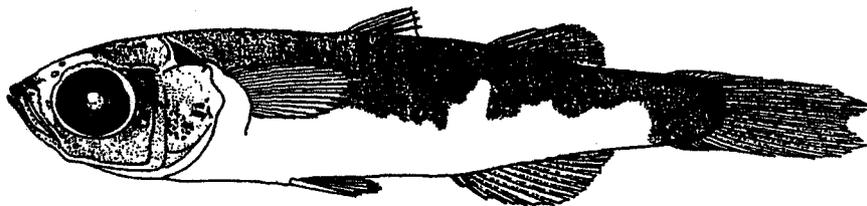
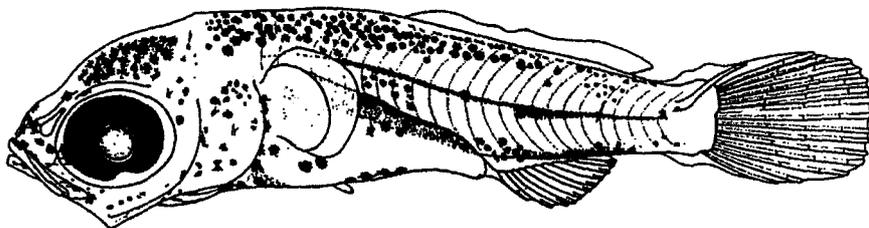




PRELIMINARY GUIDE TO IDENTIFICATION OF THE EARLY LIFE STAGES OF M^gULLET (PISCES:
MUGILIDAE) FROM THE WESTERN CENTRAL ATLANTIC

BY

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U.S. DEPARTMENT OF COMMERCE
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MUGILIDAE

By J.G. Ditty, T. Farooqi, and R.F. Shaw

Classification of mullet in the western-central North Atlantic remains unresolved (Rivas 1980). Thomson (1977) considered *M. gaimardianus* (redeye mullet) a sub-species of *M. curema* (white mullet), and did not recognize *M. gyrans* (fantail mullet) instead designating *M. trichodon* as the fantail mullet. Rivas (1980) separated *M. gyrans* from *M. trichodon* based primarily on soft dorsal fin counts and recognized *M. gaimardianus* as separate from the closely-related *M. curema* [as did Menezes (1983) and Cervigón et al. (1993)] based on differences in eye color of live specimens, length of the pectoral fin, and median number of scales mid-laterally. We adopt the taxonomy of Rivas (1980).

The relationship and placement of Mugilidae within the phylogeny of teleost fishes also remains unresolved. Greenwood et al. (1966) assigned mugilids to a separate suborder (Mugiloidei) within the superorder Percomorpha, although they have also been placed together with the barracudas (Sphyraenidae) in a single suborder Mugiloidei (Gosline 1968, 1971). Johnson (1986) removed Sphyraenidae and placed barracudas in the suborder Scombroidei as the sister group of all other scombroids. Stiassny (1990, 1993) also removed mugilids from Percomorpha but placed them in a new superorder Mugilomorpha (Stiassny 1990), a sister group of Atherinomorpha, a relationship supported by additional evidence (Johnson and Patterson 1993). Parenti (1993), however, rejects a mugilid-atherinomorph relationship and supports an alternate hypothesis.

Mullet typically inhabit estuarine/coastal waters and migrate offshore to spawn. Because most (if not all) form large schools, many species are commercially important. Mullet eggs are pelagic, spherical, and the chorion is smooth. The yolk is unsegmented, the perivitelline space is narrow, and one or more oil globules merge as eggs develop (de Sylva 1984). Oil globule diameter is about 35% of egg diameter; larvae are neustonic. Little is known about mullet early life stages, except for those of *Mugil cephalus*. Although larvae of most *Mugil* from the coverage area are undescribed, we have compiled adult characters that should help in separating taxa after median fins

are formed (Table 1). Mugilids are characterized by subabdominal pelvic fins, widely-separated dorsal fins with four spines in the first dorsal, and no lateral line. *Mugil* differ from *Agonostomus* and *Joturus* by having an adipose eyelid, pectoral axillary scale, and symphyseal knob on the lower lip. *Joturus* differs from all other species by having a snout that overhangs the upper lip. The posterior branch of the last dorsal and anal ray is forked in *Mugil* >15-20 mm SL but not so in *Agonostomus*. Young mullet are heavily-pigmented and have two anal spines until about 30-40 mm SL when the third anal element transforms into a third spine. Thus, the number of anal spines does not allow separation of *Mugil* from *Agonostomus* until >30 mm SL. Because of the late transformation of the third anal element into a spine, young mullet were often considered a separate genus, *Querimana*. The total number of anal fin elements and the relative placement of the second dorsal and anal fins also help separate taxa. Gill rakers are long, slender, numerous, and increase in number with growth; thus, counts should be used with caution. Larval mullet have 24 vertebrae (except mountain mullet, *Agonostomus* with 25) and lack (or have few, very small) preopercular spines. Larval mullet have pigment along the dorsal midline of the body unlike the superficially similar barracudas which have dorso-lateral but not dorsal midline pigment. Young mullet are very heavily pigmented and are often associated with heavily pigmented young goatfishes (Mullidae) in offshore habitats. Much of the mullet literature is confused due to incorrectly identified museum specimens and assignment of species status to immature forms (pers. comm., Dr. Donald P. de Sylva, University of Miami, School of Marine and Atmospheric Science, Florida).

Meristic data and information (where available) on eggs, larvae, and juveniles are included for three species. Table Mugilidae 1 gives meristic and other data for all 11 species. Numbers in parentheses are range or rare counts. For each species, the left page provides information on meristics, ecology, and larval identification characters, while the right page contains illustrations. Jack Javech (NOAA, NMFS, Southeast Fisheries Science Center, Miami Lab, FL) illustrated the larvae.

Table Mugilidae 1. Characters for separating adult mullet (Family Mugilidae) from the western central North Atlantic. () = range. Only *M. cephalus* & *M. liza* have longitudinal body stripes and an innermost row of bicuspid teeth. *Agonostomus* and *Joturus* have five branchiostegal rays whereas all *Mugil* have six. *Agonostomus* and *Joturus* have an innermost row of bicuspid or multicuspid teeth but no stripes. The outermost row of teeth is unicuspid in all species but are canine-like in *Agonostominae*. Dense squamation along fin bases means scales totally cover median fins except distal margins. Light squamation means scales restricted to anterior-most rays or along fin bases. Number of gill rakers should be used with caution because counts increase with size and age. Young mullet have two anal spines until about 30-40 mm SL when the third anal element transforms into the third spine. ND = No data. Distribution key: 1 - Bahamas, 2 - Gulf of Mexico, 3 - south Florida only, 4 - Cuba, 5 - Caribbean/West Indies, 6 - Central America, 7 - Venezuela, 8 - Columbia, 9 - Brazil, 10 - Bermuda.

Species	Distribution	Second Dorsal Spines & Rays	Anal Fin	Pectoral Fin Rays (Mode)/ Axillary Scale	Lower Gill Rakers	Rows of Teeth Upper/Lower	Adipose Eyelid	Enlarged Scale below First Dorsal Fin	Squamation along Dorsal & Anal Fins	Relationship of Second Dorsal Origin to Anal Fin Base		
										Anterior Third	Near Mid-Fin	Posterior Third
<i>Agonostomus monticola</i>	1, 2, 3, 4, 5, 6, 7	I,8	II,10	15/No	17-20	Several	No	No	Light		X	
<i>Joturus pilchardi</i>	1, 3, 5, 6, 7	I,9	II,11	16/No	ca. 30	Several	Yes	No	Dense	X		
<i>Mugil cephalus</i>	1 - 10	I,8	III,8	16-17/Yes	ca. 80	1-6/1-4	Yes	No	Light			X
<i>Mugil curema</i> ¹	1 - 10	I,8	III,9	16-17/Yes	ca. 65	1-3/1-3	Yes	No	Dense			X
<i>Mugil curvidens</i>	1, 4, 5, 7, 8, 9	I,8	III,8	ND/Yes	ND	2/1	Yes	Yes	Dense	X		
<i>Mugil gaimardianus</i> ^{1, 2}	3, 5	I,8	III,9	ND/Yes	ND	ND	Yes	No	Dense			X
<i>Mugil gyrans</i>	1, 3, 4, 5, 6, 7, 8, 9	I,7	III,8	17/Yes	ca. 70	ND	Yes	No	Dense	X		
<i>Mugil hospes</i>	1, 4, 5, 7, 9	I,8	III,9	ND/Yes	ND	1/1	Yes	No	Dense			X
<i>Mugil incilis</i>	5 (?), 7, 8, 9	I,8	III,9	16/Yes	ca. 70	1/1	Yes	Yes	Dense			X
<i>Mugil liza</i>	1, 3, 4, 5, 7, 9, 10	I,8	III,8	17/Yes	ca. 45	2/1	Yes	No	Light	X		
<i>Mugil trichodon</i> ³	3, 5, 7, 9	I,8	III,8	17/Yes	ND	1-2/1-2	Yes	No	Dense ²	X		

¹ Teeth inconspicuous without lens

² Only mullet with ctenoid scales

³ Teeth conspicuous, clearly visible without lens

MERISTICS

Vertebrae:	
Precaudal	12
Caudal	13
Total	25
Number of Fin Spines and Rays:	
First Dorsal	IV
Second Dorsal	I, 8
Total Dorsal Elements	13
Anal	II, 10
Total Anal Elements	12
Pectoral	15(14-16)
Pelvic	I, 5
Caudal	
Dorsal Secondary	9-10
Principal	7+7
Ventral Secondary	9-10
Total	32-34
Gillrakers on First Arch	
Upper	
Lower	17-20
Total	
Branchiostegals	5

LIFE HISTORY

Range: southeast Florida, Gulf of Mexico, Bahamas, Cuba, West Indies, and Central America south to Venezuela

Habitat: mountain streams, rivers, and estuaries

ELH Pattern: oviparous, pelagic larvae

Spawning:

 Season: summer and fall

 Area: offshore

 Migration: catadromous

LITERATURE

Meek & Hildebrand 1916
 Suttkus 1956
 Anderson 1957a
 Thomson 1977
 Cruz 1987
 Phillip 1993
 Ditty & Shaw 1996.

EARLY LIFE HISTORY DESCRIPTION

EGGS: Unknown

LARVAE:

Length at Flexión: 3-4 mm

Length at Transformation: unknown

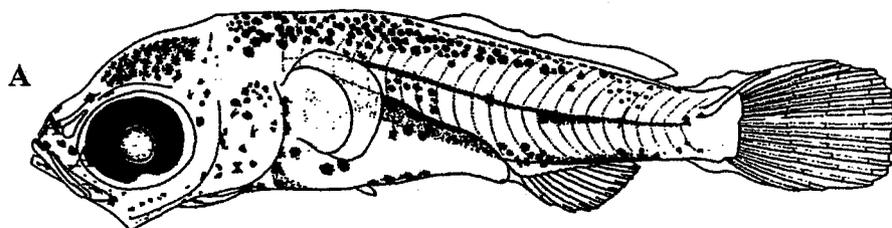
Sequence of Fin Development: unknown

Pigmentation: heavy

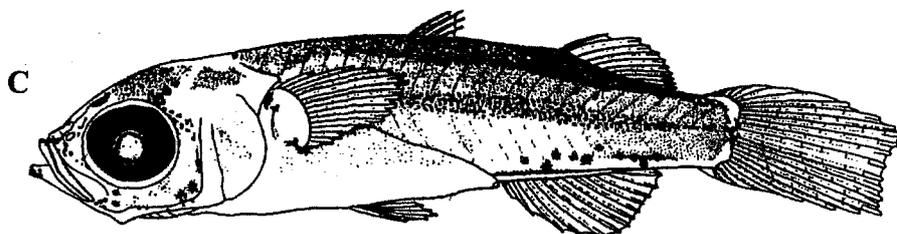
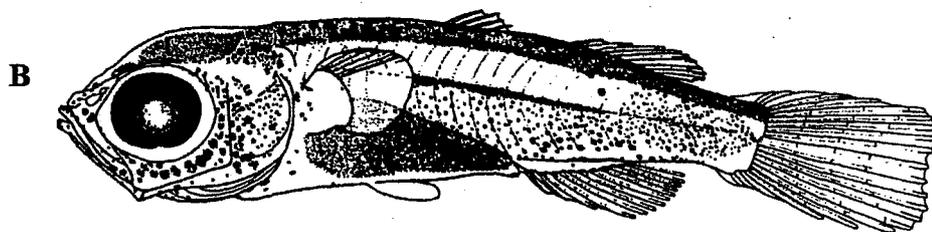
Diagnostic: from *M. curema* by length of caudal peduncle at >7 mm SL; from *M. cephalus* and *M. curema* by pigment on second dorsal fin at >13.5 mm SL; from all *Mugil* spp. >20 mm SL by lack of fork at tip of posterior branch of last dorsal and anal ray and four innermost upper and lower caudal rays.

ILLUSTRATIONS

All original

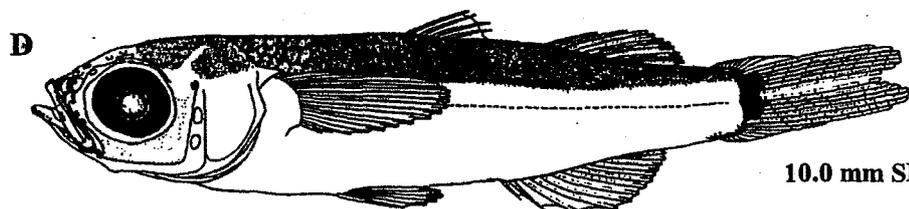


4.4 mm SL

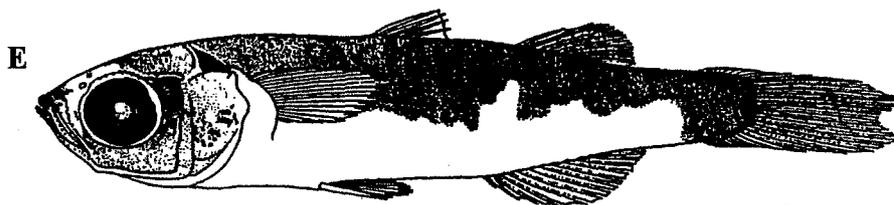


5.5 mm SL

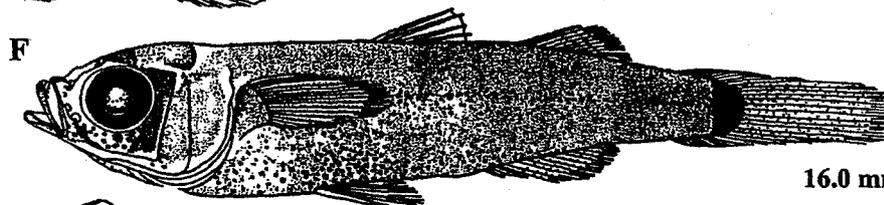
7.1 mm SL



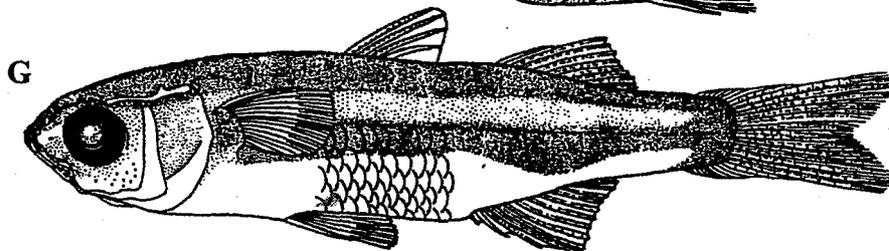
10.0 mm SL



13.5 mm SL



16.0 mm SL



25.5 mm SL

MERISTICS

Vertebrae:	
Precaudal	11
Caudal	13
Total	24
Number of Fin Spines and Rays:	
First Dorsal	IV
Second Dorsal	I, 8
Total Dorsal Elements	13
Anal	III, 8
Total Anal Elements	11
Pectoral	16-17(15-18)
Pelvic	I, 5
Caudal	
Dorsal Secondary	7+8
Principal	7+7
Ventral Secondary	7+8
Total	28-30
Gillrakers on First Arch:	
Total	ca. 80
Branchiostegals	6

LIFE HISTORY

Range: throughout area
 Habitat: estuarine and coastal waters
 ELH Pattern: oviparous, pelagic eggs and larvae
 Spawning:
 Season: fall and winter along North America
 Area: outer shelf and slope
 Mode: isochronal spawner
 Migration: inshore-offshore

LITERATURE

Meek & Hildebrand 1923
 Anderson 1958
 Miller & Jorgenson 1973
 Kuo et al. 1973
 Finucane et al. 1978
 Ditty & Shaw 1996

EARLY LIFE HISTORY DESCRIPTION**EGGS:**

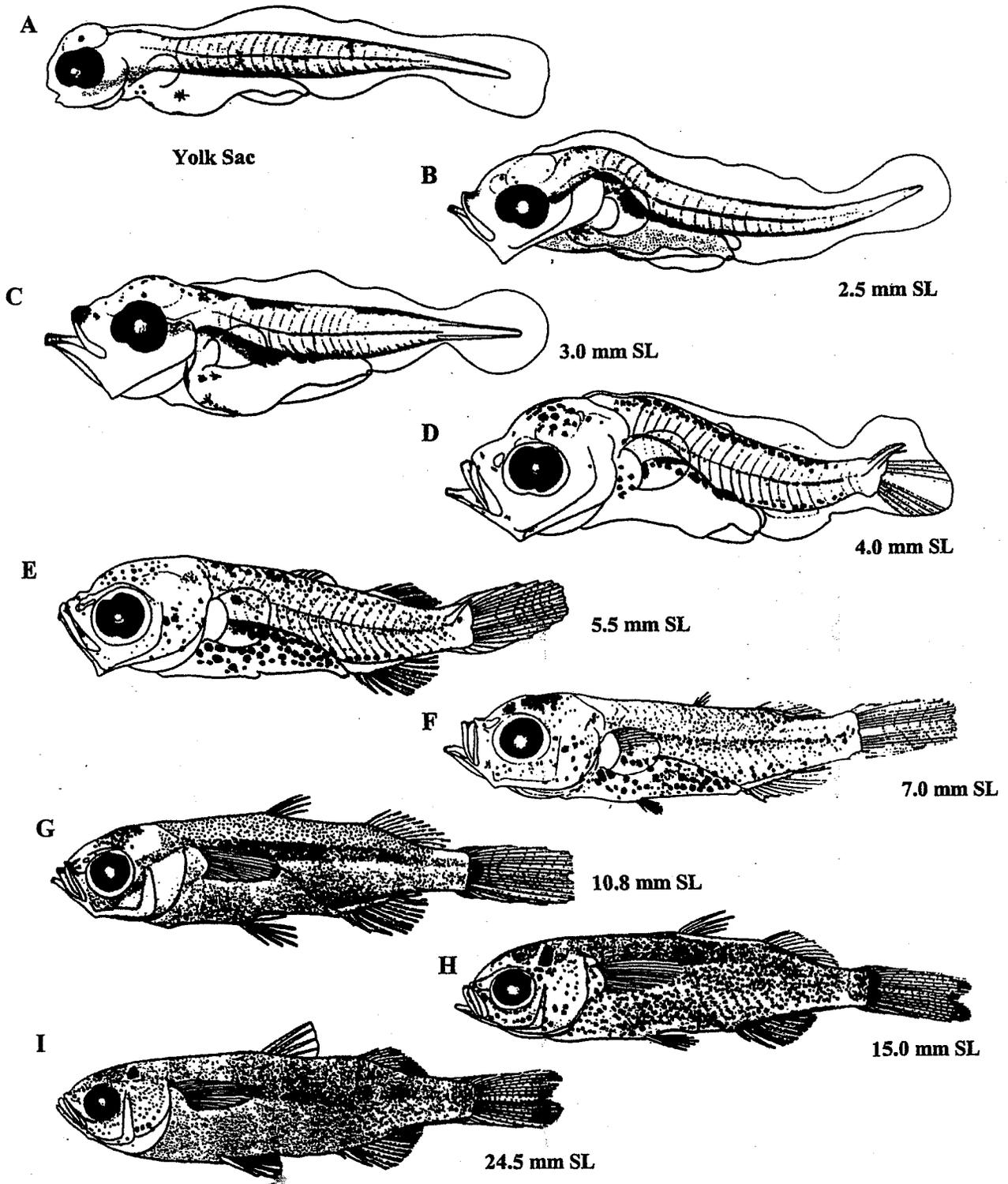
Diameter: 0.88-0.99 mm
 No. of Oil Globules: single
 Oil Globule Diameter: 0.30-0.36 mm; mean: 0.33 mm
 Yolk: unsegmented
 Shell: clear, smooth
 Hatch Size: 2.0-2.2 mm
 Incubation: 38 hrs at 23-24°C
 Pigmentation: oil globule and embryo

LARVAE:

Length at Flexion: 4-5 mm
 Length at Transformation: 10 mm
 Sequence of Fin Development: anal and second dorsal-
 first dorsal-pelvic-pectoral
 Pigmentation: heavy
 Diagnostic: from *M. curema*, *M. gaimardianus*, *M.*
hospes, and *M. incilis* by total anal element count;
 from *M. gyrans* by second dorsal fin count and
 relative position of second dorsal fin; from *M. liza*,
M. curvidens, and *M. trichodon* by relative position of
 second dorsal origin along anal fin base

ILLUSTRATIONS

All original



MERISTICS

Vertebrae:	
Precaudal	11
Caudal	13
Total	24
Number of Fin Spines and Rays:	
First Dorsal	IV
Second Dorsal	I, 8
Total Dorsal Elements	13
Anal	III, 9
Total Anal Elements	12
Pectoral	16-17(15-18)
Pelvic	I, 5
Caudal	
Dorsal Secondary	7-8
Principal	7+7
Ventral Secondary	7-8
Total	28-30
Gillrakers on First Arch:	
Total	ca. 65
Branchiostegals	6

LIFE HISTORY

Range: throughout area
 Habitat: estuarine and coastal waters
 ELH Pattern: oviparous, pelagic larvae
 Spawning
 Season: spring and summer
 Area: shelf and slope
 Migration: inshore-offshore

LITERATURE

Meek & Hildebrand 1923
 Anderson 1957b
 Cervigón 1993
 Miller & Jorgenson 1973
 Menezes & Figueiredo 1985
 Ditty & Shaw 1996

EARLY LIFE HISTORY DESCRIPTION**EGGS:**

Diameter: 0.86-0.92 mm

Hatch Size: 1.6-1.8 mm

LARVAE:

Length at Flexion: 4-5 mm

Length at Transformation: 10 mm

Sequence of Fin Development: anal and second dorsal-
 first dorsal-pelvic-pectoral

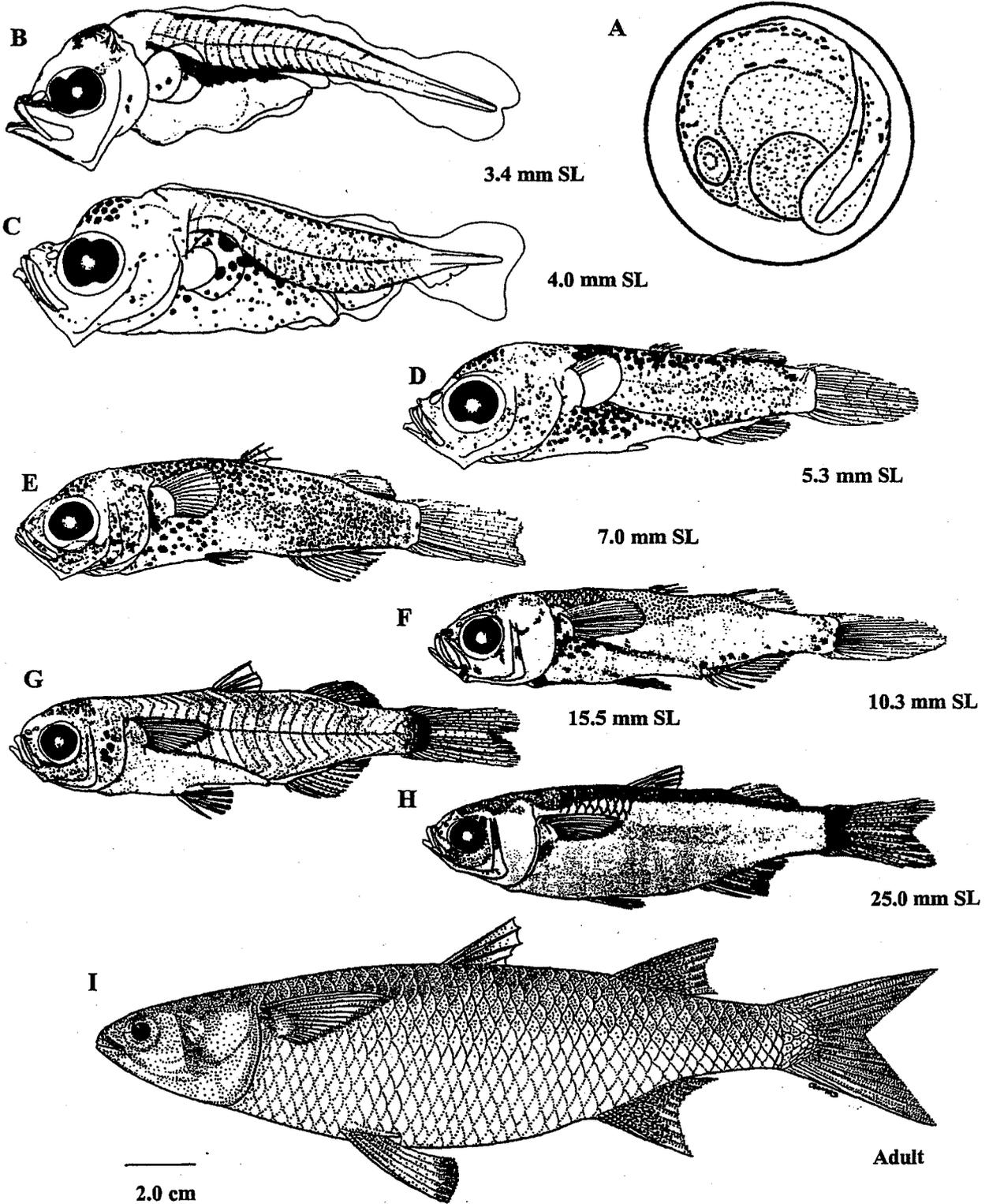
Pigmentation: heavy

Diagnostic: from *M. cephalus*, *M. curvidens*, *M. liza*,
 and *M. trichodon* by total anal element count; from
M. gyrans by second dorsal and total anal element
 count; from *M. hospes*, and *M. incilis* by relative
 position of second dorsal origin along anal fin base;
 from *M. gaimardianus* at larger sizes by type of
 scales and amount of scalation along dorsal and anal
 fins

ILLUSTRATIONS**Original**

Egg from Anderson 1957b

Adult from Menezes 1983



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