COHEN, G. M., AND C. D. FERMIN. 1978. Development of the embryonic chick's basilar papilla. Acta Otolaryngol. (Stockh.) 78:342-358.
FERMIN, C. D., AND G. M. COHEN. 1983. Prenatal ototoxicity of kanamycin in the chick: Damage to the basilar papilla. Acta Otolaryngol. (Stockh.), in press.
_____., J. C. PARK, AND G. M. COHEN. 1980. Pre-and post-natal ototoxicites of kanamycin and streptomycin in the chick. Third Midwinter Res. Meet. Assoc. Res. Otolaryngol. Abstracts. St. Petersburg Beach, Florida.
HIROKAWA, N. 1978. The ultrastructure of the basilar papilla of the chick. J. Comp. Neurol. 181:361-374.
JOLLIE, M. T. 1957. The head skeleton of the chicken and remarks on the anatomy of this region in other birds. J. Morphol. 100:389-436.
PARK, J. C., AND G. M. COHEN. 1982. Vestibular ototoxicity in the chick. I. Effects of streptomycin on equilibrium and on ampullary dark cells. Amer. J. Otolargnol. 3:117-127.
_____., B. CULLINEY, AND G. M. COHEN. 1982. Comparative actions of gentamicin and streptomycin in the chick. Fifth Midwinter Res. Meet. Assoc. Res. Otolaryngol. Abstracts. St. Petersburg Beach, Florida.
TAKASAKA, T., AND C. A. SMITH. 1971. The structure of the pigeon's basilar papilla. J. Ultrastruct. Res. 35:20-65.
TANAKA, K., AND C. A. SMITH. 1978. Structure of the chicken's inner ear: SEM and TEM study. Amer. J. Anat. 153:251-261.

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Biological Sciences

STATUS OF THE MOUNTAIN MULLET IN SOUTHERN FLORIDA

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ABSTRACT: *The mountain mullet* (Agonostomus monticola) *is a rare component of the Florida ichthyofauna. Until recently, records for the southern half of the peninsula were nearly nonexistent. We document and summarize the range, size distribution, and habitat occurrence of the mountain mullet in southern Florida. Florida populations are characterized by low numbers of small individuals that are probably recruited from the West Indies via surface ocean currents. Its rarity in southern Florida seems due to the absence of suitable freshwater stream habitats. Mountain mullet persistently occur in southern Florida in an artifically maintained stream with access to salt water. We collected 5 mountain mullet from this population, including the largest documented United States specimen. We also observed additional adult-sized mullet there. Based on current understanding of the life history of* A. monticola, *we discuss the possibility that Parrot Jungle may hold the first breeding population for the United States.*

THE mountain mullet *(Agonostomus monticola)* commonly occurs in high-gradient freshwater streams in the West Indies, Central America, and northern South America (Hildebrand, 1938; Gilbert, 1978). The larvae undergo a period of development in salt water before entering fresh water

and have been collected off the east coast of Florida (Anderson, 1957). Postlarval specimens have been collected only occasionally in the southeastern United States, mainly in Florida, Louisiana, and Texas. The northernmost record comes from the coast of North Carolina (Rohde, 1980). Although Carr and Goin (1955) and Briggs (1958) listed the Florida range of the mountain mullet as encompassing the entire state, the mountain mullet is considered to be rare (Gilbert, 1978), and no records existed for the southern half of the peninsula until recently. Previously, the southernmost published records from fresh water in Florida were from creeks in Volusia County on the Atlantic Coast (McLane, 1955) and from Pinellas County on the Gulf Coast (Suttkus, 1956). Recent records of mountain mullet from the Indian River region (Gilmore, 1977) and from Palm Beach County (J. N. Taylor, pers. comm.) have extended the known range southward along the east coast. The apparent lack of records and suitable habitat around the southern tip of the peninsula led Kushlan and Lodge (1974) to omit *A. monticola* from their list of southern Florida freshwater fishes. The mountain mullet has since been collected on several occasions in extreme southern Florida, once in a mangrove habitat in southern Everglades National Park by Tabb et al. (1974), in Black Creek (C-1) Canal (R. Metzer, pers. comm.), and twice from Miami by us. We describe the latter records, review the status of *A. monticola* in southern Florida, and discuss reasons for its scarcity there.

METHODS—We obtained data on mountain mullet through a series of observations beginning in 1977, and from collections made in 1981 and 1982. Observations made from trails that border the stream and pools were facilitated by clear, shallow waters. We collected specimens with a 30-m long seine (5.0-12.7 mm square mesh) and a backpack electrofishing unit that delivered 1.5 amps. We measured salinities at the times of collection with an optical refractometer. The fish were preserved in 10% formalin and later transferred to 70% ethanol. We measured the standard length of each specimen to 0.5 mm, used a dial caliper for all proportional measurements, and made fin and scale counts with a dissecting microscope. We also examined the stomach contents and gonads of the 1982 specimens. All fish have been deposited in the Florida State Museum, Gainesville, Florida.

To evaluate our collections, we corresponded with 15 researchers and curators from institutions suspected to house U.S. collections of mountain mullet. We asked for a listing of the numbers and lengths of U. S. specimens at each institution and also requested available information on the salinity and habitat of the collection locales. All of the information requests were answered.

RESULTS—We found mountain mullet at Parrot Jungle, a Miami tourist attraction, in an artificial stream and pool system fed by pumped ground water. This system empties into brackish water in Snapper Creek Canal (C-2). The artifically controlled head pressure of the stream seems to prevent saltwater intrustion from Snapper Creek Canal and preserves the freshwater character of the stream throughout the year. The only potential barrier to movement into the stream from saltwater via the canal is a large-mesh (2-3 cm square) culvert screen that permits passage of small fishes. Submerged aquatic vegetation in the stream is sparse because of shading by the dense tree canopy.

We had observed small mountain mullet in this stream several times

from 1977 through 1980. On 23 January 1981, we observed 3 *A. monticola* none of which appeared to exceed 80 mm TL. The fish initially eluded capture by taking cover in overhanging marginal vegetation, but we finally captured a single specimen which was photographed and preserved. The standard length was 63.0 mm, the fork length was 75.0 mm, and the weight was 6.09 g.

From 1977 to 1981, we never saw more than 5 mullet on any occasion in the stream. On 30 May 1982, we found that the numbers of mountain mullet had greatly increased. Three or 4 dozen fish were present, including 6 to 10 adults that were estimated to be from 150 to 250 mm in length. Most fish were juveniles or subadults that were swimming in groups in a large pool with moderate current. The fish often surfaced for sunflower seeds thrown into the water by visitors.

On 23 June 1982, we seined 4 specimens that ranged from 26.4 mm to 150.0 mm SL. Four larger specimens escaped by leaping over the leading edge of the seine. Dentition, meristic and morphometric measurements, and buccal characteristics of the specimens were compared with data reported by McLane (1955) and Anderson (1957). The measurements of the four 198 specimens are in Table 1. All specimens had ctenoid scales, conical teeth and no teeth on the lips. The premaxillary and maxillary bones extended below the posterior margin of the preorbital in all specimens, and the preorbital bones were wide with a distinctly serrated posterior margin. The dorsal fin count (IV, I-8), anal fin count (II,10), pectoral fin count (i,14 or i,15 and lateral scale count (39-41) of 4 of the specimens were identical to counts reported for other populations (McLane 1955; Gilbert 1978), but the fifth specimen had an anal fin count of II,9. The combination of counts, measurements, and characters clearly establishes the identity of the fish as *Agonostomus monticola*. The identification was confirmed by Carter R. Gilbert (pers. comm.).

TABLE 1. Proportional measurements of four *Agonostomus monticola* from Miami, Florida. All measurements are expressed in thousandths of the standard length.

Standard length (mm)	26.4	64.2	90.0	150.0
Head length	295	286	278	273
Snout length	83	73	71	71
Orbit length	102	84	70	63
Interorbital distance	125	120	98	97
Pectoral fin length	182	190	172	184
Pelvic fin length	159	184	158	171
Anal fin depressed length	227	224	206	201
First dorsal fin depressed length	159	174	154	161
Body greatest depth	265	294	292	270
Body greatest width	128	165	168	173
Caudal peduncle length	155	171	140	186
Caudal peduncle least depth	117	123	116	108
Dorsal fin origin to tip of snout	500	504	493	484
Anal fin origin to caudal base	227	319	294	311

Cohabiting fishes at the times of sampling included: *Amia calva*, *Lepisosteus platyrhincus*, *Anguilla rostrata*, *Notemigonus crysoleucas*, *Gambusia affinis*, *G. rhizophorae*, *Poecilia latipinna*, *Lepomis gulosus*, *L. macrochirus*, *Micropterus salmoides*, *Cichlasoma bimaculatum*, *Tilapia mariae*, *Dormitator maculatus*, and *Gobiomorus dormitor*. The crustaceans, *Callinectes sapidus* and *Macrobrachium acanthurus*, also occurred in the stream. All of the above species are also present in the adjacent Snapper Creek Canal system (Loftus and Kushlan, in press). We believe that the juvenile *Agonostomus monticola* entered the Parrot Jungle system naturally from the Atlantic Ocean via Biscayne Bay and Snapper Creek Canal. The presence of *Anguilla rostrata*, *Gobiomorus dormitor*, *Dormitator maculatus*, and *Macrobrachium acanthurus*, all of which enter fresh water as juveniles, supports our belief. Mr. Nat DeLeon, manager of Parrot Jungle, assured us that mountain mullet had never been introduced there.

We examined the stomach contents and reproductive state of the four 1982 specimens. The 150.0-mm-SL fish was a mature male with large, smooth, creamy white testes. Its intestinal tract was 120 mm long, 80% of its standard length, and contained 2 coleopteran larvae, portions of sunflower seed husks, vascular detritus, and a small quantity of algae. The 90.0-mm-SL specimen appeared to be an unripe or immature male. The stomach contained a volvocaceous alga and coenagrionid naiad remains. The 64.0-mm-SL fish was a juvenile. Its stomach contained two dipteran pupae and an ostracod. The internal organs of these 3 fish were surrounded by ample fat deposits. The stomach of the smallest individual (26.4 mm SL) was filled by several dozen palaemonid shrimp larvae.

Discussion—The collections from Parrot Jungle extend the Florida Freshwater range of *A. monticola* well to the south of previously published accounts (Anderson, 1957; Gilbert, 1978) and establish its continued presence in extreme southern Florida. Correspondence with researchers and with museum curators has revealed that approximately 100 freshwater specimens of mountain mullet have been taken in the continental United States, most from Florida, and nearly all represented unpublished records. All but 3 of the specimens were < 100 mm SL. The 3 largest specimens were 102 mm SL and 104 mm SL (McLane 1955), and 116 mm SL (Gilbert 1978). Our 150.0-mm-SL specimen is the largest we know of from the United States. The smallest Parrot Jungle fish, 26.4 mm SL, is the second smallest freshwater record we know of from the United States, and is within the size range at which juveniles first enter fresh water (Anderson, 1957). The smallest U.S. record for mountain mullet in fresh water (24.3 mm SL) was recently taken in Brevard Co., Florida (R. G. Gilmore, pers. comm.).

The preponderance of small specimens in United States collections is puzzling because this species often exceeds 200 mm TL elsewhere in its range (Erdman 1972). To account for the small size of U.S. specimens, Gilbert (1978) proposed that *A. monticola* either does not live very long in the north-

ern portion of its range or grows slowly because it does not feed to maximum capacity there throughout the year. Erdman (1972) has presented evidence that *A. monticola* is a slow-growing species even in tropical areas. Gilbert's (1978) explanations for the small size of U.S. specimens suggest that individuals may not survive long enough in northern water to reach sexual maturity and may account for the absence of large specimens in previous collections from the continental U.S. The absence of adults in collections could also be an artifact of collecting (Pezold and Edwards, 1983), considering the well-known difficulty of capturing any specimen of mountain mullet (McLane, 1955; Darnell, 1962). However, because of the number of smaller specimens in collections and the lack of published sight records for adults, we feel that the apparent scarcity of adults in U.S. waters is real.

Throughout its range, the mountain mullet is principally found in lotic, but not necessarily torrential, freshwater habitats (Hildebrand, 1938; Darnell, 1962; Caldwell, 1966; Erdman, 1972). Adults appear to be restricted to fresh water, and juveniles have only rarely been taken outside of fresh water (Erdman, 1972; Pezold and Edwards, 1983). Meek and Hildebrand (1916) collected specimens in brackish water in Panama, but did not report their number or sizes. The vast majority of U.S. specimens have been taken in flowing fresh water, either in natural streams or below dam spillways and canal structures. Only occasionally have fish been collected in lacustrine situations (McLane, 1955; Erdman, pers. comm.). We attribute the paucity of southern Florida records for *A. monticola* to the absence of suitable stream habitat there. Southern Florida has vast areas of freshwater, but the habitats are primarily swamps and marshes, not streams. Nearly all natural rivers and creeks along the southeastern coast of Florida have been channelized, and access to them from the sea has often been blocked by salinity-control structures. Natural rivers along the southwestern coast are low-gradient streams that are subject to wide seasonal fluctuations in salinity. Such conditions may not be suitable for *A. monticola*, based upon its habitat occurrence elsewhere in its range. Despite several fish surveys in rivers along the southwest coast (Odum, 1971; Tabb and Manning, 1961; Loftus and Kushlan, in press), we have found only two other collection records from extreme southern Florida (R. Metzger, pers. comm.; Tabb et al. 1974). We believe that the artificial stream and pool system at Parrot Jungle must approximate the preferred habitat of the mullet better than other available aquatic habitats in southern Florida. The number and size distribution of the Parrot Jungle population indicate that conditions there are favorable for survival and persistence.

In view of Anderson's (1957) collections of juveniles in the Gulf Stream off Florida and the absence of spawning records for *A. monticola* in the United States, we agree with him that recruitment from southern regions, probably Cuba, provides the source for mountain mullet occurring along the Gulf and Atlantic Coasts of North America. Recent studies of currents in the northern Caribbean Sea have shown that passive dispersal from the Antilles

to southern Florida via surface currents is likely (Metcalf et al. 1977; Duncan et al. 1977). The directions and speed of the major currents would allow time for larval development (Anderson, 1957) and would deliver the larvae to southern Florida. The apparently short-term, non-breeding populations of *A. monticola* in Florida are probably sustained by a supply of recruits that falls out along the Atlantic Coast and moves into freshwater. That recruitment is available to the Parrot Jungle populations is supported by the collection of juveniles nearby in Biscayne Bay (C. R. Robins, pers. comm.).

The presence of large mountain mullet at Parrot Jungle presents the possibility of this being the first reproducing population for the U.S. Male mountain mullet in Puerto Rico can mature at 83.0 mm SL, although ripe females seem to be considerably larger (Corujo-Flores, 1980; Erdman, pers. comm.). Certainly the sizes of the fish at Parrot Jungle and the gonadal state of the 150.0-mm-SL male show that adults were present.

The method of reproduction of *A. monticola* remains unclear. Several authors have considered it to be catadromous, with the adults moving out of freshwater streams to spawn at sea (Anderson, 1957; Gilbert, 1978). At Tortuguero, Coasta Rica, Gilbert and Kelso (1970) collected only juveniles in the estuaries and found adults only in mountain streams. They concluded that *A. monticola* was catadromous, but they presented the alternative possibility that spawning occurs in fresh water with the eggs being washed out to sea. Support for this latter reproductive mechanism, termed amphidromous (Myers, 1949; McDowall, 1968), is provided by the work of Erdman (1972) and Corujo-Flores (1980). C. R. Robins (pers. comm.) also discounts catadromy for this species, and has observed probable spawning behavior of *A. monticola* in Puerto Rican streams. Limited in-stream spawning movements by adults into the lower reaches of the rivers may occur, but ripe adults have always taken in fresh water (Corujo-Flores 1980). Because only larvae and juveniles have been collected at sea and out-migrations of adults from fresh water have never been reported, it seems most likely to us that spawning occurs in the freshwater streams, followed by passive transport of the eggs or larvae to salt water.

This reproductive tactic is employed by other species that inhabit mountain streams in tropical areas (e.g., prawns, *Macrobrachium* spp., and the Puerto Rican goby, *Sicydium plumieri;* Erdman 1972, 1976). These animals commonly occur with mountain mullet in the upper reaches of mountain streams in Puerto Rico (Loftus, pers. observ.). The spawning period for these species coincides with the wet season when the greater volume and velocity of the rivers carry the eggs or larvae into salt water (Erdman, 1972).

The recent increase in the number of mountain mullet at Parrot Jungle could be due either to increased recruitment from sources outside of Florida, or to indigenous reproduction by the Parrot Jungle fish. The question of whether this population is self-sustaining is presently unanswerable. We do not know if the artificial stream system provides suitable spawning conditions, nor do we know if the larvae could successfully undergo development

in local marine habitats. However, because adult-sized fish are present and are presumably capable of reproduction, the possibility exists. Its inability to establish permanent breeding populations elsewhere in the United States points to the ultimate unsuitability, either physical or biological, of most available habitats for this species.

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LITERATURE CITED

ANDERSON, W. W. 1957. Larval forms of the freshwater mullet (*Agonostomus monticola*) from the open ocean off the Bahamas and South Atlantic Coast of the United States. Fishery Bull. 57:415-425.

BRIGGS, J. C. 1958. A list of Florida fishes and their distribution. Bull. Florida State Mus. 2:223-318.

CALDWELL, D. K. 1966. Marine and freshwater fishes of Jamaica. Bull. Inst. Jamaica, Sci. Ser. No. 17, Kingston.

CARR, A., AND C. J. GOIN. 1955. Guide to the Reptiles, Amphibians, and Freshwater Fishes of Florida. Univ. of Florida Press, Gainesville.

CORUJO-FLORES, I. 1980. A study of fish populations in the Espiritu Santo River estuary. M.S. thesis, Univ. of Puerto Rico, Rio Piedras.

DARNELL, R. M. 1962. Fishes of the Rio Tamesi and related coastal lagoons in east-central Mexico. Publ. Inst. Mar. Sci., Univ. Texas. 8:299-365.

DUNCAN, C. P., D. K. ATWOOD, J. R. DUNCAN, AND P. N. FROELICH. 1977. Drift bottle returns from the Caribbean. Bull. Mar. Sci. 27:580-591.

ERDMAN, D. S. 1972. Inland game fishes of Puerto Rico. Puerto Rico Dept. of Agricul. Publ. 4:1-96.

_____. 1976. Spawning patterns of fishes from the northeastern Caribbean. Puerto Rico Dept. of Agriculture, Comm. Fish Lab., Agricul. and Fish Contrib. 8:1-36.

GILBERT, C. R. 1978. Mountain mullet. Pp. 39-40. *In:* Gilbert, C. R. (ed.). Rare and Endangered Biota of Florida–Fishes. Vol. 4. Univ. Presses of Florida, Gainesville.

_____, AND D. P. KELSO. 1971. Fishes of the Tortuguero area, Caribbean Costa Rica. Bull. Florida State Mus., Biol. Sci. 16:1-54.

GILMORE, R. G., JR. 1977. Fishes of the Indian River lagoon and adjacent waters, Florida Bull. Florida State Mus. 22:101-148.

HILDEBRAND, S. F. 1938. A new catalogue of the freshwater fishes of Panama. Zoo. Ser., Field Mus. Nat. Hist. 12.

KUSHLAN, J. A., AND T. E. LODGE. 1974. Ecological and distributional notes on the freshwater fish of southern Florida. Florida Sci. 37:110-128.

LOFTUS, W. F., AND J. A. KUSHLAN. In press. Freshwater fishes of southern Florida. Bull. Florida State Mus., Biol. Sci.

MCDOWALL, R. M. 1968. The application of the terms anadromous and catadromous to the southern hemisphere salmonid fishes. Copeia. 1968:176-178.

MCLANE, W. M. 1955. The fishes of the St. John's River system. Ph.D. dissert., Univ. of Florida, Gainesville.

MEEK, S. E., AND S. F. HILDEBRAND. 1916. The fishes of the fresh waters of Panama. Field Mus. Nat. Hist. Pulb. 191, X(15):217-374.

METCALF, W. G., M. C. STALCUP, AND D. K. ATWOOD. 1977. Mona passage drift bottle study. Bull. Mar. Sci. 27:586-591.

MYERS, G. S. 1949. Usage of anadromous, catadromous, and allied terms for migratory fishes. Copeia. 1949:89-96.

ODUM, W. E. 1971. Pathways of energy flow in south Florida estuary. Univ. Miami Sea Grant Tech. Bull. 7:1-162.

PEZOLD, F. L., AND R. J. EDWARDS. 1983. Additions to the Texas marine ichthyofauna, with notes on the Rio Grande estuary. Southwestern Nat. 28:102-105.

ROHDE, R. C. 1980. *Agonostomus monticola* (Bancroft), mountain mullet. P. 778. *In:* Lee, D. S., et al. (eds.). Atlas of North American Freshwater Fishes. North Carolina State Mus. Nat. Hist., Raleigh, North Carolina.

SUTTKUS, R. D. 1956. First record of the mountain mullet, *Agonostomus monticola* (Bancroft), in Louisiana. Proc. Louisiana Acad. Sci. 19:43-46.

TABB, D. C., AND R. B. MANNING. 1961. A checklist of the flora and fauna of northern Florida Bay and adjacent brackish waters of the Florida mainland, collected during the period July, 1957 through September, 1960. Bull. Mar. Sci. Gulf and Carib. 11:552-649.

———, B. DRUMMOND, AND N. KENNY. 1974. Coastal marshes of southern Florida as habitat for fishes and effects of changes in water supply on these habitats. Final Rept. to Bur. Sport Fish. and Wildlife (Contract No. 14-16-0004-56). Rosenstiel School of Mar. and Atmospheric Sci., Univ. of Miami.

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ESTABLISHMENT OF THE MIDAS CICHLID, *CICHLASOMA CITRINELLUM, IN FLORIDA*

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ABSTRACT: *The Midas cichlid,* Cichlasoma citrinellum, *is a polychromatic fish native to Nicaragua and Costa Rica whose color morphs range from cryptic gray to bright orange. In 1981 an established population of the Midas cichlid was discovered in a south Florida canal that contains 6 other species of established exotic fishes. Preliminary food habit studies indicate Midas cichlids in Florida feed on molluscs and other benthic material. A mean lower lethal temperature of 13° C was determined experimentally indicating range expansion in Florida may be limited to the area south of Tampa (approximately latitude 28°N). This species brings the total number of established exotic fishes in Florida to 16, of which 11 belong to the family Cichlidae.*

THE Midas cichlid, *Cichlasoma citrinellum* (Fig. 1), is a polychromatic fish native to the Atlantic slope of Nicaragua including the Great Lakes basin south to Costa Rica (Miller, 1966). In 1981 an established population of Midas cichlids was discovered in the Black Creek Canal located in southeastern Dade County, Florida. Single specimens of the Midas cichlid were first collected in the Black Creek Canal during July and December 1980 at localities 3 km apart. These were presumed to be releases from aquaria as no other specimens were observed or collected until May 1981 when several hundred Midas cichlids were seen. Adults measuring 146-217 mm SL (standard length) were collected along with 15 mm SL fry in June 1981.