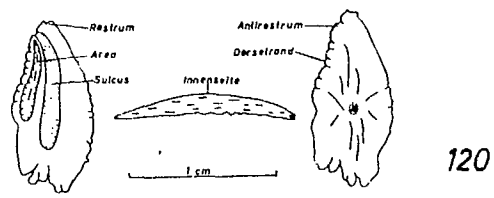
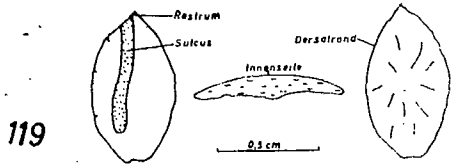


Tafel 8

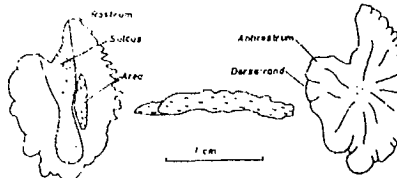
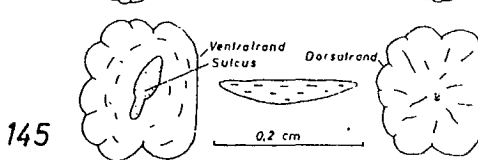
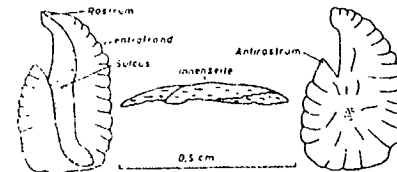
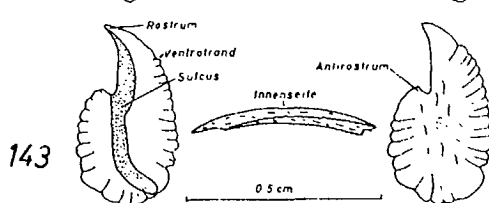
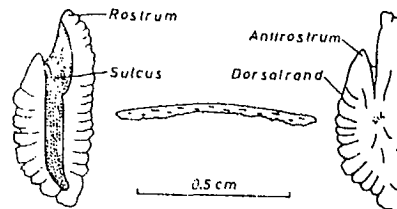
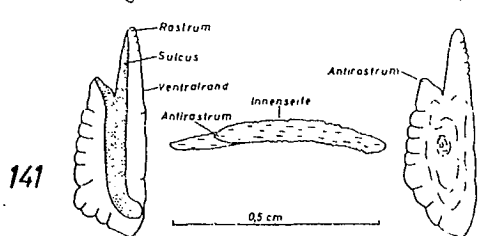
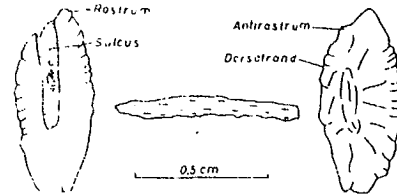
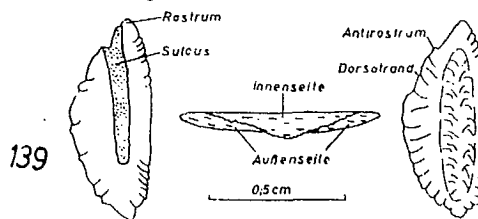
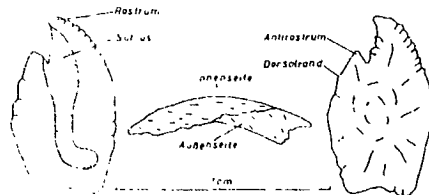
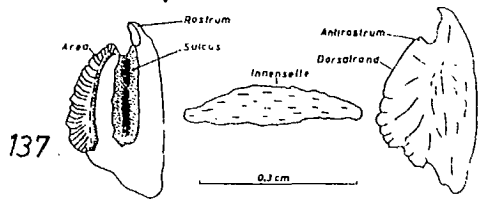
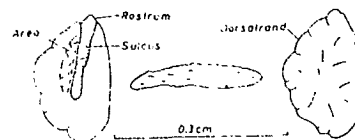
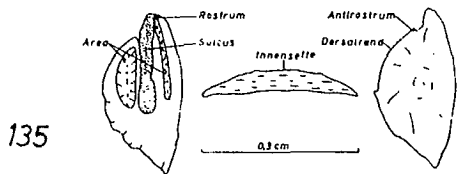
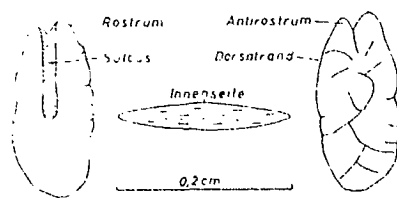
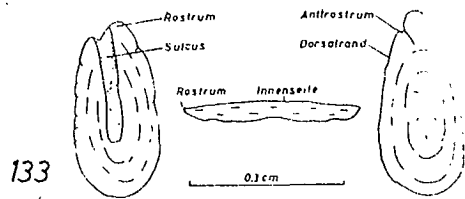
Innenseite - inner side
 Außenseite - outer side

Dorsalrand - dorsal margin

Plate 9.



Tafel 9 Dorsalrand - dorsal margin Innenseite - inner side
 Ventralrand - ventral margin Außenseite - outer side

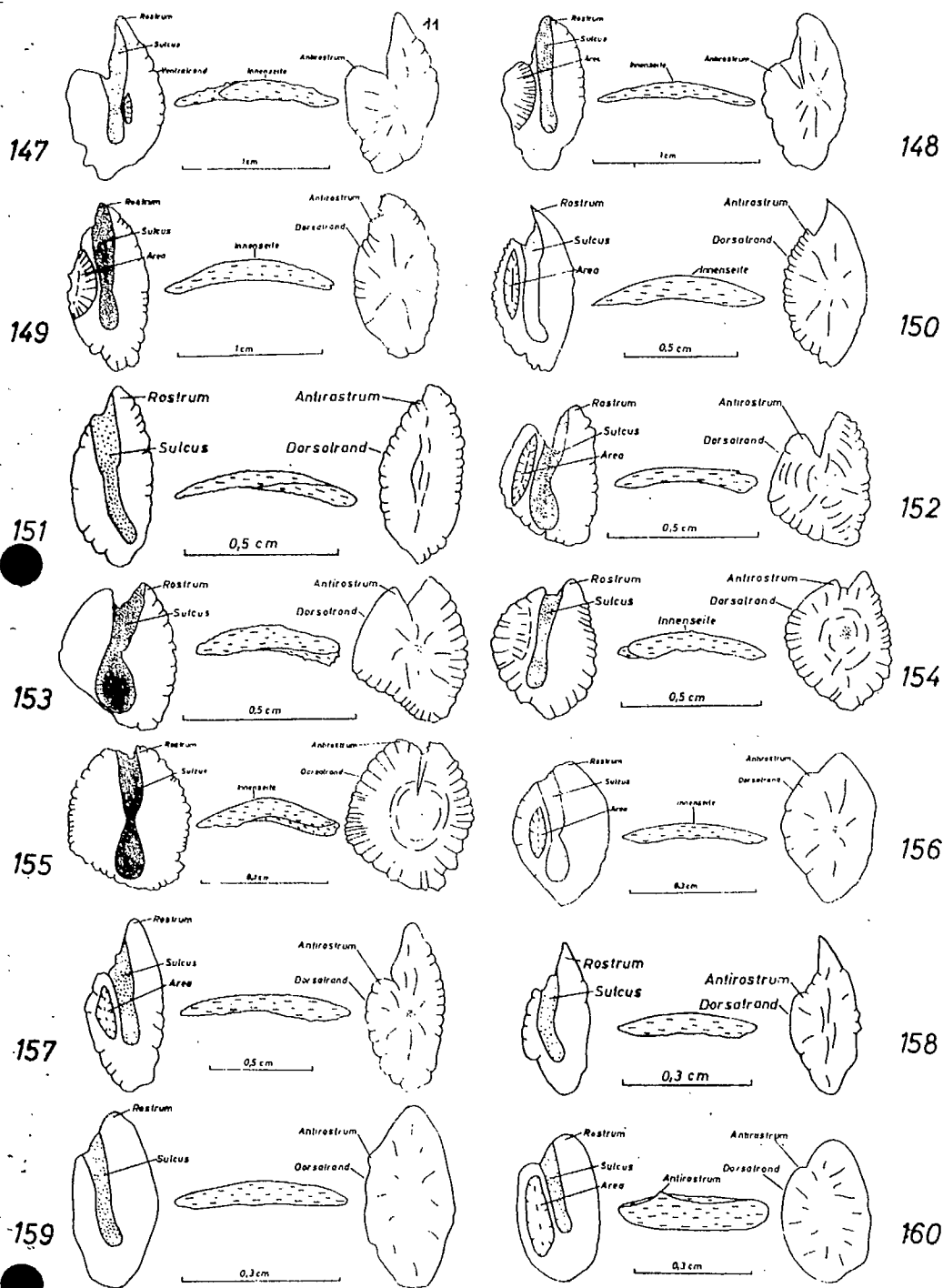


Tafel 10

Dorsalrand - dorsal margin
 Außenseite - outer side

Innenseite - inner side
 Ventralrand - ventral margin

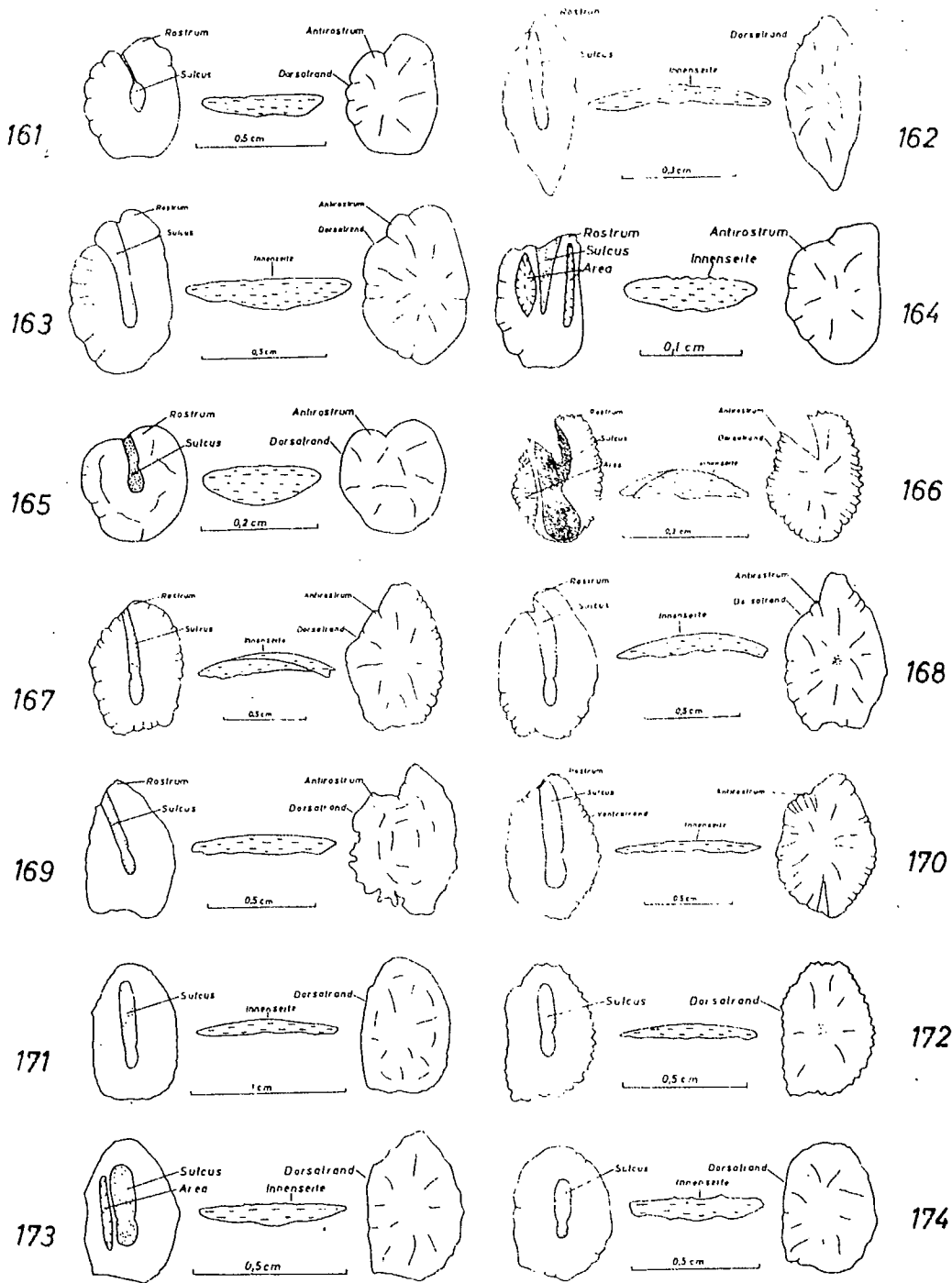
Plate 11.



Tafel 11

Ventralrand - ventral margin
Dorsalrand - dorsal margin

Innenseite - inner side

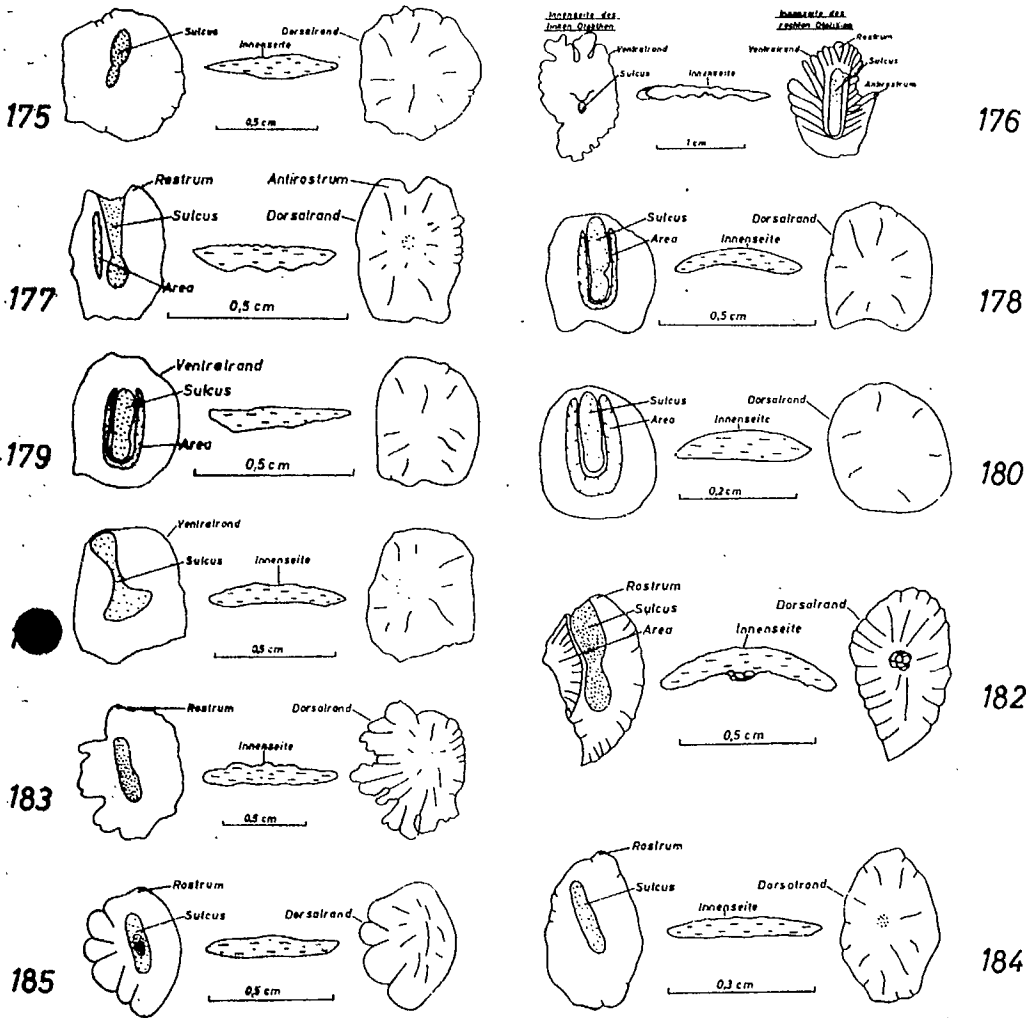


Tafel 12

Dorsalrand - dorsal margin

Innenseite - inner side

Plate 13.



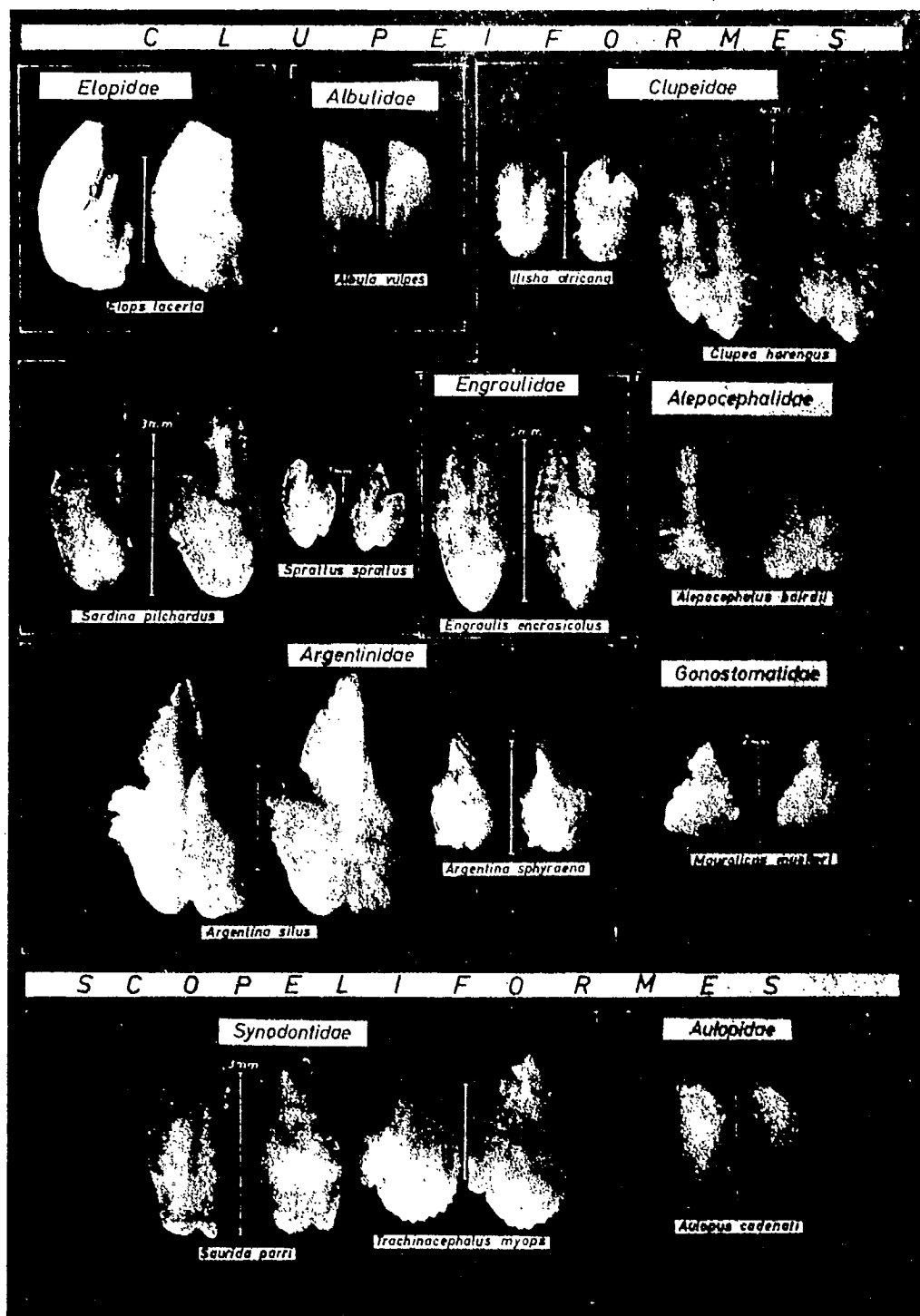
Dorsalrand - dorsal margin

Innenseite - inner side

Ventralrand - ventral margin

Innenseite des linken Otolithen - inner side of left otolith

Innenseite des rechten Otolithen - inner side of right otolith



Tafel 14

Plate 15.

ANGUILLIFORMES

Muraenesocidae



Phyllogramma regani

NOTACANTHIFORMES

Notacanthidae



Notacanthus phasganorus

BELONIFORMES

Betonidae



Belone belone

Exocoetidae



Cypselurus pinnatibarbatulus

GADIFORMES

Moridae



Mora mora



Halarogreus affinis



Lepidion eques



Laemanema laureysi



Uraleptus mar

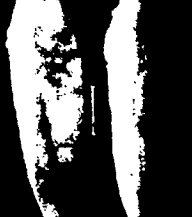
Gadidae



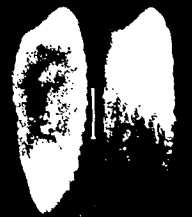
Gadus morhua



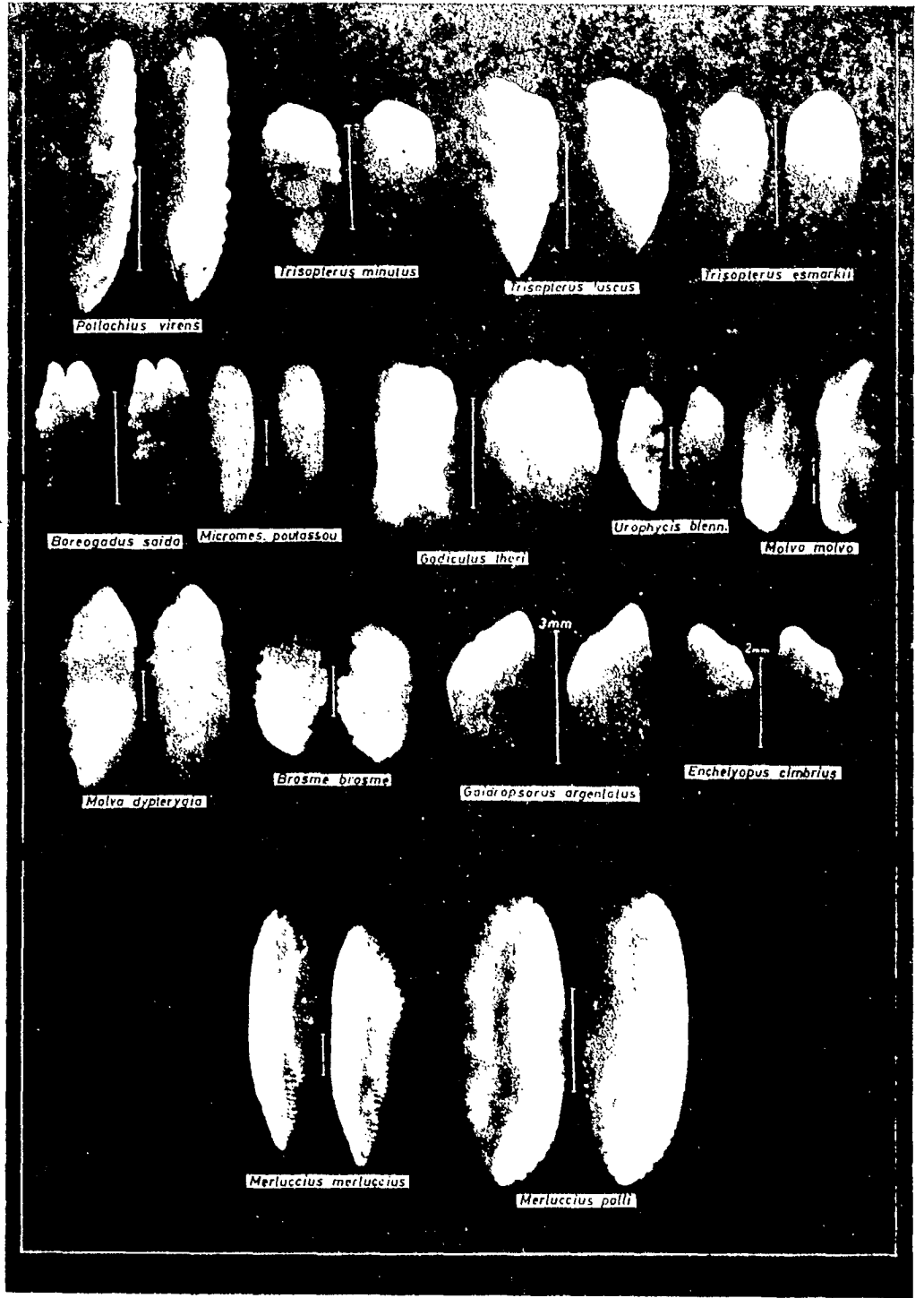
Melanogrammus aeglefinus



Merlangius merlangus



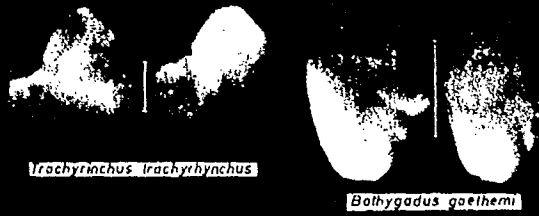
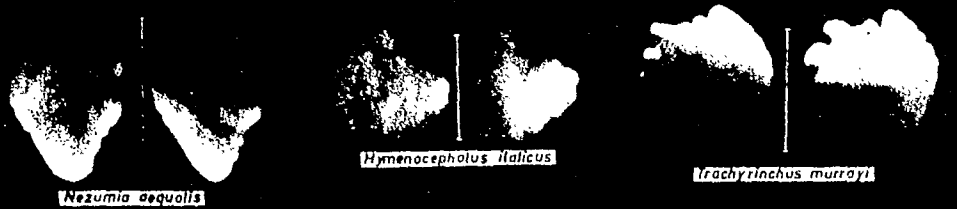
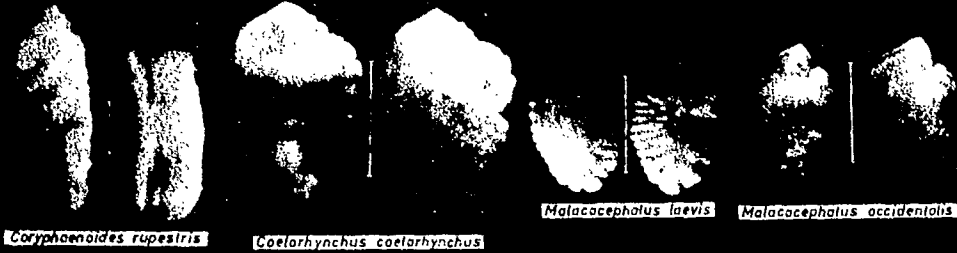
Pollachius pollachius



Tafel 16

M A C R O U R I F O R M E S

Macrouridae



B E R Y C I F O R M E S

Berycidae

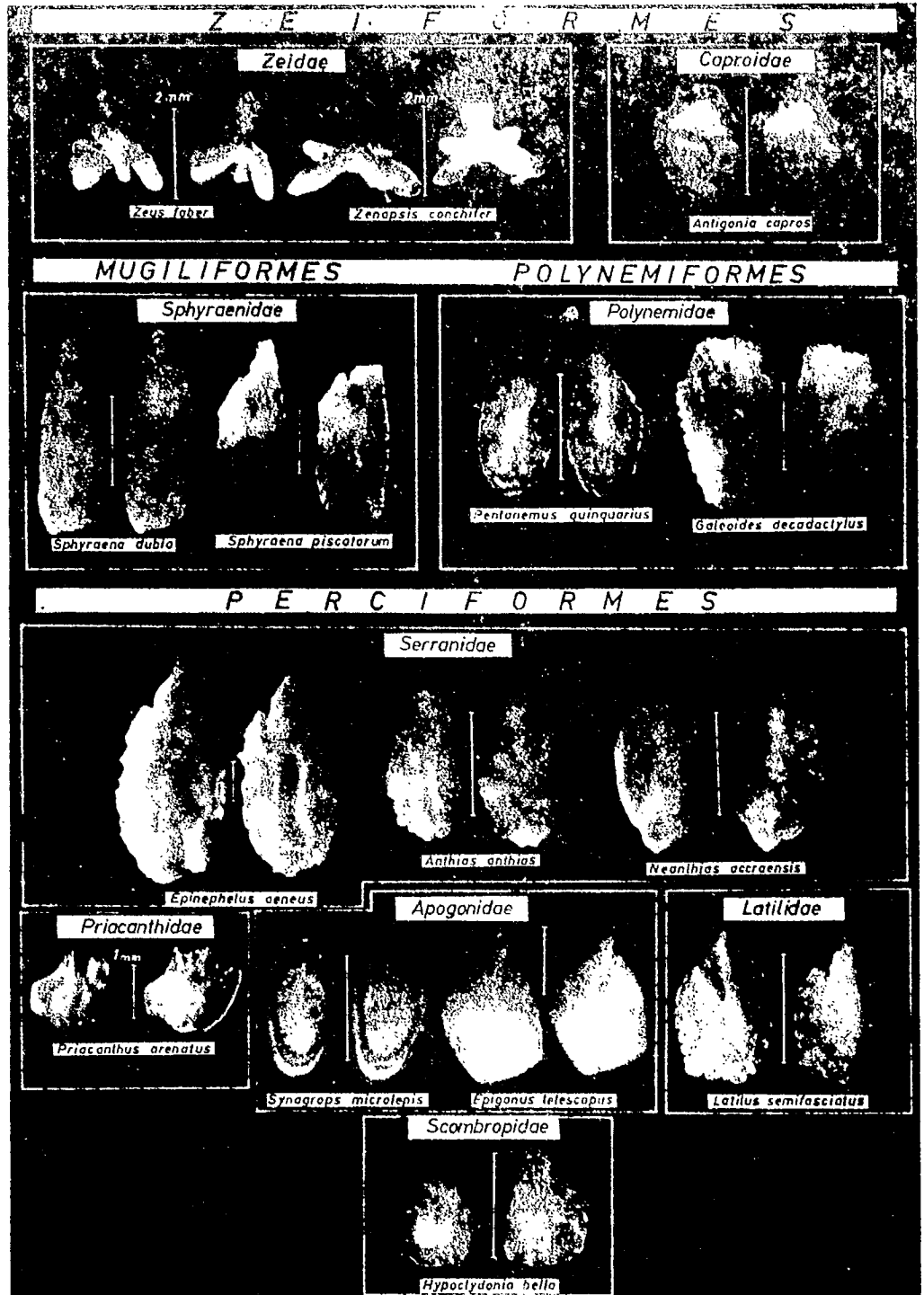


Trachichthyidae



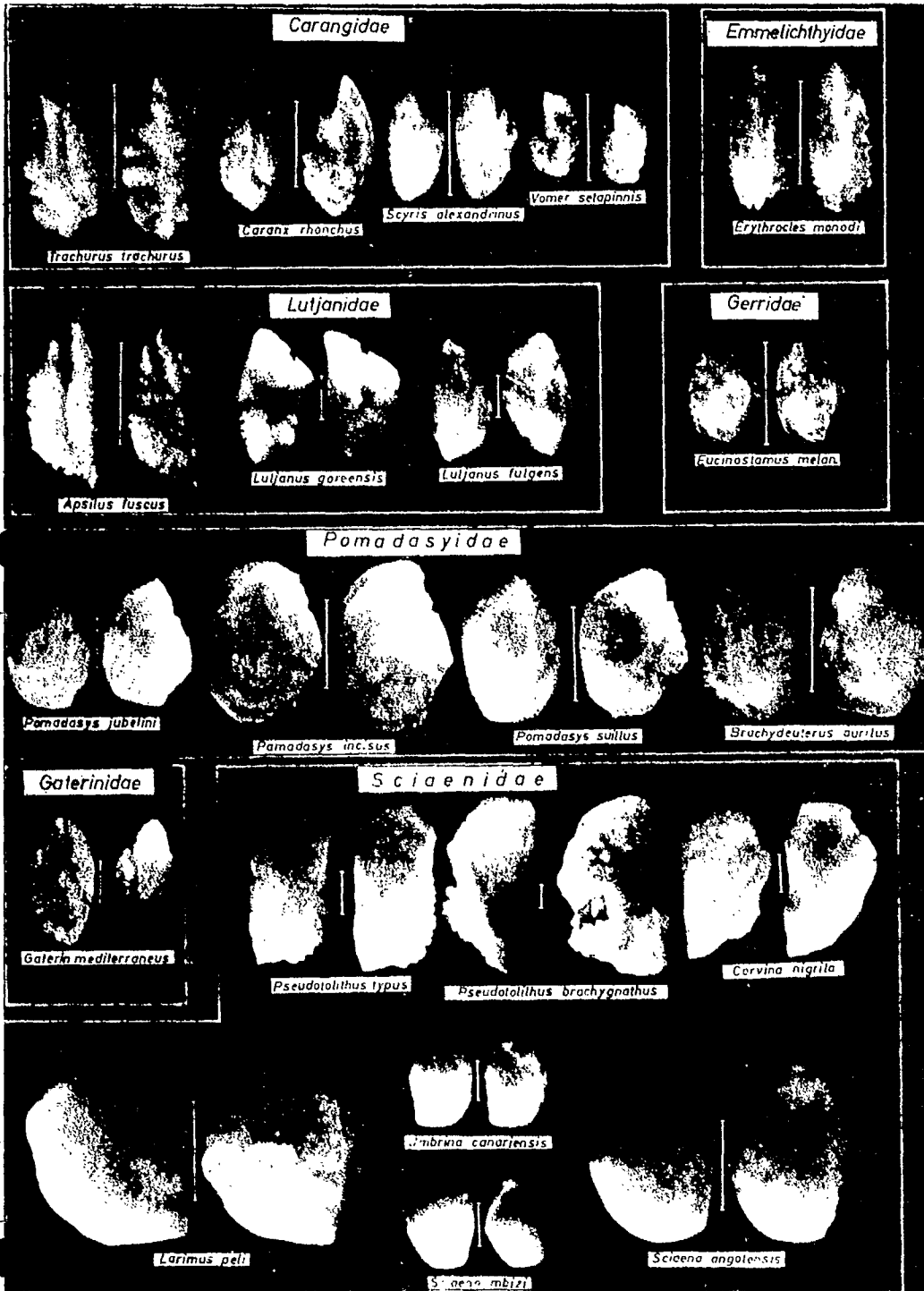
Direlmidae

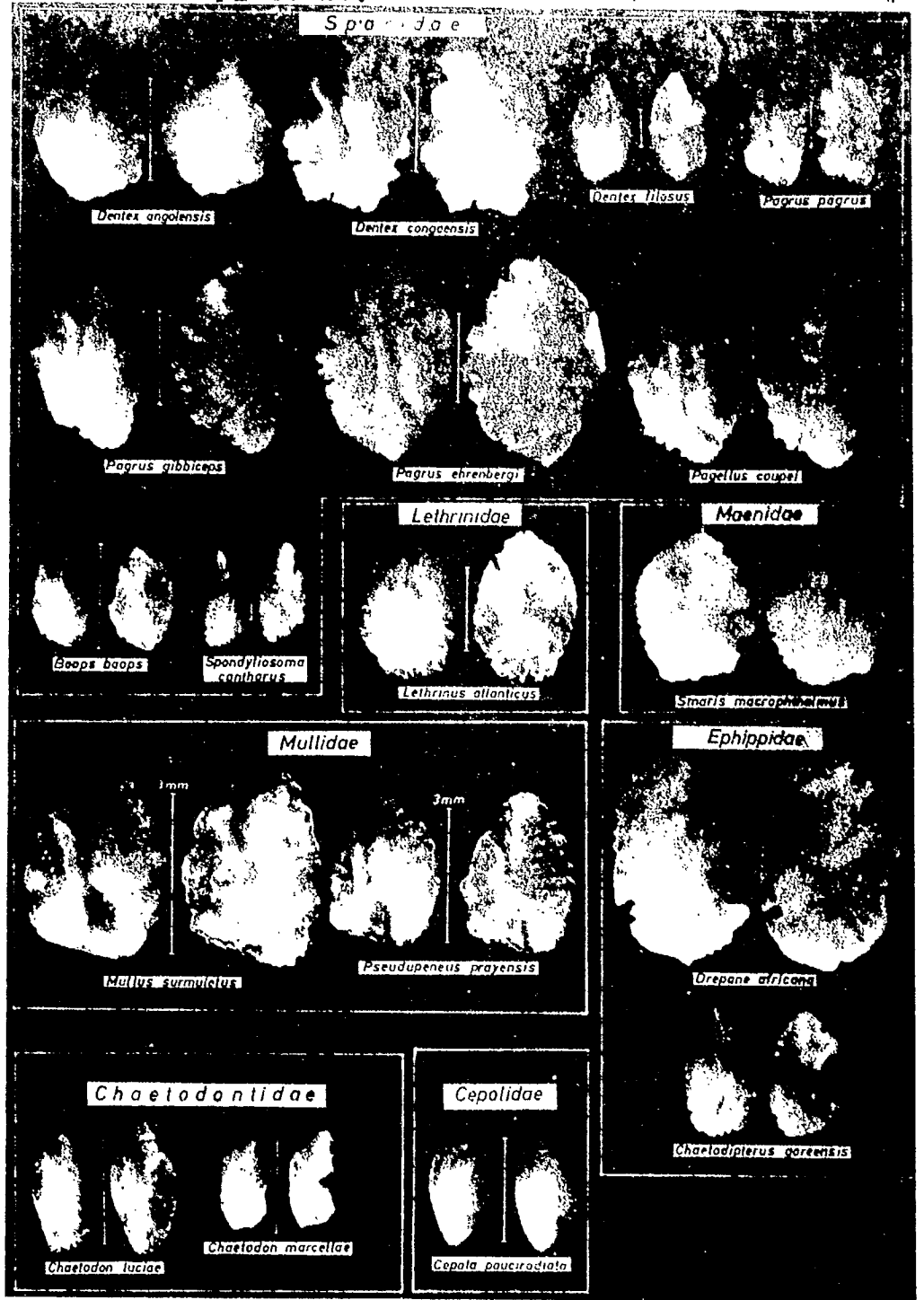




Tafel 18

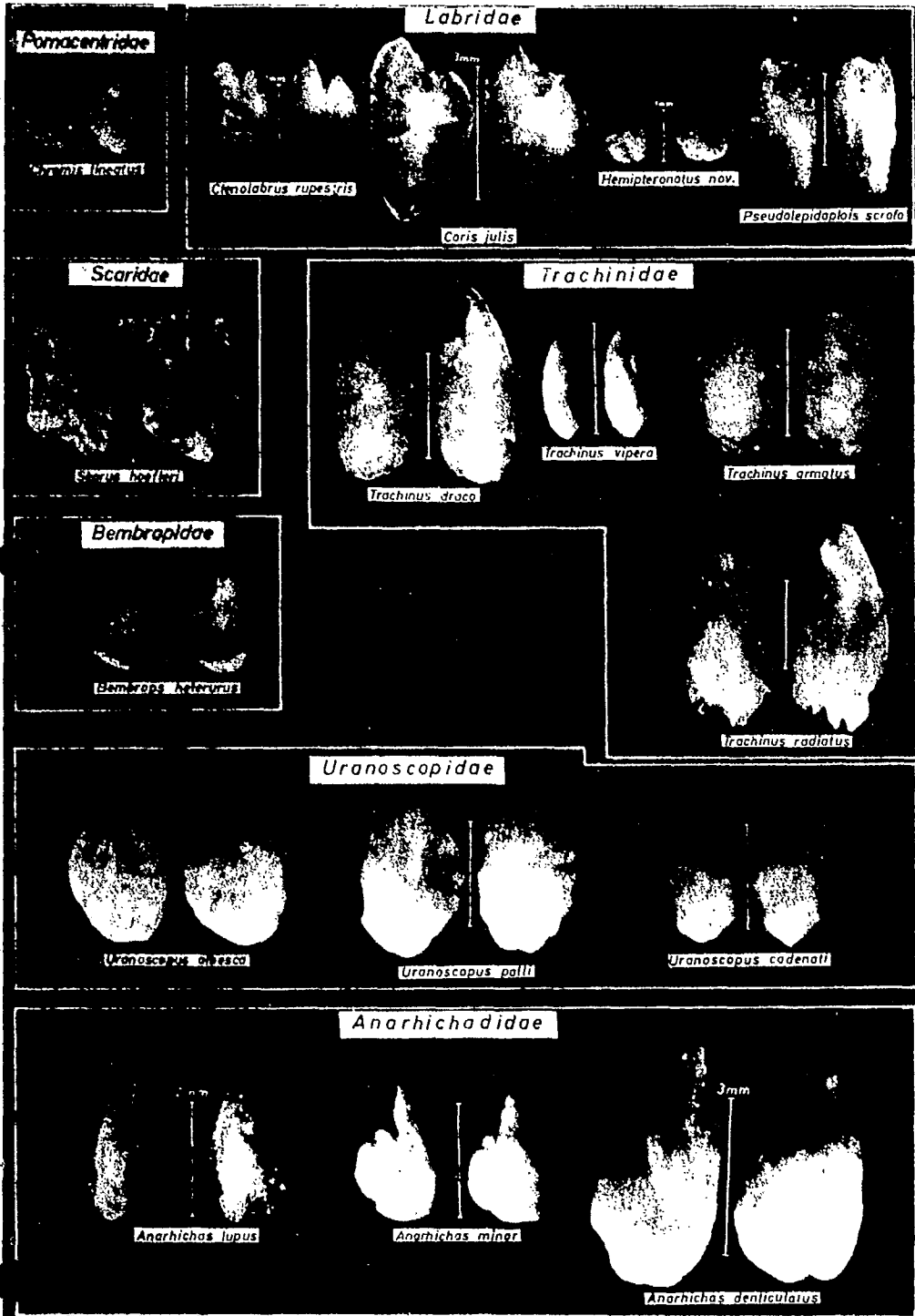
Plate 19.



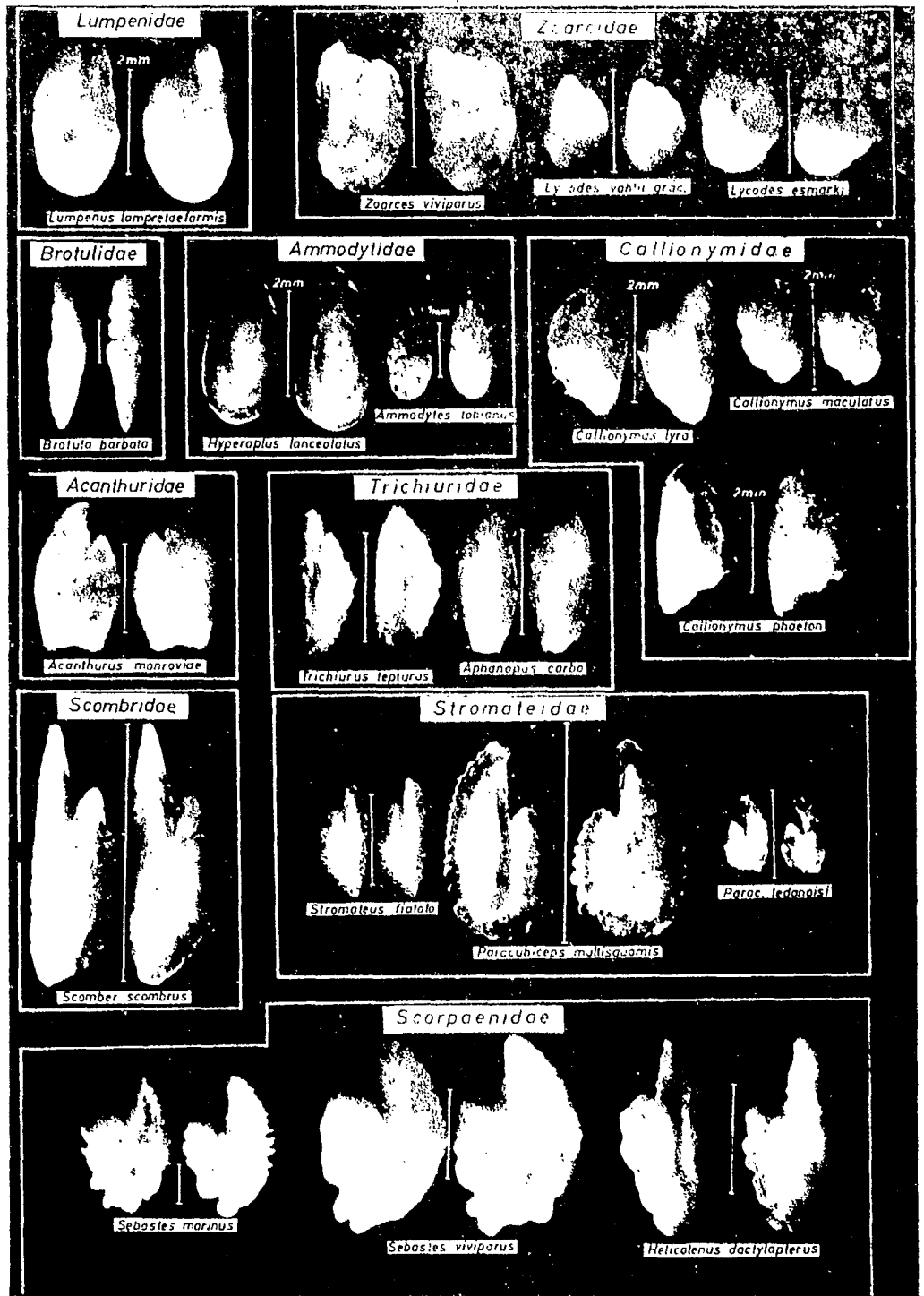


Tafel 20

Plate 21.

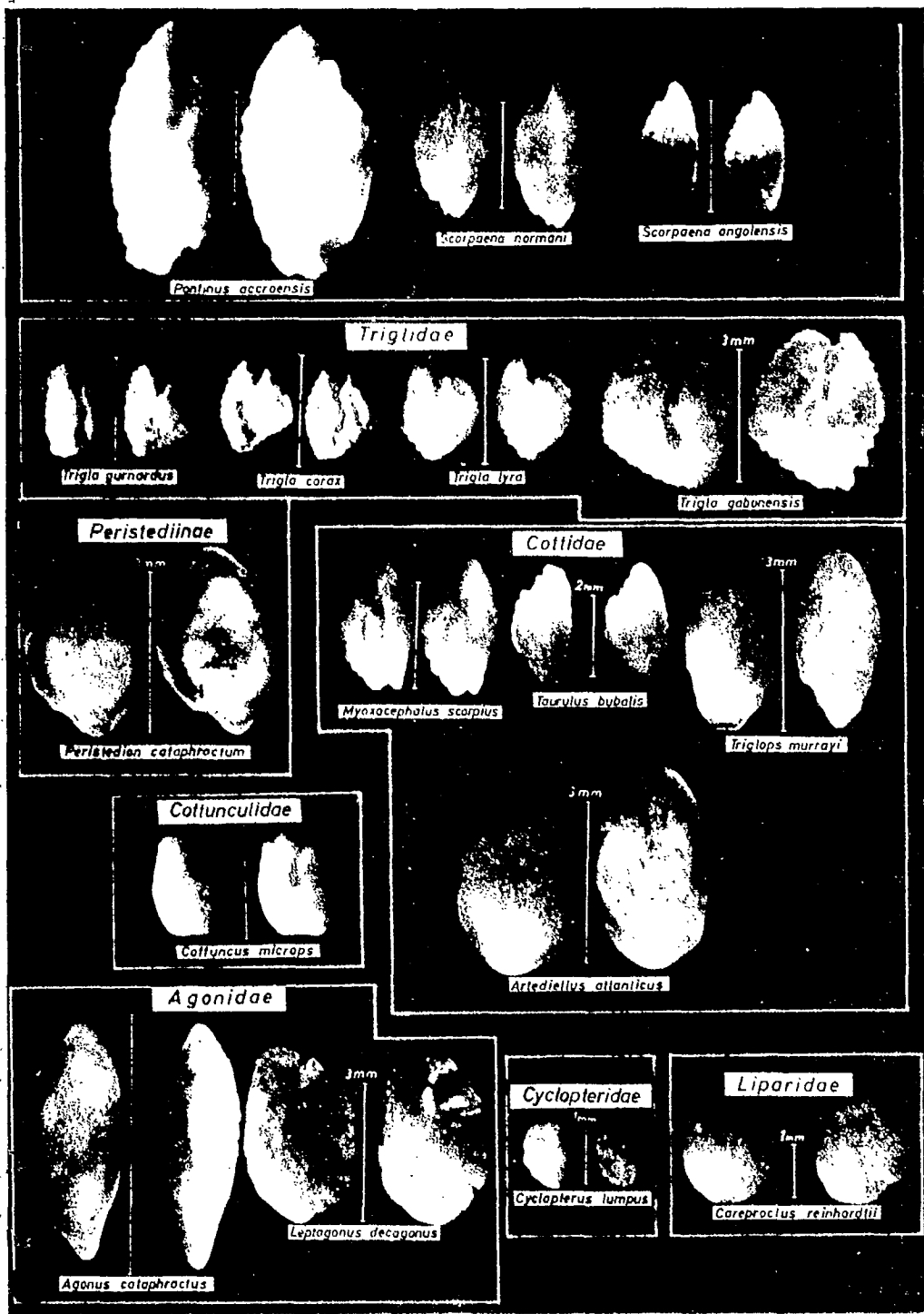


Tafel 21

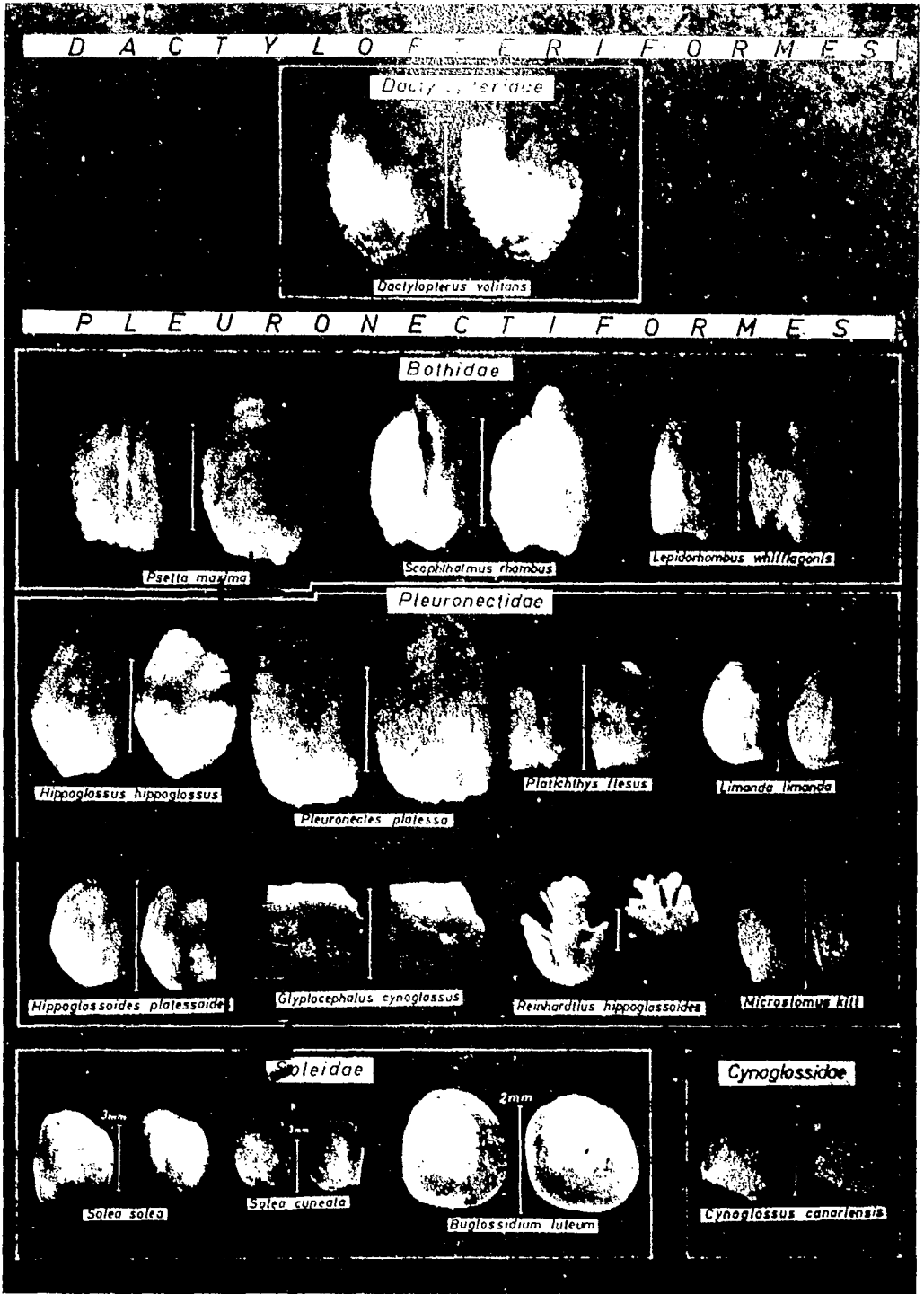


Tafel 22

Plate 23.



Tafel 23



Tafel 24

RO

DIF

B A T R A C H O I D I F O R M E S



L O P H I I F O R M E S

