Fishes of the Western North Atlantic

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MEMOIR

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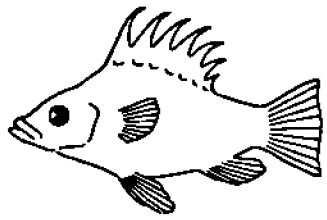
Number I

Fishes of the Western North Atlantic



PART ONE

LANCELETS

Henry B. Bigelow, *Museum of Comparative Zoology and*
Isabel Pérez Farfante, *Museo Poey,*
University of Havana

CYCLOSTOMES

Henry B. Bigelow *and* William C. Schroeder
Museum of Comparative Zoology

SHARKS

Henry B. Bigelow *and* William C. Schroeder

NEW HAVEN

SEARS FOUNDATION FOR MARINE RESEARCH, YALE UNIVERSITY

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MEMOIR I

Fishes of the Western North Atlantic

Part One
Lancelets, Cyclostomes, Sharks

Part Two
Sawfishes, Guitarfishes, Skates and Rays, Chimaeroids

Part Three
Soft-rayed Bony Fishes: Orders Acipenseroidei, Lepisostei, and Isospondyli
Sturgeons, Gars, Tarpon, Ladyfish, Bonefish, Salmon, Charrs,
Anchovies, Herring, Shads, Smelt, Capelin, et al.

Part Four
Soft-rayed Bony Fishes: Orders Isospondyli and Giganturoidei
Argentinoids, Stomiatoids, Pickerels, Bathylaconids, Giganturids

Part Five
Orders Iniomi and Lyomeri
Lizardfishes, Other Iniomi, Deepsea Gulpers

Part Six
Orders Heteromi (Notacanthiformes), Berycomorphi (Beryciformes),
Xenoberyces (Stephanoberyciformes), Anacanthini (Gadiformes)
Halosauriforms, Killifishes, Squirrelfishes and Other Beryciforms,
Stephanoberyciforms, Grenadiers

Part Seven
Order Iniomi (Myctophiformes)
Neoscopelids, Lanternfishes, and Atlantic Mesopelagic Zoogeography

Part Eight
Order Gasterosteiformes
Pipefishes and Seahorses

Part Nine, Volume One
Orders Anguilliformes and Saccopharyngiformes

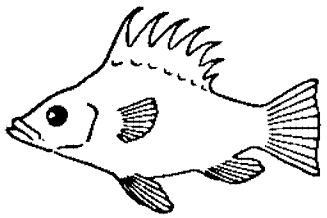
Part Nine, Volume Two
Leptocephali

Part Ten
Order Beloniformes
Needlefishes, Sauries, Halfbeaks, and Flyingfishes

MEMOIR II

The Elementary Chemical Composition of Marine Organisms
by A. P. Vinogradov

Fishes of the Western North Atlantic



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Preface

THE inhabitants of the waters of the earth have fascinated human beings ever since "God created great whales, and every living creature that moveth." Our interests have by no means been confined to the aesthetic or the gustatory; the reflections of Isaac Walton are an earnest of the composure and rapport with the universe that exists when fishes and their surroundings are contemplated; the mental relaxation of fly fisherman or surf caster needs no defense or explanation; the life of fishes, their migrations, their evolution, and the incredibly diverse facets of their activities, afford infinite opportunities for study by the scientist. In latter years man's curiosity about the inhabitants of "the water in the seas" has been increased and stimulated by his ever greater penetration into the deeps. Improved apparatus has enabled him to widen his sphere of effort and to capture fish for his markets farther from shore and deeper down than heretofore. With goggles and rubber fins he has pushed beneath the surface for momentary glimpses of those which live below; with diving helmet and diving suit he has gone deeper and investigated more closely; in the bathysphere he has dangled in the sea half a mile down and checked on the lives of the strange fishes which make their home in that dark and cold portion of the world.

Expeditions have gone forth with fishes as their prime consideration, and ichthyologists have studied what the expeditions brought back. Men and women in numerous laboratories have worked upon fisheries problems, while countless numbers of fishermen, professional and amateur, have added their bit to the knowledge of the whys and wherefores of our fishes. All this has produced an enormous quantity of information and lore which lies scattered in countless publications. The reason for the present series of volumes is to correlate the contents of the rich storehouse of knowledge relating to the fishes that live in the waters of the western North Atlantic.

This volume, the first of a series, describes the lancelets, the hagfishes and the lampreys, and those most interesting animals, the sharks. It has been written on the premise that it should be useful to those in many walks of life—to those casually or vitally interested in the general phenomena of life in our waters, to the sportsman whose interests are closely associated with pleasure and relaxation, to the fisherman whose livelihood depends upon knowledge of where fishes are gathered together, as well as to the amateur ichthyologist and the professional scientist. Special stress has been given to the relationship of the fishes to ourselves—in most cases this relationship is to man's advantage, but the present volume also carries this theme in reverse—some sharks will attack man!

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Introduction

HALF a century ago Jordan and Evermann's *Fishes of North and Middle America* was published, and up to the present time these volumes have continued to be the only comprehensive descriptive account dealing with western Atlantic fishes. With the progression of years this work has become less available and more obsolete, which is understandable in view of the scientific advances made during the intervening decades.

Vast numbers of papers, both scientific and popular, have appeared since 1896–1900 —the dates of issuance of Jordan and Evermann's work. Numerous new genera and species have been described; many groups of fishes have been subjected to detailed study and revision, especially within the last two decades; new viewpoints on classification and phylogeny have been presented; much additional information has been published on life histories and habits of many species, and some regional studies of the fish faunas have been made. However, this new information remains widely distributed in numerous books and periodicals.

Since our knowledge of the fishes on this side of the Atlantic has reached a point of relative stability, particularly with regard to purely descriptive accounts, the present time seems especially suitable for a publication which embraces all of our knowledge of the fish fauna of this region. To bring together and synthesize this scattered ichthyological information and to make it available to both the public and to marine biologists is the primary purpose of this work.

The first volume of FISHES OF THE WESTERN NORTH ATLANTIC brings to fruition, at least in part, a plan which was conceived at New Haven some years ago. With the establishment of the Sears Foundation for Marine Research at Yale University in 1937, funds became available for publication, and a group of interested ichthyologists met to discuss the preparation of a work such as is here presented. To lay a firm groundwork and to initiate production, the Editorial Board was formed, the members of which are Charles M. Breder, Jr., Samuel F. Hildebrand, Albert E. Parr, William C. Schroeder, John Tee-Van, and, until his death in 1944, the late J. R. Norman of the British Museum (Natural History). Assisting the Editorial Board is an Advisory Committee: William Beebe (New York Zoological Society), Rolf L. Bolin (Hopkins Marine Station), William K. Gregory (American Museum of Natural History), Carl L. Hubbs (Scripps Institution of Oceanography), Daniel Merriman (Bingham Oceanographic Laboratory), George S. Myers

(Stanford University), John T. Nichols (American Museum of Natural History), Luis Howell-Rivero (University of Havana) and Leonard P. Schultz (U.S. National Museum).

The articles in this and subsequent volumes, which will be co-operatively produced by many ichthyologists, are intended to be critical reviews or revisions of each group rather than perfunctory compilations or mere reprintings of previously published works. An outline of the general classification has been prepared, based on widely accepted schemes of classification (such as that used at the British Museum). Standards for both the text and the illustrations have been formulated so as to achieve a fairly uniform treatment for all volumes. Under each species will be found both the distinctive characters which set it apart from its nearest relatives, a detailed description, as well as discussions of its color, size, general habits, abundance, range, relation to man (that is, its economic importance, danger to man, sporting qualities, etc.), and its occurrence in the western Atlantic. Since the publication will be used by lay persons as well as by ichthyologists and marine biologists, the use of highly technical words and phrases has been avoided as far as possible. Because of the large number of references which are included in a study of this nature, particularly in the "Synonyms and References," abbreviations have been used throughout. References to periodicals are listed and abbreviated in accordance with the standards established in *A World List of Scientific Periodicals, Published in the Years 1900–1933* (Oxford University Press, Second Edition, 1934), and an approximate consistency has been developed for books and periodicals not listed in that publication. The final volume will contain a complete and extended bibliography. Common names which are most generally used have been included; for future volumes it is possible that the recommendations of the Committee on Common Names of the American Fisheries Society will be available.

The geographical range of FISHES OF THE WESTERN NORTH ATLANTIC embraces the western half of the North Atlantic, including the adjoining gulfs and seas, from Hudson Bay southward to the Amazon River. But this range is not strictly adhered to in all instances; a number of species living close to the outer borders of the region covered by this publication are included, particularly when their inclusion assists in a more adequate understanding of the group under consideration. Brackish water species are included, and naturally those which are cosmopolitan. As far as oceanic forms are concerned, pelagic species are treated in full, while the strictly deep-sea (bathypelagic) fishes are referred to only in keys and by references to the more recent reports describing these animals. Two factors dictate this decision: 1) The relative paucity and incompleteness of our knowledge of these animals, and 2) the fact that they rarely, if ever, come within the provenance of the nonspecialist in fishes, since special vessels and gear are required to effect their capture.

The map which accompanies this first volume is by no means complete. Since it was prepared before the manuscript was finished, all the localities given in the text could not be included, particularly in such heavily worked areas as New England. However, it will

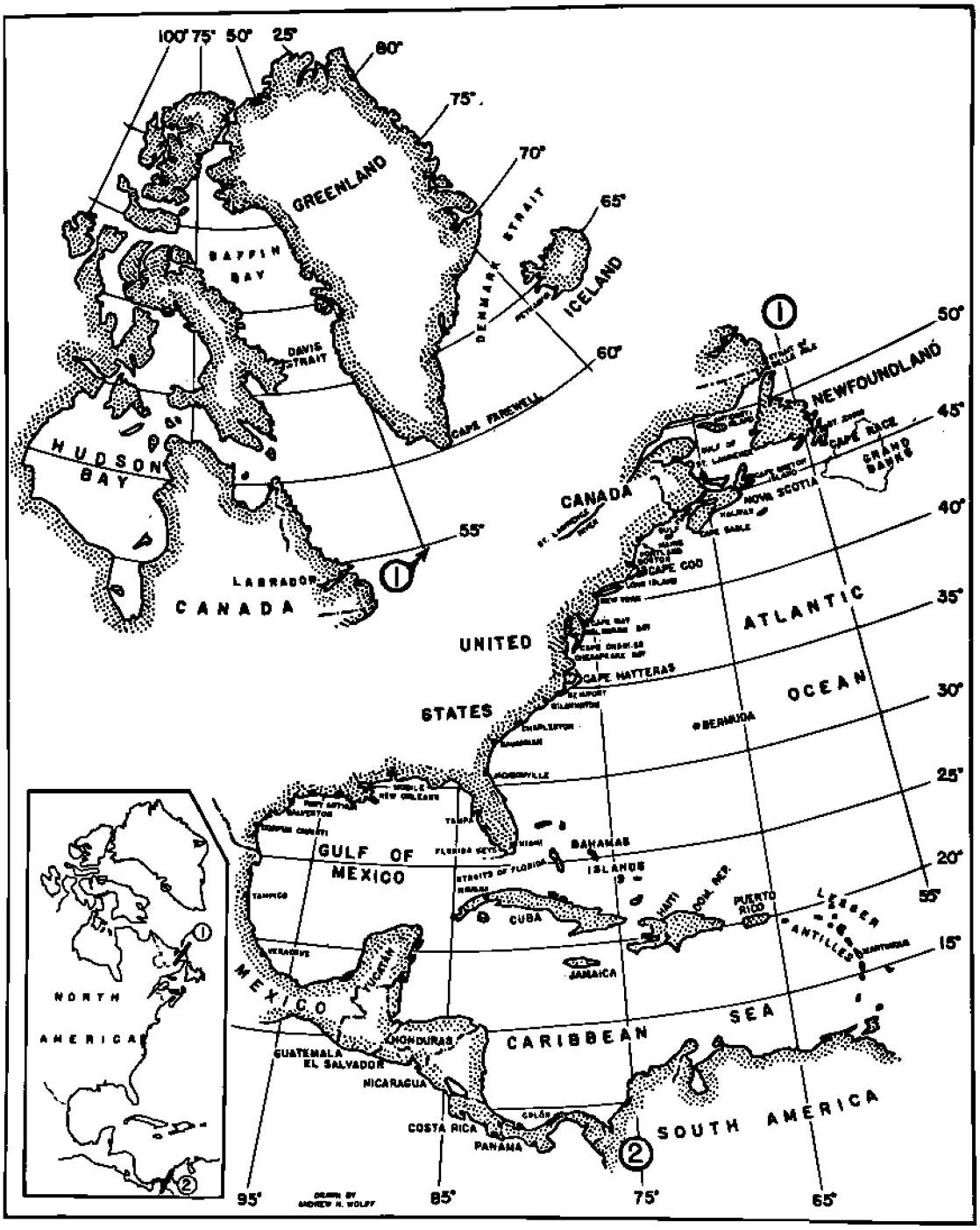
serve to give at least a general idea of locations; in future volumes there will be a closer relationship between the localities given in the text and those included on the map.

The expense incurred in the preparation of this volume has been extensive, and due appreciation and thanks are extended to the Sears Foundation for its share in making publication possible and to the institutions that supported the work of the authors and editors. Income derived from the sales of the volume will be used for the production of the remainder of the publication.

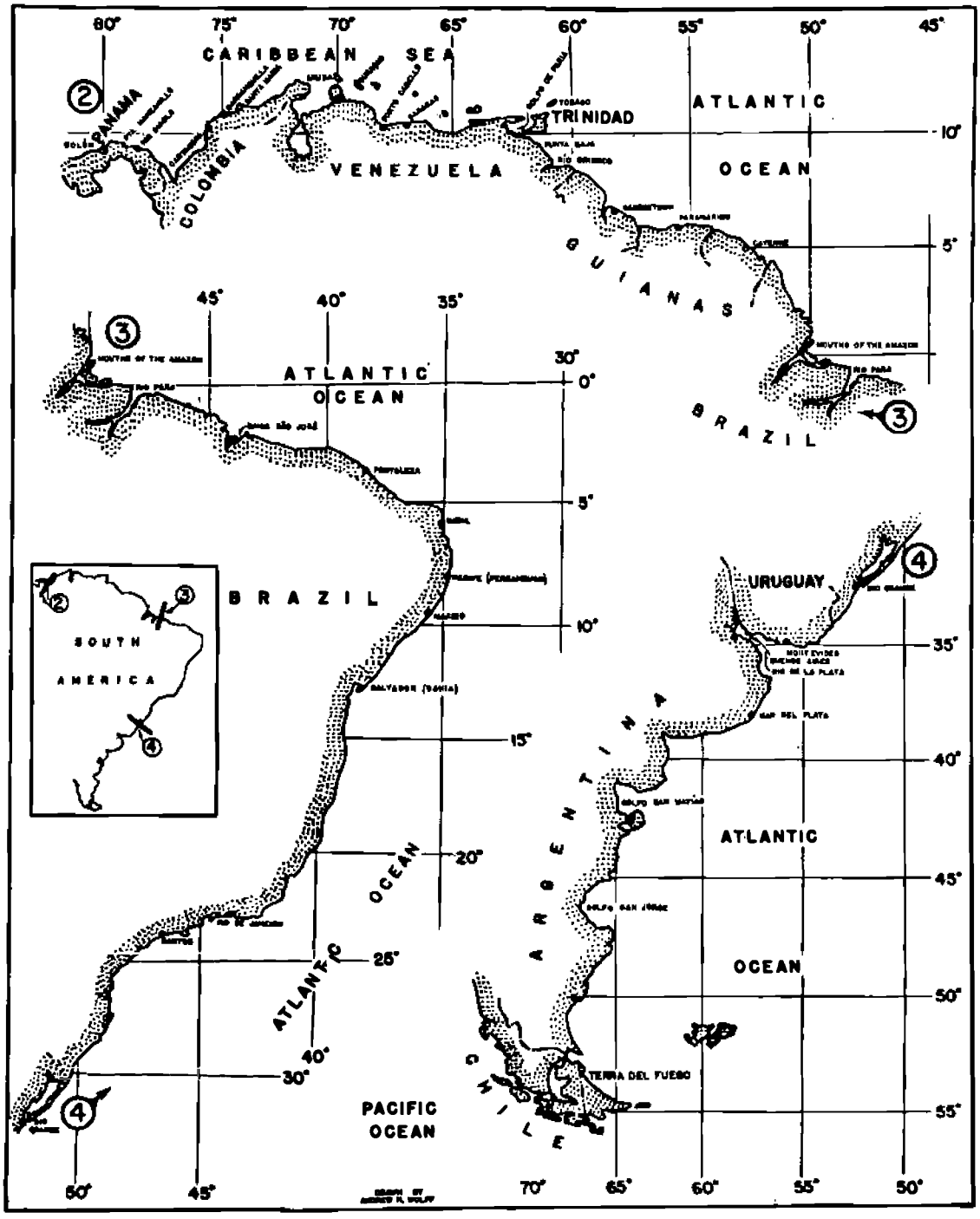
The Editorial Board would like to express its appreciation and gratitude to Yngve H. Olsen, Assistant Editor of the Sears Foundation for Marine Research, for his diligent and able editing of the manuscripts and for the guidance of the publication through the press.

To Henry Sears the members of the Editorial Board owe a personal and collective debt of gratitude for his understanding and for his unswerving continued support.

JOHN TEE-VAN
New York Zoological Society



North America



South America

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CHAPTER ONE

Lancelets

BY

HENRY B. BIGELOW *and* ISABEL PÉREZ FARFANTE

ACKNOWLEDGMENTS

We are indebted to Thomas Barbour and Leonard P. Schultz for putting the Lancelet collections of the Museum of Comparative Zoology and of the United States National Museum at our disposal for study. Also, hearty thanks are due to Gerardo Canet for preparing all the original drawings included here.

GENERAL DISCUSSION

The Lancelets of the western Atlantic Ocean are included in the present volume for convenience, following the precedent established in existing manuals of the fishes of various parts of the world. Actually they are not fishes at all, although fish-like in appearance, but belong to a separate subphylum (Cephalochordata) of the Chordata, since they are much simpler in structure than are any of the true vertebrates of the subphylum Euchordata, or Vertebrata.

Class LEPTOCARDII

The notochord, extending the entire length of the body and persisting throughout life, is surrounded by a resistant sheath, this notochord and sheath forming a firm but flexible supporting structure. But there is neither protective skeleton nor cranium for the anterior part of the neural tube, no bony structures of any sort, and no jaws. The pharynx in the adult is surrounded by an atrial chamber, formed by the outgrowth and coalescence of two ridges (the metapleura) of the body wall; the pharynx opens into the atrium by a double series of gill slits, the number of which continues to increase throughout life; posteriorly, the atrial cavity opens to the exterior by a small aperture, the atriopore. The dorsal nerve tube terminates anteriorly some distance behind the anterior end of the notochord; it is much compressed laterally, and the only suggestion of a brain is that its axial canal widens anteriorly into a cerebral vesicle. The nerves given off by the neural tube (except

for the first two) are dorsal and ventral in origin, but the dorsal and ventral roots do not join, and there are no ganglia on the dorsal roots. The muscular system is segmented, the successive muscle blocks, or myotomes, being separated one from the next by septa of connective tissue, or myocomma. The final number of myotomes is established early in life, but the number is somewhat variable in every species. The gonads are segmented. The circulatory system is very simple; there is no heart, but the larger blood vessels are peristaltically contractile. There is a well developed coelom, or body cavity. The outer surface of the body is clothed with an epidermis consisting of a single layer of columnar epithelial cells, without scales or other hard epidermal structures, and without cilia except in the mouth, pharynx, atrial cavity and intestine. There are no eyes and no limbs. The sexes are usually separate although similar in external appearance, but hermaphrodites have been reported on several occasions. Development is described below.

The Lancelets differ from all the higher groups of fish-like animals—cyclostomes, elasmobranchs, chimaeroids, and bony fishes—in the following important morphological features.

A. Their epidermis consists of a single layer of cells of ectodermal origin in contrast to several layers of cells in all higher groups.

B. They have no hard epidermal or tooth-like structures of any sort.

C. They have no eyes, no external nostrils and no true ears.

D. When adult, the pharyngeal region with the gill clefts is enclosed, on the ventral side, in a so-called atrial cavity.

E. The gill clefts increase in number throughout life whereas in all the higher groups their number is fixed.

F. They have no specialized internal respiratory structures, no true brain, no heart, no trace of a cranium and no hard vertebral structures, cartilaginous or bony.

G. The notochord extends forward beyond the anterior end of the dorsal nerve tube.

H. Their blood is colorless, without red corpuscles.

I. The neural canal, entirely closed dorsally in higher vertebrates, extends through the dorsal wall of the nerve tube as a longitudinal fissure, reminiscent of the ectodermal infolding by which the tube is formed.

J. The excretory organs are nephridia-like rather than kidney-like, consisting of numerous (up to 91) pairs of tubules in the pharyngeal region, each discharging independently into the atrial cavity.

K. The gonads are numerous, compared to only a single pair in higher groups, and segmentally arranged; each discharges its products directly into the atrial cavity, there being no permanent genital ducts.

L. The lining of the intestine bears cilia.

The relationship that the Lancelets bear to the Cyclostomes and to higher fishes has been actively discussed, one view being that they represent the specialization of some primitive prevertebrate stage in evolution, another that they are degenerate descendants of some early type of vertebrate comparable to the Cyclostomes that have developed pe-

culiar adaptations for a very special mode of life. Perhaps the most that can be said at present is that possibly they may be "fairly close to the primitive types from which the vertebrates have arisen,"[1] although their atrial cavity has no parallel among the vertebrate series.[2]

Order AMPHIOXI

Description. This order includes all known representatives of the subphylum. They are slender, fish-like in external appearance, the body tapers at both ends and varies in length from one to eight cm. at maturity; they inhabit tropical and temperate seas. In the adult the buccal cavity, which leads into the mouth proper, opens on the ventral surface of the body a little behind the anterior end. It is bounded laterally by a pair of expanded muscular membranes, the so-called oral hood, the free edge of which bears 20 to 30 slender oral tentacles or cirri, each supported by a cartilaginous rod arising from a cartilaginous ring situated immediately behind the margin of the hood. Proximally, the inner surface of the oral hood bears a series of finger-like projections of ciliated epithelium, jointly forming the wheel organ, the ciliary action of which drives water inward through the buccal cavity to the mouth, and so to the pharynx. The mouth, at the bottom of the buccal cavity, is very small and surrounded by a vertical membrane, the so-called velum, from which several short velar tentacles project inward into the capacious pharynx. The linings of the pharynx, and of the vertical gill clefts that pierce its two sides, are clothed with cilia (those of the former having a complex pattern), the joint action of which is to drive the water from the mouth, along the pharynx, through the gill clefts and so out through the atrial cavity and atriopore. The pharynx serves chiefly as a feeding organ, as described below.

The integument is expanded as a single continuous finfold which extends along the ventral surface from close behind the atriopore, around the posterior end of the body, thence forward along the dorsal surface and around the anterior end of the latter, where it forms a snout or rostrum. The finfold thus surrounds the anterior end of the notochord and contains a lymph space; in the dorsal fin this is segmentally divided by vertical septa into a series of compartments known as fin-ray chambers and this is sometimes true of the ventral fin as well. These chambers are partially subdivided by so-called fin rays, the lateral and apical surfaces of which are free but the bases of which are connected with the continuous ridge of connective tissue that is derived from the roof of the neural sheath. The final number of rays and of ray chambers is established early in life, *i.e.*, at a small size, but is somewhat variable in all species. Anterior to the ventral fin the ventral surface of the body also bears a pair of prominent longitudinal ridges called the metapleura. As a result of their presence, the anterior part of the body is roughly triangular in cross section in adults, the dorsal fin forming the apex of the triangle, the two metapleura its other two

1. Romer, Man and Vert., 1941: 10.
2. The atrium of the Lancelets, while analogous to that of the tunicates, cannot be regarded as homologous with the latter, for the method of formation is very different.

angles, and the space between the latter forming its base, which is also the floor of the atrial chamber.

There is a rather conspicuous pigment spot at the anterior end of the nerve cord, which has been called an eye spot or median eye, but which appears not to be a light receptor. Also, an olfactory function has been ascribed to a small diverticulum from the cerebral vesicle, but it is doubtful whether this is correct.

Habits. Lancelets spend most of the time buried in the sand, in an oblique position, with the anterior end alone protruding.[3] If removed from the sand they swim actively, bending the body from side to side with a sinuous eel-like motion; it is with this same motion that they bore into the sand, which they do very rapidly. In most cases they burrow tail foremost, but they have been seen to do this with the anterior end foremost, in which case they then assume a U-contour to bring the anterior end out again from the sand. It seems that adults of the genus *Branchiostoma* seldom emerge spontaneously from the sand, or only for very brief periods, except at spawning time, for we find no record of their capture in tow nets.[4] But *Asymmetron* has been so taken (p. 21).

It has long been known that they feed on microscopic organisms which they strain out from the current of water that is drawn in through the mouth and driven by ciliary action through the gill apertures to the atrium, to be expelled through the atriopore. The buccal tentacles, folding over one another, prevent larger objects from entering. Particles small enough to pass through this screen are carried inward to the pharynx, where they become mixed with mucus and are driven against the gill bars. The cilia on the inner faces of the latter, beating in a ventro-dorsal direction, then drive the mingled food and mucus to the dorsal pharyngeal groove, along which it is swept to the oesophagus.[5] Feeding appears to be a continuous process. No doubt the diet includes whatever kinds of microscopic organisms may be available at any given time and place. The intestines of the European *Branchiostoma lanceolatum* have been found to contain diatoms chiefly, but also desmids, Foraminifera, Infusoria, Radiolaria, Cladocera and the eggs of various small invertebrates, as well as plant detritus.[6] Diatoms have also been reported from the intestines of Lancelets from Ceylon[7] and were again the most abundant item in the diet of young *Branchiostoma belcheri* at Amoy, China, although the adults also contained the larvae of tunicates, echinoderms and crustaceans.[8] At another time[9] this same species in the same general local-

3. For an excellent photograph of the European *Branchiostoma lanceolatum* in this situation, see Hagmeier and Hinrichs (Senckenbergiana, *13*, 1931: fig. 3b, 4b, facing p. 258).
4. Hensen (Ergebn. Plankton-Exped. Humboldt Stiftung, *1* A, 1892: 24–25) reported the capture of young Lancelets up to several centimeters long in plankton nets. But the fact that none so large were to be found subsequently in the collections (Goldschmidt, Dtsch. Sud-polar Exped., *11* Zool. 3, 1909: 235) suggests that the stated size was an error.
5. Condensed from a detailed account of the feeding mechanism in *Branchiostoma lanceolatum*, by Orton (J. Mar. biol. Ass. U.K., *10* [1], 1913: 19). For an account of the passage of food material through the gut, see Barrington (Philos. Trans., [B] *228*, 1937: 271).
6. For a list of the food of *B. lanceolatum* compiled from various sources, see Franz (in Grimpe and Wagler, Tierwelt N- u. Ostsee, Lief 7, 12b, 1927: 26).
7. Tattersall, in Herdman, Rep. Gov't. Ceylon Pearl Oyster Fish., Gulf of Manaar, pt. 1, suppl. 6, 1904: 221.
8. Chin, Philip. J. Sci., *75*, 1941: 393.
9. Reeves, Ginling Coll. Mag. for Jan. 1931: 29.

ity was found feeding chiefly on bacteria, with a few protozoa also. The intestines of some of the specimens were filled with sand, showing that the oral tentacles do not always bar entrance to inedible particles.

Development. The larval development of the Lancelets has been the subject of several major investigations and has been much discussed in relation to the problem of the ancestry of the vertebrates. The process in the European *Branchiostoma lanceolatum,* which may serve as representative of the group, is briefly as follows.

Spawning takes place at sunset. The eggs are minute (0.1 mm. in diameter) and float freely in the water. Segmentation is not only complete but nearly equal and affords one of the classic examples of endoderm formation by invagination. About twelve hours after fertilization the embryo, now oval in shape and clothed externally with cilia, breaks out from the vitelline membrane and swims near the surface by ciliary action. By about the thirty-sixth hour the yolk is entirely absorbed; the mouth has appeared on the left-hand side; the first gill opening has been formed in the midline, soon to shift to the right side, however; and the anus has formed at the hinder end of the body a little to the left of the midline. During subsequent larval development, which may occupy as much as three months, the larvae live pelagically some distance below the surface of the sea, hanging for the most part in a vertical position which is maintained by the action of the long cilia, or flagellae, one of which is borne by each cell of the ectoderm. The larvae (Fig. 1), which

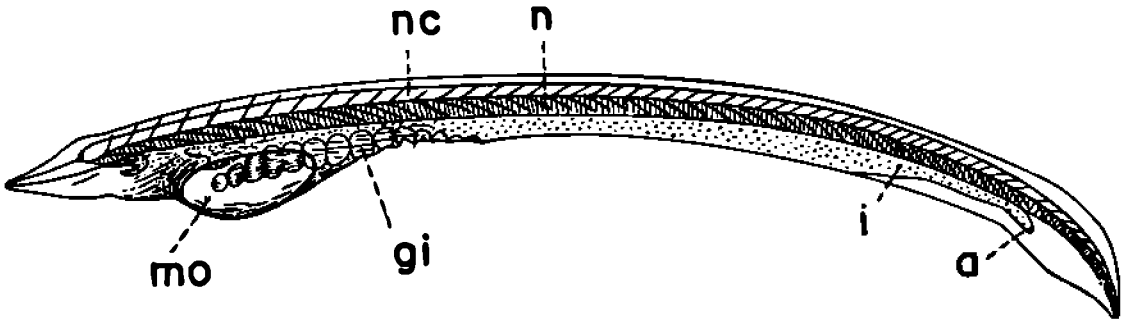

FIGURE 1. *Branchiostoma lanceolatum* Pallas; larva, with 61 myotomes, after Franz. *a* anus. *gi* gills. *i* intestine. *mo* mouth. *n* notochord. *nc* nerve cord.

have a very characteristic appearance because of the swollen gill region in an otherwise slender body, gradually assume the characters of the adult without any abrupt metamorphosis. The most striking of the external accompanying changes are in the numbers and locations of the gill openings, and the formation of the atrium, of the atriopore and of the adult mouth. The latter, at first on the left side and forming a most conspicuous feature of the larva because of its enormous size, shifts to the midline and decreases in relative size toward the end of larval life, while the preoral hood then develops above it. Additional gill openings, up to the number of 14 or more, are formed successively along the mid-ventral line, corresponding at first in number and location to the myotomes in that part of

the body but later losing this relationship. Of these primary gill openings, only the second to ninth persist, however.

After the formation of the primary series of gill openings the number of segments increases at the posterior end of the body, the final number being attained early in larval life. In the meantime the embryonic tail fin, a simple ridge of columnar ectoderm cells, is replaced by the adult fin; this forms as an ectodermal fold, enclosing serial expansions of the body cavity, the ray chambers; the fin rays develop as columnar outgrowths of mesoderm upward into these chambers. A secondary series of gill openings, eight or nine in number, appear on the right side of the body, dorsal to the primary series; and each member of each set, except the first, becomes U-shaped and then entirely subdivided by a dorsoventral bar. The primary series of gill openings then shift to the left side of the body, so that from then on the larva is bilaterally symmetrical so far as the location of its gills is concerned.

The metapleural ridges first appear in larvae with eight to ten gill openings of the second series. The atrial cavity results from the union of the median sides of these ridges, commencing posteriorly and progressing anteriorly. The canal so enclosed expands laterally in the pharyngeal region to the dimensions of the atrium of the adult, while it continues open posteriorly as the atriopore. During the formation of the metapleura the larva abandons its pelagic habit and comes to lie on one side or the other on the bottom. By the time the mouth has moved to the median position the oral hood has formed and the gills have assumed the final symmetrical arrangement. The little Lancelet, now resembling the adult in general appearance, buries itself in the sand; the only further change is the formation of pairs of tertiary gill openings, a process that continues throughout the life of the individual. The curious asymmetry of the larval Lancelet has been much discussed, but in our opinion none of the explanations which have been offered for it is adequate.

Gonads are formed in the second or third year, and the oldest noted among a large collection of *Branchiostoma belcheri* was four years old.[10]

Relation to Man. Lancelets are neither large enough or numerous enough to be of any commercial value anywhere in the western Atlantic, except as subjects for biological investigation; nor are they ever likely to be. However, near Amoy in southern China there has long been a fishery for Lancelets. Recently this employed about four hundred men in two hundred boats who fished with shovel- or scoop-shaped dredges from two to four hours each day on the ebb tide from August until April. This fishing ground is only about six miles long and less than one mile wide, but it has been estimated that the annual catch is in the neighborhood of 35 tons, or more than one billion Lancelets. Some of these are consumed in the near vicinity, while others are dried and shipped to Java and Singapore.[11] Lancelets are also used occasionally as food in Naples and Sicily.[12]

10. See Wells (Science, N.S. *64*, 1926: 188) for *Branchiostoma caribaeum* from Florida; Chin (Philip. J. Sci., *75*, 1941: 400) for *B. belcheri* from Amoy, China.
11. For more detailed accounts, from which the foregoing is condensed, see Light (Science, N.S. *58*, 1923: 57) and Chin (Philip. J. Sci., *75*, 1941: 369).
12. Franz, in Grimpe and Wagler, Tierwelt N- u. Ostsee, Lief 8, b, 1927: 44.

Families. The order includes two well defined families, Branchiostomidae and Epigonichthyidae, separated as indicated in the following key. A third assemblage of pelagic forms, usually grouped together as the genus *Amphioxides*, have sometimes been classed as a third family, Amphioxididae. But their chief distinguishing characters—mouth on the left side, atrial chamber unclosed and gill slits in an unpaired medio-ventral series—are those of larval Lancelets in general at an early stage of development (p. 23), and it now seems established in fact that they are larvae that have continued their pelagic existence for one reason or another until much larger and much further advanced in development than is usually the case, rather than taking to the bottom at a smaller size, as most of them do.[13] In fact, we think it is likely that these *Amphioxides* larvae never do descend to the bottom once they are carried out over deep water, but that they simply continue to exist for an indefinite period as they are swept along with the currents, finally perishing without producing offspring. On the other hand, it has been suggested that their existence may provide a means for the dissemination of the species. Up to the present time, none of them has been positively connected with any particular parent species.

Key to Families[14]

1a. Mouth nearly median, with oral cirri; closed atrial chamber and atriopore; a series of gill clefts on either side.
  2a. Series of gonads developed on each side; both metapleura terminating close behind atriopore. Branchiostomidae, p. 7.
  2b. Gonads developed on right side only; the right metapleuron continuous with ventral fin, the left-hand metapleuron terminating behind atriopore. Epigonichthyidae, p. 18.

1b. Mouth on left side without oral cirri; no closed atrial chamber; gill clefts in a single series along ventral side. Amphioxididae, p. 23.[15]

Family BRANCHIOSTOMIDAE

Description. Mouth nearly in midline, surrounded by oral cirri; tentacles with lateral sensory papillae, giving them a toothed appearance; closed atrial chamber; a series of gill slits on each side; gonad pouches developed on both left and right sides; both metapleura terminate close behind atriopore, including between their posterior ends the anterior end of the ventral fin; rostral fin continuous with right side of oral hood, but not with left side; posteriorly the median fin is expanded both dorsally and ventrally in lancet form as a distinct caudal fin, with its ventral lobe lying to the right of anus; ventral fin-ray chambers, except for the more anterior and more posterior, each contain a pair of fin rays in most species, although perhaps only a single fin ray in some;[16] but dorsal fin-ray chambers con-

13. For a recent discussion, see Goldschmidt (Biol. Bull. Wood's Hole, *64*, 1933: 321).
14. Amphioxididae included to facilitate identification. 15. See above discussion of these.
16. Willey (Quart. J. micr. Sci., *44*, 1891: 270) stated that in his *Dolichorhynchus indicus* the ventral fin rays are single; but they appear as paired in his illustration.

tain a single series of fin rays only; rostral fin, with anterior part of dorsal fin, lacks fin rays; dorsal fin-ray chambers much more numerous than myotomes, with four or five chambers to each myotome; the atrial chamber extends posterior to atriopore as a single blind sac as far as the anus; olfactory pit present.

Genera. Two genera, *Branchiostoma* and *Dolichorhynchus,* are commonly recognized in the family and are separated as indicated in the following key. In addition, a new subgenus of *Branchiostoma* has recently been proposed under the name *Amphipleurichthys*[17] for a species in which "the form is more elongated and less robust" than in *Branchiostoma,* "with the myotomes more acutely tapering at each end of the animal," and in which the "caudal fin is reduced to a low fold."[17] But the differences appear to us specific, rather than generic.

Key to Genera

1a. Rostral process, including anterior end of notochord, extends far beyond preoral hood. *Dolichorhynchus* Willey, 1901
Ceylon.

1b. Rostral process, including anterior end of notochord, extends only a short distance beyond preoral hood. *Branchiostoma* Costa, 1834, p. 8.

Genus *Branchiostoma* Costa, 1834

Branchiostoma Costa, Ceni. Zool., 1834: 49; type species, *B. lubricum* Costa. Naples.

Generic Synonyms:

Limax Pallas, Specil. Zool., Fasc. 10, 1774: 19, pl. 1, fig. 11; for *L. lanceolatus* Pallas, Cornwall; not *Limax* Linnaeus, 1758.

Gasterobranchus ? Rasch, Mag. Naturvid., Physiogr. Foren. Christiania, *12* (2) *2*, 1836: 325, footnote; evidently *Branchiostoma,* from the excellent account, but only provisionally identified by that author; western Norway; not *Gasterobranchus* Bloch, 1795, which is a synonym for the cyclostome *Myxine* Linnaeus, 1758.

Amphioxus Yarrell, Brit. Fish., 2, 1836: 468; type, *Limax lanceolatus* Pallas, 1774.

Amphipleurichthys (subgenus) Whitley, Aust. Zool., 7 (3), 1932: 256; type, *A. minucauda* Whitley. Queensland.

Generic Characters. The rostral process, including the anterior end of the notochord, projects for only a short distance beyond the preoral hood; the characters are otherwise those of the family.

Range. European coasts from northern Norway to the Mediterranean, the Black Sea and tropical West Africa; western Atlantic from Chesapeake Bay[18] to the Rio de La Plata (including Bermuda); Pacific coast of the Americas from Middle California to Chile; Japan; China; East Indies; Philippines; Queensland; India; Ceylon; Madagascar; East and South Africa.

17. Whitley, Aust. Zool., 7 (3), 1932: 256.

18. Lancelets were said by Garman (in Kingsley, Stand. Nat. Hist., 3, 1885: 62) to range as far north as New York; but we find no positive record of any member of the group in the western Atlantic farther north than Chesapeake Bay.

Species. The characters that have been used chiefly in the classification of the species of the genus are: (1) number of ventral fin-ray chambers; (2) number of dorsal fin-ray chambers; (3) height of dorsal fin in relation to height from its crest to the margins of metapleura; (4) shape of caudal fin; (5) location of anus in lower lobe of caudal fin; (6) number of preatrial myotomes; (7) total number of myotomes. The five species that have been described from the western Atlantic (*B. caribaeum* Sundevall, 1853; *B. bermudae*, *B. floridae*, *B. platae* and *B. virginae* Hubbs, 1922) with the anus near, or posterior to, the midpoint of the ventral lobe of the caudal fin differ sharply from *B. lanceolatum* and *B. africae* of the eastern Atlantic, in which it is considerably farther anterior to it. Among this western Atlantic group, *B. bermudae* and *B. platae* are set apart by the fact that the lower lobe of the caudal fin originates considerably anterior to the origin of its upper lobe (Fig. 2 A, F), whereas in the others the two lobes originate opposite one another. *B. bermudae* is sharply separated from *B. platae* by a considerably smaller number of dorsal fin-ray chambers (200–242 vs. 278–330), and fewer myotomes (not more than 56 vs. at least 58). But *B. floridae* and *B. virginae* agree with *B. caribaeum* in the position of the anus, while counts of fin-ray chambers and myotomes in the specimens we have studied (Study Material, p. 13), together with those previously published, fail to show any clear distinctions among the populations of Virginia, North Carolina, Florida (including the Tortugas) or Porto Rico (representing the West Indian region). The most that can be said is that some Florida and West Indian specimens have fewer precaudal fin-ray chambers than have yet been recorded for more northerly localities. But this is not always true, since the maximum recorded counts are in fact for one specimen from Florida and for one from North Carolina. Therefore it cannot be invoked as a basis for specific separation.

Key to Species of *Branchiostoma*

1a. Caudal fin hardly higher than dorsal and ventral fins. *minucauda* Whitley, 1932. Queensland.

1b. Dorsal or ventral lobe of caudal fin, or both, considerably higher than dorsal and ventral fins.

2a. Caudal fin not clearly marked off from ventral fin. *capense* Gilchrist, 1902. South Africa.

2b. Caudal fin clearly marked off from ventral fin.

3a. Anus about at point of origin of caudal fin.

4a. Distance from anus to tip of caudal fin only ½ distance from anus to atriopore. *bazarutense* Gilchrist, 1923. East Africa.

4b. Distance from anus to tip of caudal fin about as great as from anus to atriopore. *haeckeli* Franz, 1922. Ceylon.

3b. Anus clearly posterior to origin of caudal fin.

5a. Anus far in advance of midpoint of lower lobe of caudal fin.

6a. 77 or more myotomes. *elongatum* Sundevall, 1852.
West coast of South America, Chile to Galapagos Islands.

6b. Not more than 73 myotomes.

7a. 42 to 44 myotomes anterior to atriopore.
africae Hubbs, 1927.
Tropical West Africa.

7b. Not more than 41 myotomes anterior to atriopore.

8a. 68 to 72 myotomes in all. *tattersalli* Hubbs, 1922.[19]
Ceylon.

8b. Not more than 66 myotomes.

9a. Not more than 62 myotomes; ventral lobe of caudal fin a little longer than distance from its origin to atriopore; anus clearly anterior to origin of dorsal lobe of caudal fin.
lanceolatum Pallas, 1778.
Northern Norway to Mediterranean and Black Sea.

9b. At least 63 myotomes; ventral lobe of caudal fin only as long as distance from its origin to the atriopore; anus below origin of dorsal lobe of caudal fin. *belcheri* Gray, 1847.
Japan, China, the East Indies, Philippines, India, and Ceylon to East Africa.

5b. Anus near midpoint of lower lobe of caudal fin or posterior to it.

10a. Origin of lower lobe of caudal fin considerably anterior to origin of its upper lobe.

11a. Not more than 242 dorsal fin-ray chambers or 56 myotomes. *bermudae* Hubbs, 1922, p. 11.

11b. At least 278 dorsal fin-ray chambers.

12a. Rostrum not marked off from dorsal fin by a notch; 65–74 myotomes. *californiense* Andrews, 1893.
Monterey, California to Gulf of California.

12b. Rostrum marked off from dorsal fin by a notch; 59–65 myotomes. *platae* Hubbs, 1922, p. 16.

10b. Origin of lower lobe of caudal fin about opposite origin of its upper lobe. *caribaeum* Sundevall, 1853, p. 13.[20]

19. Including *gravelyi* Prashad (Rec. Indian Mus., *36*, 1934: 333).
20. Including *floridae* Hubbs, 1922, and *virginiae* Hubbs, 1922.

Branchiostoma bermudae Hubbs, 1922

Figure 2 A–D

Study Material. Nineteen specimens, 29 to 49 mm. long, from Bermuda (U. S. Nat. Mus. and Harv. Mus. Comp. Zool.).

Distinctive Characters. Among Atlantic species, *B. bermudae* differs noticeably from *B. lanceolatum* and from *B. africae* in that its anus is about opposite the midpoint of the lower lobe of its caudal fin. In this respect it closely resembles *B. platae* and *B. caribaeum*, but it is separable from both of these by a smaller number of myotomes (56 at most) as well as by generally fewer precaudal fin-ray chambers (9 to 24, usually less than 16). The average number of dorsal fin-ray chambers also is smaller.

Additional Description. Anterior end of notochord extending forward in rostrum in a straight line; rostral fin marked off from dorsal fin by a subtriangular notch; origin of lower lobe of caudal fin anterior to origin of its upper lobe by a distance about ½ as great as length of lower lobe; dorsal fin ⅛ to ⅐ as high as distance from its base to margin of metapleura in the midregion of body; anus a little behind the midpoint of lower lobe of caudal fin; origin of lower caudal lobe about midway between its tip and atriopore; distance from tip of caudal to anus about 0.4 of distance from anus to atriopore; dorsal fin-ray chambers 204 to 242, the highest 3 to 4 times as high as long; precaudal fin-ray chambers 9 to 24; 35 or 36 myotomes anterior to atriopore; 12 to 14 between atriopore and anus, 5 to 7 posterior to anus, total number 54 to 56; gonads, 22 to 28 pairs.

Color. Living specimens are semitransparent and iridescent, but they become opaque after preservation.

Size. Maximum recorded length, 53.5 mm.[21]

Habits. The Bermuda Lancelets are usually found in one-half to six fathoms of water on coarse sandy bottom into which they burrow tail first and there remain most of the time with only the anterior part of the body exposed. If disturbed they swim vigorously for a short time but soon return to the sand. Observations in aquaria have shown that normally they are no more active by night than by day. Under experimental conditions they usually swim with the anterior end foremost. If a stimulus is applied to the anterior end, the Lancelet may dart backward for a short distance, or it may turn end for end. But this reversal in direction is of short duration, for it soon turns again and proceeds at only a slight angle from its original course. In taking to bottom after swimming, Lancelets usually sink quietly through the water to the sand; when in contact with the latter they may either lie there, passive for some time; or they burrow at once, usually tail first, or head first on rare occasions. When buried they usually are tortuous in outline, probably from being crowded among the grains of sand.[22]

Specimens adapted to the summer temperatures of Bermuda (about 31° C.) dart

21. Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 10.
22. For detailed accounts of the experiments on which the above is based, see Arey (J. exp. Zool., 29 [1], 1915: 37) and Parker (Proc. Amer. Acad. Arts Sci., 43 [16], 1908: 413).

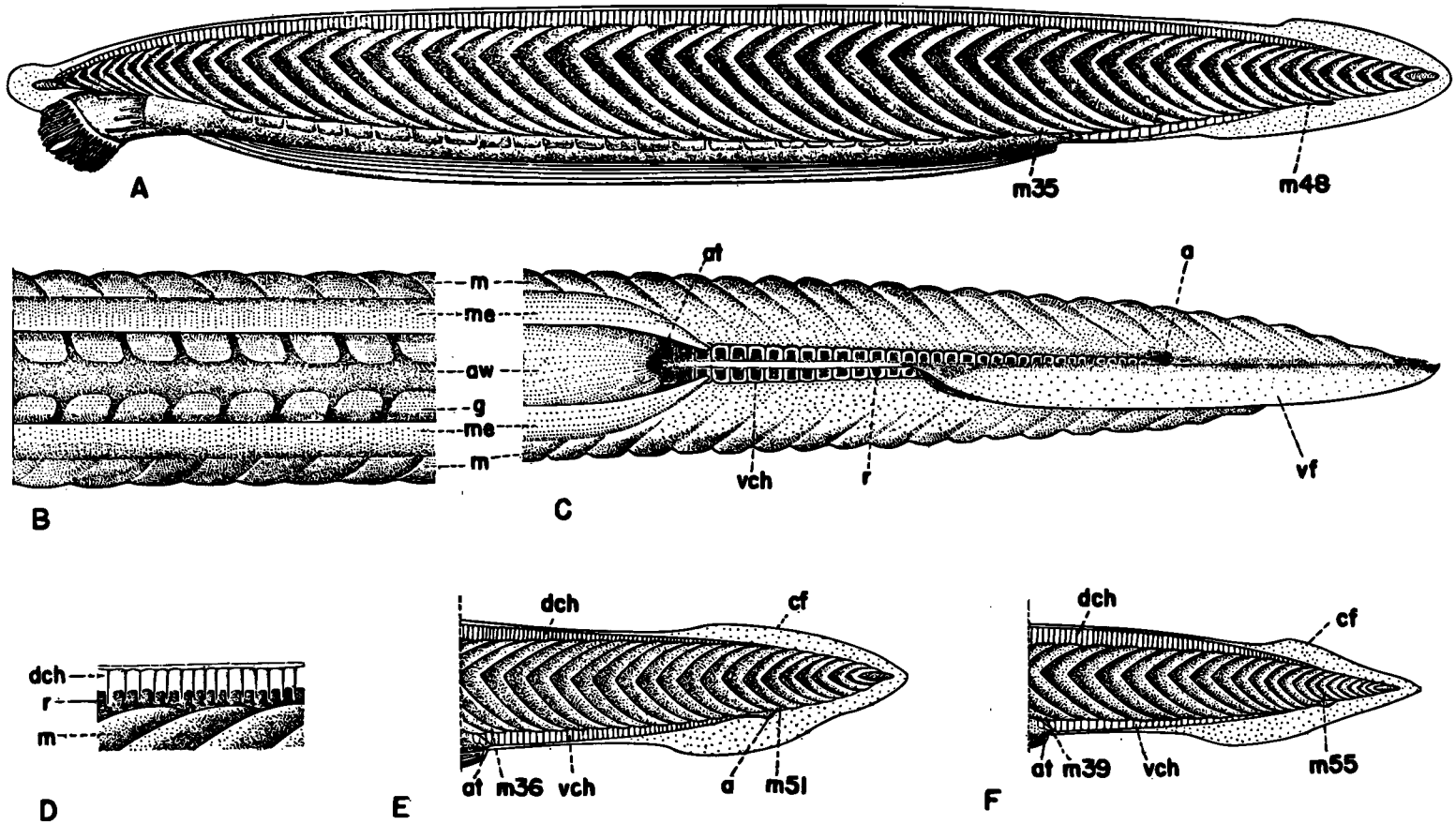

FIGURE 2. *A Branchiostoma bermudae* Hubbs, specimen 47 mm. long, from Bermuda. *B* Ventral view of same, 20th to 27th myotomes, to show gonads as seen through atrial wall. *C* Ventral view of posterior part of same. *D* Part of dorsal fin of same to show fin ray chambers and fin rays. *E Branchiostoma caribaeum* Sundevall, posterior part of specimen 55 mm. long, from Tampa Bay, Florida. *F Branchiostoma platae* Hubbs, posterior part of specimen 50 mm. long, from off mouth of Rio de la Plata ("Albatross" Station 2765). *a* anus. *at* atriopore. *aw* atrial wall. *cf* caudal fin. *dch* dorsal fin ray chambers. *g* gonads. *m* myotomes. *me* metapleuron. *r* fin rays. *vch* ventral fin ray chambers. *vf* ventral lobe of caudal fin. The fin rays have been omitted from *A*, *E* and *F* for the sake of clarity.

rapidly about for a short time if the temperature be either raised or lowered. If heated to 40° C. or higher they die; if chilled to 10° C. they become inactive and may die, as they invariably do if kept in a temperature of 4° C. for half an hour. But the thermal reactions are not known for specimens adapted to the winter temperatures that prevail at Bermuda.

It has been found that *B. bermudae* tends to swim away from a source of light; also it is stimulated to activity by the presence of light, *i.e.*, it is photokinetic,[23] and hence it may be expected to bore deeper into the sand if strongly illuminated, as by the sun. But it is more sensitive to mechanical than to photic stimulation, as is the European *B. lanceolatum.*[24] This is especially true of the preoral tentacles and of the outer fringes of the oral hood, which close and open with a sudden winking motion if touched. It is through this reaction that the Lancelet rids itself of the debris that may accumulate on its preoral tentacles, for when these become laden they contract sharply to loosen any waste particles, which are then swept away by water that is expelled simultaneously from the cavity of the oral hood.

Presumably it spawns chiefly in late spring, for the peak of the breeding season is passed before June–July.

Range. Bermuda.

Synonyms and References:

Branchiostoma lubricum Goode, Amer. J. Sci., *14*, 1877: 293 (Bermuda); not *B. lubricum* Costa, 1834.

Amphioxus (no specific name) Brooks, 3rd Annu. Rep. Johns Hopk. Univ., 1878: 54 (Bermuda).

Branchiostoma caribaeum Bristol and Carpenter, Science, N.S. *11*, 1900: 170 (Bermuda); Verrill, Trans. Conn. Acad. Arts Sci., *11*, 1901: 55 (Bermuda); Bean, Field Mus. Publ. Zool., 7 (2), 1906: 29 (Bermuda); Kutchin, Proc. Amer. Acad. Arts Sci., *49* (10), 1913: 571 (peripheral nervous system).

Amphioxus caribaeus Mark, Science, N.S. *20*, 1904: 179 (Bermuda).

Branchiostoma caribbaeum Barbour, Bull. Mus. comp. Zool. Harv., *46*, 1905: 110 in part (specimen from Bermuda); Parker, Proc. Amer. Acad. Arts Sci., *43* (16), 1908: 413 (sensory reactions, Bermuda); Arey, J. exp. Zool., *29* (1), 1915: 37 (swimming habits, Bermuda).

Branchiostoma carribaeum Mark and Crozier, Anat. Rec., *11* (6), 1917: 520 (photo receptors); Conklin, J. Morph., *54* (1), 1932: 70 (breeding season at Bermuda); not *B. caribaeum* Sundevall, 1853.

Branchiostoma bermudae Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 9 (descr., discus., Bermuda); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 7 (Bermuda); Beebe and Tee-Van, Field Bk. Shore Fish. Bermuda, 1933: 2 (descr., ill., Bermuda); Goldschmidt, Biol. Bull. Wood's Hole, *64* (3), 1933: 321 (Bermuda); Pratt, Manual Common Invert. Anim., 1935: 757 (no. of myotomes and gonads, Bermuda).

Branchiostoma caribaeum Sundevall, 1853

Figure 2 E

Study Material. Numerous specimens, 12 to 66 mm. long, from Maryland, Chesapeake Bay, Virginia, North Carolina, eastern and western Florida, the Tortugas, Florida, and Vieques Island, Porto Rico.

23. Parker, Proc. Amer. Acad. Arts Sci., *43* (16), 1908: 426.
24. Franz, Wiss. Meeresuntersuch. Helgoland, *15* (14), 1924: 6.

Distinctive Characters. B. caribaeum differs from *B. lanceolatum* and from *B. africae* in that its anus is about in the middle of the lower lobe of the caudal fin. It is distinguished from *B. bermudae* by the shape of the caudal fin and by the origin of the ventral lobe below that of the dorsal lobe; by the position of the anus, in advance of the midpoint of the lower lobe of the caudal fin; and by the generally greater number of myotomes and dorsal fin-ray chambers (at least 230 of the latter). It is separated from *B. platae* by the shape of the caudal fin, as well as by the position of the anus and by its tendency to have fewer myotomes and dorsal fin-ray chambers.

Additional Description. Anterior end of notochord in rostrum extending forward in a straight line; rostrum marked off from dorsal fin by a subtriangular notch; caudal fin symmetrically lanceolate with narrowly rounded tip, its lower lobe considerably higher than ventral or dorsal fins, its origin opposite origin of its upper lobe and about midway between tip of caudal fin and atriopore; distance from tip of caudal to anus about ⅓ distance from anus to atriopore; dorsal fin ⅛ as high as distance from its crest to margins of metapleura in midregion of body; highest dorsal ray chambers 5 to 8 times as high as long; dorsal ray chambers 230 to 320; precaudal (ventral) fin-ray chambers 18 to 37; 35 to 38 myotomes anterior to atriopore, 13 to 17 between atriopore and anus, and 6 to 9 posterior to anus, recorded totals, 57 to 64; gonads 22 to 29.

Recorded counts for specimens from different localities.

Locality	*Dorsal fin-ray chambers*	*Precaudal fin-ray chambers*	*Myotomes*
Virginia and North Carolina	256–320	33–42	58–64[25]
Florida, including Tortugas	274–330	18–28	57–61
Porto Rico; Bahamas	227–300	15–37	58–61

Color. Live specimens are flesh-color or semitransparent, with a metallic iridescence; those kept in alcohol become opaque and whitish.

Size. The greatest length so far recorded is 66 mm. (see Study Material, p. 13).

Developmental Stages. In the Chesapeake region the pelagic larvae, of the sort usual for the group (p. 5), tend to settle to the bottom by the time they have reached a length of about 7.5 to 8 mm.[26]

Habits. The adults, like those of other species, live buried in coarse or fine sand. In Florida, and presumably elsewhere also, they are most numerous along the edges of sand bars just below the low tide mark where their presence is indicated by small holes in the sand. If the sand is laid bare by a low run of tides it appears that they simply burrow more

25. Andrews (Stud. Biol. Lab. Johns Hopk. Univ., 5, 1893: 241) reports a total of only 48 myotomes for a specimen from Jamaica. But this is so much fewer than any other recorded count that we judge it to have been erroneous; see also Franz (Jena Z. Naturw., *58*, 1922: 399).

26. See Rice (Amer. Nat., *14*, 1880: 17, pl. 1, fig. 5) for a good illustration of the late larva.

deeply for the time being, instead of moving down the slope.[27] If driven out of their holes, as when a shovel is thrust into the sand close by, they shoot upward into the water and swim vigorously for a brief period with either the ventral or dorsal side uppermost, but always with the anterior end foremost. However, they soon sink to the bottom again. "Generally as soon as they touched the sand, they would half-arch their bodies and almost instantaneously disappear from sight . . . after their disappearance, they very rarely entirely emerged"[28] but continue buried in an oblique position, ventral side uppermost, either with the opening of the oral hood at the surface of the sand or with the anterior portion of the body protruding. Aquarium observations suggest that they protrude and feed chiefly at night. No specific information is available as to the diet of this species (p. 4). *B. caribaeum* has been recorded from the low tide zone down to a depth as great as 24 fathoms. In Florida, sexually mature males, and females "heavy with eggs,"[29] have been reported in March; they are to be expected perhaps two months or so later in the Chesapeake Bay region, where pelagic larvae are to be found in July and August. Sexual maturity is attained in the second or third year.

Range. Atlantic coast of America from Chesapeake Bay to the West Indies. Recorded localities are: several localities in Chesapeake Bay; North Carolina; many localities in Florida, both on the west coast north to Pensacola and on the east coast; the Tortugas; the Snapper Banks; Gulf of Mexico; Bahamas; Porto Rico; Jamaica. It is so common in Florida that one collector reports taking 5,000 of them.

Synonyms and References:

Branchiostoma caribaeum[30] Sundevall, Öfvers. Vet. Akad. Forh., Stockholm, *10*, 1853: 12 (in part, specimens from St. Thomas, West Indies); Gill, Rep. U.S. Comm. Fish. (1871–1872), 1873: 814 (listed, C. Hatteras to Fla.); Yarrow, Proc. Acad. nat. Sci. Philad., 1877: 218 (Bird Shoal, N. Carolina); Jordan and Gilbert, Bull. U.S. nat. Mus., *16*, 1883: 3 (Chesapeake Bay to West Indies); Günther, Rep. Zool. Coll. "Alert," Brit. Mus., 1884: 32 (in part, specimens from St. Thomas, West Indies, characterization, discus.); Garman, in Kingsley, Stand. Nat. Hist., *3*, 1885: 64 (Gulf of Mexico); Andrews, Stud. Biol. Johns Hopk. Univ., *5*, 1893: 240 (in part, specimens from Florida, Gulf of Mexico and West Indies, myotome formula); Jordan and Evermann, Bull. U.S. nat. Mus., 47 (1), 1896: 3 (in part, but *B. platae* also included);[31] Evermann and Kendall, Rep. U.S. Comm. Fish. (1899), 1900: 48 (Snapper Banks, Gulf of Mexico, and Tampa, Florida); Evermann and Marsh, Bull. U.S. Fish Comm., *20* (1), 1902: 59 (in part, Porto Rico, but not the ill., which probably is *B. platae* because of shape of caudal); Tattersall, Trans. Lpool. Biol. Soc., *17*, 1903: 271, 280 (comp. with *lanceolatum*); Lönnberg, Bronn's Klassen., *6*, Abt. 1, Buch 1, 1904: 339 (descr., distrib.); Barbour, Bull. Mus. comp. Zool. Harv., *46*, 1905: 110 (in part, but *bermudae* and *platae* also incl. because of distrib.); Fowler, Proc. Acad. nat. Sci. Philad., *59*, 1908: 461 (Vieques Island, Porto Rico); Smith, N. C. Geol. econ. Surv., Fishes, *2*, 1907: 27 (N. Carolina, but not the ill., which appears to be of *B. platae* because of shape of caudal); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 146, 199 (in part, but *B. platae* probably included also); Fowler, Proc. biol. Soc. Wash., *33*, 1920: 143, footnote (mentioned); Hubbs, Occ. Pap. Mus. Zool.

27. For an interesting account of their occurrence in Florida, and of methods of collecting them, see Wells (Science, N.S. *64*, 1926: 187).
28. Rice, Amer. Nat., *14*, 1880: 8.
29. Wells, Science, N.S. *64*, 1926: 188.
30. Sometimes spelled *caribbaeum*.
31. The illustration of *caribaeum* by Jordan and Evermann (Bull. U.S. nat. Mus., 47 [4], 1900: pl. 1, fig. 1) appears from the shape of the caudal to have been based on a specimen of *B. platae*.

Univ. Mich., 105, 1922: 6 (descr.); Ribeiro, Fauna brasil., Peixes, *2* (1), Fasc. 1, 1923: 4 (in part, but *B. platae* included because of loc.); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 1 (descr., but *B. platae* included because of loc.); Nichols, Ann. N. Y. Acad. Sci., *10* (2), 1929: 180, fig. 1 (descr., distrib., Porto Rico); Jordan, Evermann and Clark, Rep. U.S. Comm. Fish. (1928), 2, 1930: 7 (West Indies); Pratt, Manual Common Invert. Anim., 1935: 757 (no. of myotomes, West Indies); Longley and Hildebrand, Pap. Tortugas Lab., No. 34, 1941: 1 (listed for Tortugas, Florida); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 262 (Sanibel, Florida).

Branchiostoma lanceolatum Günther, Cat. Fish. Brit. Mus., *8*, 1870: 513 (in part, specimens from Caribbean Sea); Rep. Zool. Coll. "Alert," Brit. Mus., 1884: 32 (in part, specimens from N. America); Jordan and Gilbert, Bull. U.S. nat. Mus., *16*, 1882: 867 (in part, specimens from east coast of N. America); Adams and Kendall, Bull. U.S. Fish Comm., *9*, 1891: 292, 293, 298 (SW. Florida); Andrews, Stud. Biol. Johns Hopk. Univ., *5*, 1893: 239 (myotome formula of specimens from Chesapeake Bay); not *Limax lanceolatus* Pallas, 1774.

Amphioxus caribaeus Jordan and Gilbert, Proc. U.S. nat. Mus., *1*, 1879: 388; also, Smithson. misc. Coll., *19*, 1880: 388 (Bird Shoal, N. Carolina); Kirkaldy, Quart. J. micr. Sci., *37*, 1895: 313 (in part, descr., and distrib., but *B. platae* also included); Lönnberg, Bronn's Klassen: 6, Abt. 1, Buch 1, 1904: 239 (descr., distrib.).

Branchiostoma lubricum Goode and Bean, Proc. U.S. nat. Mus., 2, 1880: 121 (E. Florida, name only).

Amphioxus lanceolatus Rice, Amer. Nat., *14*, 1880: 1, 73, pl. 34, fig. 1, 2 (habits, struct., develop.); not *Limax lanceolatus* Pallas, 1774.

Branchiostoma lanceolata Gill, Proc. U.S. nat. Mus., *5*, 1883: 515 (Atlant. coast of U.S.); not *Limax lanceolatus* Pallas, 1774.

Amphioxus (no specific name) Wright, Amer. Nat., *24*, 1890: 1085 (Port Tampa, Florida); Andrews, Circ. Johns Hopk. Univ., *11*, 1892: 75 (young stages recorded from Jamaica); Wells, Science, N.S. *64*, 1926: 187 (ecology, habits, breeding season, age at sexual maturity and coll. methods, Florida).

Branchiostoma caribbaeum Tattersall, Trans. Lpool. Biol. Soc., *17*, 1903: 241, 280 (cf. with *B. lanceolatum* and *B. belcheri*).

Branchiostoma floridae Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 7 (descr., Tampa and other Florida loc.); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 4 (Florida); Jordan, Evermann and Clark, Rep. U.S. Comm. Fish. (1928), 2, 1930: 7 (Florida); Pratt, Manual Common Invert. Anim., 1935: 757 (no. of myotomes, gonads, Florida).

Branchiostoma virginiae Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 8 (descr., Chesapeake Bay); Hildebrand and Schroeder, Bull. U.S. Bur. Fish., *43*, 1928: 42 (descr., habits, Chesapeake Bay); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 4 (Chesapeake Bay); Jordan, Manual Vert. Anim. NE. U.S., 1929: 4 (descr., Chesapeake Bay to N. Carolina); Jordan, Evermann and Clark, Rep. U.S. Comm. Fish. (1928), 2, 1930: 7 (Chesapeake Bay to Florida); Cowles, Bull. U.S. Bur. Fish., *46*, 1931: 367 (Chesapeake Bay); Pratt, Manual Common Invert. Anim., 1935: 757 (no. of myotomes, Chesapeake Bay to Florida).

Branchiostoma platae Hubbs, 1922

Figure 2 F

Study Material. Thirty-six specimens, 31 to 51 mm. long, from the vicinity of Rio de Janeiro and San Sebastiao I., Brazil, and off the mouth of the Rio de La Plata, Argentina (Lat. 36° 43′ S.; Long. 56° 23′ W.), in the collection of the United States National Museum.

Distinctive Characters. B. platae differs from the two eastern Atlantic species of this genus (*lanceolatum, africae*), and from *caribaeum* as well, in having its anus considerably posterior to the midpoint of the lower lobe of its caudal fin; it differs further from *caribaeum* in that the lower lobe of its caudal fin originates considerably anterior to the origin

of the upper lobe. The number of myotomes and dorsal fin-ray chambers is often larger also in *B. platae*, although there is no clear distinction between the two in these respects. *B. platae* differs from *B. bermudae* (which it resembles in the shape of the caudal fin) in its more numerous myotomes (at least 59) and dorsal fin-ray chambers (at least 275).

Additional Description. Anterior end of notochord in rostrum extends forward in a straight line; rostrum marked off from dorsal fin by a shallow notch; caudal fin lanceolate but asymmetrical, the origin of its lower lobe anterior to origin of its upper lobe by a distance ⅓ to ¾ as great as length of upper lobe, about midway between its tip and atriopore; anus considerably posterior to midpoint of lower lobe of caudal; distance from tip of caudal to anus ⅓ as long as from anus to atriopore; dorsal fin ⅕ to ⅐ as high as distance from its crest to the margins of the metapleura; highest dorsal fin-ray chambers 3 to 6 times as high as long; dorsal fin-ray chambers 280 to 330; precaudal fin-ray chambers 19 to 33; myotomes 37 to 40 anterior to atriopore, 13 to 17 between atriopore and anus, and 6 to 9 posterior to the anus, the recorded totals from 58 to 65; gonads 26 to 31.

Color. Presumably as in *B. caribaeum* (p. 14), but no specific information is available.

Size. Recorded specimens have ranged from 28 to 56 mm. in length.

Developmental Stages. Presumably as in other members of the genus.

Habits. Nothing is known of the habits of *B. platae* to differentiate it from its relatives.

Range. Specimens positively identified as *B. platae* are known up to the present time only from off the mouth of the Rio de La Plata and from southern Brazil (San Sebastiao I., the vicinity of Rio de Janeiro). But it seems probable that the Lancelets that have been recorded as *B. caribaeum* from Santos, from Santa Catharina at the mouth of the Amazon, from the Rio de La Plata and from Buenos Aires, were *B. platae*.

Synonyms and References:

Branchiostoma platae Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 102, 1922: 10 (descr., off Rio de La Plata); Jordan, Evermann and Clark, Rep. U.S. Comm. Fish. (1928), 2, 1930: 7, footnote.

Probable References:

Amphioxus mülleri Moreau, Bull. Acad. Roy. Belg., (2) *39*, 1875: 312, 1 pl., 12 figs. (micr. anat. of notochord, Rio de Janeiro, Brazil).[32]

Branchiostoma caribaeum[33] Günther, Rep. Zool. Coll. "Alert," Brit. Mus., 1884: 32 (in part, specimen from Botafogo, near Rio de Janeiro, Brazil); Jordan and Evermann, Bull. U.S. nat. Mus., 47 (1), 1896: 4 (in part, Brazil incl. in range); Bull. U.S. nat. Mus., 47 (4), 1900: pl. 1, fig. 1 (probably *B. platae* because of shape of caudal); Evermann and Marsh, Bull. U.S. Bur. Fish., *20* (1), 1902: 59 (ill., after Jordan and Evermann 1900, as above, but account is of *B. caribaeum*, N. Carolina); Barbour, Bull. Mus. comp. Zool. Harv., *46*, 1905: 110 (in part, because Rio de La Plata incl. in distrib.); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 146, 199; Fauna brazil., Peixes, 2 (1), Fasc. 1, 1923: 4 (in part, because Brazil incl. in

32. The name *mülleri* would have priority over *platae* if the specimens in question actually were identical with the latter, as the locality suggests. But Moreau gave no account of their external characters, nor is it likely that the sections on which his studies of microscopic anatomy were based are still in existence.

33. Sometimes spelled "*carribaeum*."

range); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 77 (Santa Catharina, Brazil, probably *B. platae* because of loc.); Marelli, Elenc. Sist. Fauna B. Aires (Procord. Vert.); Mem. Ministr. Obras Publ. B. Aires (1922–1923), Fishes, 1924: 543 (no descr., Rio de Janeiro, Rio de La Plata, Buenos Aires, ident. probably because of loc.); Luderwaldt, Rev. Mus. paul., *16*, 1929: 40 (San Sebastiao I., Brazil); Sawaya and Carvalho, Bol. biol. Fac. Med. S. Paulo, N.S. *2*, 1938: 43 (no. of myotomes, behavior in aquarium, Santos, Brazil, at 25 meters).

Amphioxos (no specific name) Luderwaldt, Rev. Mus. paul., *16*, 1929: 11, 15 (in plankton, and from bottom in shallow water, San Sebastiao I., Brazil).

Family *EPIGONICHTHYIDAE*

Description. Gonads developed on right side only; right-hand metapleuron continuous with preanal fin. Characters otherwise those of the order.[34]

Genera. The family includes two well defined genera: in *Epigonichthys* the caudal fin does not extend as a long narrow process, and the oral tentacles are united, one to the next, by a uniformly low intertentacular membrane; in *Asymmetron* the caudal fin, as well as the notochord, is much prolonged posterior to the myotomes as a narrow process, and the intertentacular membrane is much higher ventrally than laterally.

Key to Genera

1a. Caudal fin prolonged as a narrow process; the intertentacular membrane much higher ventrally than laterally (Fig. 3). *Asymmetron* Andrews, 1893, p. 18.[35]

1b. Caudal fin not prolonged as a narrow process; the intertentacular membrane but little higher ventrally than laterally. *Epigonichthys* Peters, 1876.[36]
New Zealand; Australia; East Indies; Ceylon; Maldive and Laccadive Archipelagos, to East Africa.

Genus *Asymmetron* Andrews, 1893

Asymmetron Andrews, Stud. Biol. Lab. Johns Hopk. Univ., *5*, 1893: 237; type species, *A. lucayanum* Andrews. Bahamas.[37]

Generic synonyms:

Branchiostoma (in part) Willey, Amphioxus and Ancest. Vert., 1894: 41; including *A. lucayanum* Andrews, 1893; not *Branchiostoma* Costa, 1834.

Epigonichthys Fowler, Proc. Acad. nat. Sci. Philad., *59*, 1907: 461; including *A. lucayanum* Andrews, 1893; not *Epigonichthys* Peters, 1876.

34. Whitley (Aust. Zool., 7, 1932: 257, 260) divides this family into Epigonichthyidae and Asymmetrontidae.
35. Including *Notasymmetron* Whitley (Aust. Zool., 7, 1932: 260, pl. 13, fig. 6). Whitley mentions, as characters distinguishing this genus from *Asymmetron*, only that it is larger, with the origin and termination of the dorsal fin farther forward in relation to the myotomes.
36. Including *Bathyamphioxus* and *Merscalpellus* Whitley, 1932. The differences on which Whitley (Aust. Zool., 7, 1932: 257–259) has separated these two new genera from *Epigonichthys* are so small that we hesitate to judge their validity, not having seen specimens of them. *Paramphioxus* Haeckel, 1893, is clearly a synonym of *Epigonichthys* Peters, 1876, in our opinion.
37. The characters of this new genus were given also, but without a generic name, by Andrews (Johns Hopk. Univ. Circ., *12*, 1893: 104).

Generic Characters. Median finfold extending far beyond last myotome as a narrow urostyloid process, with notochord reaching nearly to its tip; intertentacular membrane much higher ventrally than laterally; ventral fin-ray chambers lacking in type species, but perhaps present in others;[38] caudal sector of median fin not demarked from more anterior portions dorsal or ventral; gonad pouches begin at myotomes 13 to 15; rostrum continuous ventrally with both right and left sides of oral hood, and these in turn with each metapleuron; atrial chamber extending behind atriopore as a pair of blind sacs; preoral tentacles lack sensory papillae; no olfactory pit.

Species. The type species of the genus is *A. lucayanum* Andrews, 1893, of the West Indian region and Bermuda with which *A. macricaudatum* Parker, 1904, of Florida is doubtless identical (pp. 19, 22); it is also reported from the Philippines. Our examination of its type specimens leads to this same conclusion for *A. orientale* Parker, 1904, of the Maldive Islands, Indian Ocean; nor does *A. caudatum* Willey, 1896, from the Louisiade Archipelago, southeast of New Guinea, appear to have any better claim to specific recognition.[39]

Asymmetron lucayanum Andrews, 1893

Figure 3 A–E

Study Material. Twelve specimens, from North Bimini I., Bahamas, and from Vieques I., Porto Rico (U. S. Nat. Mus.). Five specimens (all of them types of *A. macricaudatum* Parker, 1904) from Salt Key, Florida (Harv. Mus. Comp. Zool., No. 26282). Seven specimens (all of them types of *A. orientale* Parker, 1904) from the Maldive Is., Indian Ocean (Harv. Mus. Comp. Zool., No. 32816).

Distinctive Characters. The long, narrow caudal process marks this species off at a glance from all other Atlantic Lancelets, from which it differs further in the still more important morphological respects stated above (Key, p. 7).

38. Whitley's (Aust. Zool., 7, 1932: pl. 13, fig. 6) illustration of a specimen identified by him as *caudatum* Willey, 1896, and on which he based the new genus *Notasymmetron*, shows ventral fin-ray chambers, although he made no mention of them in his description.

39. *A. caudatum* Willey (Quart. J. micr. Sci., *39*, 1896: 219, pl. 13, fig. 1–4) supposedly differs from *A. lucayanum* in that its rostrum is marked off by definite notches or constrictions both dorsally and ventrally. But Goldschmidt (Biol. Bull. Wood's Hole, *64*, 1933: 323, fig. 1a) has recently pictured the rostrum as of this same shape for a specimen of *A. lucayanum* from Bermuda, while we have seen one from the latter locality and another from Porto Rico with a notch on the dorsal side, although with none on the ventral side. *A. orientale* Parker (Bull. Mus. comp. Zool. Harv., *46*, 1904: pl. 1, fig. 4) was separated from *A. lucayanum* on the basis of a supposedly narrower caudal fin. But no sharp line can be drawn in this respect between its type specimens, which we have examined, and *A. lucayanum* of Florida and the West Indies (Fig. 3). We may also point out that the tail region of one specimen, a male, described by Willey (1896) as *A. caudatum* was what may be termed the "*lucayanum*" shape, that of the other, a female, of the "*orientale*" shape. It is possible, however, that the Australian form identified by Whitley (Aust. Zool., 7, 1932: 260, pl. 13, fig. 6) as *caudatum*, and on which he founded the genus *Notasymmetron*, may represent a distinct species, in which case a new specific name would be needed for it; he has pictured it as having ventral fin-ray chambers, although these are not mentioned in his description of it. We may further note that ventral fin-ray chambers are also indicated in the illustration of *A. lucayanum* from the Maldives, by Forster-Cooper (in Gardiner, Fauna Geol., Maldive Laccadive Archip., *1*, 1903: pl. 18, fig. 1). But no trace of such is to be seen in the Maldive specimens that we have examined; nor are they indicated in Franz' (Jena Z. Naturw., *58*, 1922: 426, fig. 30) figure of a Philippine specimen.

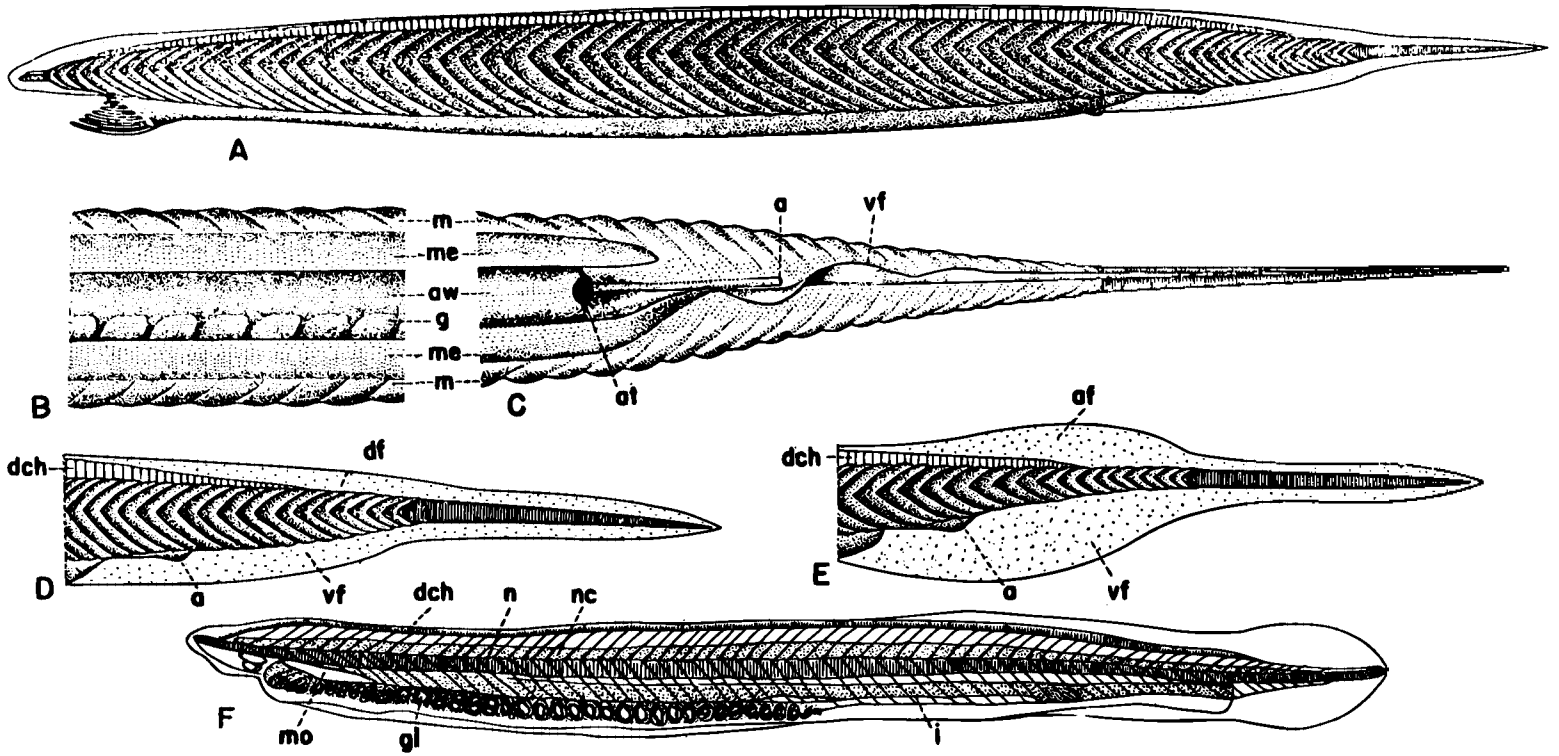

FIGURE 3. *A Arymmetron lucayanum* Andrews, 17 mm. long, from off Culebra, Porto Rico. *B* Ventral view of same from 27th to 33rd myotome showing gonads as seen through atrial wall. *C* Ventral view of posterior part of same to show continuity of right-hand metapleuron with ventral fin. *D* Lateral view of posterior region of same to show shape of caudal fin. *E* Posterior part of another specimen, 16 mm. long, from the same locality, showing the variation in the shape of the caudal fin. *F Amphioxides valdiviae* Goldschmidt, after Goldschmidt. *a* anus. *at* atriopore. *aw* atrial wall. *dch* dorsal fin ray chambers. *df* dorsal fin. *af* anal fin. *g* gonads. *gi* gills. *i* intestine. *m* myotomes. *me* metapleuron. *mo* mouth. *n* notochord. *nc* nerve cord. *vf* ventral fin.

Additional Description. Rostrum, continuous with dorsal fin, varies in shape from very narrow both above and below the notochord to more rounded in shape, and marked off by definite notches both dorsally and ventrally; dorsal fin-ray chambers from 170 to 180; preoral tentacles 21 to 29; intertentacular membrane much higher around the ventral side of oral hood than laterally, where the tentacles on either side are interconnected only near their bases.[40] Median fin (dorsal and ventral), posterior to atriopore, paddle-shaped in some specimens (wider ventrally than dorsally), narrowing rather abruptly between anus and last few myotomes; however, it is narrower in some, with a more gradual transition to the caudal process, there being a wide range of variation in this respect, even among specimens of a single lot, as illustrated in Fig. 3, D, E; the distance from the anus to tip of caudal process nearly twice as great as from last myotome to anus; myotomes 42 to 46 anterior to atriopore, 8 to 9 between atriopore and anus, 11 to 14 posterior to anus, total number 62 to 68;[41] gonads 26 to 29, in a single series on the right-hand side.

Color. This has not been described for living specimens.

Size. Nineteen mm. is the greatest length yet recorded for Atlantic specimens.[42] If, however, the Lancelets recorded as *A. lucayanum* from the Philippines are actually identical with the western Atlantic form, then the species grows larger in the Far East waters, for lengths up to 30 mm. have been reported there.

Developmental Stages. In larvae of 6 mm., with only 22 pairs of gill openings, the caudal extremity is expanded as a rounded fin; by the time the number of gill openings has increased to 27 pairs it has become pointed, after which it elongates to the adult form.[43]

Habits. This species, like other Lancelets, lives much of the time buried in the sand. But apparently it emerges more freely to swim about, for large numbers have been taken in tow nets at or near the surface in Bahaman waters; they are taken most abundantly during the early part of the ebb when the tide has been high about nine o'clock in the evening; rarely are they taken in the daytime, or late at night. In aquaria they seldom leave the sand in the daytime. Experiments have shown them to be negatively phototropic. The posterior part of the body has considerable power of regeneration if cut off just posterior to the

40. In the original account of *A. lucayanum*, Andrews (Stud. Biol. Lab., Johns Hopk. Univ., Zool., *5*, 1893: pl. 13, fig. 6) pictures the median ventral tentacle as considerably shorter than those next to it, with the membrane joining it to them lower than that which joins the next three or four tentacles; Kirkaldy (Quart. J. micr. Sci., *37*, 1895: 318, pl. 34, fig. 3), on the other hand, describes and pictures it as entirely free from the neighboring pair. Forster-Cooper (in Gardiner, Fauna Geogr., Maldive Laccadive Archip., *1*, 1903: 348, fig. 76) shows the membrane as notched where it connects with the ventro-median tentacle. But the membrane is higher there in a specimen from that same region that we have examined; it is so described and pictured also by Franz (Jena Z. Naturw., *58*, 1922: 429, 430, fig. 321) for one from the Philippines. Evidently, then, the difference in this respect is not geographic. Unfortunately, however, our West Indian series are not in good enough condition to clarify this point.

41. Parker (Bull. Mus. comp. Zool. Harv., *46*, 1904: 48) reported only four or five between atriopore and anus for the Florida specimens which he named *A. macricaudatum*. But re-examination of these same specimens yielded counts of eight to nine.

42. Kirkaldy, Quart. J. micr. Sci., *37*, 1895: 319.

43. Larval development is described by Andrews (Stud. Biol. Lab., Johns Hopk. Univ., *5*, 1893: 219, pl. 13, fig. 3, 5).

anus, although it is not known how far regeneration of the tail can proceed. The feeding habits are as described for the group in general (p. 4). The time occupied by the passage of food pellets through the digestive tract, as indicated by carmine particles, may be much less than an hour. In Bahaman waters sexually mature specimens have been taken in June and less often in July.[44]

Range. Circumtropical, with widely separated centers of distribution, and perhaps with local races; known in the western Atlantic from Bermuda, the Florida Keys, North and South Bimini in the Bahamas, Vieques I., Culebra I. and Humacao, Porto Rico, and off Pernambuco, Brazil. Known also from the Maldive Islands (Indian Ocean), the Philippines, the Louisiade Archipelago southeast of New Guinea, Zanzibar, and perhaps from North Australia. Evidently it is abundant locally in the tropical belt of the western Atlantic in suitable situations, for large numbers have been taken both in the Bahamas and at Castle Harbor, Bermuda.

Synonyms and References:

1. Atlantic:

Asymmetron lucayanum Andrews, Stud. Biol. Lab., Johns Hopk. Univ., *5*, 1893: 213, pl. 13, 14, fig. 1–25 (descr., anat., habits, sensory reactions, Bahamas); Kirkaldy, Quart. J. micr. Sci., *37*, 1895: 319, pl. 34, fig. 3 (descr., Bahamas); Jordan and Evermann, Bull. U.S. nat. Mus., 47 (1), 1896: 4 (descr., Bahamas); Evermann and Marsh, Bull. U.S. Fish Comm., *20* (1), 1902: 60 (descr., Porto Rico); Tattersall, Trans. Lpool. Biol. Soc., *17*, 1903: 291, 297, 302 (descr., discus., distrib.); Parker, Bull. Mus. comp. Zool. Harv., *46*, 1904: 49, pl. 1, fig. 2 (myotome formula, number of gonads); Mark, Science, N.S. *20*, 1904: 179 (Bermuda); Bean, in Shattuck, Bahama Islands, Fish., 1905: 296 (Bahamas); Barbour, Bull. Mus. comp. Zool. Harv., *46*, 1905: 110 (Bahamas and Bermuda); Lönnberg, Bronn's Klassen, *6*, Abt. 1, Buch 1, 1905: 244 (descr., Bahamas); Bean, Field Mus. Publ. Zool., 7, 1906: 29 (Bermuda); Gibson, Trans. Linn. Soc. Lond., Zool., (2) *13*, 1910: 241, 242 (number of myotomes; Bahamas, *Amphioxides pelagicus* perhaps the neotenic larva of this species); Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 16 (off Brazil); Franz, Jena Z. Naturw., *58*, 1922: 377, 426, fig. 30–32 (descr., discus., distrib.); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 4 (Bahamas); Nichols, Mem. N. Y. Acad. Sci., *10*, 1929: 181, fig. 2 (descr., Bahamas, Porto Rico); Goldschmidt, Biol. Bull. Wood's Hole, *64*, 1933: 231, fig. 1 A, B (relation to *Amphioxides* larvae, Bermuda); Beebe and Tee-Van, Field Bk. Shore Fish. Bermuda, 1933: 21 (descr., distrib., Bermuda); Goodrich, Quart. J. micr. Sci., *75*, 1933: 723 (nephridia; Bermuda); Pratt, Manual Common Invert. Anim., 1935: 757 (no. of myotomes and gonads); Andrews, Bigelow and Morgan, Sci. Mon., 61 (5), 1945: 341, 343 (habits, ill., Bimini, Bahamas).

Branchiostoma lucayanum Willey, Amphioxus and Ancestr. of Vert., 1894: 41 (Bahamas).

Asymmetron macricaudatum Parker, Bull. Mus. comp. Zool. Harv., *46*, 1904: 47, pl. 2, fig. 7 (descr., discus., Salt Key, Florida); Pratt, Manual Common Invert. Anim., 1935: 757 (no. of myotomes and gonads).

Epigonichthys leucayanum Fowler, Proc. Acad. nat. Sci. Philad., *59*, 1907: 461 (Bermuda).

2. Indo-Pacific:

Asymmetron caudatum Willey, Quart. J. micr. Sci., *39*, 1896: 219, pl. 13, fig. 1–4 (descr., ill. of head and tails of male and female; size; Louisiade Archipel.); Quart. J. micr. Sci., *44*, 1901: 271 (*caudatum* a subspecies of *lucayanum*); Willey's Zool. Res., *6*, 1902: 725 (ill., *caudatum* a subspecies of *lucayanum*); Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 16 (refs.); Lönnberg, Bronn's Klassen, *6*, Abt. 1, Buch 1, 1905: 244 (doubts if distinct from *lucayanum*).

Asymmetron lucayanum Forster-Cooper, in Gardiner, Fauna Geogr., Maldive Laccadive Archip., *1*, 1903:

44. The foregoing account is based on observations by Andrews, 1893.

348, pl. 18, fig. 1 (descr., ill., size, Maldive Is., see footnote 39, p. 19); Punnett, in Gardiner, as above, 1903: 362 (number of myotomes, sizes); Tattersall, in Herdman, Rep. Govt. Ceylon Pearl Oyster Fish., Gulf of Manaar, suppl. 6, 1903: 222 (listed for Maldives and Zanzibar); Gibson, Trans. Linn. Soc. Lond., Zool., (2) 13, 1910: 241 (Maldives, by ref. to Forster-Cooper, 1903, *Amphioxides pelagicus* perhaps its neotenic larva); Raff, Zool. Res. "Endeavour," Austral. Dep. Trade. Customs, 1 (3), 1912: 305 (listed for Louisiade Archipel., Maldives, Zanzibar, Torres Strait); Franz, Jena Z. Naturw., *58*, 1922: 426, 427, fig. 30 (ill., myotome counts, size, Philippine specimens).

Asymmetron orientale Parker, Bull. Mus. comp. Zool. Harv., *46*, 1904: 46, pl. 1, fig. 4 (descr., ill., Maldive Is.); Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 16 (ref.).

Epigonichthys caudatus Jordan and Evermann, Bull. U.S. Bur. Fish., *25*, 1906: 191 (name only, Louisiade Archipel.); Fowler, Mem. Bishop Mus., *10*, 1928: 17 (name only, Louisiade Archipel.).

Probable References:[44a]

Heteropleuron (*Asymmetron*) *lucayanum* Haswell, Rec. Aust. Mus., 7, 1908: 35 (Murray I., Torres Str., specimen subsequently named *Notasymmetron* by Whitley, 1932).

Notasymmetron caudatum Whitley, Aust. Zool., 7, 1932: 260, pl. 13, fig. 6 (descr., ill., Torres Str. spec.); Fish. Aust., *1*, 1940: 250, fig. 290 (N. Queensland, Murray I., Torres Str.).

Amphioxides Larvae

Synonyms:

Branchiostoma (in part) Günther, "Challenger" Rep., Zool., *31* (2), 1889: 43, for *B. pelagicum* Günther; not *Branchiostoma* Costa, 1834.

Amphioxides Gill, Amer. Nat., *29*, 1895: 458; type species, *Branchiostoma pelagicum* Günther, 1889.

"Pelagic larvae," Forster-Cooper, in Gardiner, Fauna Flora, Maldive Laccadive Archip., *1* (4), 1903: 354, pl. 6, fig. 3–6.

Asymmetron (in part) Pietschmann, in Kükenthal and Krumbach, Handb. Zool., *6* (1), Lief 1, 1929: 110, fig. 107, for *Branchiostoma pelagicum* Günther, 1889.

Group Characters. Small Lancelets, living pelagically, in which (as in larval Lancelets in general) the mouth is on the left side, without oral tentacles, the metapleural folds are separate, one from another, so that there is no closed atrial cavity, and in which the gill clefts are in a single row on the ventral side, but which grow to a greater length (up to 21 mm.)[45] and develop a greater number of gill clefts than is usual for Lancelet larvae before metamorphosis and which may show at least the rudiments of gonads.

As pointed out above (p. 7), these *Amphioxides* are juvenile specimens that retain their larval characteristics not only to a greater size than is characteristic of their parent species[46] but to a more advanced stage in their own development; they are not a primitive group as was originally supposed.[47] While they may develop gonads, as just stated, there is no evidence that Lancelets ever become mature sexually as *Amphioxides*.

44a. See footnote 35, p. 18.

45. Forster-Cooper (in Gardiner, Fauna Geogr., Maldive Laccadive Archip., *1*, 1903: 352, pl. 4) reports as *Branchiostoma pelagicum* a 21-mm. specimen from the central Indian Ocean that appears to be an *Amphioxides* because no trace of oral tentacles was to be seen.

46. Larvae of this sort are known, technically, as "neotenic."

47. Their larval nature, first suggested by Goldschmidt (Zool. Anz., *30*, 1906: 443) and accepted by Gibson (Trans. Linn. Soc. Lond., Zool., [2] *13*, 1910: 239), was substantiated by Goldschmidt (Dtsch. Sud-polar Exped., *11*, Zool. 3, 1909: 237), who discovered *Amphioxides* in which the secondary series of gill openings had begun to form, *i.e.*, which had commenced their metamorphosis.

Range. *Amphioxides* larvae have been reported from localities so generally distributed and so widely separated[48] that they are to be expected anywhere on the high seas, within the latitudinal belt where Lancelets of the family Epigonichthyidae occur in any abundance.

Species. One specimen of *Branchiostoma lanceolatum* has been reported in the *Amphioxides* stage, *i.e.*, it still retained its larval characters at a length of 5.5 mm., although this species usually undergoes its metamorphosis at about 4.5 mm.[49] The other *Amphioxides* larvae that have been described fall in two categories; the dorsal fin-ray chambers of the one extend forward well beyond the first myotome, those of the other terminate at the dorsal margin of the first myotome. Among the specimens of the second group, some agree in number of myotomes with the *Branchiostoma pelagicum* of Günther, 1889, and have been identified with the latter for this reason.[50] Other specimens of the group with a larger number of myotomes (70) for only two recorded specimens have been described as a distinct species, *Amphioxides stenurus* Goldschmidt, 1905. But it is doubtful whether the distinction between it and *pelagicus* is valid. The other category, with dorsal fin-ray chambers extending far forward, has been named *valdiviae* Goldschmidt, 1905.

None of these has been definitely connected with any particular parent species. In the few specimens in which the rudiments of gonads were to be seen, however, these were in a single series and on the left-hand side, suggesting an *Epigonichthys* or an *Asymmetron* parentage; *i.e.*, that they belong to the family Epigonichthyidae.

Key to Species of *Amphioxides*

1a. Dorsal fin originates opposite 21st to 25th myotome; ventral fin about opposite 40th myotome; dorsal fin-ray chambers do not extend forward beyond dorsal edge of 1st myotome.

2a. Not more than 68 myotomes. *pelagicus* Günther, 1889, p. 25.

2b. 70 myotomes. *stenurus* Goldschmidt, 1905. Indian Ocean.

1b. Dorsal fin originates opposite 32nd to 33rd myotome or even farther back; ventral fin about opposite 43rd myotome; dorsal fin-ray chambers extend forward considerably beyond dorsal edge of 1st myotome. *valdiviae* Goldschmidt, 1905, p. 27.[51]

48. Reported from the English Channel, Bermuda, off the Amazon and at several other localities in the equatorial and south tropical Atlantic; mouth of the Red Sea; widespread in the tropical Indian Ocean; from the vicinity of the Hawaiian Islands. For a distribution chart, to which might be added a few more recent records, see Goldschmidt (Dtsch. Sud-polar Exped., *11*, Zool. 3, 1909: pl. 11).

49. Goldschmidt, Zool. Anz., *30*, 1909: 443.

50. So identified by Goldschmidt (Wiss. Ergebn. 'Valdivia,' *12*, 1905: 46). But this identification cannot be regarded as final until the type specimen of Günther's *pelagicum* is re-examined, because his illustration of it ("Challenger" Rep., Zool., *31* [2], 1889: pl. 6, fig. B) does not show the anterior termination of the fin-ray chambers clearly.

51. Previous accounts (Goldschmidt, Wiss. Ergebn. 'Valdivia,' *12*, 1905: 46, pl. 1, fig. 3, 4; Gibson, Trans. Linn. Soc. Lond., Zool., [2] *13*, 1910: 217, pl. 15, fig. 1) base the distinction between *valdiviae* and *pelagicus* chiefly on the shape of the tail fin, which is supposedly more sharply marked off and blunter at the tip, with the notochord ending more bluntly in the former than in the latter. But the two supposed species appear to intergrade in this respect.

Amphioxides pelagicus (Günther), 1889

Study Material. None.

Distinctive Characters. Amphioxides larvae differ from adult Lancelets in that they have neither atrial cavity nor oral cirri; their mouths are on the left-hand side, and their gill clefts are in a single series. *Pelagicus* is separable from *valdiviae* by the facts that its dorsal fin-ray chambers do not extend forward past the first myotome, and that the dorsal fin originates about opposite the 21st to 25th myotome, while in *valdiviae* it commences opposite the 32nd to 33rd myotome, or even more posteriorly; *pelagicus* is separated from *stenurus* by fewer myotomes (not more than 68 in *pelagicus*).

Additional Description.[52] Caudal fin usually not sharply marked off, although sometimes more definitely so, its tip lancet-shaped, usually pointed; notochord tapering to a narrowly pointed tip; dorsal finfold originates about opposite the 21st to 25th myotome; the ventral farther posterior in some (opposite the 40th myotome), but farther forward in others; the dorsal fin-ray chambers extend forward only to the posterior edge of the first myotome, anterior to which they are replaced by an undivided tapering canal; two chambers per myotome anteriorly, increasing to 3 or 4 per myotome posteriorly; gill clefts 16 to 18 in specimens of 5 to 6 mm., with 24–26 reported for Bermuda specimens of 8 to 10 mm. or longer, and up to 30 for the Indian Ocean form; myotomes usually 63 to 64 (50 or 51 preanal and 13 postanal) with totals of 67 also reported from Bermuda, and 62 to 68 from Indian Ocean.

Color. No information available.

Size. Pelagicus has been recorded up to 16 mm. in length from Bermuda; up to 10 mm. from the Indian Ocean.[53]

Parentage. It is probable that the *pelagicus* of the Atlantic is the neotenic larva of *Asymmetron lucayanum*, the *pelagicus* of the Indian Ocean that of the local representative of *lucayanum*.[54]

Habits. Nothing positive is known of the habits of this or of any other *Amphioxides*, except that it is planktonic. In the Indian Ocean *Amphioxides* of the *pelagicus* type have been taken in abundance at or near the surface and similarly at several localities in the tropical Atlantic. On the other hand, many of the records have been from nets fished at considerable depths.[55] In most instances, however, there is no certainty that the specimens were actually taken at the depth at which the major part of the haul was made, because the nets also fished while being lowered and hauled up again. Consequently, the depth of chief abundance is still to be learned. We think it probable that the odd speci-

52. Based on previous descriptions and illustrations.

53. A 21-mm. specimen from the Indian Ocean, reported and pictured by Forster-Cooper (in Gardiner, Fauna Geogr., Maldive Laccadive Archip., *1*, 1903: 352, pl. 4) was in such poor condition that its specific identity is doubtful.

54. This identity has been maintained by Gibson (Trans. Linn. Soc. Lond., Zool., [2] *13*, 1910: 241). Although Goldschmidt (Biol. Bull. Wood's Hole, *64*, 1933: 324) has questioned it, the number of myotomes that he records for the Bermudian *pelagicus* (50 to 51 preanal and 13 postanal, as well as a stated total of 67) falls within the limits reported for *lucayanum* from the Bahamas (62 to 68).

55. Ostensibly down even to 1,000 fathoms (1,829 meters).

mens that have been brought up from as deep as 250 to 500 fathoms in closing nets[56] were taken while in the process of sinking into the oceanic abyss, as may be the eventual fate of all the *Amphioxides* that drift out into deep water.

The frequency with which *pelagicus* has been reported from deep hauls makes it likely that it can exist for a time in considerably cooler water, although it is primarily tropical in its thermal relationships. But we have yet to learn how low a temperature may be fatal to it, and how rapidly.

Nothing is known of its feeding habits, nor of those of any *Amphioxides*.

Range. Specimens showing the characters of *pelagicus* have been reported from the vicinity of the Hawaiian Islands, the type locality; from numerous localities distributed across the tropical belt of the Indian Ocean between latitudes 10° 8′ S. and 9° 6′ N.; from five stations between the St. Helena and Ascension Islands and the African Coast (Lat. about 14° S. to about 4° N.); from one station off the mouth of the Amazon; and from the vicinity of Bermuda, whence 87 specimens were recorded from 27 townet hauls;[57] perhaps also from the Bahamas.[58]

Synonyms and References:

Branchiostoma pelagicum Günther, "Challenger" Rep., Zool., *3* (2), 1889: 43, pl. 6, fig. B (descr., ill., N. Pacific near Honolulu); Kirkaldy, Quart. J. micr. Sci., *37*, 1895: 320 (mention); Tattersall, Trans. Lpool. Biol. Soc., *17*, 1903: 296 (distrib.); in Herdman, Rep. Govt. Ceylon Pearl Oyster Fish., Gulf of Manaar, Suppl. 6, 1903: 214, plate not numbered, fig. 16 (descr., Indian Ocean); Lönnberg, in Bronn's Klassen, *6*, Abt. 1, Buch 1, 1904: 245 (ref. to type specimen); Franz, Jena Z. Naturw., *58*, 1922: 433 (refs., discus., incl. *valdiviae*); Pietschmann, in Kükenthal and Krumbach, Handb. Zool., *6* (1), Lief 1, 1929: 109 (discus.).

Amphioxides pelagicus Gill, Amer. Nat., *29*, 1895: 458 (name); Tattersall, Trans. Lpool. Biol. Soc., *17*, 1903: 275 (diagn.); Goldschmidt, Wiss. Ergebn. 'Valdivia,' *12*, 1905: 45, pl. 1, fig. 3, 4 (descr., ill., Indian Ocean and trop. Atlantic); Willey, Quart. J. micr. Sci., *50*, 1906: 581 (ref. to Goldschmidt, 1905); Goldschmidt, Dtsch. Sud-polar Exped. (1901–1903), *11*, Zool. *3*, 1909: 234, pl. 27 (discus., trop. Atlant., chart of distrib.); Gibson, Trans. Linn. Soc. Lond., Zool., (2) 13, 1910: 217, pl. 15, fig. 1 (descr., discus., ill., Indian Ocean); Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 4 (listed); Goldschmidt, Biol. Bull. Wood's Hole, *64*, 1933: 324 (meas., no. of myotomes, discus., Bermuda).

Asymmetron pelagicum Pietschmann, in Kükenthal and Krumbach, Handb. Zool., *6* (1), Lief 1, 1929: 110, fig. 107 (ill.).

Doubtful References:

Branchiostoma pelagicum Forster-Cooper, in Gardiner, Fauna Geogr., Maldive Laccadive Archip., *1* (4), 1903: 352 (21 mm., Indian Ocean; ident. doubtful because of poor condition).

Not *Branchiostoma pelagicum* Parker, 1904, Bull. Mus. comp. Zool. Harv., *46*, 1904: 40, pl. 1, fig. 1 (this was *valdiviae* in reality; see below, p. 28).

56. Gibson (Trans. Linn. Soc. Lond., Zool., [2] *13*, 1910: 214) lists two such instances from the Indian Ocean.

57. For a list of Bermuda records, see Goldschmidt (Biol. Bull. Wood's Hole, *64*, 1933: 322).

58. A six-mm. specimen from the Bahamas, pictured by Andrews (Stud. Biol. Lab., Johns Hopk. Univ., *5*, 1893: pl. 13, fig. 5) as *Asymmetron lucayanum*, is classed by Gibson (Trans. Linn. Soc. Lond., Zool., [2] *13*, 1910: 241) as *Amphioxides*. But Andrews' statement (p. 219) that it had "22 branchial clefts on a side" suggests that it was a specimen in the process of metamorphosis.

Amphioxides valdiviae Goldschmidt, 1905

Figure 3 F

Study Material. One specimen, 9 mm. long, with 33 gill clefts, from the Maldive Islands.[59]

Distinctive Characters. Amphioxides larvae of the *valdiviae* type are separated from those of the *pelagicus-stenurus* type by the following features: their dorsal fin-ray chambers extend forward well past the first myotome, and the dorsal fin originates about opposite the 32nd or 33rd myotome (in *pelagicus* about opposite the 21st to 25th myotome). Differences in the shape of the tail that have been given specific weight appear not to be constant.

Additional Description.[60] Caudal sector of fin paddle shaped with blunted tip and rather definitely marked off from more anterior portion (dorsal and ventral) by a constriction, about opposite anus; notochord blunt-tipped posteriorly; dorsal finfold originates opposite 32nd to 33rd myotome, the ventral finfold about opposite 43rd myotome; dorsal fin-ray chambers extend forward beyond first myotome; about 5 dorsal fin-ray chambers per myotome; gill clefts 25 to 35 in specimens of 5.7 to 8 mm., 33 to 35 in those of 8 to 9.25 mm.; myotomes 55 to 58 anterior to anus, 11 to 15 posterior to it, with recorded totals of 67 to 70.

Color. No information available.

Size. The maximum recorded length is 9.25 mm.

Parentage. If *Amphioxides* of this type are the neotenic larvae of species of *Epigonichthys*, as seems probable,[61] the parentage of *valdiviae* of the Atlantic presents an interesting question, because *Epigonichthys* is not yet known to occur there.

Habits. Nothing is known of the thermal or bathymetric occurrence of *valdiviae* to separate it from *pelagicus* (p. 25).

Range. Tropical Atlantic and Indian Oceans. While *valdiviae* has not yet been reported from the western Atlantic, it is to be expected in this section of the tropical belt, many specimens having been taken at the surface off tropical West Africa (Portuguese Senegal), some of them showing the beginnings of metamorphosis.[62] It has been reported also off the African Coast, south of Tenerife, and at a number of localities in the tropical Indian Ocean, including the vicinity of Sumatra, Bay of Bengal, Maldive Islands, near the Chagos Archipelago, southeast of the Seychelles, and in the vicinity of Farquhar Islands.

59. This is the specimen described and pictured by Parker (Bull. Mus. comp. Zool. Harv., *46*, 1904: 40, pl. 1, fig. 1, 2). The gonads credited to it in the original account prove actually to have been the gill bars.
60. Based on descriptions by Goldschmidt (Wiss. Ergebn. 'Valdivia,' *12*, 1905: 47, pl. 1, fig. 1), Gibson (Trans. Linn. Soc. Lond., Zool., [2] *13*, 1910: 217), and on the specimen listed above.
61. Gibson (Trans. Linn. Soc. Lond., Zool., [2] *13*, 1910: 241) suggests this parentage for *Amphioxides valdiviae* of the Indian Ocean.
62. Goldschmidt, Dtsch. Sud-polar Exped., *11*, Zool. 3, 1909: tab. p. 11.

Synonyms and References:

Branchiostoma pelagicum Parker, Bull. Mus. comp. Zool. Harv., *46*, 1904: 40, pl. 1, fig. 1 (ill. showing blunt notochord, rounded tail, and dorsal fin-ray chambers extending well beyond the first myotome; this is clearly *valdiviae*; see also Study Material, p. 27, and footnote 59, p. 27); not *B. pelagicum* Günther, 1889.

Branchiostoma pelagicum (in part) Franz, Jena Z. Naturw., *58*, 1922: 434 (*valdiviae* incl. in synonymy).

Amphioxides valdiviae Goldschmidt, Wiss. Ergebn. 'Valdivia,' *12*, 1905: 47, pl. 1, fig. 1 (descr., ill., trop. Atlant. and trop. Indian Oceans); Gibson, Trans. Linn. Soc. Lond., Zool., (2) *13*, 1910: 217 (descr., comp. with *pelagicus*); Goldschmidt, Dtsch. Sud-polar Exped., *11*, Zool. 3, 1909: 234, pl. 27 (specimens commencing metamorphosis, trop. Atlant., chart of distrib.); Hubbs, Occ. Pap. Mus. Zool. Univ. Mich., 105, 1922: 4 (listed); Goldschmidt, Biol. Bull. Wood's Hole, *64*, 1933: 321 (ref. to spec. showing beginning of metamorphosis).

CHAPTER TWO

Cyclostomes

BY

HENRY B. BIGELOW *and* WILLIAM C. SCHROEDER

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GENERAL DISCUSSION

Scope of Study. The following pages give descriptions, life histories, geographic distribution so far as known, and lists of published citations for the genera and species of marine Cyclostomes that are known to occur on the western side of the North Atlantic. The characterizations of the orders, families and genera cover the Cyclostomes as a whole, as does the key to the species of the only genus in question that includes more than a single marine representative.

Descriptions. These are based on the Study Material listed under each species. The accounts of the habits and geographic distribution are taken partly from the published records, partly from data of our Study Material, and partly on information from numerous correspondents, supplemented by our own observations.

Keys. The keys, from the higher groups down to species, have been prepared solely

for ease of identifying any Cyclostome that may come to hand; for that reason we have selected characters which are most easily used.

References. All citations listed among the references, with the few exceptions noted, were consulted in the original; for a list of co-operating libraries, see the general discussion for the section on Sharks.

Sources of Material. The collection of Cyclostomes in the Museum of Comparative Zoology has been the chief basis of our studies, but the collections at the United States National Museum and the Academy of Natural Sciences at Philadaelphia have also been drawn upon.

Class AGNATHA

Subclass CYCLOSTOMATA

Fish or fish-like vertebrates,[1] eel-like in form, the skeleton cartilaginous or fibrous, without bone; no definitely developed jaws or bony teeth; at least the rudiments of a cranium present in the form of a simple trough below the brain in some, but partially roofed in others; notochord not constricted at all segmentally; vertebral column represented by a simple notochordal sheath, without vertebral centra, but with rudimentary neural arches (not joined above) in some; no shoulder or pelvic girdles, no paired limbs and no true ribs; 6 to 14 pairs of gill pouches opening either directly into the pharynx internally or into a separate respiratory tube, which in turn opens into the mouth below the gullet, and opening to the exterior either separately or by a single aperture on each side; skin without scales; nostril single, either opening into the mouth or not; intestine with internal longitudinal ridges, or with a slight spiral fold; ear with either 1 or 2 semicircular canals only; no sympathetic nervous system, or spleen; heart without conus arteriosus; no cloaca, the genital apertures being separate from anus. Development oviparous, with or without a definite larval stage; the sexes separate or not.

The Cyclostomes are generally considered the most primitive of true vertebrates; structurally they are the simplest. They are easily distinguishable from all the higher fishes by their peculiar jawless mouths, by the fact that there is only one nostril, and by the very primitive cranium.[2]

Key to Orders

1a. Snout with prominent barbels; no separate dorsal fin; eyes not visible externally; nasal opening at tip of snout; mouth not funnel- or disc-like. Myxinoidea, p. 31.

1b. Snout without prominent barbels; one or more dorsal fins separate from caudal; eyes in adult well developed, and visible externally; nasal opening on upper side of head; mouth opens as a funnel or disc. Petromyzonida, p. 43.

1. Opinions differ as to whether the Cyclostomes are to be regarded as a class distinct from the true fishes, or as a subclass of the latter.

2. For detailed accounts of the anatomy of the Cyclostomes, see especially Lönnberg, Favaro, Mozejko and Rauther in Bronn's Klassen, 6, Abt. 1, Buch 1, 1905–1924: 16–39, pl. 13–32; also Pietschmann, in Kükenthal, Handb. Zool., 6, 1st half, 1929–1935: 2–5.

Order MYXINOIDEA

Description. Six to 15 pairs of gill pouches, opening internally into the pharynx, those on each side opening either separately to the exterior or by a single common aperture; 2 pairs of barbels on side of nostril and 1 or 2 pairs at side of mouth; single continuous fin running posteriorly around tail and anteriorly on lower surface; fin rays restricted to tail region; nostril at tip of snout opening into mouth and serving as the entrance for water in respiration; mouth not funnel-like; tongue evertible, with two rows of horny, rasp-like teeth; prominent row of segmentally arranged mucous pores along each side; anus near posterior end; eye, without lens or iris, not visible externally, and apparently degenerate; cranium a simple, unroofed trough below brain; barbels and tongue supported by cartilaginous bars; branchial basket reduced to a vestige; ear with one semicircular canal only; a pancreas-like gland well developed; notochordal sheath without rudimentary neural arches; intestine with internal longitudinal folds, but without spiral valve.

Development. According to recent studies (see discussion and footnote 14, p. 35) the myxinoids, although structurally hermaphroditic, are not functionally so. Development is direct, without a larval stage.[3]

Habitat. Exclusively marine.

Families. Only one, Myxinidae, is known.

Family MYXINIDAE

Hags

Characters. Those of the order.

Discussion of Genera. The members of the family fall in two sharply alternative groups, depending on whether the gill pouches of each side open to the exterior by a single common orifice, or separately. By common consent, members of the first group fall in one genus, *Myxine*. But the members of the second group have been divided, depending on the importance given by different students of classification to the number of gills and the grouping of their openings. Since none of the latter group occur in the western North Atlantic we need only point out that the use of the number of gills for generic separation does not seem permissible, for species occur with 5, 6 to 7, 8, 10, 11 to 12, and 14. But the difference between the close grouping of the gill openings in *Paramyxine*, and their wide spacing in all the others, does seem worth generic recognition, as indicated in the following key.[4]

3. Dean's detailed description of the early development of *Eptatretus stouti*, in "Festschrift von Kupfer's" (1899: 221–277, pls. 15–26) has formed the basis for subsequent accounts in many textbooks.

4. Holly (in Schultze, Kükenthal, *et al.*, Tierreich, Lief 59, 1933: 45) includes the shape of the gill openings as an additional generic character, but Matsubara (J. Imp. Fish. Inst. Tokyo, *32* [1], 1937: 13) has recently shown that this varies so widely in *Paramyxine* as not to be reliable.

Key to Genera

1a. Gill pouches on each side connect with exterior by single common aperture.
Myxine Linnaeus, 1758, p. 32.
Atlantic and Pacific Oceans.

1b. All gill pouches on each side open independently to exterior.

2a. Gill openings on each side (16 in number) are close together.
Paramyxine Dean, 1904.
Japan.

2b. Gill openings on each side (5–14 in number) separated by interspaces of considerable width.
Eptatretus Cloquet, 1819.[5]
Pacific Ocean.

Genus *Myxine* Linnaeus, 1758

Hags

Myxine Linnaeus, Syst. Nat., 1758: 650; type species, *M. glutinosa* Linnaeus. Atlantic Ocean.

Generic Synonyms:

Petromyzon (in part) Walbaum, P. Artedi Genera Pisc. Emend. Ichthyol., Pt. 3, 1792: 500, for *M. glutinosa*; not *Petromyzon* Linnaeus, 1758.

Gastrobranchus Bloch, Naturg. Ausländ. Fische, Pt. 9, 1793: 66, pl. 413; type species, *G. coecus* Bloch. Denmark, Sweden, Norway and Iceland.

Muraenoblenna Lacépède, Hist. Nat. Poiss., 5, 1803: 652; type species, *M. olivacea* Lacépède. Straits of Magellan.

Pholis Oken, Lehrb. Naturg., 3 (2), 1816: 122; alternative name for *Myxine*.

Gasteobranchus Buckland, Nat. Hist. Brit. Fish., 1881: 144; evident misspelling for *Gastrobranchus*.

Generic Characters. Five or 6 gill pouches on each side opening to exterior by a single aperture on ventral surface, close in front of origin of ventral finfold, the left-hand gill opening, which receives the oesophago-cutaneous duct, being much the larger; fleshy flap ("rostrum" or "labrum") overhanging nostril anteriorly; nostril close to tip of snout; snout with 6 barbels, flanking both nostril and mouth; each side with a series of large mucous pores, segmentally arranged, extending from a short distance behind the mouth rearward nearly to the caudal extremity. Characters otherwise those of the family and order.[6]

Range. Continental shelves and slopes of the North Atlantic in north temperate and

5. This genus has been called most commonly *Bdellostoma* Müller, 1835. It has been argued by Apstein (Sitzber. Gesellsch. Naturf. Berlin, 1915: 187) and Rauther (in Bronn's Klassen, 6, Abt. 1, Buch 1, Lief 39, 1924: 685) that it would be well to accept this as a *nomen conservandum*. But, awaiting action by the International Commission on Zoological Nomenclature, it seems to us wiser to use the older name. As Rauther points out, the original description of *Eptatretus* was based by Cloquet (Dict. Sci. Nat., 15, 1819: 135) on a combination of two species—the Chilean *dombei* and an unnamed species from the South Seas. But even if *Eptatretus* were to be abandoned as a generic name on that account, *Bdellostoma* is long antedated by *Homea* Fleming (Phil. Zool., 2, 1822: 374) and by M'Murtrie's *Heptatremus* (Anim. Kingd. [after Cuvier], 2, 1831: 298).

6. For an excellent account of the general morphology of *Myxine*, see Smitt (Hist. Scand. Fish., 2, 1895: 1196).

subarctic latitudes, including the Mediterranean (Adriatic) in moderate depths; coasts of southern Argentina, Chile, Japan, and South Africa; Gulf of Panama in deep water (1,335 meters), the latter being the only locality where the genus is known to occur in tropical or subtropical latitudes.

Species. The representatives of the genus fall in two well defined groups, according to whether the first three lingual teeth of the anterior row are fused at the base, or only the first two, which is more usual. One member of the first of these groups, *M. circifrons*, is further set apart from all others in the genus by the fact that it has only five pairs of gill sacs. Unfortunately this feature is not apparent from the exterior, and other characters that have been used to separate supposed species, such as relative length of head and number of mucous pores, overlap to such an extent that it is doubtful how many of the named forms will finally stand. For further discussion, see p. 38.

Key to Species of *Myxine*

1a. First 3 lingual teeth in anterior series fused together at base.

2a. Lingual teeth $\frac{13}{11}$; head nearly or quite 33.3% of total length.

circifrons Garman, 1899.[7]
Gulf of Panama.

2b. Lingual teeth only $\frac{12}{11}$ or fewer; head not more than 29% of total length.

3a. 26 or 27 mucous pores anterior to gill openings, and 12 or 13 posterior to anus. *garmani* Jordan and Snyder, 1901.
Japan.

3b. Only 22 mucous pores anterior to gill openings and 9 posterior to anus.

tridentiger Garman, 1899.
Straits of Magellan.

1b. Only 1st 2 lingual teeth in anterior row fused together at base.

4a. Lingual teeth only $\frac{6}{7}$. *paucidens* Regan, 1913.
Japan.

4b. Lingual teeth $\frac{7}{7}$ or more.

5a. 10–11 teeth in anterior series in adult. *affinis* Günther, 1870.
Straits of Magellan.

5b. Not more than 7–9 teeth in anterior series in adult.

glutinosa Linnaeus, 1758, p. 34.[8]
Both sides of North Atlantic.

7. This species is set apart from all others of the genus by the fact that it has only five pairs of gill sacs. This, however, is not apparent externally.

8. Including *capensis* Regan, 1913, South Africa, and *australis* Jenyns, 1842, Chile and southern Argentina; these species and *glutinosa* so overlap one another in the number of teeth and mucous pores and in the relative length of head that we have not been able to construct a key by which individual specimens could be identified with certainty. Neither can the presence of seven pairs of gill pouches in *capensis* be regarded as a unique specific character, since occasional specimens of *glutinosa* may have this same number (footnote 11, p. 35). Information on the number of teeth ($\frac{10}{10}$) and gill pouches of *capensis*, which was not included in the original description of the species (Regan, Ann. Mag. nat Hist., [8] *11*, 1913: 398), has been obtained subsequently (Barnard, Ann. S. Afr. Mus., *21* [1], 1925: 15).

Myxine glutinosa Linnaeus, 1758

Hagfish

Figure 4

Study Material. Forty-seven specimens of various sizes up to 610 mm. in length, from the Grand Banks and localities on both sides of the Gulf of Maine, north slope of Georges Bank, outer part of the continental shelf off Nantucket Island and off Cape Lookout. Also 13 specimens from the eastern Atlantic—Norway, Denmark, Kattegat, the Adriatic and Liverpool, England.

Distinctive Characters. The combination of jawless mouth, single nasal aperture, only a single pair of external gill openings, no operculum or covering fold of skin, worm-like form and lack of paired fins separate the Hag from all other fish-like vertebrates of the western North Atlantic.

Description. Trunk cylindrical throughout most of its length, its diameter about $\frac{1}{24}$ to $\frac{1}{25}$ of its total length, tapering rearward from dorsal origin of finfold to narrowly

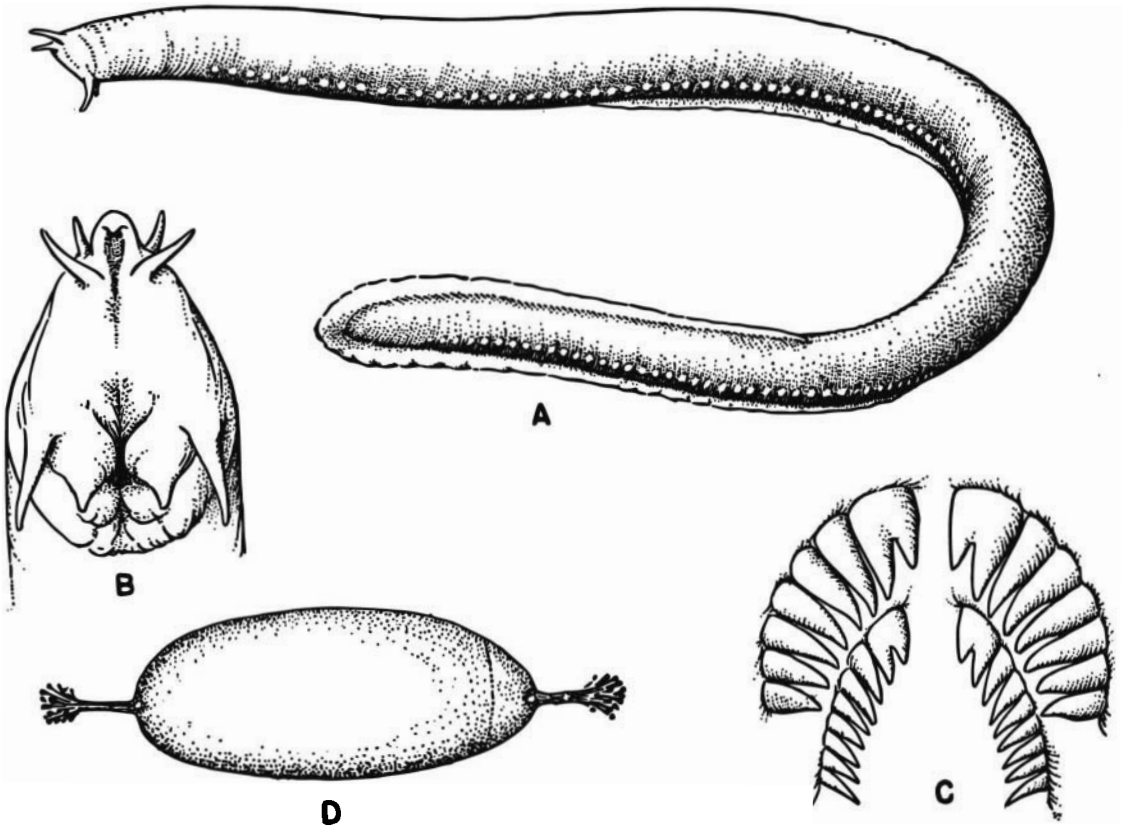

FIGURE 4. *A Myxine glutinosa*, specimen 380 mm. long, from the Gulf of Maine. *B* Oral view of anterior part of head of same. *C* Lingual teeth of same viewed from above, about 3 x. *D* Egg after being laid, after Dean, about 2 x.

rounded caudal extremity; a segmentally arranged row of mucous pores low down on each side, extending from about 1/13 the way back from snout to beyond anus; 26 to 33 pores in front of gill openings, 57 to 66 between gill openings and anus in those seen (53 to 70 recorded), and 11 to 13 posterior to anus in 9 specimens examined from Grand Manan Island, New Brunswick.[9]

Length of head to gill openings about 25 to 29% of total length (3.4 to 4 inches total length); snout obliquely truncate; fleshy rostrum a little higher than wide and broadly rounded in well preserved specimens, but sometimes more narrowly pointed, possibly due to contraction in the preservative; nostril an open pore on ventral surface near tip of snout; 2 pairs of slender, flexible barbels flanking either side of nostril, with a third pair, about twice as large, flanking the anterior part of mouth; mouth irregularly stellate when closed, without definite lip, but with a prominent, conical projection on either side of its margin;[10] gill openings close in front of origin of ventral finfold; usually 6 pairs of gill pouches, not visible externally, but sometimes 7 pairs.[11]

Lingual teeth comb-like, with swollen bases and sharp tips, moderately curved rearward, close together, decreasing in size from front to rear, of a strong orange color; those of anterior series about twice as large as those of posterior series, and partially overlapping the latter when tongue is retracted within mouth; 7 to 9 on either side in the anterior series and 8 to 10 in the posterior series; the first 2 in each series fused together at the base.

Ventral finfold originates about 1/3 of distance back from snout to caudal extremity, the dorsal fin about 2/3 the distance back and slightly anterior to anus,[12] both fins about 1/3 to 1/4 as high as the trunk is deep; ventral fold unsupported anterior to anus, but posterior to the latter it has a series of very slender, tapering cartilaginous rods, which extend around caudal extremity and forward along dorsal finfold (decreasing in length) nearly or quite to origin of latter.

Color. Grayish or reddish brown above, either plain, variously suffused, or mottled, with darker or paler gray, brown or bluish; whitish, or pale gray below. The variations in color may correspond more or less closely with the local color of the sea bottom.

Size. In American waters, on the coast of Maine, Hags are recorded up to 790 mm. in length, with one series of adults averaging 620 mm.[13] Apparently this is a greater size than they reach on the opposite side of the Atlantic, where the maximum recorded length is only 420 mm. (see discussion, p. 38).

Developmental Stages. The Hag was at first believed to be a functional protandrous hermaphrodite, its single unpaired sex organ first developing sperm in the posterior portion, then eggs later in the anterior portion.[14] However, recent detailed studies of the sex

9. 24–34, 54–64 and 10–14 respectively are recorded for European specimens.
10. These projections have sometimes been interpreted as a fourth pair of barbels.
11. Specimens with seven gill pouches on one side, or on both, are recorded by Cole (Anat. Anz., 27, 1905: 326).
12. Its origin is not clear-cut. The first indication of it is nearly as far anterior to the anus as the latter is distant from the tip of tail, in both American and Norwegian specimens.
13. Conel, J. Morph., 29, 1917: 77.
14. For a summary of earlier studies, see Smitt (Hist. Scand. Fish., 2, 1895: 1205) and Conel (Dean Memor. Vol., Amer. Mus. nat. Hist., Art. 3, 1931: 70).

organ[15] appear to show that this is not the case; either the male portion of the common sex organ matures in each individual, with the female portion remaining rudimentary, or vice versa. It has long been known that the eggs are few in number (only 19 to 30 having been counted in any one female) and large (up to 25 mm. in length), the horny shell with a cluster of anchor-tipped filaments at each end very characteristic in appearance.[16] But it was not until 1900 that any were found which had been laid naturally.[17] The eggs are deposited on the bottom, where they stick firmly in clusters to some fixed object[18] by means of their filaments and by threads of slime. The newly hatched Hag has not been seen as yet, but inasmuch as the smallest described, which is about two and one-half inches long and probably not long out of the egg, resembled the adult, there is no reason to suppose that the Hag passes through a larval stage.

Habits. The Hag is found chiefly, if not exclusively, where the bottom is soft mud or clay; its actions in aquaria[19] suggest that it spends most of its time imbedded in the clay or mud, with only the tip of its snout and the nasal barbels projecting, although it swims actively by an undulating motion in the horizontal plane when disturbed or when aroused by food in the vicinity; it is most active in the dark. Its depth range is considerable, extending commonly from 15 to 20 fathoms down to 250 fathoms or so, and it has been taken as deep as 524 fathoms.[20] The fact that it seldom, if ever, attacks hooked or netted fishes unless they are close to the bottom suggests that it never rises much above the latter.

In aquaria Hags die soon if the salinity is as low as 2.0 to 2.5 per cent;[21] survive for some weeks but do not feed if it is 2.9 to 3.1 per cent;[22] feed and thrive if it is as high as 3.2 to 3.4 per cent.[21] Also, it appears to be rather definitely limited in its dispersal toward the surface by high temperature, since it is rarely if ever found in water warmer than about 50 to 55 degrees, which in all but the most northerly part of its range would confine it to depths of 15 to 20 fathoms or more, except in the cold season. On the other hand, polar temperatures are probably a barrier to its northward dispersal (p. 40).

By its preference for soft bottom, comparatively high salinity (p. 37) and low temperature (see above), the Hag is confined within its area of regular occurrence to the deeper furrows and troughs on the Nova Scotian slope and in the Gulf of Maine, to the outer parts of the deeper bays, such as Fundy, Passamaquoddy, Massachusetts and prob-

15. Schreiner (Biol. Zbl., *24*, 1904: 91–104, 121–159, 162–173); Schreiner and Schreiner (Arch. Biol., *21*, 1905: 183–314, 8 pls., 315–355, 2 pls.; Arch. Zellforsch., *1*, 1908: 152); Conel (J. Morph., *29*, 1917: 75–163, 12 pls.; Dean Memor. Vol., Amer. Mus. nat. Hist., Art. 3, 1931: 70).
16. For reference to early accounts of eggs, see Smitt (Hist. Scand. Fish., *2*, 1895: 1206).
17. Dean, Mem. N. Y. Acad. Sci., *2* (2), 1900: 34, pl. 2.
18. To a Bryozoan in one case; see Jensen (Vidensk. Meddel. dansk. Naturhist. Foren., Copenhagen, 1900: 1).
19. For an interesting account of the habits of the Hag in aquaria, see Gustafson (Arkiv. f. Zoologi, Stockholm, *28A* [2], 1935).
20. Southeast slope of Georges Bank, Lat. 41° 32′ N., Long. 65° 55′ W. (Goode and Bean, Smithson. Contr. Knowl., *30*, 1895: 3; Spec. Bull. U.S. nat. Mus., 1895; Mem. Harv. Mus. comp. Zool., *22*, 1896).
21. Gustafson (Arkiv. f. Zoologi, Stockholm, *28A* [2], 1935), in western Sweden.
22. This is the usual summer range for surface water in Passamaquoddy Bay, where Hags were kept in captivity by Coonfield (Trans. Amer. micr. Soc., *59*, 1940: 398).

ably Penobscot, and offshore on the continental slope to the zone deeper than about 100 fathoms.

The Hag is not a parasite, as has sometimes been suggested, there being no reason to believe that it ever attacks living, uninjured fish. But it is a scavenger, feeding largely on dead or disabled fish of any sort, into which it bores by means of its rasp-like tongue. It is best known for its habit of penetrating the body cavities of hooked or gilled fishes, eating out first the intestines and then the meat, leaving nothing but a bag of skin and bones, inside of which the Hag itself is often hauled on board; or it may be captured clinging to the side of a fish it has just attacked. In Norwegian waters as many as six Hags have been reported in a single haddock.[23] It is also known to prey on marine polychaete worms, at least in Norwegian waters, and it has been suggested that these may be its normal diet.[24]

Being blind, the Hag evidently finds its food by scent, and so successfully that large numbers are sometimes taken in pots baited with dead fish or other offal; a local instance is mentioned below.

The fact that the eggs of the Hag have been found off southern Newfoundland at the mouth of the Bay of Fundy and on Georges Bank on one side of the Atlantic, and on the other side, near the Faroes, in Norwegian waters and off Morocco, shows that it spawns throughout its range; also, it spawns throughout the year, for females nearing ripeness, and others nearly spent, have been recorded for various months, winter and spring, as well as summer and autumn; in Norwegian waters eggs have been taken from November to May. The few eggs so far reported have been from depths of 50 to 150 fathoms, and most of them have been trawled on mud, clay, or sandy bottoms.[25]

Numerical Abundance. In American waters the Hag has usually been noted as being not very common. Actually it occurs in very considerable numbers on suitable mud bottoms at the appropriate depths, though rarely elsewhere, if at all. Thus, in the spring of 1913 the Hag was so plentiful on the Boon Island–Isles of Shoals fishing grounds that three to five per cent of all the haddock that we saw taken in gill nets had been attacked by them. Similarly, fishermen report that in certain areas of soft bottom in the northern part of the Gulf of Maine they damage a large proportion of the fish caught on long lines, unless the latter are tended frequently. The vicinity of Grand Manan Island at the mouth of the Bay of Fundy, and the trough with mud bottom between Jeffrey's Ledge and the coastline on the western side of the Gulf of Maine, are centers of abundance with which local fishermen have long been familiar. And evidently they are plentiful locally on the upper part of the continental slope off southern New England as well, for we took 11 large ones in an hour or less with one set of the Monaco trap off Nantucket at 260 fathoms on July 8, 1908. But we question whether they ever occur in American waters in such numbers as in the fjords of western Sweden and southern Norway, where catches of 100 are

23. S. Nilsson, Prod. Ichthyol. Skand., 1832: 124.
24. Gustafson, Arkiv. f. Zoologi, Stockholm, *28A* (2), 1935.
25. Hjort, Rep. Norweg. Fish. Invest., *1* (1), 1900: 75.

usual in eel pots set overnight on suitable bottom, with 1,400 recorded as captured in one set of 24 hours.[26]

Relation to Other Species. The American form has been considered specifically distinct from the European by some authors (*M. limosa* Girard, 1859), but not by others. However, the American form falls well within the limits of the European *M. glutinosa* in numbers of lingual teeth and slime pores. Its rostrum is also of the same obtuse shape in the better preserved specimens we have examined, although it has been pictured as more acutely pointed in some.[27] Nor has our own comparison of specimens from the two sides of the Atlantic revealed any significant differences in other respects. While the American form may grow larger than the European (p. 35), we hesitate to use size as a basis for specific separation unless accompanied by other differences of a sort that could allow any given individual to be referred to the one species rather than to the other. *M. atlantica* Regan, taken off Nova Scotia, seems also clearly referable to *glutinosa.*

The relationship of *glutinosa* of the northern hemsiphere to *australis, affinis* and *capensis* of the southern hemisphere is not so clear, but is a question of interest from the standpoint of geographical distribution. The only clear-cut difference between *capensis* on the one hand and the *australis-affinis* group on the other (the former overlaps the latter in number of teeth and slime pores) is that *capensis* is described as having seven gill pouches while there are only six in *australis* and *affinis.* However, we doubt whether or not this apparent difference is of specific importance, for while in *glutinosa* the usual number is six, seven also have been recorded (p. 35).

According to Norman's[28] recent comparison of *australis* with *affinis,* the number of teeth is less and the average number of abdominal slime pores is smaller in the former (8 teeth in first series, 8 or 9 in second; 56 to 64 abdominal pores) than in the latter [10 or 11 (9 in young) teeth in first series, 9–11 in second; 63 to 69 abdominal pores]; and its rostrum or labrum is longer and more acutely pointed. But this last character, being somewhat variable in *glutinosa,* may be equally so in the southern hemisphere forms. However, although the number of pores overlap in the two species, it appears that individual specimens can be referred to the one or the other, depending on the number of teeth. The large number of teeth in its anterior series also appears to mark *affinis* apart from *glutinosa* (7–9), although it overlaps the latter in the number of teeth in the posterior series, and falls within the range of variation recorded for *glutinosa* in the number of abdominal pores; however, *australis,* by Norman's definition, falls within the limits recorded for *glutinosa,* both in numbers of teeth and in numbers of pores. Neither have we been able to separate individual specimens of the one from those of the other by shape of rostrum. But since none of the considerable series of *australis* that we have examined are in good condition, we hesitate to unite the two species, in view of their widely separated areas of distribution.

26. Lyngnes, Z. Wiss. Biol., Abt. A, Z. Morph. Ökol., *19,* 1930: 591.
27. Garman, Mem. Harv. Mus. comp. Zool., *24,* 1899: pl. 68, fig. 7.
28. "Discovery" Rep., *16,* 1937: 4; see this publication also for the somewhat confused synonymy of the two.

Relation to Man. The Hag, being of no value itself, is only a nuisance to the fishermen because of its habit of damaging better fish, and a loathsome one, owing to its ability to discharge slime from its mucous sacs out of all proportion to its size. One Hag, it is said, can fill a two gallon bucket, and we think this no exaggeration.[29]

In American waters the commercial fishes most often damaged by it are the haddock and the hakes (*Urophycis*), these being the species most often fished for with long lines or with gill nets over the particular type of bottom that the Hag frequents. But it sometimes damages cod also, and European authors describe it as attacking ling (*Molva*) and other gadoids, herring, mackerel, sturgeon, and even mackerel sharks (*Isurus*) under similar circumstances.

Range. Both sides of the northern North Atlantic. In the eastern North Atlantic it occurs on the Murman coast and in northern Norway[30] southward in abundance to the northern part of the North Sea, the Kattegat (not known from the Baltic) and the Irish Sea; less commonly to the English Channel (Cornwall); occasionally to Portugal. There are two records of it off Morocco, one just outside the Straits of Gibralter,[31] the other just inside in the Mediterranean.[32] It has been credited to the Adriatic[33] also, no doubt on the strength of the fact, reported by Garman,[34] that there are three specimens labelled "Trieste" in the collection of the Museum of Comparative Zoology (see Study Material, p. 34). But so far as we can learn it is not included otherwise in any of the general surveys of Mediterranean fishes[35] that have appeared. This makes it much more probable that the specimens in question were mislabelled, and that *Myxine* is actually not a regular member of the fauna of the inner parts of the Mediterranean.

On the western side of the Atlantic it occurs at least occasionally as far north as the northern part of Davis Strait (see p. 40), and southward as far as the latitude of Cape Fear in North Carolina. It is represented in the corresponding thermal belt in the southern hemisphere (Chile, southern Argentina, Straits of Magellan, Tierra del Fuego, South Africa) by a form, or forms, so closely allied that it is doubtful whether any sharp line can be drawn between them (see discussion, p. 33).

Occurrence in the Western Atlantic. While not known for certain along the west coast of Greenland,[36] so far as we can learn, the Hag has been taken on one occasion in the

29. Linnaeus (Sys. Nat., 1758: 650), referring to this habit, wrote "aquam in glutem mutat."
30. Apparently it does not occur around Iceland, for it is not included by Saemundsson (Skr. Komm. Havunders. Kbh., No. 5, 1900) in his survey of Icelandic fishes.
31. Egge; Koefoed (Rep. Sars N. Atlantic Deep Sea Exped., Zool., *4* [1], 1927: 18).
32. Roule, Result. Camp. sci. Monaco, *52*, 1919: 129.
33. Schnakenbeck in Grimpe and Wagler, Tierwelt N- u. Ostsee, Lief 7, Teil 12d, 1927: 3; Cons. explor. Mer., Faune Ichthyol. N. Atlant., 1931.
34. Mem. Harv. Mus. comp. Zool., *24*, 1899: 348.
35. Müller (Vergl. Anat. Myxinoiden, Pt. 1, 1835: 17, footnote) long ago rejected Bloch's (Schr. Ges. Naturf. Freunde Berlin, *10*, 1792: 251) suggestion that *Myxine* is in the Mediterranean, which was based on Aristotle's account of the slime-producing habit of his Pholis.
36. It has been credited repeatedly to Greenland on the strength of Fabricius' (Fauna Groenl., 1780: 344) characterization of it as "rari in mari Groenlandico." But we find no other record of it among the many subsequent lists of fishes of Greenland, east or west, except as noted above.

northern part of Davis Strait, just south of the Greenland–Baffin Land Ridge.[37] But there is no report of it either in the region of Hudson Bay, along the Atlantic coast of Labrador, or on the east coast of Newfoundland; nor did any of the many cod that we saw caught by hook and line or nets in the summer of 1900 along the outer Labrador coast show any evidence of attack by Hags. Apart from the Davis Strait record just mentioned, the most northerly known stations for it on the American coast are the Grand Banks and the south coast of Newfoundland, where its eggs have been trawled.[38] Type of bottom, temperature and salinity are such that it is also to be expected in the deep trough of the Gulf of St. Lawrence, though we found no definite record of it there.

To the southward it is generally distributed at appropriate depths wherever the bottom is suitable: over the continental shelf and down the continental slope along Nova Scotia, throughout the Gulf of Maine, along the seaward slope of Georges Bank, and off southern New England and New York, where specimens have been taken at many localities by trawl or otherwise, at depths of 100 to 250 fathoms and deeper. Apparently this marks the limit of its common occurrence in this direction, however, for the only records of its occurrence south of the latitude of New York are: one specimen taken off Delaware Bay in 126 fathoms, and one or more in 178 fathoms off Cape Fear, North Carolina, many years ago.[39]

Synonyms and References:[40]

Myxine glutinosa Linnaeus, Syst. Nat., 1758: 650 (Atlant. Oc., grouped among the worms); Müller, O. F., Prod. Fauna Danica, 1776: 227 (Denmark); Pennant, Brit. Zool., *4*, 1777: 39, pl. 20, fig. 5 (habits, ill.); Fabricius, Fauna Groenl., 1780: 344 ("rari in mari Groenlandico"); Retzius, Fauna Sueciae, 1, 1780: 302 (refs., habits, west. seas); Gmelin, Syst. Nat., *1* (6), 1790–1791: 3082 (descr., Atlant. Oc.); Retzius, Svenska. Vet. Akad. Handl., *11*, 1790: 110, pl. 4 (*Myxine* and *Petromyzon* considered more worm-like than fish-like; plate referred to is not in copy seen); Abildgaard, Schr. Ges. naturf. Freunde, Berlin, *10*, 1792: 193, 244, pl. 4 (descr., ill.; a fish, not a worm); Bloch, Schr. Ges. naturf. Freunde, Berlin, *10*, 1792: 244 (disc. of earlier accounts; believed same as Pholis of Aristotle, therefore in Mediterranean, Greece); Fleming, Hist. Brit. Anim., 1828: 164 (descr., habits, England); Cuvier, Règne Anim., 2nd Ed., 1829: 406 (North Sea); Nilsson, Prod. Ichthyol. Skand., 1832: 123 (habits, type of bottom, feeding, north. Norway); Johnston, London's Mag. Nat. Hist., *6*, 1833: 15 (Scotland); Jenyns, Manual Brit. Vert. Anim., *1*, 1835: 413 (Ireland); Müller, J., Vergl. Anat. Myxinoiden, 1, 1835: 3 (history), 15 (class., diag., North Sea, Norway, Sweden, Greenland), 17 (footnote considers Bloch's reference of it to Mediterranean on basis of Aristotle incorrect); Templeton, Charlesworth's Mag. Nat. Hist., *1*, 1837: 413 (Ireland); Cuvier, Règne Anim., Poiss., 1838–1843: 383, pl. 120, fig. 3 (ill.); Krøyer, Danmarks Fisk., *3*, 1838–1853: 1068 (descr., habits, Denmark); Swainson, Nat. Hist. Fish. Amphib. Rept., *2*, 1839: 338; Fries, Ekstrom and Sundevall, Skand. Fisk., 6, 1840: 121, pl. 28 (descr., ill., Scandinavia); Gray, List Fish. Brit. Mus., Chondropt., *1*, 1851: 147 (Norway, Gt. Brit.); White, List Spec. Brit. Mus., Fish., *8*, 1851: 145 (north. England, Scotland); Nilsson, Skad. Fauna Fisk., *4*, 1855: 750 (not seen); Thompson, M., Nat. Hist. Ireland, *4*, 1856: 267 (Ireland, Scotland); Thomson, A., Art. "Ovum," in Todd's Cyclop. Anat. Physiol., *5* (suppl. vol.), 1859: 50, fig. 33, c, d (earliest descr. of egg, ill.);

37. Lat. 66° 37′ N., 450 meters, temp. 3.12° C.; Jensen, Rapp. Cons. explor. Mer., *39*, 1926: 98.
38. Dean, Mem. N. Y. Acad. Sci., *2* (2), 1900: 34.
39. One specimen from this lot is in the Harv. Mus. Comp. Zool.
40. *Myxine*, as representative of its order (subclass in some schemes of classification), has been the subject of many anatomical accounts and discussions, in reports of original observations as well as in general textbooks, etc. This list is confined to such citations as bear directly on its classification, on its habits or on its distribution.

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41. Sometimes spelled *caecus*.