

# Order Lepisostei

---

ROYAL D. SUTTKUS

University

*Acknowledgments.* My thanks are due the following persons for the loan of specimens or for help in making specimens available for study: Leonard P. Schultz, Ernest A. Lachner, William Ralph Taylor, Robert Kanazawa, and James Tyler of the United States National Museum; James E. Böhlke of the Academy of Natural Sciences at Philadelphia; Henry B. Bigelow and Mrs. Myvanny Dick of the Museum of Comparative Zoology at Harvard University; Reeve M. Bailey, Robert R. Miller, and Carter Gilbert of the Museum of Zoology, University of Michigan; Clark Hubbs of the University of Texas; Charles M. Breder and Vladimir Walters of the American Museum of Natural History; Luis Rivas of the University of Miami; William M. Clay and Louis A. Krumboltz of the University of Louisville; Loren P. Woods, Robert F. Inger, and Pearl Sonoda of the Chicago Natural History Museum, and Shelby D. Gerking of the University of Indiana. Thanks are also due Edward C. Raney and Henry B. Bigelow for reading the manuscript and for making helpful suggestions for improvement; to Bill Komodore for delineation of Figs. II, 14, 15, 16; to Rudolph J. Miller for Figs. 12, 13, 18; and to Miss Patricia Hale for Fig. 17. Preparation of the illustrations and examination of many specimens at various museums and institutions were made possible by financial aid from the Sears Foundation through a grant-in-aid from the National Science Foundation (N. S. F. No. G 7123), and from a National Science Foundation grant to the author (N. S. F. No. G 9026).

*Scope of Study.* This account gives detailed descriptions of the Order Lepisostei and family Lepisosteidae, of the genus *Lepisosteus*, and of four species—*oculatus*, *osseus*, *platyrhincus*, and *spatula*. The "Key to Species of the Western North Atlantic" encompasses subgenera as well as species and gives the alternate characters that are

readily recognizable. The *Study Material* is listed for each species; in most cases this includes specimens from the many institutions listed. For easy and quick identification, the *Distinctive Characters*, as in the Key, compare the easily recognizable features of one species with the others. Many specimens were examined in preparing the taxonomic accounts, and the methods of measuring and counting the characters are detailed on p. 68.

The *Descriptions* are broken down into three major categories: (1) Proportional measurements in per cent of length, (2) Proportional measurements in per cent of head length, and (3) Meristic counts. Thus measurements for most of the head characters (snout, lower jaw, etc.) are given in per cent of head length as well as in per cent of length of fish. Following submission of this account for publication, a small specimen of *spatula*, 49.5mm (57.3 mm TL), came to hand; the measurements for this individual have been incorporated in the *Description* with figures enclosed in brackets.

What is known of the life history of Gars in general and of the species in particular has been culled from the literature and gained by direct observation and personal communication with field workers. The Synonyms and References at the end of each species account include references to only those taken in salt water; these are not numerous, because Gars for the most part frequent fresh water, and less commonly brackish or salt water.

*Characters.* Lepisostei are slender ray-finned fishes with well-ossified skeletons, as in the teleosts, but with ganoid scales (see below), an archaic character shared by the polypteroids alone among living fishes. The arterial cone of the heart has eight transverse rows of 4-8 valves each, a number of rows greater than in any other living ray-finned fish; this character also puts the Gars apart from the polypteroids. The caudal fin has no prolonged fleshy axis, but all of the hypural bones that bear the fin rays are supported by the upturned end of the vertebral column (caudal "abbreviate heterocercal," Fig. 11), and the rear boundary of the fleshy caudal peduncle slopes obliquely dorsoposteriorly, the latter character shared by *Amia* alone among living fishes.

The vertebrae are completely ossified and opisthocoelus, i. e. posterior face concave and anterior face convex, a conformation unique among living fishes though paralleled in some tailed Amphibia and in the thoracic region of penguins, gulls, and plovers among birds. In the adult the pleural ribs extend from the vertebrae to the skin (Balfour and Parker, 7: 387, pl. 28 fig. 72; Emelianov, 20: 176-180, figs. 8-10).

The elongated snout, with nasal openings and olfactory sacs at its end, is the result of a lengthening of the ethmoid region, and olfactory nerves course through long canals in the ethmoid cartilage (Regan, 58: 447, fig. 3). The preorbital (lacrimar or maxillary of some authors) is subdivided into a row of 6-8 bones that bear small, medium, and large teeth (Holmgren and Stensio, 10: 474, fig. 363; Hammarberg, 29: figs. 41, 43; Berg, 8: 211, 414); the larger teeth are radially grooved at the base. The infraorbital sensory canal is a prominent surface feature of the preorbitals in the early

x. For an excellent illustration and for a table giving the numbers of valves in various other fishes, see Bertin (25: 402, fig. 1005B, 1404

developmental stages (Collinge, 15: 265, pl. 4, fig. 2; 14: 511, 512; Landacre and Conger, 42: 593, 594; Hammarberg, 29: 309, figs. 39-43). A small sliver-shaped bone is present, at least in the young, at the angle of the mouth; this bone is continuous with the preorbitals in its dentition but is not traversed by the infraorbital canal; thus it is considered to represent the maxillary. The vomer is paired. There is no opisthotic

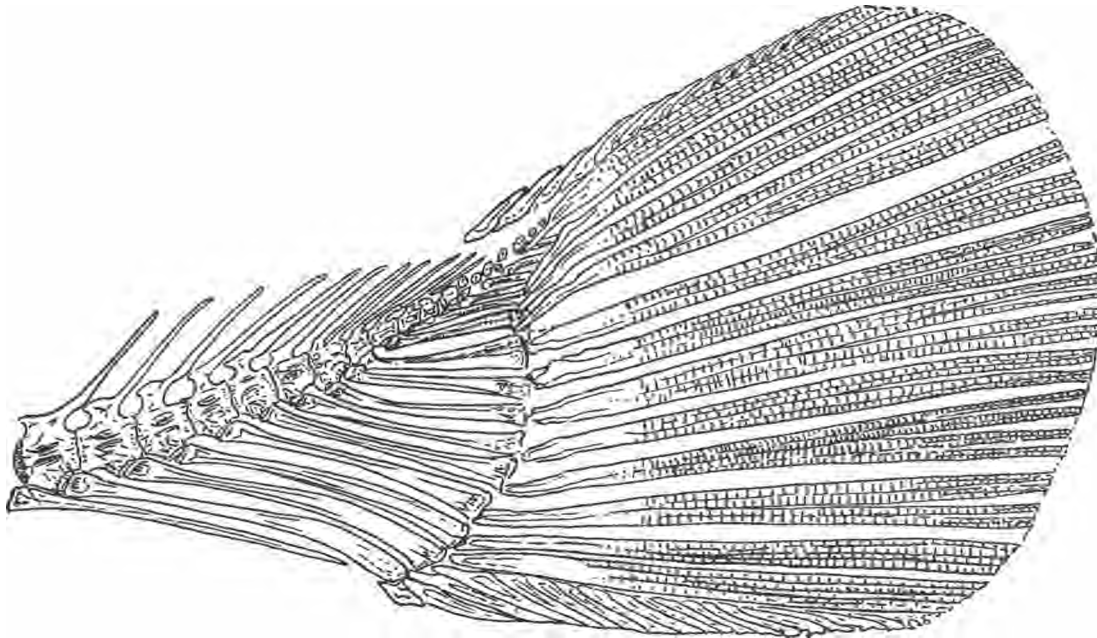


FIGURE 11. *Lepisosteus spatula*. Caudal fin skeleton; original drawing (natural size) of a specimen from Lake Pontchartrain, Louisiana.

(Mayhew, 47: 327), supraoccipital, gular plate, or myodone in the Garfishes. The lower jaw, a complex of six dermal bones—dentary, articular, angular, preangular, prearticular, and coronoid (Arambourg and Bertin, 25: 2185, fig. 1546)—articulates in front of the eye. The sacculus and lagena form a common sac, the largest otolith being in the former. Three pairs of branchiostegals support the gill membrane. The opercular gills are especially well developed in the Garfishes, an upper horizontal "arm" and a bisegmented lower one being noticeable (Wright, 76: 483).

The dorsal fin is situated posteriorly, above the anal fin. The fins are without spines, and the rays of the dorsal and anal fins are equal in number to the supporting radials. There is no adipose fin.

The body of the adult is completely encased in an armor of rhombic ganoid scales, which may be denticulated and sculptured on the exposed surface.<sup>2</sup> Most of the scales

2. The degree of sculpturing is of some taxonomic value when specimens of comparable size are used.

are hinged by a peg- and groove-type articulation. Although the bony scales form nearly an impenetrable covering, the articulations, the fibrous connections, and the arrangement in diagonal rows allow some flexibility of the body. The lepisosteid ganoid scale is composed of two layers, ganoine above and isopedine below, both of which are irregularly penetrated by vascular canals. In addition, both layers, especially the latter, are perforated by a system of small tubes; these tubules penetrate the scale from all sides and are dendritic at their inner terminations. A similar layer of ganoine is present on the dermal bones about the head. Both margins of the caudal fin as well as the leading margins of the other median and paired fins are fortified with a biserial row of fulcra. The cheeks are covered by numerous irregular plates.

The swim bladder,<sup>4</sup> cellular and highly vascularized, is connected to the pharynx by the enlarged pneumatic duct (Wiedersheim, 70: 1-16, pls. 1-3). The gonads are staggered (Muller, 49: pl. 6, fig. 2), i. e. the right one is mostly anterior to the pelvic fins and the left one mostly posterior to them. The ovaries are closed, and the right and left oviducts join the respective urinary ducts. A short distance posterior to their junction, a common chamber is formed by the union of right and left parts; thus the products from both systems exit from the body through a single urinogenital sinus. No vestigial Müllerian ducts exist in the male (Pfeiffer, 52: 465). The conus arteriosus is a contractile vessel with several rows of valves (49: pl. 5, fig. 2). Remnants of the spiral valve occur in the posterior part of the gut. There is no luminescent organ.

*Taxonomic Rank.* In 1844, Johannes Muller combined his family Lepidosteini (evidently to include the amiids) with his family Polypterini to constitute his Order Holostei (49: 201-204), and they have been similarly ranked as one of the constituent divisions of a more widely inclusive Order by some subsequent authors. Thus they were associated: with the Amiidae and Polypteridae by Günther (28: 328) and with the Amiidae (among living fishes) by Bridge (12: 495, 502) as the Order Holostei; with the Amiidae (among living fishes) by Arambourg and Bertin (25: 218 1-2 194) in 1958 as the Order Amiiformes.

They have been regarded, however, as the sole living representatives of a separate Order by the majority of recent authors: Ginglymodi by Cope (16: 452, 453), Rhomboganoidea by Jordan and Evermann (37: 108), Lepidosteoidei by Goodrich (23: 340), Holostei by Jordan (36: 115), Ginglymodi by Regan (59: 313), Holostei by Jordan *et al.* (38: 36), Lepidosteiformes by Berg (8: 211, 414), Semionotoidea by Romer (62: 580), Lepisosteida by Matsubara (46: 170), and Ginglymodi by Norman (57: 61). Here also they are regarded as representing a separate Order.

*Name of the Order.* The choice here lies between Ginglymodi and some derivative

3. For accounts of the scales, see especially L. Agassiz (2: 74, 75, 77, tab. c, figs. 8-so), Williamson (73: 435-447, 470, pl. 40, figs. 1, 2; 74: 651, 658, 687, 699), Reissner (61: 254-268, pl. 5, figs. 1-6), Nickerson (50: 115-139, 4 pls., 31 figs.), Scupin (63: 166, 167, pl. 10, fig. 1), Goodrich (23, 758, 759, fig. 199; 43: 218, 219, fig. 192), Kerr (40: 63-66, figs. 3, 4).

4. Apparently the swim bladder functions as a breathing organ (Potter, 54: 63) in addition to the gills. When removed from water, the Garfishes regularly breathe air into and out of the swim bladder.

of Lepisosteidae.<sup>5</sup> Lepisosteidae is chosen here because of the connotation carried by this name.

*Relationships.* It is customary in general works on living fishes to place the Lepisosteidae next to the amiids, with which they agree: in the abbreviate-heterocercal nature of their caudal fin skeleton (made evident externally by the dorsoposterior slope of the rear boundary of the fleshy caudal peduncle); in their flattened, overlapping pelvic bones; in their chambered swim bladder that serves as an accessory respiratory organ; and in the presence of a rudimentary spiral valve in their intestine. However, they differ widely from the amiids in many respects. The body scales, for example, which are thick and interlocking but not overlapping in the lepisosteids, are thin and widely overlapping in the amiids, but the fulcral scales that arm the margins of the fins in the former are rudimentary in the latter. The long snout, the segmented "maxillary" bones, a lower jaw articulating anterior to the eye, and the three rod-like branchiostegals of the lepisosteids are replaced in the amiids by a short snout, unsegmented maxillaries, a lower jaw articulating posterior to the eyes, and by 10-12 broad plate-like branchiostegals; and the free margin of the branchiostegal membrane, which crosses the isthmus in a continuous arc of long radius in the lepisosteids, is deeply incised there in *Amia*, one side overlapping the other. In lepisosteids the preopercular bone does not extend as far forward as that in the amiids, the cheek region is covered by irregular plates in lepisosteids but not in amiids, there is no bony gular plate in the chin region between the branches of the lower jaw as in *Amia*, and the dorsal is much shorter in lepisosteids than in amiids. The following internal differences deserve mention: the vertebral centra, which are concave posteriorly but convex anteriorly in the lepisosteids, are concave anteriorly as well as posteriorly in *Amia*; the vertebral column in the tail region is diplospondylous; and the arterial cone of the heart, which has eight transverse rows of valves in the lepisosteids, has only two rows in the amiids.

Among fossil groups, lepisosteids are usually associated with the Semionotidae, some of which are known from as far back as the Jurassic.

*Spawning and Development.* Spawning takes place entirely in fresh water during a rather brief period beginning about mid-May and lasting until mid-June, in the latitude of New York (I [1879]: 65, 67). When Garfish move into shallows to spawn, each female is accompanied by one to four males and there is a great amount of thrashing during the breeding activities. Fertilization is external. The large numbers of individuals that concentrate in the shoal areas suitable for spawning disperse rather suddenly to other areas afterwards.

The eggs are adhesive and adhere to the substratum. No parental care is given to the eggs or young. On the ventral surface at the end of the snout the larvae have peculiar adhesive suckers that are used for attachment to objects on or above the bottom. The larvae are relatively inactive until the yolk mass is absorbed, but then they become very active predators.

A characteristic caudal filament that develops at the termination of the upturned

5. Many authors have preferred the spelling *Lepidosteus*.

vertebral column is generally kept in constant rapid motion, as are the fringed, fleshy pectoral fins. The caudal filament atrophies at different times in the various species. Fin rays develop much sooner in the pelvic than in the pectoral fins; hence the pelvics are actually well-defined fins while the pectorals are still delicately fringed, fleshy stumps.<sup>6</sup>

The lateral-line sensory system appears early in life, before any scales are formed. The lateral-line scales develop in a posterior-to-anterior direction, as do the other body scales. Usually by the time the anterior lateral-line scales are developed, lateral scales have formed on the caudal peduncle; on the lateral areas, scales develop ahead of those on the mid-dorsal and midventral regions. Moreover, those of the mid-dorsal area develop ahead of the ones on the midventral section, so the breast is the last to become scaled. The most posterior fringe of scales that is superimposed on the bases of the caudal rays does not appear until after the scales on the whole anterior part of the lateral line and on the body up to the region of the pelvic fins have developed. This terminal fringe of scales usually contributes one to three scales to the lateral-line count. Fulcral scales appear after the fins are otherwise well developed. The caudal fin is somewhat of an exception in that one to three rays form in the superior region following the caudal filament. The last of these upper rays may not be fully developed until the early juvenile stage is reached.

Differential growth of structures is pronounced in the Garfishes; although it becomes less marked with age, it does not terminate with maturity. The diameter of the orbit continually changes in proportion to other parts of the body—particularly to snout length, interorbital distance, and postorbital distance. Primarily because workers have failed to consider such changes properly, the systematics of these fishes has been in a chaotic condition for many years.<sup>7</sup> Males not only mature at a smaller size but grow to a smaller size than females, and sexual dimorphism exists in some structures, e. g. length of snout in the Spotted Gars.

*Habits and Food.* The Garfishes are sluggish creatures most of the time. During the summer they frequent the surface waters and appear more or less motionless for minutes at a time. In streams below barriers, such as dams or falls, frequently large numbers of Longnose Gar can be seen near the surface on bright sunny days. In this quiet state, the caudal fin is usually undulated slowly while they are at rest or moving slowly forward or backward. But they are capable of swimming rapidly for short distances by rapid undulations of the body. When disturbed, they immediately "sound." In the winter they are found in the deeper waters; the shrimp trawlers frequently catch Alligator and Longnose Gars in their trawl nets from the deep holes of estuaries and bayous in the salt marshes of Louisiana.

During the summer months the periodic surfacing of Garfishes is a common sight, and there is some debate about their successfulness in gulping air during these surface

6. A young specimen of *L. osseus* without scales and with the peculiar fleshy pectoral fins induced Rafinesque to describe the form as a new genus, *Sarchirus* (56: 418).

7. L. Agassiz (4: 360) recognized the remarkable changes that take place in the ontogeny of Garfishes, and possibly this was the reason he never followed through with the description of 22 supposed new species, most of which were discovered during a journey in the eastern United States (L. Agassiz, 3: 536).

excursions. However, considering their anatomy, results of experimentation, observations on individuals in their natural habitat, and the regular breathing actions of individuals removed from water, there is little doubt that the swim bladder and associated structures leading to it serve as a supplementary respiratory mechanism.

Gars feed primarily on other fishes, most of which are forage species (Bonham, *II*: 358–360). There are very few published accounts of cannibalism, but Gars with portions of their tails missing are frequently captured, indicating that they have been snapped at by other individuals; this has been observed in streams and canals of peninsular Florida, where the Florida Gar (*L. platyrhincus*) is very abundant. In estuarine waters of Louisiana, Alligator Gar frequently consume the blue crab, *Callinectes sapidus*, as well as garbage (Weed, 69: 9, 10; Gudger, 26: 120, 121) where refuse is regularly thrown into the water.

*Relation to Man.* Although Alligator Gar, *L. spatula*, attain a large size, no authenticated records of an attack on man are available (69: 9, 10; 26: 120, 121). The usual response by Gar when disturbed by a bather or fisherman is a dash for deeper water. While Gars are considered to be a nuisance and are detrimental to game fishes, sport fishing for Alligator Gars has become popular in recent years in Louisiana, Arkansas, Mississippi, and other states in the Mississippi Valley.

Alligator Gar are sold in the French Market in New Orleans at the present time, and small numbers are consumed elsewhere in the United States. Dr. Robert R. Miller contributes the information that *L. tropicus* is of considerable importance as a food item on the Pacific side of southern Mexico and Guatemala. And personal conversation with Nicaraguans reveals that *L. tropicus* is used for food in the Lago de Nicaragua area and lower Rio San Juan. The North and Central American Indians used the ganoid scales and bones for arrow points, ritual instruments, and ornaments. The late Mr. Percy Viosca, Jr., of New Orleans, at one time made an array of ornaments and jewelry from their scales.

*Habitat and Range.* Their range extends from Quebec in the northeast, west to the upper Mississippi Valley and Great Lakes region, and south to Costa Rica in Central America and southwestern Cuba, including the Isle of Pines. Although they are primarily inhabitants of freshwater streams and lakes, several species enter brackish and marine waters. *L. spatula* is a common inhabitant of brackish water in Louisiana, and several specimens have been captured from the Gulf of Mexico, on the Gulf side of Breton Island and Grand Isle, Louisiana, and at Destin, Florida. The Longnose Gar, *L. osseus*, is somewhat less tolerant of marine waters and is seldom captured outside of the brackish estuarine areas. The Spotted Gar, *L. oculatus*, is a common summer inhabitant of the fresher parts of the estuaries in Louisiana.

One species, *L. sinensis* (Bleeker, 9: 148, 154), supposedly occurs in China (Wagner, 68: 738-741). Most standard references fail to mention an extant Asiatic form.

*Geological History.* Garfishes are known from the Upper Cretaceous to Lower Miocene time; in the Eocene of India and in North America from the Middle Eocene to Recent period (Berg, 8: 214, 415; Romer, 62: 548).

*Measurements and Counts.*

**LENGTH:** measurement from tip of snout to posterior margin of last lateral-line scale at base of caudal fin. Unless stated otherwise, **LENGTH** is used.

**STANDARD LENGTH (SL):** nearly equivalent to length.

**TOTAL LENGTH (TL):** measurement from tip of snout to longest rays of caudal fin.

**CAUDAL BASE:** defined as a point at end of lateral-line row of scales, located approximately at center of caudal fin in a vertical direction; this point is used in : **LENGTH; CAUDAL PEDUNCLE:** length; and **CAUDAL FIN:** length.

**CAUDAL PEDUNCLE:** length—measurement from caudal base to posterior tip.

**HEAD:** mid-dorsal length—measurement from tip of snout to occiput.

**HEAD:** length—distance from tip of snout to posterior margin of bony opercle.

**HEAD:** depth—measurement at occiput.

**HEAD:** width—measurement at occiput.

**SNOUT:** length—measurement from tip of snout to anterior rim of bony orbit.

**SNOUT:** least width—measurement immediately behind perforations usually formed by the large anterior teeth of lower jaw; these tooth perforations are immediately posterior to the nares and should not be confused.

**SNOUT:** width—measurement at posteriormost teeth.

**LOWER JAWS:** width—measurement at articulation with skull.

**LOWER JAWS:** least width—measurement immediately posterior to symphysis of dentaries.

**POSTORBITAL DISTANCE TO:** bony margin—measurement from posterior bony rim of orbit to posterior margin of bony opercle.

**POSTORBITAL DISTANCE TO:** fleshy margin—distance from posterior rim of orbit to posterior margin of fleshy opercular valve.

**POSTSNOUT:** distance—measurement from anterior rim of orbit to free margin of bony opercle.

**FRONTAL BONES:** least width—measurement at central constriction.

**SCALES:** lateral line—includes the small scales at base of caudal fin, whether pores are discernible or not, so long as they are within the lateral-line scale row.

**SCALES:** predorsal—includes all median dorsal scales anterior to the paired structures (fulcra) on the anterior margin and at the origin of dorsal fin.

**SCALES:** transverse rows—includes all those in an anteriorly slanted diagonal row from the single median anal plate to the mid-dorsal scale, including the anal plate and mid-dorsal scale.

**GILL RAKERS:** total—number on left outer arch.

Family *LEPISTHEIDAE*

Garfishes

*Characters.* Those of the Order.

*Genera and Subgenera.* All modern Garfishes fall within a single genus, *Lepisosteus*. Rafinesque (55: 69, 71, 76) placed the Gar or Gar-like fishes in three genera: *Sarchirus*,



*Lepisosteus*, and *Litholepis*, the first being based on a young individual of *L. osseus* and the last on inaccurate information communicated personally by J. J. Audubon. The sketch and description (long dorsal and anal, bil bed tail) of the fish in Rafinesque's field notes and the description in "Ichthyologia Ohiensis" clearly indicate a fictitious fish that should not be recognized with a valid name. Rafinesque subdivided the genus *Lepisosteus* into two subgenera, *Cylindrosteus* and *Atractosteus*.

Fowler recognized two genera, *Lepisosteus* and *Cylindrosteus* (22: 604, 605). Holly divided the genus *Lepisosteus* into three subgenera: *Litholepis*, *Lepisosteus*, and *Cylindrosteus* (65: 49). More recently, Moore (67: 54) and Eddy (19: 39-41) have recognized a single genus, *Lepisosteus*. When Fowler split the Gars into two genera on the basis of presence or absence of enlarged teeth on the palatine (22: 604), he did not find a second row of enlarged teeth on the palatine surface in the smallest specimens of *L. osseus*; however, small examples of the same form in the Tulane University collection reveal an inner row of enlarged teeth on the upper jaw.

Two subgenera, *Lepisosteus* and *iltractosteus*, are recognized here. The nomenclature of fossil Gar material has been confused because of chaotic conditions that have existed for many years with regard to the recent forms. Perhaps additional subgenera will have to be recognized for some of the fossil forms.

#### Genus *Lepisosteus* Lacépède 1803

*Lepisosteus* Lacépède, Hist. Nat. Poiss., 5, 1803: 331; type species, *Lepisosteus gavalis* Lacépède 1803 equals *Esox osseus* Linnaeus.

##### Generic Synonyms:

*Esox* Linnaeus (in part), Syst. Nat., 10th ed., 1758: 313; type species, *Esox osseus* Linnaeus 1758.

*Litholepis* Rafinesque, Amer. Mon. Mag., 3, 1818: 447; type species, *Litholepis adamantinus* Rafinesque 1818; based on a fictitious description personally communicated by J. J. Audubon.

*Sarchirus* Rafinesque, J. Acad. nat. Sci. Philad., 1 (2), 1818: 418; type species, *S archirus vittatus* Rafinesque 1818; young of *Lepisosteus osseus*.

*Cylindrosteus* Rafinesque, Ichthyol. Ohiensis, 1820: 72; type species, *Lepisosteus platostomus* Rafinesque 1820.

*tractosteus* Rafinesque, Ichthyol. Ohiensis, 1820: 75; type species, *Lepisosteus ferox* Rafinesque 1820.

*Lepidosteus* Koenig, Icon. Foss., :825: t. 12, emended spelling for *Lepisosteus* Lacépède 1803; *Lepidosteus* Agassiz, Rech. Poiss. Foss., 2 (2), 1843: 1, emended spelling for *Lepisosteus* Lacépède.

##### Doubtful Synonym:

*Psallisostomus* Walbaum, P. Artedi Genera Pisc., Emend. Ichthyol., 1792, 581; *Psallisostomus* Fowler (after Walbaum), Fish. New Jersey in Rep. N. J. Mus., Pt. 2, 1905: 89; Suppl. Acct. Fish. N. J., Pt. 3, 1906: 263, 387, pl. 83 (after Agassiz, Rech. Poiss. Foss., "43).

**Characters.** TEETH numerous, of various sizes on both jaws and on most bones lining roof of oral and pharyngeal cavities; one row of enlarged teeth with radially grooved base on lower jaws, and two rows on upper jaws, at least during younger stages; outer margin of both upper and lower jaws fortified with a closely set row of needle-shaped teeth; a pair of large teeth at anterior end of lower jaws fitting into depressions in upper jaws and, in many individuals, perforating anteriormost pre-

orbital (maxillary auctorum). A peculiar wedge-shaped BLIND POCKET in skin of gular region. TONGUE bifurcate-spatulate. Three MODIFIED SCALES bordering anus; median scale, anterior to anus, a large shield-shaped plate; lateral plates elongate and slightly curved. Other characters those of the Order.

*Species.* Currently seven species are recognized in North American waters, but detailed studies that are in progress may show that two of these forms are only subspecifically distinct. There is some indication of hybridization, but verification of this must await further study. *L. oculatus*, *osseus*, *plavrhincus*, and *spatula* are treated in the following account.

#### Key to Species of the Western North Atlantic

- 1 a. Total gill raker count on left outside arch, 59-81 (70 specimens); palatines of adult with a series of enlarged teeth. Subgenus *Atractosteus* Rafinesque 1820.
    - 2a. Lateral-line scales, 58-62 (25 specimens); diagonal rows between insertion of pelvic and origin of dorsal fin, 34-38; predorsal scales, 48-54.
      - 3a. Total gill rakers on left outside arch, 59-66 (20 specimens); females maturing at a larger size, probably not less than 600 mm; anterior body scales of 400-mm specimens finely serrated on posterior border.
 

*spatula* Lacépède 1803, p. 83.
      - 3b. Total gill rakers, 67-81 (5 specimens); females maturing at a smaller size, 470 mm; anterior body scales of 400-mm specimens strongly serrated on posterior border. *tristoechus* (Bloch and Schneider) 1801.
 

Fresh waters of southwestern Cuba and Isle of Pines; not yet recorded for salt water but likely to be found there.
    - 2b. Lateral-line scales, 51-56 (60 specimens); diagonal rows between insertion of pelvic and origin of dorsal fin, 28-32; predorsal scales, 43-48 (usually 44-47).
 

*tropicus* (Gill) 1863.  
Rio Usumacinta of Guatemala and Mexico and tributaries of Lake Nicaragua and Rio San Juan in Costa Rica on the Atlantic slope, and from Pacific drainage of Chiapas, Mexico (Miller, 48: 230, 23).<sup>8</sup>  
*Atractosteus bocourti* Duméril 1870; mouth of (Rio) Nagualate, 14 N.
  - b. Total gill rakers, 14-33 (148 specimens); palatines of adult without enlarged teeth. Subgenus *Lepisosteus* Lacépède 1803.
    - 4a. Snout's least width 13-25.5 times in its length (specimens more than 50 mm long).
 

*osseus* (Linnaeus) 1758, p. 75.
    - 4b. Snout's least width 4.5-11 times in its length (specimens more than 50 mm long).
8. There are no records from salt water on the Atlantic side but *L. tropicus* is common in the tidal zones of the Pacific drainages.

- 5a. Lateral-line scales, 59-65, usually ~~60-63~~ (47 specimens); predorsal scales ~~50-55~~, usually 52 or 53; anterior part of body and head without dark spots.  
*platostomus* Rafinesque 1820.  
Larger rivers of the Mississippi River drainage.
- 5b. Lateral-line scales, 53-59, usually 54-58 (249 specimens); predorsal scales ~~45-54~~, usually 47-50, rarely more than 51; anterior part of body and head with dark spots and blotches.
- 6a. Adults with bony plates on ventral surface of isthmus, under gill membrane (~~177~~ specimens); snout and lower jaw longer and narrower. *oculatus* Winchell 1864, below.
- 6b. Adults without bony plates on ventral surface of isthmus (76 specimens); snout and lower jaw shorter and broader.  
*plavrhincus* DeKay 1842, p.8 I.

*Lepisosteus oculatus* Winchell 1864

## Spotted Gar

Figures 12, 14

*Study Material.* A total of 177 specimens, 32-819 mm TL, including the type of *L. oculatus* Winchell 1864 (dry mount with fins broken; length 700 mm, estimated caudal length 119 mm, total length 819 mm, UMMZ 55062), from Michigan, Indiana, and Ohio south to the Gulf of Mexico, and from western Florida to central Texas along the Gulf coast, in TU, UMMZ, ANSP, USNM, AMNH, and UT collections.

*Distinctive Characters.* *L. oculatus* is readily distinguished from *L. osseus* and *L. spatula* by the profusion of dark spots on the body, head, and fins, and from *L. platyrhincus* by the plates on the ventral surface of the isthmus. The Spotted Gar has a head of medium width, approximately intermediate between the narrow head of *L. osseus* and the very broad head of *L. spatula*.

*Description.* Proportional dimensions in per cent of length, based on 32 specimens: from Lake Pontchartrain near New Orleans, Louisiana (5), Sabine R., Texas (3), Mermentau R., Louisiana (4), Biloxi R., Mississippi (1), Pearl R., Louisiana and Mississippi (19); specimens 180-512 mm length.

*Body:* depth 9.2-12.8; width 8.6-12.6.

*Caudal peduncle:* length 10.8-13.4; least depth 5.0-7.3.

*Head:* mid-dorsal length 24.5-33.9;

length 27.1-36.2; depth 6.6-8.3;

width 7.6-10.0.

*Snout:* length 15.9-23.3; least width

2.3-3.2; width 3.8-5.3.

9. All of the types listed under *Study Material* were examined by me.

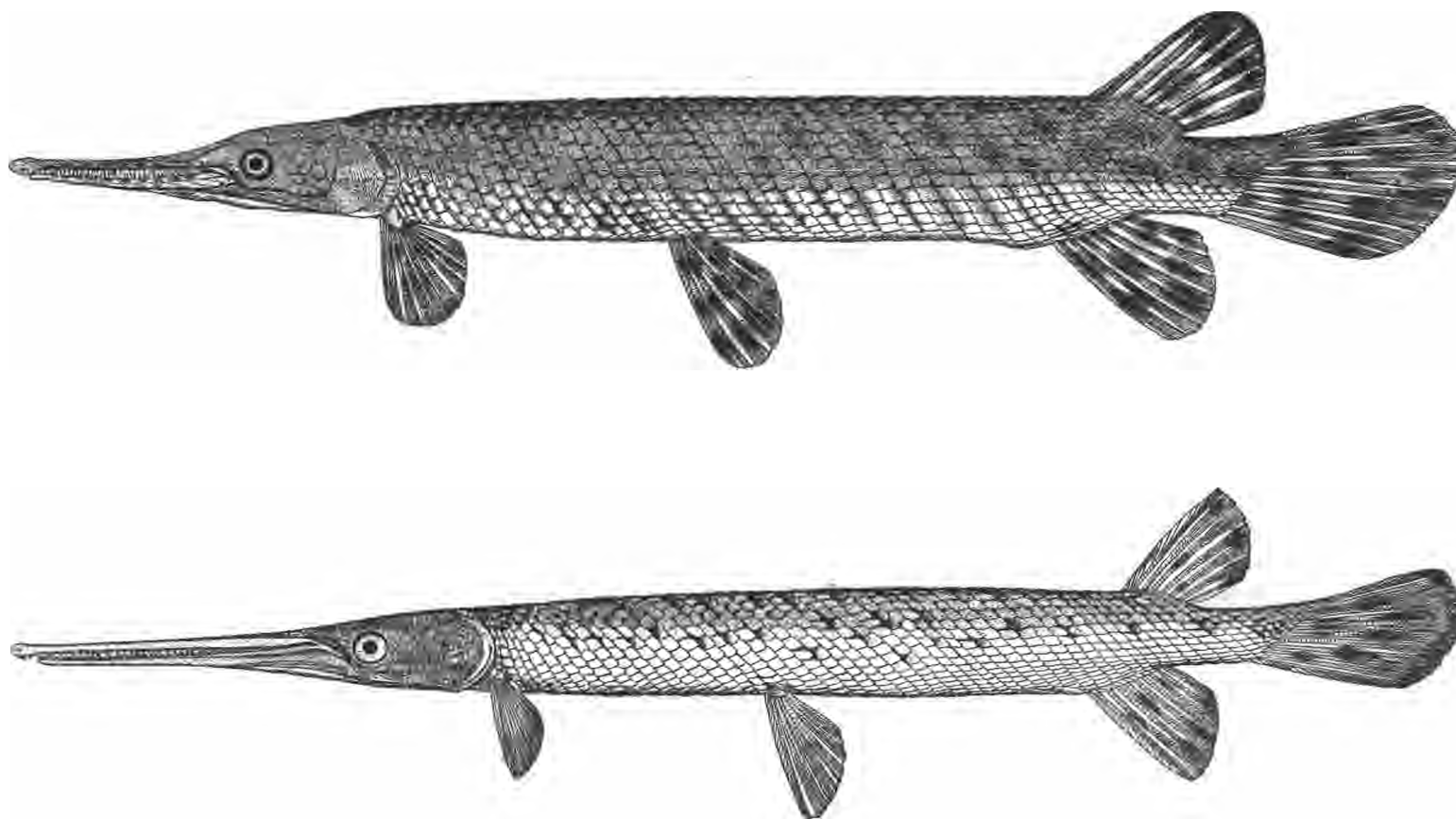


FIGURE 12. TOP. *Lepisosteus oculatus*, 534 mm TL, from Lake Pontchartrain at Goose Point, St. Tammany Parish, Louisiana, TU 6454.  
FIGURE 13. BOTTOM. *Lepisosteus osseus*, 554 mm TL, from Pearl River, Washington Parish, Louisiana, six miles east of Varnado, TU 1119.

*Orbit:* length 2.3-3.3.

*Interorbital:* least bony distance 4.8-5.9.

*Postorbital distance to:* bony margin 7.8—9.8; fleshy margin ~~8.9-11.0~~.

*Frontal bones:* least width 2.0-3.1.

*Lower jaws:* least width 1.7-3.0.

*Mandible:* length 13.6-20.8; posterior width 4.8-6.9.

*Dorsal fin:* depressed length 13.7-17.6.

*Anal fin:* depressed length 12.0-18.7.

*Caudal fin:* length 13.5-24.3.

*Pectoral fin:* length 8.2-12.8.

*Pelvic fin:* length ~~10.2-15.0~~.

*Distance from tip of snout to:* dorsal origin 83.2-87.6; pelvic insertion 53.4—61.2.

*Distance from pelvic insertion to:* anal origin 23.8-29.9; pectoral insertion 23.5-29.3; lateral line 4.6-6.8.

*Distance from dorsal origin to:* occiput 52.4-60.2; caudal base 14.0-17.2; lateral line 5.2-7.6.

*Distance from anal origin to:* caudal base ~~16.8-20.6~~.

Proportional dimensions in per cent of head length for 31 specimens, 180-700 mm length, with head lengths 65.1-196.0 mm.

*Snout:* length ~~57.0-65.0~~; least width 6.5-10.6.

*Orbit:* length 8.2-11.0.

*Interorbital:* least bony distance ~~15.4-~~ 21.5.

*Postorbital distance to:* bony margin 26.4-32.2.

*Lower jaws:* least width 5.0-10.8.

*Mandible:* length 50.0-57.5.

Proportional dimensions in per cent of snout length (sl) and mandible length (ml).

*Snout:* least width 5.1-9.9 times in sl.

*Lower jaw:* least width 4.8-11.6 times in ml.

Statistics of meristic characters: first number—number of specimens; second and third numbers—extremes in range of variation; fourth number—mean figure.

*Scales:* transverse rows between pelvic and dorsal origins 172, 27-32, 30.3; transverse rows ~~170~~, 18-24, ~~20.6~~; predorsal <sup>1</sup>73, 45-54, 4<sup>8.2</sup>; lateral line 177, 53-59, ~~56.1~~.

*Gill rakers:* total 32, 15-24, 19.3.

*Fin rays:* dorsal 33, ~~6-9~~, 7.4; anal 33, 7-9, 7.8; caudal 32, 12 and 13, ~~12.5~~; pectoral on left 32, 9-13, ~~10.6~~, and on right 32, 9-13, 10.7; pelvic on left 33, all with 6 rays, and on right 33, all with 6 rays except 1 with 5.

*Sexual Dimorphism.* It is apparent in this species (Hubbs and Lagler, 33: 76, 77) and occurs in at least one proportion. The female proportionally has a longer snout than the male, but this difference is not easily demonstrated because the snout-length/head-length ratio changes with size of individual.

*Color.* General coloration darker than in *L. osseus*; intervening spaces between numerous dark spots also dark in some specimens, making such individuals appear

black; contrast between dark spots and background coloration usually greater in specimens living in clear water. Seemingly the intensity of pigmentation and the area of body pigmented are somewhat correlated with the color of the water, i. e. how darkly stained; streams and bayous that course through pinelands and cypress swamps have light brown to nearly black water and their fish inhabitants tend to be darkened also, even to the extent of a darkened ventral surface.

The young are brightly colored as in *L. osseus* p. 78, but a few differences in color and pattern are apparent. Median dorsal stripe very broad and dark brown in contrast to narrow reddish or cinnamon stripe in *L. osseus*. Dark lateral band nearly straight on its upper margin, and narrow reddish-brown stripe above usually separated from lateral band. Ventral surface usually a chocolate color as in *L. osseus*. Mid-dorsal stripe and lateral band each breaking up into a single row of spots. Mid-dorsal spots developing first and forming in a posterior-to-anterior direction. These spots begin to form when the fish is between 100 and 150 mm length. The lateral spots appear in the same sequence but do not start to form until the individuals have reached an approximate length of 170 mm.

**Size.** The 26 *oculatus* collected from the brackish waters of Lake Pontchartrain from July 1953 to February 1955 were 297-690 mm TL. On March 25, 1959, four *oculatus* were seined in one haul from a borrow pit in the Bonne Carre Spillway, near Norco, Louisiana. The total length for the largest individual, a female, was 757 mm; for the three males, 522, 524, and 575 mm. This was probably a spawning group, but no spawning activity was observed prior to capture. The female was greatly distended at the time of capture because of the enlarged ovaries, but no ova were present in the oviducts.

**Development.** The scales develop in a posterior-to-anterior manner as described in Development p. 66, but the Spotted Gar develops scales and other structures at a small size. Specimens 100 mm long have a fully developed lateral line as well as lateral body scales forward to the region of the pelvic fins at the same time as the pectoral fin rays are just starting to develop. Specimens of 130 mm have scales on the body except for the anterior belly and breast, and the pectoral fins may have half to all of their rays formed. The body scalation is complete in specimens 140-150 mm. Plates begin to form on the ventral surface of the isthmus in individuals of about 200 mm. The enlarged teeth in the row on the palatines remain as prominent structures until about 200 mm, and some retain them until they reach 300 mm; however, most individuals have only relatively small teeth at that size. The caudal appendage may be atrophied in individuals as small as 160 mm but may not be completely atrophied until a length of 225 mm.

**Habits.** The feeding habits of this species are similar to those described for *L. osseus* p. 78. In the Lake Pontchartrain area, the diet of the Spotted Gar is composed of fishes and crustacea, the crustacean most often eaten being the blue crab, *Callinectes sapidus*.

**Relation to Man.** The Spotted Gar is usually considered an obnoxious fish.

**Range.** *Lepisosteus oculatus* ranges from the Great Lakes south in the Mississippi

Valley to the Gulf of Mexico, and from western Florida to central Texas along the Gulf coast. It does not invade brackish or marine waters as much as either the Longnose or Alligator Gars. In the Lake Pontchartrain area, *L. oculatus* is found most often along the marshy shore, and seldom very far out in the lake.

Specimens in the Tulane University collection were obtained from the tidewater section of Deer River on the west side of Mobile Bay, Alabama, and from Choctawhatchee River in Florida. Bailey, *et al.* reported the Spotted Gar for the tidewater section of the Escambia River, Florida (5: 117). Gunter reported the capture of two from Copano Bay, Texas (27: 23), and Reid gave records of it for East Bay, Texas (60: [1955]: 431). All records cited above indicate that, of the four Gar considered, this species and the Florida Gar (*L. platyrhincus*) are the least tolerant of saline conditions.

Synonyms, with References to Occurrence in Brackish or Salt Water:

*Lepisosteus oculatus* Winchell, Proc. Acad. nat. Sci. Philad., 16, 1864: 183 (Huron R., Michigan); Gunter, Publ. Inst. mar. Sci. Texas, 1 (1), 1945: 23 (Copano Bay, Texas); Bailey, Winn, and Smith, Proc. Acad. nat. Sci. Philad., 106, 1954: 117 (in tidewater, Florida); Reid, Texas Sci., 7 (4), 1955: 431 (East Bay, Texas).

*Cylindrosteus productus* Cope, Proc. Acad. nat. Sci. Philad., 17, 1865: 86 (San Antonio, Texas).

*Cylindrosteus agassizii* Duméril, Hist. Nat. Poiss., 2, 1870: 347-348, 351 (St. Louis, Missouri).

*Cylindrosteus bartonii* Duméril, Hist. Nat. Poiss., 2, 1870: 347-348, 356 (New Orleans, Louisiana).

*Lepisosteus osseus* (Linnaeus) 1758

Longnose Gar

Figures 13, 15

*Study Material.* Many specimens, including 42, 139-779 mm TL, used for the *Description*; from tributaries of the Gulf of Mexico from Florida to Mexico; from the Mississippi River drainage, Louisiana to Indiana; in USNM, CNHM, UMMZ, UI, UL, UT, and TU collections; also, the head only of the type of *Lepisosteus leptorhynchus* Girard 1858, USNM 1002.

*Distinctive Characters.* *Lepisosteus osseus* is distinguishable from *L. spatula*, *L. oculatus*, and *L. platyrhincus* at a glance by its long narrow snout.

*Description.* Proportional dimensions in per cent of length, based on 42 specimens, 114-695 mm length, as listed under *Study Material*. Although the variability of most dimensions for a limited size range is not very great, the following figures nevertheless include allometric variation.

*Body:* depth 7.0-10; width 5.9-9.5.

*Caudal peduncle:* length 9.4-13.0; least depth 3.7-5.1.

*Head:* mid-dorsal length 29.4-38.8; length 31.8-41.2; depth 5.4-7.2; width 5.3-7.6.

*Snout:* length 21.4-28.9; least width 1.1-2.1; width 2.6-3.7; very narrow.

*Orbit:* length 2.2-3.7.

*Interorbital:* least bony distance 3.8-5.2.

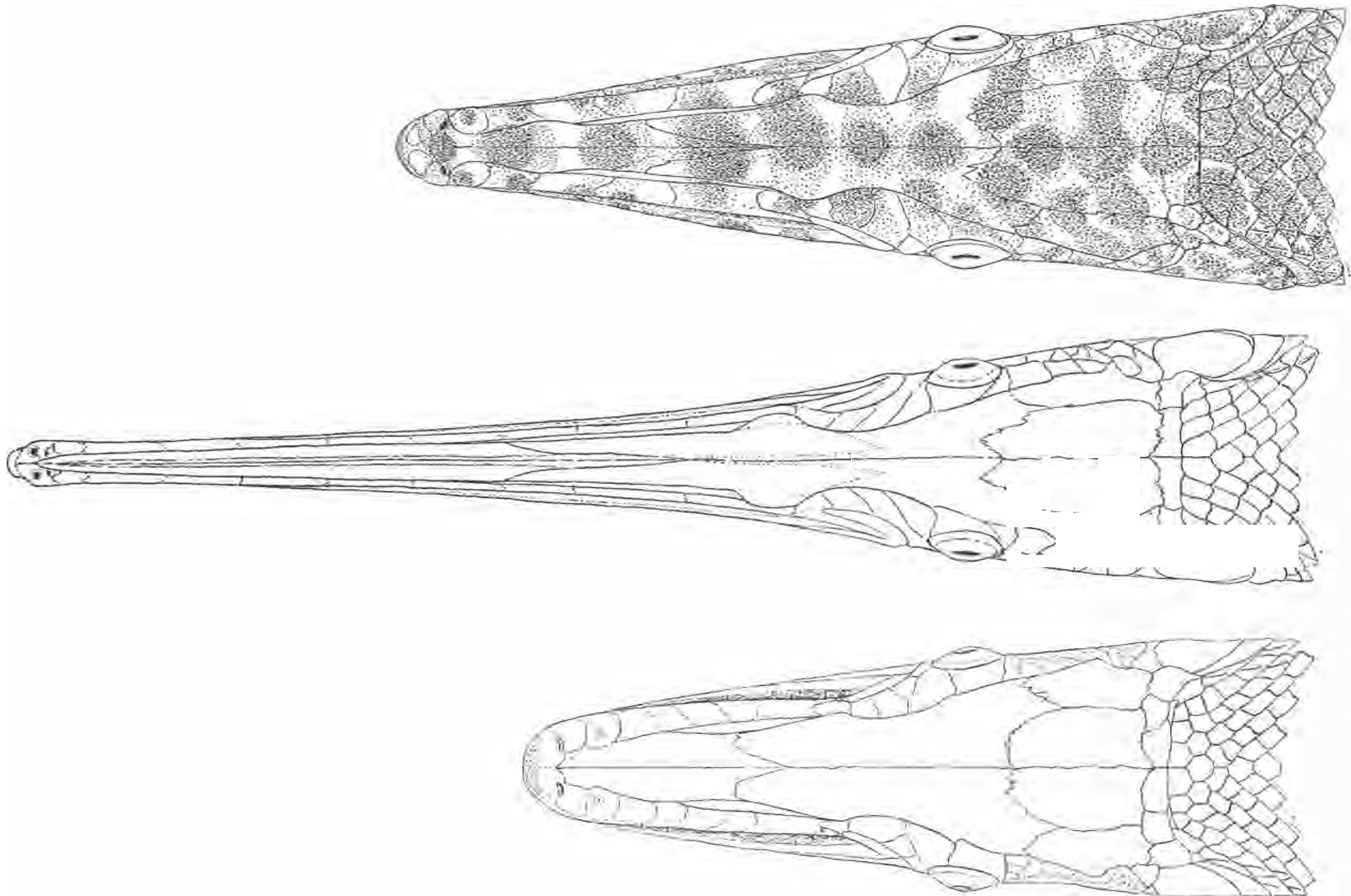


FIGURE 14. TOP. Mid-dorsal view of head (522.7 mm) of *L. oculatus* in Fig. 12. FIGURE 15. CENTER. Mid-dorsal view of head (165.0 mm) of *L. osseus* in Fig. 53. FIGURE 16. BOTTOM. Mid-dorsal view of head (102.3 mm) of *L. spatula* in Fig. i8.



|  |  |
|--|--|
| <i>Postorbital distance to:</i> bony margin 6.6-8.9; fleshy margin 7.5-10.0. | <i>Distance from tip of snout to:</i> dorsal origin 84.8-89.3; pelvic insertion 56.1-62.1.                           |
| <i>Frontal bones:</i> least width 1.7-2.5.                                   | <i>Distance from pelvic insertion to:</i> anal origin 20.4-26.1; pectoral insertion 18.7-24.4; lateral line 3.3-4.7. |
| <i>Lower jaws:</i> width 3.6-5.2; least width 0.7-1.3.                       | <i>Distance from dorsal origin to:</i> occiput 48.2-56.9; caudal base 10.6-15.2; lateral line 4.2-5.4.               |
| <i>Mandible:</i> length 20.4-26.4.   | <i>Distance from anal origin to:</i> caudal base 15.3-19.2.  |
| <i>Dorsal fin:</i> depressed length 10.2-14.8.                               |  |
| <i>Anal fin:</i> depressed length 11.1-15.9.                                 |  |
| <i>Caudal fin:</i> length 12.0-22.3.   |  |
| <i>Pectoral fin:</i> length 2.6-10.3.  |  |
| <i>Pelvic fin:</i> length 8.1-13.2.  |  |

Proportional dimensions in per cent of head length for 39 specimens, 114.1-695 mm length, with head lengths 81.8-272 mm, including head of type (see *Study Material*).

|  |  |
|--|--|
| <i>Snout:</i> length 67.4-73.8; least width 3.1-4.5. | <i>Postorbital distance to:</i> bony margin 17.7-23.6. |
| <i>Orbit:</i> length 6.3-9.1.                        | <i>Lower jaws:</i> least width 1.8-3.6.                |
| <i>Interorbital:</i> least bony distance 10.6-13.4.  | <i>Mandible:</i> length 64.3-68.4.                     |

Proportional dimensions in per cent of snout length.

|                                      |                                     |
|--------------------------------------|-------------------------------------|
| <i>Snout:</i> least width 12.9-25.7. | <i>Postsnout:</i> distance 2.1-3.0. |
|--------------------------------------|-------------------------------------|

Statistics of meristic characters: first number—number of specimens; second and third numbers—extremes in range of variation; fourth number—mean figure.

|   |  |
|---|--|
| <i>Scales:</i> transverse rows between pelvic and dorsal origins 35, 31-35, 32.5; transverse rows 37, 19-24, 21.2; predorsal 38, 47-55, 50.8; lateral line 40, 57-63, 60.1. | <i>Fin rays:</i> dorsal 40, 6-9, 7.4; anal 40, 8-10, 8.8; caudal 40, 1-14, 12.8; pectoral on left 39, 10-13, 11.1, and on right 39, 10-13, 11.2; pelvic on left 40 and on right 40, all with 6 rays. |
| <i>Gill rakers:</i> total 38, 14-31, 22.6.  |  |

*Color.* In general, olivaceous brown above and white below, with specimens from clear water showing more contrast in coloration; their backs usually more greenish, those from turbid waters more brownish. Dark spots on median fins and on body, more clearly defined on specimens from clear water; darkened areas on body frequently appearing as blackened margins of scales (as if ink were dropped on the body and then wiped off, leaving traces in grooves between the scales); old individuals sometimes lacking dark spots on body or fins. Catesby has described and figured "*acus maxima squamosa viridis*" from Virginia as having a pink belly and pink fins (13: 30, pl. 30).

This peculiar coloration may be indicative of a hemorrhagic condition that is easily produced by exposure and rough handling before preservation.

Young individuals, colorful with various shades of brown to black, and white to cream. Broad dusky or dark brown band on the side of body, extending from snout through eye to base of caudal fin; upper margin of band scalloped, the elevated portions fusing into an interrupted stripe of reddish brown or cinnamon. A narrow mid-dorsal stripe of similar color. Ventral surface of small young chocolate colored on midbelly and bordered above on either side by a milky to cream stripe, the dark coloration disappearing in larger young and leaving only a narrow ventrolateral stripe. All fins more or less spotted or blotched with dark brown, the dark color of fins usually in the form of bars on pelvic, dorsal, and anal.

*Size.* The maximum size of *osseus* is about 1,500 mm TL. Abbott gave a length of five feet for a specimen speared in Crossweelssen Creek, New Jersey (31: 270). The 28 specimens collected from July 1953 to February 1955 from Lake Pontchartrain were 541-1,180 mm TL.

*Spawning and Development.* The early life history of *L. osseus* is quite well known (A. Agassiz, 1 [1878]; Mark, 45). The more extensive studies were made by Wilder (71 155-163; 72: 1-12, 192, 195, 10 figs.), Balfour (6: chap. 6), Balfour and Parker (7), and Eycleshymer (21). Agassiz has described the spawning activities and early development of the Longnose Gar of Black Lake, New York (1 [1879]: 65-75, 5 pls.), and many illustrations represent the developmental stages of the fins and adhesive organs. The adhesive organs on the ventral surface at the tip of the snout on newly hatched fry are used for attachment to objects above the bottom silt. Although larvae are relatively inactive until the yolk supply is absorbed, they are capable of very rapid movements when disturbed. At three weeks of age the yolk has been used, and the adhesive organs are reduced to a small swelling.

The following data give an approximation of the size of individuals at the time of atrophy of the fleshy caudal appendage projecting from the upturned end of the vertebral column. A caudal appendage has been observed at the following lengths: 191, 219, 233, 245, 260, and 271 mm.; but none was seen on specimens of these lengths: 266, 268, 271, 274, 284, and 286 mm. Wilder's observation of a 300-mm specimen with the caudal appendage nearly atrophied is in line with measurements given above. Our largest specimen (271 mm) is actually 323 mm TL when the caudal fin length is added. Apparently no one has yet determined the maximum age attained by Garfish, but numerous specimens have been kept in aquariums for a number of years. Mark, who kept *L. osseus* for nearly 3 1/2 years in aquariums at Cambridge, obtained the material from Black Lake, New York, when it was in early stages of segmentation (45: 5).

*Food and Feeding.* The Longnose Gar usually waits for its prey to get within "easy reach" and then, with a sudden thrust, grasps the victim (Abbott, 31: 269, 270). The prey is often held crosswise in the mouth for several minutes before it is swallowed. In the brackish waters of Lake Pontchartrain, this Gar feeds on various fishes

and crustacea; largescale menhaden (*Brevoortia patronus*), bay anchovy (*Anchoa mitchilli*), sea catfish (*Galeichthys felis*), and the blue crab (*Callinectes sapidus*) were found in the stomachs by Dr. Rezneat M. Darnell.

**Relation to Man.** In most areas the Longnose Gar is considered not only an obnoxious predatory fish but a destructive one as well, gill and trawl nets often being damaged by it in the brackish waters of Louisiana, and probably elsewhere. In some parts of the country it is used as food, although most fishermen throw it out on the banks, or mutilate it before release back into the water. Smith (64: 59) reported (after Earl, 18: 485) that in 1880 this was one of the principal foodfishes in the New Bern market. The roe, being poisonous, is not used in caviar production as is that of the sturgeons and the paddlefishes.

**Range.** It frequents waters from Quebec to Florida along the Atlantic except for the eastern part of the New England states, and in the west it ranges from the Great Lakes region south to northern Mexico.

The adult is frequently found in the brackish waters of Louisiana; Smith has stated that the Longnose Gar sometimes enters salt water and is not rare in Albemarle Sound (64: 59). In winter it frequents the deeper waters of Lake Pontchartrain, where, during a biological survey, several specimens were collected with trawl nets from dredge holes 30 feet in depth. Uhler and Lugger reported it as common in brackish water of the Potomac and Patapsco rivers (66: 154), but Hildebrand and Schroeder recorded it as not common in Chesapeake Bay (32: 77). Joseph and Yerger reported three specimens, 1,000-1,070 mm TL, for Alligator Harbor, Florida (39: 120).

The type of *Lepidosteus crassus* Cope 1865 was collected from brackish water at Bombay Hook, near the mouth of the Delaware River.

Synonyms, with References to Occurrence in Salt Water:

- Esox osseus* (in part) Linnaeus, Syst. Nat., 10th ed., 1758: 313; after Artedi, based on "Acus maxima squamosa viridis," Catesby, 1738: 30, pl. 30 (Virginia).  
*Esox viridis* Gmelin in Linnaeus, Syst. Nat., 13th ed., r (3), 1789: 1389.  
*Lepisosteus gavalis* Lacépède, Hist. Nat. Poiss., 5, 1803: 333 (lakes, rivers of both Indies).  
*Sarchirus vittatus* Rafinesque, J. Acad. nat. Sci. Philad., 1 (2), 1818: 419, pl. 17, fig. 2 (based on juv.).  
*Lepisosteus oxyurus* Rafinesque, Ichthyol. Ohiensis, 1820: 73 (Ohio R.).  
*Lepisosteus longirostris* Rafinesque, Ichthyol. Ohiensis, 1820: 74 (Muskingum R., Ohio, descr. based on head).  
*Lepisosteus huronensis* Richardson, Fauna Boreal. Amer., 3, 1836: 237 (Penitanguishene, Lake Huron).  
*Lepisosteus rostratus* Cuvier in Richardson, Fauna Boreal. Amer., 3, 1836: 238 (Penitanguishene, Lake Huron).  
*Lepisosteus semiradiatus* Agassiz, Rech. Poiss. Foss., 2, 5836: 2, pl. 2.  
*Lepisosteus gracilis* Agassiz, Rech. Poiss. Foss., 2, 1836: 3.  
*Lepisosteus bison* DeKay in Zool. N.Y., 1842: 271, pl. 43, fig. 139 (Lake Erie, Buffalo, New York).  
*Lepisosteus lineatus* Thompson, Hist. Vermont, 1842: 545 (ill., Winooski R., Burlington, Vermont; based on juv.).  
*Macragnathus loricatus* Gronow in Gray, Cat. Fish. Coll. and Descr. by L. T. Gronow, in Brit. Mus., 1854: 148 (after Linnaeus).  
*Lepisosteus leptorhynchus* Girard in Pacif. R. R. Surv., Fish., 10 (4), 1858: 35 (Devil R., Texas; head only, USNM 1002).  
*Lepisosteus otarius* Cope, Proc. Acad. nat. Sci. Philad., 17, 1865: 86 (Platte R. near Fort Riley).  
*Lepisosteus crassus* Cope, Proc. Acad. nat. Sci. Philad., 17, 1865: 86 (type from brackish water at Bombay Hook, near mouth of Delaware R.).

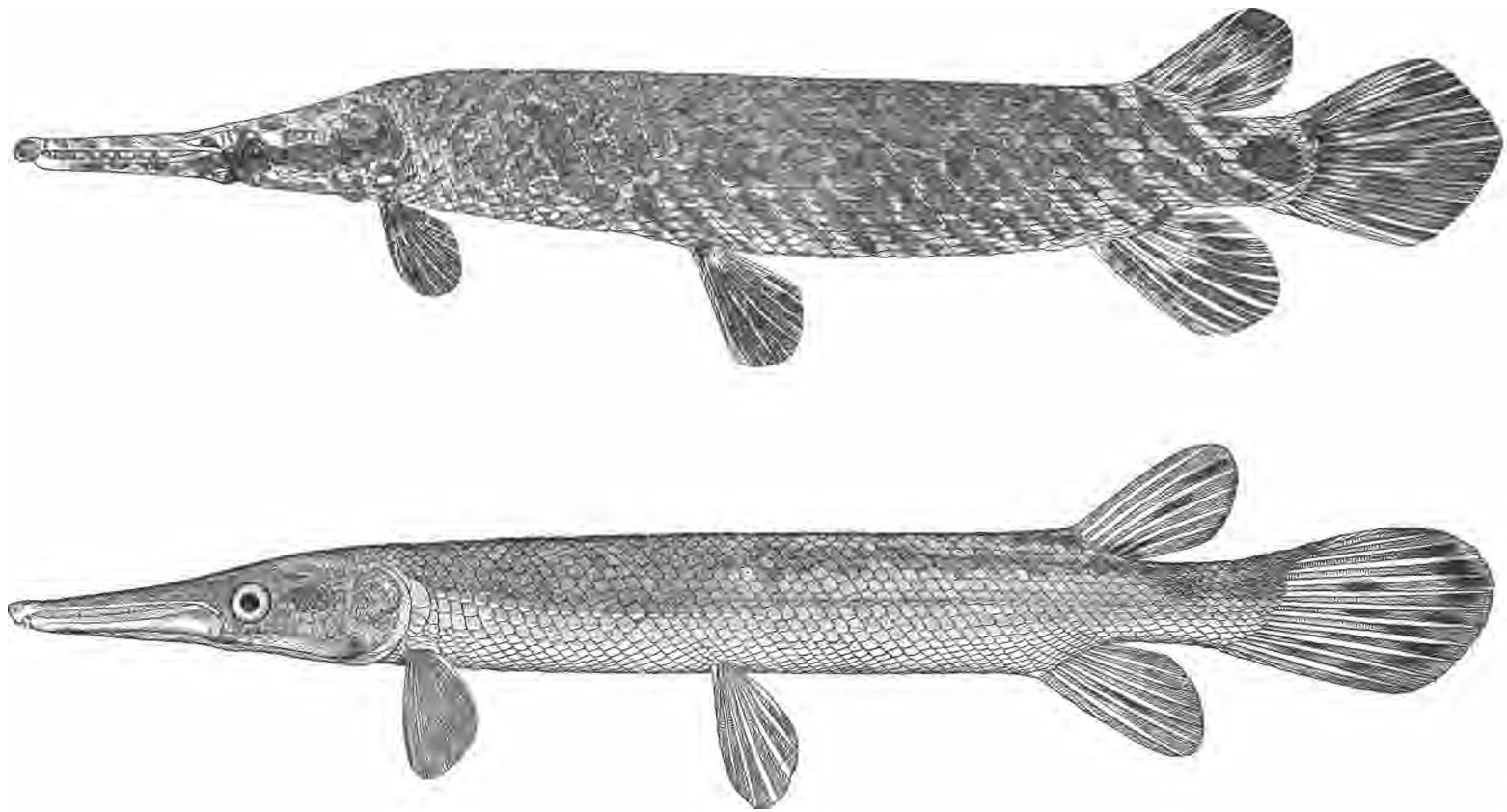


FIGURE 17. TOP. *Lepisosteus platyrhincus*, 516 mm TL, from Tamiami Canal, Collier County, Florida, 2.7 miles W. of Collier and Dade County line, U. S. Hwy. 41, TU 16920.

FIGURE 18. BOTTOM. *Lepisosteus spatula*, 488.8 mm TL, from Lake Pontchartrain, Tangipahoa Parish, Louisiana, at mouth of Tangipahoa River, TU 8619.

## Fishes of the *Western North Atlantic*

- Lepidosteus treculi* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 327 (Mississippi R.).  
*Lepidosteus milberti* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 328 (New York).  
*Lepidosteus harlani* Dumeril, Hist. Nat. Poiss., **2**, 1870: 323-324, 329, Atlas, pl. 21, fig. I, I a, r b (Wabash R.).  
*Lepidosteus smithi* Dumeril, Hist. Nat. Poiss., **2**, 1870: 323-324, 330 (upper Mississippi R.).  
*Lepidosteus ayresii* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 331 (Wabash R.).  
*Lepidosteus copei* Dumeril, Hist. Nat. Poiss., **2**, 1870: 323-324, 332 (n. North America).  
*Lepidosteus lesueurii* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 335 (Wabash R.).  
*Lepidosteus elisabeth* Dumeril, Hist. Nat. Poiss., **2**, 1870: 323-324, 336 (no local).  
*Lepidosteus lamarii* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 337 (n. North America).  
*Lepidosteus dintonii* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 338 (no local).  
*Lepidosteus troostii* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 339 (U.S.A.).  
*Lepidosteus piquotianus* Dumeril, Hist. Nat. Poiss., **2**, **1870**: 323-324, 34.0 (Lake Erie).  
*Lepidosteus boratii* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 341 (n. North America).  
*Lepidosteus thornpsoni* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 342 (upper Mississippi R.).  
*Lepidosteus louisianensis* Dumeril, Hist. Nat. Poiss., **2**, 1870 : 323-324, 34.3, Atlas, pl. 22, fig. 3 (*New Orleans, Louisiana*).  
*Lepidosteus osseus* Gunther, Cat. Fish. Brit. Mus., **8**, **1870**: **330**.  
*Lepidosteus osseus* Jordan and Evermann, Bull. U.S. nat. Mus., **47** (**1**), 1896: **109**; Uhler and Lugger, Rep. Comm. Fish. Md., 1876: **154** (brackish water, Chesapeake Bay region); Smith, N.C. geol. econ. Surv., **2**, 1907: **59** (brackish and salt water, N. Carolina); Hildebrand and Schroeder, Bull. U.S. Bur. Fisher., **43**, 1928: **77** (Chesapeake Bay); Joseph and Yerger, Pap. oceanogr. Inst. Fla. St. Univ. Stud., **22**, 1956: **120** (brackish or salt water, Florida).

### Doubtful Synonyms:

- Lepisosteus stenorhynchus* Rafinesque, Amer. Mon. Mag., **3**, **1818**: 447; no description (Ohio, Wabash, Green rivers).  
*Sarchirus argenteus* Rafinesque, Ichthyol. Ohiensis, **1820**: **86** (Licking R., Slate Creek; brief descr. based on communication from Mr. Owings).

## *Lepisosteus plavrhincus* DeKay 1842

### Florida Gar, Florida Spotted Gar

#### Figure 17

**Study Material.** A total of 76 specimens, 187-516 mm TL; and type of *Cylindrosteus megalops* Fowler **1910**, 369.4 mm length, 419.0 mm TL, ANSP 25371 (in alcohol); from peninsular Florida, in TU, ANSP, and AMNH collections.

**Distinctive Characters.** Like *L. oculatus*, *L. platyrhincus* differs from *L. osseus* and *L. spatula* by the presence of numerous dark spots on the anterior part of its body and head, but it is distinguished from *L. oculatus* primarily by its lack of plates on the ventral surface of the isthmus, by its wider snout, and by the wider lower jaws.

**Description.** Proportional dimensions in per cent of length, based on **30** specimens, **157.0-416.0** mm length; from peninsular Florida.

**Body:** depth 10.5-14.3; width **9.2-12.0**.

**Caudal peduncle:** length **9.8-13.0**; least depth 5.7-7.5.

**Head:** mid-dorsal length 24.5-33.1;

length 27.4-36.2; depth 7.2-8.5; width 8.1-9.8.

**Snout:** length 15.8-22.5; least width 2.6-3.4; width 4.1-5.4.

*Orbit:* length 2.6-3.5.

*Interorbital:* least bony distance ~~5.0-5.9~~,

*Postorbital distance to:* bony margin 8.3-10.1; fleshy margin 9.5-11.5.

*Frontal bones:* least width 2.2-2.7.

*Lower jaws:* width 5.3-6.8; least width <sup>2</sup>.3-3.5.

*Mandible:* length 13.7-19.6.

*Dorsal fin:* depressed length 13.9-16.4.

*Anal fin:* depressed length 14.3-16.5.

*Caudal fin:* length ~~15.1-19.3~~.

*Pectoral fin:* length ~~8.8-11.8~~.

*Pelvic fin:* length 11.4-13.8.

*Distance from tip of snout to:* dorsal origin 81.0-88.5; pelvic insertion 52.6-61.3.

*Distance from pelvic insertion to:* anal origin ~~24.9-32.0~~; pectoral insertion 23.5-28.1; lateral line 4.5-7.5.

*Distance from dorsal origin to:* occiput 53.8-61.3; caudal base 14.2-16.3; lateral line 5.4-7.5.

*Distance from anal origin to:* caudal base 16.0-19.8.

Proportional dimensions in per cent of head length for 30 specimens, 157-416 mm length, with head lengths 61.5-118.3 mm.

*Snout:* length 57.3-62.3; least width 7.5-12.0.

*Orbit:* length 9.0-11.2.

*Interorbital:* least bony distance ~~15.5-21.0~~.

*Postorbital distance to:* bony margin ~~28.0-32.2~~.

*Lower jaws:* least width 6.3-12.6.

*Mandible:* length 49.3-54.8.

Proportional dimensions in per cent of snout length (sl) and mandible length (ml).

*Snout:* least width 4.8-8.2 in sl.

*Postsnout:* distance 1.3-1.6 in sl.

*Lower jaws:* least width 4.0-8.5 in ml.

Statistics of meristic characters: first number—number of specimens; second and third numbers—extremes in range of variation; fourth number—mean figure.

*Scales:* transverse rows between pelvic and dorsal origins 76, 30-33, 31.7; transverse rows 76, 21-25, 22.3; predorsal 76, ~~47-51~~, 48.6; lateral line 76, 54-59,

*Gill rakers:* 30, 19-33, 24.9.

*Fin rays:* dorsal 30, 7 or 8, 7.3; anal 30, 7 or 8, 7.6; caudal 30, 12 or 13, 12.7; pectoral on left 30, ~~9-11~~, 9.9 and on right 30, ~~9-11~~, 9.7; pelvic 30, all with 6 rays on both sides.

*Sexual Dimorphism.* As in the case of *L. oculatus*, sexual dimorphism is apparent in this species also, i. e. females attain a larger size and proportionally have a longer snout than males. In length of snout, the females of *platyrhincus* overlap the males of *oculatus*.

*Color.* General coloration on back darker than in *L. oculatus*; coloration and pattern on ventral surface highly variable, with specimens taken from the same place and at the same time exhibiting variation from immaculate to solid black. Many specimens

with a pattern of two or four or more dark stripes on ventral surface. Two other color phases also, a brown and an orange (Phillips, 53: 331).

Young, similar in coloration to color given for *L. oculatus* (pp. 73, 74).

*Size.* Kilby reported observations on specimens taken off Bayport, Florida, a mile from shore in the Gulf of Mexico (41: 91); and three specimens, 169, 445, and 495 mm, were collected from the coastal marsh near Bayport. Hammett and Hammett reported a maximum of 1,330 mm TL in a sample of 225 specimens (30: 197).

*Development.* In this species the development is probably similar to that in *L. oculatus* (p. 74).

*Habits.* The diet of this species in brackish and marine waters is unknown.

*Relation to Man.* Kilby reported that this species is a nuisance to fishermen (41: 191).

*Range.* *L. platyrhincus* ranges from the southern tip of peninsular Florida northward into the lowlands of Georgia. The paucity of records for salt water seems to indicate little tolerance of this species for saline conditions, but there may be a lack of collections from the areas of its occurrence.

Synonyms, with Reference to Occurrence in Salt Water:

*Lepisosteus platyrhincus* DeKay, Zool. N.Y., 1, 1842: 273, p. 43, fig. 137 (Florida); Kilby, Tulane Stud. Zool., 2 (8), 1955: 151 (salt water, off Florida).

*Cylindrosteus castelnaudi* Dumeril, Hist. Nat. Poiss., 2, 1870: 347-348, 355, Atlas, pl. 21, figs. 2, 2 a, 2 b. (Lake Lafayette, Florida).

*Cylindrosteus megalops* Fowler, Proc. Acad. nat. Sci. Philad., 62, 1910: 609, pl. 38, figs. 15, 16 (Bayport, Florida)

### *Lepisosteus spatula* Lacépède 1803

Alligator Gar

Figures 16, 18

*Study Material.* A total of 29 specimens: 28, 187-2,159 mm TL<sup>10</sup> (dry mounts or preserved in alcohol), from western Florida along the Gulf coast to Mexico; including the type of *Lepisosteus berlandieri* Girard 1858, from Matamoros, Tamaulipas, Mexico, USNM 003; 1, 49.5 mm length, 57.3 mm TL, from Hildebrandt Bayou near Port Acres, Jefferson County, Texas, TU 22288; all in TU, UMMZ, USNM, ANSP, AMNH, CNHM, and UT collections.

*Distinctive Characters.* *Lepisosteus spatula* is separable from *L. osseus* and *L. oculatus* by its large size and broad, short snout. The young of *spatula* are distinguishable from the young of *oculatus*, *osseus*, *platyrhincus*, and *platostomus* by the light dorsal stripe.

*Description.* Proportional dimensions in per cent of length, based on 25 specimens, 156.5-1,760.0 mm length; also the 49.5-mm specimen [with measurements enclosed in brackets].

<sup>10</sup> The largest specimen is now at Tulane University (TU Osteol. Coll. 360).

*Body:* depth 9.8-14.2 [12.5]; width 9.1-14.0 [9.0].

*Caudal peduncle:* length  $11.7-14.2$  [10.9]; least depth 5.8-7.5 [6.2].

*Head:* mid-dorsal length 21.5-32.4 [31.5]; length  $28.4-36.5$  [35.7]; depth 8.2-10.6 [9.4]; width 9. - 12.9

*Snout:* length 15.7-21.4 [19.5]; least width 3.9-5.1 [5.0]; width 5.3-6.7 [6.8].

*Orbit:* length 2.5-4.1 [5.6].

*Interorbital:* least bony distance 7.2-9.0 [7.2].

*Postorbital distance to:* bony margin 9.7-12.8 [10.5]; fleshy margin 10.5-12.8 [11.1].

*Frontal bones:* least width 3.7-4.4 [4.8].

*Lower jaws:* width 6.1-9.8 [7.8]; least width 4.5-5.5 [4.6].

*Mandible:* length 13.7-18.5 [15.9].

*Dorsal fin:* depressed length 13.4-18.4 [15.1].

*Anal fin:* depressed length 13.0-17.9

*Caudal fin:* length 13.6-19.0 [16.7]; filament

*Pectoral fin:* length 9.1-13.3 [5.0].

*Pelvic fin:* length 11.1-15.0 [8.0].

*Distance from tip of snout to:* dorsal origin 82.8-86.0 [82.0]; pelvic insertion 53.5-59.4 [56.7].

*Distance from pelvic insertion to:* anal origin 23.2-30.7 [25.2]; pectoral insertion 21.0-32.9 [21.4]; lateral line 5.3-8.2.

*Distance from dorsal origin to:* occiput 51.9-59.8 [50.9]; caudal base 14.5-17.5 [16.9]; lateral line 5.8-7.5.

*Distance from anal origin to:* caudal base 17.0-20.8 [18.1].

Proportional dimensions in per cent of head length for 27 specimens, 156.5-1,760.0 mm [49.5], including 2,159—specimen, TU Osteol. Coll. 360 (see [ftn. 10](#)), with head lengths 54.6-562.0 mm [17.7].

*Snout:* length 54.1-59.7 [54.7]; least width 13.0-15.3 [14.1].

*Orbit:* length 5.4-12.1 [15.8].

*Interorbital:* bony distance 23.0-30.5 [20.3].

*Postorbital distance to:* bony margin 28.6-36.5 [29.3].

*Lower jaws:* least width 13.5-19.2 [12.9].

*Mandible:* length 46.7-52.4 [44.6].

Proportional dimensions in per cent of snout length (sl) and mandible length (ml).

*Snout:* least width 3.7-4.5 [3.9] times in sl.

*Postsnout:* distance 1.2-1.5 [1.2] in sl.

*Lower jaws:* least width 2.7-3.8 times in ml.

Statistics of meristic characters: first number—number of specimens; second and third numbers—extremes in range of variation; fourth number—mean figure.

*Scales:* transverse rows between pelvic and dorsal origins 24, 34-38, 35.3; transverse rows 27, 23-32, 26.3;

pectoral 27, 49-54, 5.1; lateral line 27, 58-62, 60.3.

*Gill rakers:* total 20, 59-66, 62.7.



*Fin rays:* dorsal 22, 7-10, 7.7; anal 22, 7-10, 7.8; caudal 22, 12-14, 12.9; pectoral 22, 11-15, 12.7 on left and 2, 2, 8-16, 12.6 on right; pelvic 22, all with 6 rays except with 5 on left.

*Color.* In general, dark olivaceous brown above and white to yellowish beneath, but some nearly black dorsally; this coloration not unusual for specimens kept in aquariums. Two small specimens (156.5 and 170.5 mm length) dark brown except for light flesh-color on belly, breast, and throat regions. Skin between mandibles finely speckled with brown; numerous dark spots on sides—only below lateral line anteriorly, but above, below, and along lateral line on peduncle posteriorly. Rays of all fins dark brown, the dorsal, anal, and caudal having noticeably darker spots. Individuals of about 500 mm have few dark spots on sides, and then usually on peduncle; although only a few dark spots are present, there are numerous places where the groove between the scales is markedly darker than the surface of the scale; a few dark spots on dorsal, anal, and caudal fins; some large individuals from Lake Pontchartrain devoid of spots on fins as well as on body.

*Color of 49.5-mm specimen.* Light median dorsal stripe extending from tip of snout to origin of dorsal, and from posterior insertion of dorsal to upper base of caudal fin; this light stripe bordered on either side by a broad dark brown area extending about a third of the way down the sides and reaching to dorsal rim of orbit. Dark lateral band from anterior tip of mandible to anterior rim of orbit, thence posteriorly from posterior rim of orbit to base of caudal. Dark lateral band extending posteriorly along mandible from its anterior tip to anterior rim of orbit, and from posterior orbit to base of caudal; this dark band on body composed of close-set mottlings, forming irregular borders dorsally and ventrally. Venter light except for dark strip along inside of rami of lower jaws, thus leaving a light midventral band. All fins with dark brown blotches.

*Size.* The smallest Alligator Gar seen is the 49.5-mm specimen described above. The largest one on record, a female taken from Belle Island Lake, Vermilion Parish, Louisiana, was 9 feet 8.5 inches long and weighed 302 pounds; statistics on other large individuals are given by Gudger (26: 118-120), Weed (69: 5, 6), and Hussakof (34-2). During a recent biological survey of Lake Pontchartrain and adjoining brackish waters, 21 specimens, 410-1,472 mm TL, were collected. Additional specimens were taken from the Gulf of Mexico at Grand Isle, Jefferson Parish, Louisiana.

*Spawning and Development.* Practically nothing is known of the spawning and development of the Alligator Gar, but according to the unpublished writings of George Powers Dunbar (Wortman, 75: 385), it spawns during December and January. The egg is enveloped in gelatinous material, and the egg strands are draped on snags and vegetation; by the end of August the young fish has reached 14 inches in length. These notes by Dunbar need verification. [Recent observations prove the foregoing to be incorrect. The Alligator Gar spawns in April, May, and June in the Louisiana

11. The remains of several taken from the Gulf side of Breton Island as well as the head of a specimen (ca. 6 ft.) taken from the Gulf of Mexico at Destin, Florida, are in the Tulane University osteology collection.

area. The description of the eggs probably was of some amphibian, as suggested by Dr. Edward C. Raney (personal communication)].

The 49.5-mm specimen (see Description and Color above) has neither scales nor lateral line developed, the pelvics and pectorals are relatively much shorter than in older fish, and in the head region, the lower jaws, mandible, and interorbital dimension are relatively shorter while the orbit is much larger, as is common in the young of many species. In coloration it is distinguished by the light median stripe from the snout to the upper caudal except for its interruption by the dorsal.

Specimens 156.5 and 170.5 mm length have the caudal appendage but lack scales in the mid-dorsal region and on the midventral surface except for a partially developed anal plate. The rays of the pectoral as well as those of the other fins are fully developed.

Food and Feeding. *L. spatula* is credited with eating large numbers of game fishes in fresh water (Gudger, 26: 120), but little has been published about its diet in brackish and salt water. Raney reported that it ate ducks and water turkey (*Anhinga anhinga*) in Cuartez, Resaca, Texas (57: 50), and Gunter found mullet (*Mugil*) in the gut tract of 12 out of 24 specimens (27: 24). No other food items were mentioned by these authors. Those examined during the Lake Pontchartrain studies contained striped mullet (*Mugil cephalus*) and blue crabs (*Callinectes sapidus*).

Jordan (35: 313), Weed (69: 9), and Gunter (27: 24) have given evidence that the Alligator Gar is a scavenger.

Relation to Man. It is sold at present for human consumption in the French Market in New Orleans, and its scales were used by the Indians (Gowanloch, 24: 389-392) and by the late Mr. Percy Viosca in his jewelry industry. Many unauthenticated accounts of Gar attacks on humans have appeared in both popular and semipopular literature, but swimmers probably need have very little fear of them (24: 389-392; 26: 120, 12 i). With the recent development of underwater spear-fishing, all of the Gars are desirable targets. Gar fishing rodeos are common annual events in Louisiana.

Range. The Alligator Gar is a frequent invader of brackish and marine waters, and of the four species it is the most tolerant to higher salinities. It occurs in fresh water in the Mississippi River and lower parts of its major tributaries from the Ohio and Missouri rivers southward to the Gulf of Mexico, and in brackish and salt waters along the Gulf coast from Choctawhatchee Bay, Florida, to northern Mexico (26: 118-120; 69: 5, 6; 34: 2). Gunter recorded Alligator Gars from Copano Bay, Aransas Bay, and from a Gulf beach, Texas (27: 24), and Reid reported the capture of one from East Bay, Texas (60 [1956]: 302). Bailey, et al. gave catch records for the tidewater section of Escambia River, Florida (5: 117), and specimens frequently on display at the Gulfarium at Ft. Walton, Florida, are captured in Choctawhatchee Bay.

Synonyms, with References to Occurrence in Salt Water:

*Lepisosteus spatula* Lacépède, Hist. Nat. Poiss., 5, 1803: 333 (no local.); Bailey, Winn, and Smith, Proc. Acad. nat. Sci. Philad., 106, 1954: 117 (tidewater, Florida); Reid, Texas J. Sci., 1956: 302 (salt water, Texas).

*Lepisosteus ferox* Rafinesque, Ichthyol. Ohiensis, 1820: 73 (Ohio River).

*Lepisosteus berlandieri* Girard in Pacif. R. R. Surv., Fish., 10 (4), 1858: 353 (Tamaulipas, Mexico).

*Atractosteus lucius* Duméril, Hist. Nat. Poiss., 2, 1870: 360, 364 (Tampico, Mexico).

## TEXT AND FOOTNOTE REFERENCES

- I.** **AGASSIZ** (A.), Proc. Amer. Acad. Arts Sci., *13*, 1878; *14*, 1879.
2. Agassiz (L.), Poiss. Foss., **833-1843**.
3. Agassiz (L.), Amer. J. Sci., (**2**) *16*, 1853.
4. Agassiz (L.), Amer. J. Sci., (**2**) *17*, 1854.
  
- 5.** **BAILEY**, Winn, and Smith, Proc. Acad. nat. Sci. Philad., *106*, **1954**.
6. Balfour, Ganoidei (London), **188s**.
7. Balfour and Parker, Philos. Trans., *173*, 1883.
8. Berg, Class. Fish., Tray. Inst. zool. Acad. Sci. URSS., *5* (**2**), 1940; also reprinting by J. W. Edwards, Ann Arbor, Mich., 1947 (Russ. and Eng.).
9. Bleeker, Ned. Tijdschr. Dierk. Amst., *4*, **1873**.
- 10.** **Balk, et al.**, Handb. **Vergl.** Anat. Wirbelt., *4*, 1936.
- 11.** **Bonham**, Trans. Amer. Fish. Soc. (**1940**),
12. Bridge, Cambr. Nat. Hist. **I**, 1904.
  
13. **CATESBY**, Nat. Hist. Carolina, 1754.
14. Collinge, Quart. **J.** micr. Sci., N.S. **144** (36), 1894.  
Collinge, Proc. Bgham. nat. Hist. Soc., *8*, 1893.
- 16.** **Cope**, Trans. Amer. philos. Soc., *14*, 1871.
  
- 17.** **DUMRIL**, Hist. Nat. Poiss., *2*, **1870**.
  
18. **EARL** in Goode, *et al.*, Fish. Fisher. Industr. U.S., *2*, 1887.
19. **Eddy**, How to Know Freshw. Fish. (Iowa), 1957.
20. **Emelianov**, Zool. Jb., (Anat.) *60*, 1935.
21. **Eycleshymer**, Publ. Univ. Chicago, (Biol.) **10**, 1903.
  
- 22.** **FOWLER**, Proc. Acad. nat. Sci. Philid., *62*, **1910**.
  
- 23.** **GOODRICH**, Proc. zool. Soc. Lond., **1907**.
24. **Gowanloch**, Bull. La. Cons. Dep., *23*, **1933**.
25. **Grassé, et al.**, Trait. Zool., **13**, 1958.
26. **Gudger**, Nat. Hist., N.Y., **49**, **1942**.
27. **Gunter**, Publ. Inst. mar. Sci. Texas, **1** (**1**), **1945**.
28. **Gunther**, Cat. Fish. Brit. Mus., **8**, **1870**.
  
29. **HAMMARBERG**, Acta Zool., **18**, 1937.
30. **Hammett and Hammett**, Growth, **3** (**2**), 1939.
31. **Hardwicke**, Sci. Gossip, 1873.
32. **Hildebrand and Schroeder**, Bull. U.S. Bur. Fish., **43**, 1928.
33. **Hubbs and Lagler**, Invest. **Ind. Lakes... Streams**, **1943**.
34. **Hussakof**, Copeia, **1914**.
  
- 35.** **JORDAN**, Guide to Study Fish., 1905.
36. **Jordan**, Stanf. Univ. Publ. Biol., **3** (**2**), 1923.
37. **Jordan and Evermann**, Bull. U.S. nat. Mus., **47** (**1**), **1896**.
38. **Jordan, Evermann, and Clark**, Rep. U.S. Comm. Fish. (1928), **2**, **1930**.
39. **Joseph and Yerger**, Pap. oceanogr. Inst. Fla. St. Univ. Stud., *22*, 1956.
40. **KERR**, Proc. **Zool.** soc. Lond., 1952.
- 41.** **Kilby**, Tulane Stud. Zool., *2* (8), 1955.

42. **LANDACRE** and Conger, J. comp. Neurol., 23, 1913.
43. Lankester, Treat. Zool., 9, 1909.
44. Deleted.
45. **MARK**, Bull. Mus. comp. Zool. Harv., 19, 1890.
46. Matsubara, Fish. Morph. Hierarch., Pt. 1, 1955 (11).
47. Mayhew, J. Morph., 38, 1924.
48. Miller, Copeia, 3, 1954.
49. Muller, Abh. Akad. Wiss. Berl., Phys.-Math. Kl., 1844.
50. **NICKERSON**, Bull. Mus. comp. Zool. Harv., 24, 1893.
51. Norman, Synop. Orders, Families, Genera of Recent Fish. (mimeo), 1947.
52. **PFEIFFER**, J. Morph., 54, 1933.
53. Phillips, Copeia, 1958.
54. Potter, J. exp. Zool., 49 (1), 1957.
55. **RAFINESQUE**, Ichthyol. Ohiensis, 1820.
56. Rafinesque, J. Acad. nat. Sci. Philad., 1 (2), 1818.
57. Raney, Copeia, 1942.
58. Regan, Proc. zool. Soc. Lond., 1923.
59. Regan, Encyc. Britt., ed. 4, 9, 1937.
60. Reid, Texas. J. Sci., 7 (4), 1955; 8 (3), 1956.
61. Reissner, Arch. Anat. Phys., 1859.
62. Romer, Vert. Paleont., ed. 2, 1945.
63. **SCUPIN**, Arch. Naturgesch., 62 (1), 1896.
64. Smith, N. C. geol. econ. Surv., 2, 1907.
65. Das Tierreich (Berlin and Leipzig), 1936.
66. **UHLER** and **Lugger**, Rep. Comm. Fish. Md., 1876.
67. VERTEBRATES of U.S., 957.
68. **WAGNER**, Zool. Anz., 39, 1912.
69. Weed, Leaf. Field. Mus. nat. Hist., 5, 1923.
70. Wiedersheim, Zool. Jb., Suppl., 7, 1904.
71. Wilder, Amer. Ass. Adv. Sci., 24 B, 1876.
72. Wilder, Pop. Sci. Mon., 11, 1877.
73. Williamson, Philos. Trans., 139 (2), 1849.
74. Williamson, Philos. Trans., 141 (2), 1851.
75. Wortman, Amer. Nat., 16, 1882.
76. Wright, J. Anat., London, 19, 1885.