GEORGE H. BURGESS

SURVEY OF INTRODUCED NON-NATIVE FISHES

Phase I Report

INTRODUCED EXOTIC FISHES IN NORTH AMERICA:

STATUS 1979

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INTRODUCTION

U.S. Fish and Wildlife Service Contract 14-16-0009-78-021, Survey of Introduced Non-Native Fishes, is divided into two phases. Phase I is designed to result in a status report of the established exotic fishes in North America.

Early in Phase I, it was recognized that two established exotic fishes, namely the carp (*Cyprinus carpio*) and the brown trout (*Salmo trutta*), would present many problems in attempting to trace their complete histories of introduction; such attempts, we felt, would detract from our efforts to secure necessary documentation on lesser known exotic fishes. Therefore, while the carp and the brown trout appear in our lists of established species for the respective families, Cyprinidae and Salmonidae, individual species accounts are not included in this report. Much of the available information on the carp and the brown trout, prepared by other authors, will be summarized in species accounts in the Atlas of North American Freshwater Fishes.

This report is the final report for Phase I of U.S. Fish and Wildlife Service Contract 14-16-0009-78-021. The Results section is divided into two parts: one on the established (reproducing) species, arranged by families and with individual species accounts, both in alphabetical order; and an annotated list of the non-established (formerly reproducing or non-reproducing) species.

We anticipate that much, if not most, of the contents of this report will be published within the near future. More importantly, we hope that the information contained in this report will serve as the document on our knowledge of the status of introduced exotic fishes as of the middle of 1979.

Because of the nature of this topic, this report must not be interpreted as being complete. As noted earlier in this section, the carp and the brown trout are not treated in individual species accounts. Also, all records of findings of exotic fishes in North America are unavailable; for example, some persons may have found a given species at one or more localities but never reported it to anyone or to any agency. Therefore, we would hope that the present report and all publications that may result from it will stimulate readers to document findings of exotic fishes and report such findings to the National Fishery Research Laboratory, U.S. Fish and Wildlife Service, University of Florida, Gainesville, FL 32611. Without such input, an effective and highly important monitoring system of introductions cannot be developed properly.

As this project was underway, we realized that we would have to exceed the project description and requirements as stated in the proposal and the contract to provide the results that we believe are necessary. We have attempted to do so but not to the extent that we would have preferred.

METHODS

Lachner et al. (1970) attempted to summarize the exotic fishes known to be established in North America. Later, in the period 1970-72, Dingell-Johnson Project F-28 (Florida) revealed that there were far more species of exotic fishes established in Florida than was suggested previously (Courtenay et al., 1974). In June 1977, Courtenay prepared mimeographed lists of established and non-established exotic fishes in North America; these lists, which are preliminary, served as the nuclei for the development of the present project.

In late 1977 and throughout much of 1978-79, Courtenay and Hensley wrote to a series of ichthyologists, fishery biologists, and state agency officials to obtain information on the status of exotic fishes in their states. At times, these efforts resulted in a "mini-chain letter" situation. Hensley joined the project at the end of July 1978 and subsequently began an in-depth literature survey on introduced fishes that turned up new records, taxonomic problems, and reasons for sending out more letters to experts. This has resulted, we feel, in the most comprehensive survey ever made on the status of introduced fishes of foreign origin in the United States. In addition, field studies in Florida undertaken under Phase II of this project added greatly to what is contained in this report.

In summary, our methods were of the survey type, employing literature reviews, exchanges of letters (and, in several instances, telephone communication) with knowledgeable persons, and, in Florida, field studies. An acknowledgments section is included in this report to thank the numerous individuals who provided much of the information that made this report possible.

RESULTS

This portion of the report, as noted earlier, is divided into two sections: established species with individual species accounts, and an annotated list of non-established species. We record at least 35, perhaps 36, species of exotic fishes as established in North America, exclusive of the states of Alaska and Hawaii and at least 49 species of non-established fishes of foreign origin as having been found in North America; the term "at least" is used purposefully because, among the established and non-established genera, more than one as-yet-unidentified species are involved.

In both sections, the family and species accounts are presented in alphabetical, rather than phylogenetic, order. Drawings of specimens and distribution maps are included for many but not all of the established species.

ESTABLISHED SPECIES

This section deals with those species that are known to have reproducing populations in continental North America.

To facilitate the use of this report, we have indexed each family. The index tab is on the page listing the established species for that family. The species are listed with a five-letter family code and each has an alphabetical suffix. Each page of a species entry is numbered in sequence following the family code and species suffix. For example, *Cichlasoma meeki* is the fourth entry for the family Cichlidae; its family code is CICHL and its suffix is D; therefore, all pages numbered for CICHL-D are part of the entry for *Cichlasoma meeki* .

In summary, the family index page lists all established (reproducing) species and provides the family code and species suffix for each, along with abbreviations for the states and provinces in which each species is established.

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Gobiidae - gobies [GOBII]
Loricariidae - armored catfishes [LORIC]
Oryziatidae - medakas [ORYZI]
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BELONTIIDAE

Gouramis

Trichopsis vittatus	[BELON-A]	FL

Order Perciformes
Family Belontiidae

Trichopsis vittatus (Kuhl and van Hasselt)

Croaking gourami

Original description citation: Kuhl and van Hasselt in Cuvier and Valenciennes, 1831. Histoire naturelle des poissons, 7, p. 387.

Type locality: Java.

Native range: Java, Borneo, Sumatra, Malaya, Indo-China, and Thailand (Smith, 1945).

U.S. range: One established population of T. vittatus is found in a canal in Delray Beach, Palm Beach County, Florida. Although no juveniles of this species have been collected, many adults have been collected and those brought back to the laboratory readily spawn at water temperatures lower than those at the collecting locality (James Pestrak, personal communication).

Sources of introduction: Introduction of this species was probably due to releases by home aquarists.

Life history: T. vittatus appears to be at least partially insectivorous.

In its native range T. vittatus abounds in small weedy streams,

often in the company of Betta species (Smith, 1945). Within the canal in Delray Beach, Florida, it is always closely associated with vegetation and is often difficult to collect (Paul Shafland, personal communication).

T. vittatus is a bubble-nest builder. At spawning the male builds a nest of bubbles covered by a mucous secretion from the mouth. When the eggs are shed and fertilized, the parents (usually the male) gather the eggs and place them in the nest. The male defends the nest and eggs. Hatching occurs in ca. 36 hours. Nest building activity is reported to require a temperature of at least 22°C (Breder and Rosen, 1966; Sterba, 1966; Goldstein, 1971).

This species can live in waters with low oxygen content due to aerial respiration by means of an accessory respiratory (labyrinth) organ.

Environmental impress: No information is available on the environmental impress of T. vittatus.

Status: Established in a canal in Delray Beach, Palm Beach County, Florida.

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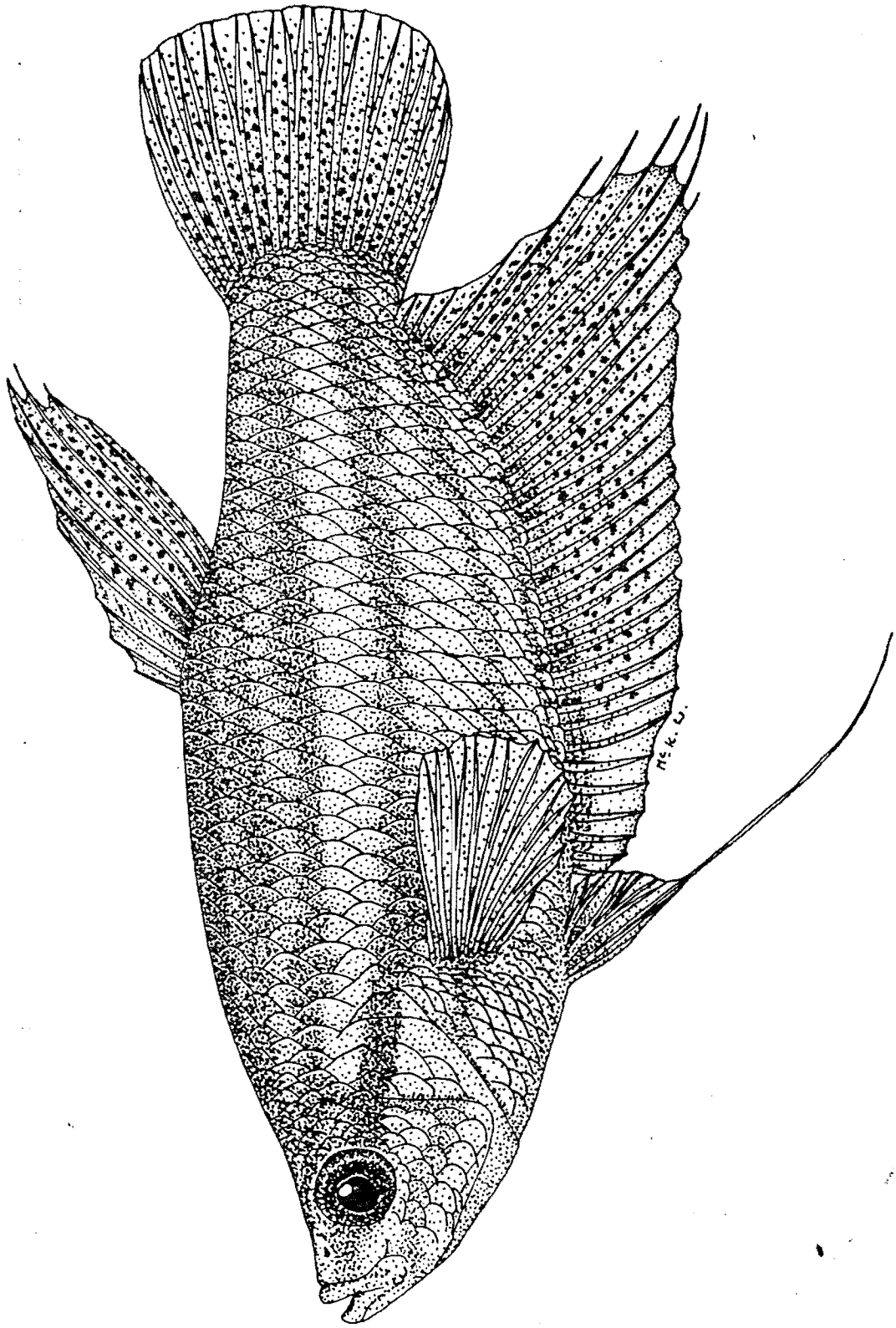
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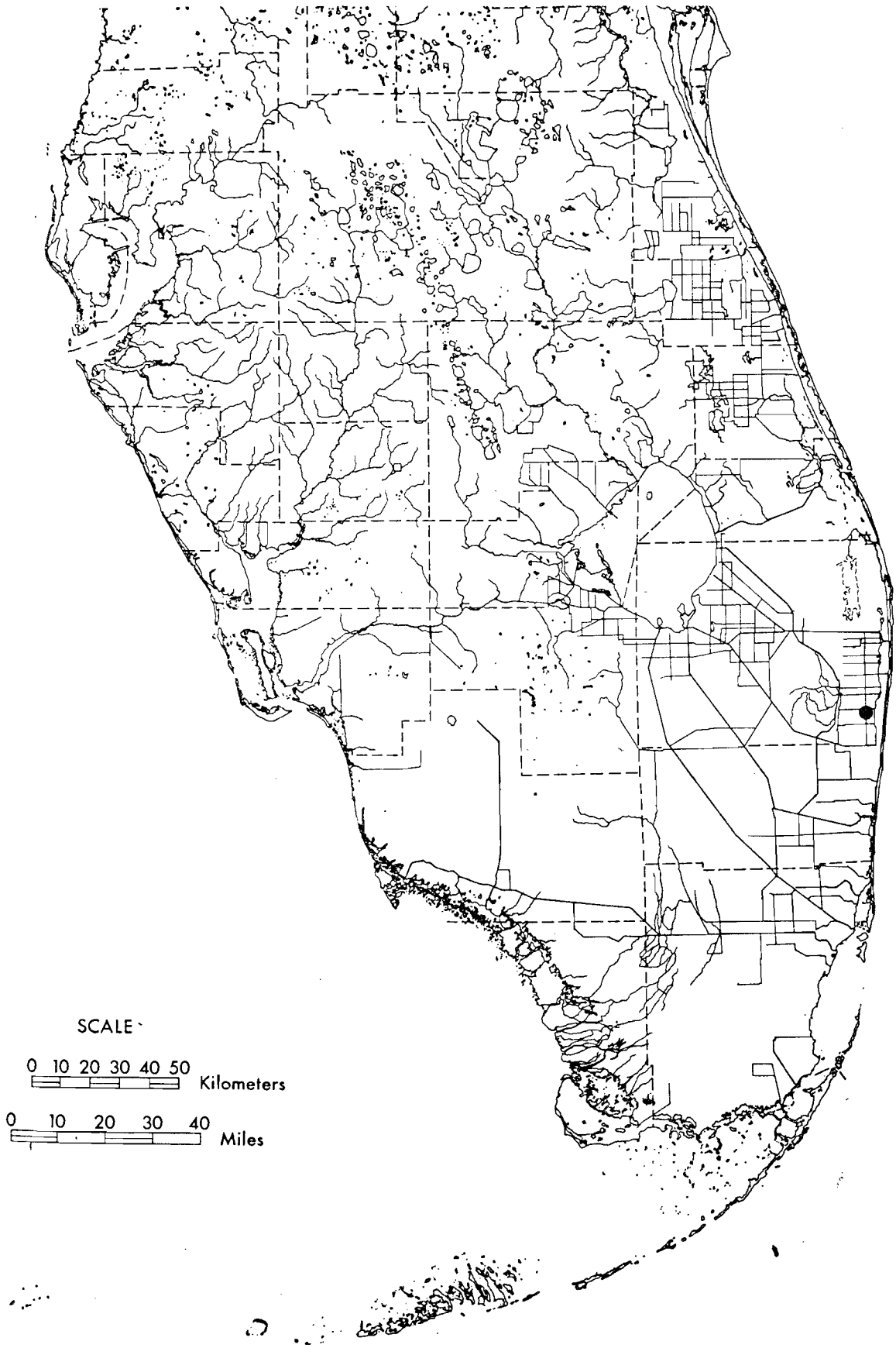
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Compiled by: Dannie A. Hensley




SCALE
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Kilometers
0 10 20 30 40
Miles

CICHLIDAE
Cichlids

Astronotus ocellatus	[CICHL-A]	FL
Cichlasoma bimaculatum	[CICHL-B]	FL
Cichlasoma cyanoguttatum	[CICHL-C]	FL
Cichlasoma meeki	[CICHL-D]	FL
Cichlasoma nigrofasciatum	[CICHL-E]	NV; Alb.; possibly AZ
Cichlasoma octofasciatum	[CICHL-F]	FL
Cichlasoma severum	[CICHL-G]	possibly NV
Hemichromis bimaculatus	[CICHL-H]	FL
Tilapia aurea	[CICHL-I]	AZ, FL, TX, possibly GA
Tilapia mariae	[CICHL-J]	FL
Tilapia melanotheron	[CICHL-K]	FL
Tilapia mossambica	[CICHL-L]	AZ, CA, FL, NC, TX; possibly GA
Tilapia zillii	[CICHL-M]	CA; possibly AZ

Order Perciformes
Family Cichlidae

Astronotus ocellatus (Cuvier)

Oscar

Original description citation: Cuvier in Spix and Agassiz, 1831. Selecta genera et species piscium quos in itinere par Brasiliam ..., p. 129, pl. LXVIII.

Type locality: Atlantic Ocean; erroneous, probably Brazil.

Native range: Venezuela, Guyana, Surinam, French Guiana, Amazonia, Peru, and Paraguay (Ringuelet et al., 1967).

U.S. range: A. ocellatus is established in Dade, Broward, and Palm Beach counties, Florida (Courtenay et al., 1974; Hogg, 1976, 1976a; Frank Morello, personal communication; personal observation).

Specimens are occasionally collected in Pennsylvania (Clark Shiffer, personal communication); the species is not established in this state.

Sources of introduction: The species was deliberately released from a fish farm in southeastern Dade County in the late 1950s. During the same period, attempts were made to popularize the species as a sport fish under the name "velvet cichlid."

Introductions to other sites were made by local fishermen (Courtenay et al., 1974).

Specimens collected in Pennsylvania were released by local aquarists.

Life history: Although A. ocellatus is a popular aquarium fish, little is known about its biology within its native range. The aquarium literature implies that it has carnivorous tendencies (Innes, 1955; Goldstein, 1973). It is known to take both natural and artificial baits and is frequently caught by anglers (Courtenay et al., 1974). From the population in Dade County, Hogg (1976a) recorded the following classes of food items: insect parts, fishes, larval amphibians, seeds, fish scales, molluscan shell fragments, chironomid larvae, coleopterans, Cichlasoma bimaculatum fry, oligochaetes, bryozoans, fish eggs, and vascular plant fiber. Although some plant material was present, in a trophic gradient from herbivore to carnivore, Hogg found A. ocellatus to be a carnivore. Among animal material insect parts, fishes, fish scales, and amphibians were the most important components.

In South America, Astronotus spp. are principally caught by local fishermen in rivers and small lateral lakes (Lowe-McConnell, 1975). Hogg (1976a) found in Dade County that A. ocellatus does not maintain territories on low-cover shallow areas as do the other cichlids established there (i.e.,

Cichlasoma spp., Tilapia spp., and Hemichromis bimaculatus); it is usually seen in deeper areas under ledges or near logs or weedy areas. It is most commonly caught by angling near brushy spots. In addition, Hogg often observed individuals at the surface under overhanging banks; this behavior is likely correlated with feeding on insects and seeds.

Most information on reproduction in A. ocellatus has come from aquarium observations. However, Sawaya and Maranhão (1946; fide Breder and Rosen, 1966) have described spawning behavior of this species in natural ponds in Brazil as similar to that observed in aquaria. A. ocellatus spawns in the manner typical of most American cichlids. As spawning time approaches, the parents clean an area of hard substrate on which eggs will be deposited and dig several pits in softer substrate nearby. Based on the number of ripe ova in females, estimates of the number of eggs laid range from 961 to 3452. Eggs are gray-yellow and about the size of millet seed. After they are deposited and fertilized, the eggs are guarded and fanned by the parents until hatching. The fry hatch in three or four days and are moved to the previously dug sand pits and guarded. When the young become free swimming, the parents continue to guard them and keep them in a group until they reach a considerable size. This behavior gradually breaks down and the young disperse (Innes, 1955; Breder and Rosen, 1966; Lowe-McConnell, 1975). In canals in Dade County, Hogg (1976a) observed that parents usually guard the young until they are

ca. 30 mm in length (total length?), but that smaller individuals are often seen in shallow water in the absence of parents. He also found the mean brood size to be ca. 235.

A. ocellatus apparently does not spawn at temperatures below 26-28°C (Breder and Rosen, 1966). In Venezuelan savanna waters, it begins to spawn at the start of the rainy season, which extends from May to November (Lowe-McConnell, 1975). In Dade County, Hogg (1976a) found spawning to occur from June to October. He observed spawning at daily maximum temperatures of 28 and 33°C.

In aquaria, A. ocellatus is reported to reach sexual maturity at 100-120 mm in length (probably total length; Sterba, 1966).

Environmental impress: Virtually no information is available on the environmental impress of A. ocellatus in Florida. However, there are two noteworthy observations concerning its status and distribution. One is that its range has expanded considerably since its release in southeastern Dade County in the late 1950s. It is now established as far north as the West Palm Beach Canal, Palm Beach County. To what extent this spread has been due to additional introductions by fishermen, however, is unknown. Secondly, even in southeastern Dade County, population densities of this species are low (Hogg, 1976a; personal observation). This is in marked contrast to most or the other cichlid species established in that county. In his stomach analyses, Hogg (1976a) found A.

ocellatus occupying a comparatively narrow, carnivorous trophic level. Other cichlids for which he had sufficient data were much more omnivorous than A. ocellatus, except for the markedly herbivorous Tilapia mariae. One possible explanation for the low population densities of A. ocellatus may be that it is in competition with centrarchids for food. In this regard, the food habits of centrarchids in Florida should be studied to ascertain the possibility of trophic competition with A. ocellatus and other exotic fishes.

One concern with the establishment of cichlids in North America is the possibility that they will compete with centrarchids for shallow-water spawning areas. In the canal systems of southeastern Florida, such areas are a limited resource. However, in Dade County Hogg (1976a) noted that A. ocellatus, in contrast to the other established cichlids, does not maintain territories in shallow areas, but is more often seen in deeper water under ledges or near logs or weedy areas. Thus, at least on a comparative basis, A. ocellatus probably poses less of a competitive threat to centrarchids for this resource than the other established cichlids.

Status: Established in Dade, Broward, and Palm Beach counties, Florida; has been collected in Pennsylvania but is not established.

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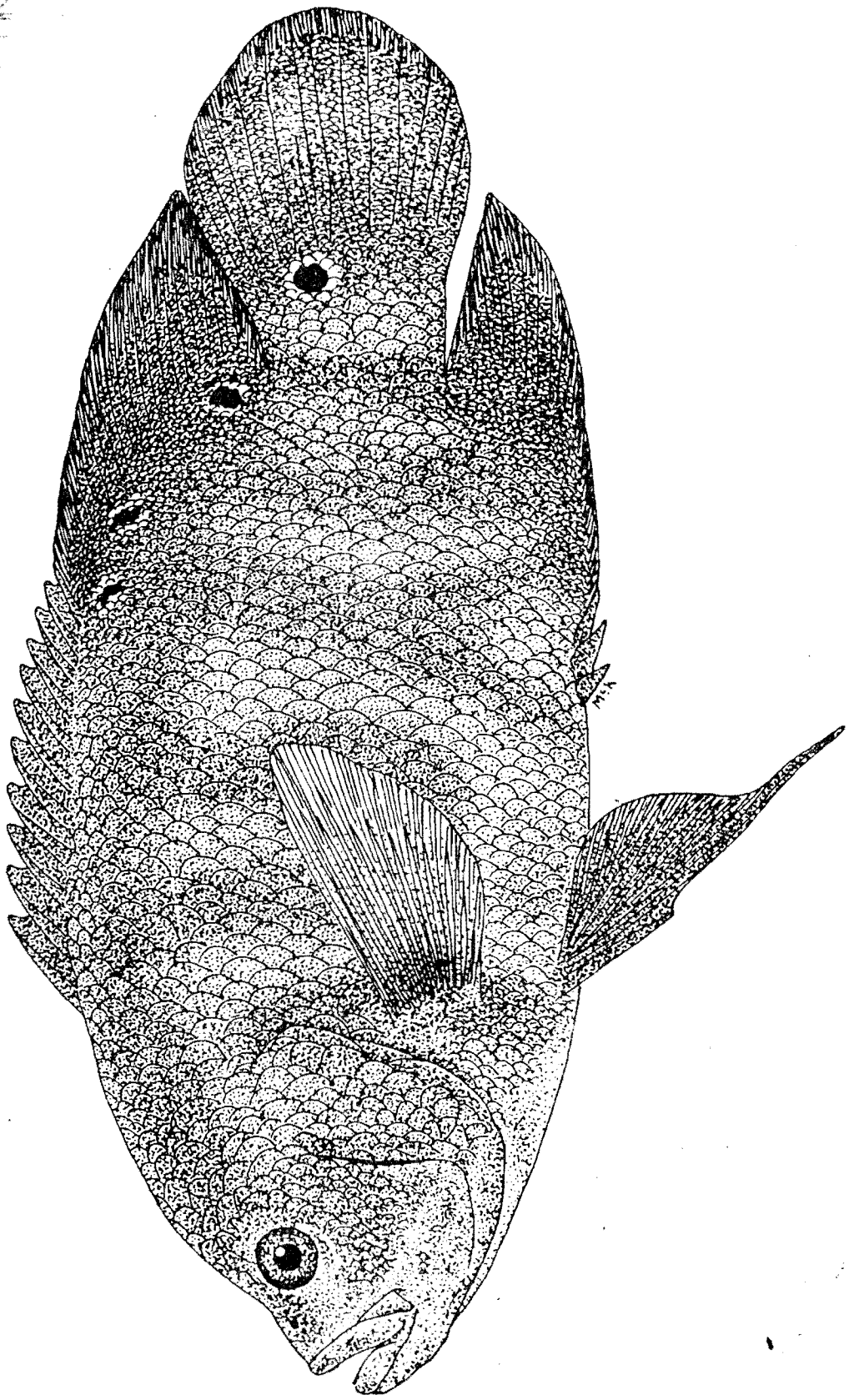
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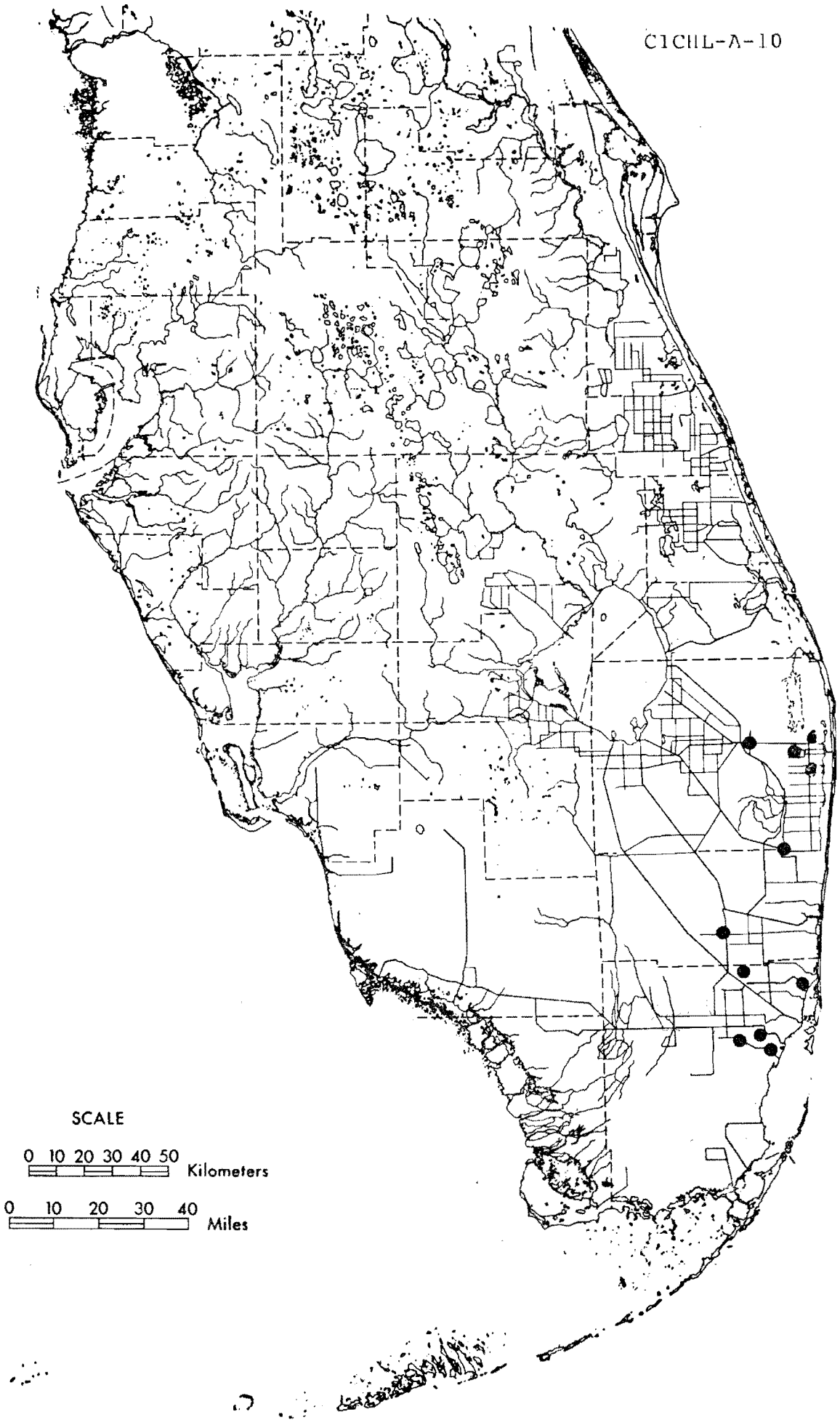
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Sterba, Günther. 1966. Freshwater fishes of the world. Pet Library, Ltd., N.Y. 877 pp.

Compiled by: Dannie A. Hensley

Addendum: A. ocellatus was recently reported as having been collected from Congamond Pond, Southwick, Hamden County, Massachusetts (Halliwell, 1979. Massachusetts fish list. Fauna of Mass., Ser. 4, 13 pp.), Maine (Anonymous, 1979. Lateral line. Newsletter of the North American Native Fish Assn.), and Rhode Island (William Krueger, personal communication). All of these introductions were probably due to reseases of aquarium fish.




SCALE
0 10 20 30 40 50
Kilometers
0 10 20 30 40
Miles

Order Perciformes
Family Cichlidae

Cichlasoma bimaculatum (Linnaeus)

Black acara

Original description citation: Linnaeus, 1758. Systema naturae, Vol. I, p. 285.

Type locality: Mediterranean Sea; erroneous, probably Brazil.

Native range: Brazil, Surinam, Guyana, French Guiana, southern and eastern Venezuela, and Trinidad (Regan, 1905).

U.S. range: C. bimaculatum is established in Dade, Broward, Palm Beach, Monroe, Collier, and Hendry counties, Florida (Rivas, 1965; Lachner et al., 1970; Kushlan, 1972; Courtenay et al., 1974; Hogg, 1976, 1976a; personal observation).

Sources of introduction: The introduction of C. bimaculatum was due to escapes and intentional releases from fish farms in southeastern Florida, probably during the mid to late 1950s (Walter Courtenay, personal communication).

Life history: C. bimaculatum was classified an "insect feeder" by Lowe-McConnell (1964). However, in a later paper (Lowe-McConnell, 1969) she reports the following food items from 101 specimens collected in Georgetown, Guyana: mollusc shells, palaemonid shrimps, insects, fish scales and bones, vegetable

debris, filamentous green algae, and seeds. She states that most full stomachs contained several of these catagories and concludes that C. bimaculatum is an omnivore. Marlier (1968; fide Lowe-McConnell, 1975) in a study of the trophic ecology of fishes in a floodplain lagoon near Manaus, Brazil, found C. bimaculatum feeding on filamentous algae and higher plants and catagorized it as a stenophagous (i.e., feeding only on plant material), non-specialist (i.e., feeding on both algae and higher plants), herbivore. The inconsistencies in these reports probably result from C. bimaculatum being an opportunistic omnivore for which food habits depend upon food availability (resulting from geographic locality, time of year, water quality, etc.) and competition. Hogg (1976a) had sufficient data to characterize the food habits of five cichlids established in Dade County. Of these, the greatest diversity of food types was recorded from C. bimaculatum. He recorded the following classes of food from this species: filamentous green and blue-green algae, vascular plant fiber, chironomid larvae, fish scales, insect parts, molluscan shell fragments, cladocerans, bryozoans, crayfish exoskeletons, fishes, oligochaetes, hirudineans, amphipods, fish eggs, sand, hymenopterans, copepods, amphibian larvae, bone fragments, dipterans, Platyhelminthes, anisopterans, ephemeropterans, trichopterans, amphibian eggs, and seeds. Filamentous green and blue-green algae and vascular plant fibers were dominant by weight and frequency of occurrence, but chironomid larvae and fish scales were also important

components. It is probable that the frequency of occurrence of fish scales in these stomachs was due to nipping during aggressive encounters rather than any form of scale-eating behavior. The presence of several benthic forms is probably related to substrate sifting behavior which Hogg observed in this species. On a quantitative basis Hogg found C. bimaculatum to be an omnivore with plant material being slightly more important than animal material in the diet. His size range of specimens examined was sufficient for him to detect ontogenetic shifts in feeding. In fish less than or equal to 139 mm TL filamentous algae and vascular plant fiber were less important, while chironomid larvae and fish scales were more important in the diet than in larger fish. In addition, these smaller fish were found to be more omnivorous than those larger than 319 mm TL, which were more herbivorous. Hogg observed immature (probably ca. 10-80 mm TL) C. bimaculatum traveling in schools grazing on Aufwuchs. These fish are particularly aggressive toward spawning centrarchids and cichlids, and if spawning sites are abandoned momentarily these schools move in and eat the eggs from the substrate. Hogg's data on feeding periodicity are highly variable but seem to indicate a tendency toward more feeding activity in afternoon hours.

In South America C. bimaculatum has been recorded from savanna ponds, river pools, floodplain lakes, and man-made trenches (Eigenmann, 1912; Lowe-McConnell, 1964, 1969, 1975). Lowe-McConnell (1969) found this species to be one of the commonest

cichlids in fresh waters of the coastal plain and Rupununi savanna district of Guyana. It was the most abundant cichlid in collections made in the system of man-made trenches in Georgetown, Guyana, by Eigenmann (1912) and Lowe-McConnell (1969). C. bimaculatum is very well adapted to tolerate poor environmental conditions (i.e., low oxygen levels, desiccation, and crowding). Lowe-McConnell (1964, 1969) suspects that C. bimaculatum may have the stomach modified to form an accessory respiratory organ. She has noted that specimens in Guyana fish markets remain alive out of water for a considerable length of time. She found that the stomach is highly vascularized and usually contains air. Such an adaptation would be most useful in South America at the end of dry seasons, when oxygen levels are low and there is often intense crowding in isolated pools. Food is scarce during this time and an empty stomach may facilitate its use for aerial respiration. However, Lowe-McConnell's hypothesis needs experimental verification. Within its range in Florida, C. bimaculatum is abundant in all shallow areas of canals, being found over sand, silt, matted organic material, and horizontal and vertical rock surfaces (Hogg, 1976a; personal observation). Hogg (1976a) found this species to be especially tolerant of canal habitats with low oxygen concentrations. Although it has been established in Dade County for ca. 20 years, C. bimaculatum has not been able to colonize canals in the southern part of the county. In salinity tolerance tests 60% seawater was fatal to gradually acclimated individuals. It is possibly a low salinity tolerance that has prevented

C. bimaculatum from becoming established in these more southern areas (Hogg, 1976).

C. bimaculatum spawns in the manner typical of most American cichlids (Breder and Rosen, 1966). At the start of the spawning period, pits are dug in soft substrate by use of the mouth and head. These pits will later be used to contain the fry. Both parents clean an area of substrate in shallow water where eggs will be deposited. This substrate is usually a smooth flat surface on rocks, leaves, plant stems or roots. In Florida the pits are usually made in protected cavities or narrow gorges near the outer edges of the shallow shelves along canal banks, usually at a depth of ca. 1 m. Areas cleaned for egg deposition are often in water no more than 10 cm deep (Hogg, 1976a). A 120 mm SL female is reported to be able to lay up to 700 eggs per spawning (Lowe-McConnell, 1969). Hogg (1976a) recorded a range of 280-494 ($\bar{X}$ = 450) eggs laid per spawning in the Florida population. After fertilization the parents guard and aerate the eggs until hatching. In substrate-spawning cichlids the usual method of egg aeration involves fanning them with the paired fins. However, Hogg (1976a) observed an interesting variation of this behavior. Some individuals were observed to lay eggs on dead leaves, but instead of fanning them, a parent would pick up the leaf by mouth and swim forward, backward, and in circles. After hatching, the fry are moved to one of the previously dug pits. In Florida

Hogg (1976a) found the brood size to vary from 200 to 450 ($\bar{x}$ = 340) fry. The parents continue to guard the young and keep them in a group until they are ca. 10 mm in length (TL?). Larger juveniles continue to travel in schools unattended by parents (Hogg, 1976a). In Guyana juveniles grow to 30-70 mm SL in the first four or five months (Lowe-McConnell, 1964, 1969).

Near Georgetown, Guyana, Lowe-McConnell (1969) collected ripe female C. bimaculatum in every month of the year except December (no collections were made) and February (some individuals were ripening). Thus, spawning in this species does not appear to be well correlated with the onset of the rainy season. In Florida it spawns throughout the year with peaks of activity in spring and fall. Eggs and larvae have been observed in Dade County canals when water temperatures were as low as 19-20°C (Hogg, 1976a).

Lowe-McConnell (1969) found that female C. bimaculatum mature at 70 mm SL but was unable to determine the maturation size of males.

Environmental impress: In ca. 20 years C. bimaculatum has expanded its range to include seven counties. At many localities within this range it is the dominant fish. In 1970-72 Courtenay et al. (1974) found this species in 24 of 44 collections made in southeastern Florida, and in 16 of these it comprised 5% or more of the total fish biomass. In four collections C. bimaculatum accounted for 30% or more of the fish biomass. In some

collections from Broward County they found that 64-80% of the fish biomass was comprised of this species. In two collections made in Dade County in 1975 by Hogg (1976a), C. bimaculatum ranked first in percent by weight (26.8-30.6%) and second and third in percent by number (16.3-27.4%).

Cichlids and centrarchids have many similarities in structure and habit (Jordan and Evermann, 1898; Breder and Rosen, 1966), and an obvious concern with the establishment of any cichlid in North America is the possibility of it competing with native centrarchids. This is especially true when the cichlid has become as abundant and widely distributed as C. bimaculatum in southeastern Florida. Both centrarchids and cichlids use shallow-water spawning areas, a limited resource in the canal systems of southeastern Florida. Hogg (1976a) found C. bimaculatum and Lepomis macrochirus occurring together in these shallow-water areas during spawning; competition here is possible.

Although Hogg (1976a) found fish eggs to be of minor importance in the stomach contents of C. bimaculatum in Dade County, he has observed spawning L. macrochirus surrounded by aggressive bands of juvenile C. bimaculatum which would move in and search the L. macrochirus nests for eggs if they were left unattended.

Most collections containing C. bimaculatum were made from the canals of southeastern Florida, and the species is generally

considered to be primarily confined to these areas and absent from marsh and swamp habitats. However, it was recorded from an alligator pond in Big Cypress Swamp, Monroe County (Kushlan, 1972), where it is reported to be increasing in abundance (Hogg, 1976a). It is possible that C. bimaculatum regularly disperses across marshes and swamps. The fact that it is so rarely found outside of canals may be due to a lack of adequate sampling in these other habitats. Its known occurrence at one locality in Big Cypress Swamp and the possibility that it may be more commonly found in marshes and swamps than we are aware are causes for concern that the species may be or become established in the Everglades National Park.

It is interesting to note that Eigenmann (1912) and Lowe-McConnell (1969) found C. bimaculatum to be the most abundant cichlid in the man-made canals in Georgetown, Guyana. From these authors' descriptions of these canals they appear to be similar to those of southern Florida. The success of C. bimaculatum in these disturbed habitats is probably due to its tolerance of poor environmental conditions, and it omnivorous food habits. A prediction of its success and ecology in Florida could have been made from existing literature.

Since the introduction and establishment of Tilapia mariae, probably in 1973 or 1974, a shift in dominance appears to be occurring between this species and C. bimaculatum in the canals of Dade County (Courtenay and Hensley, 1979). In collections

made there in 1970-72 and 1974-75, C. bimaculatum was the most abundant cichlid (Courtenay, et al., 1974; Hogg, 1976, 1976a). However, collections made in 1978 showed T. mariae to be more important than C. bimaculatum in terms of percent biomass and numbers at most localities in Dade County (Table 1)*. It is possible that these species are competitors in these canals for food and spawning sites. Although Hogg (1976a) found C. bimaculatum to be more omnivorous than T. mariae in Dade County, both species feed predominately on filamentous algae. Both species spawn in the shallow-water habitat of canals, and observations indicate direct competition between these species for this resource (Hogg, 1974; Courtenay and Hensley, 1979).

Status: Established in Dade, Broward, Palm Beach, Monroe, Collier, and Hendry counties, Florida.

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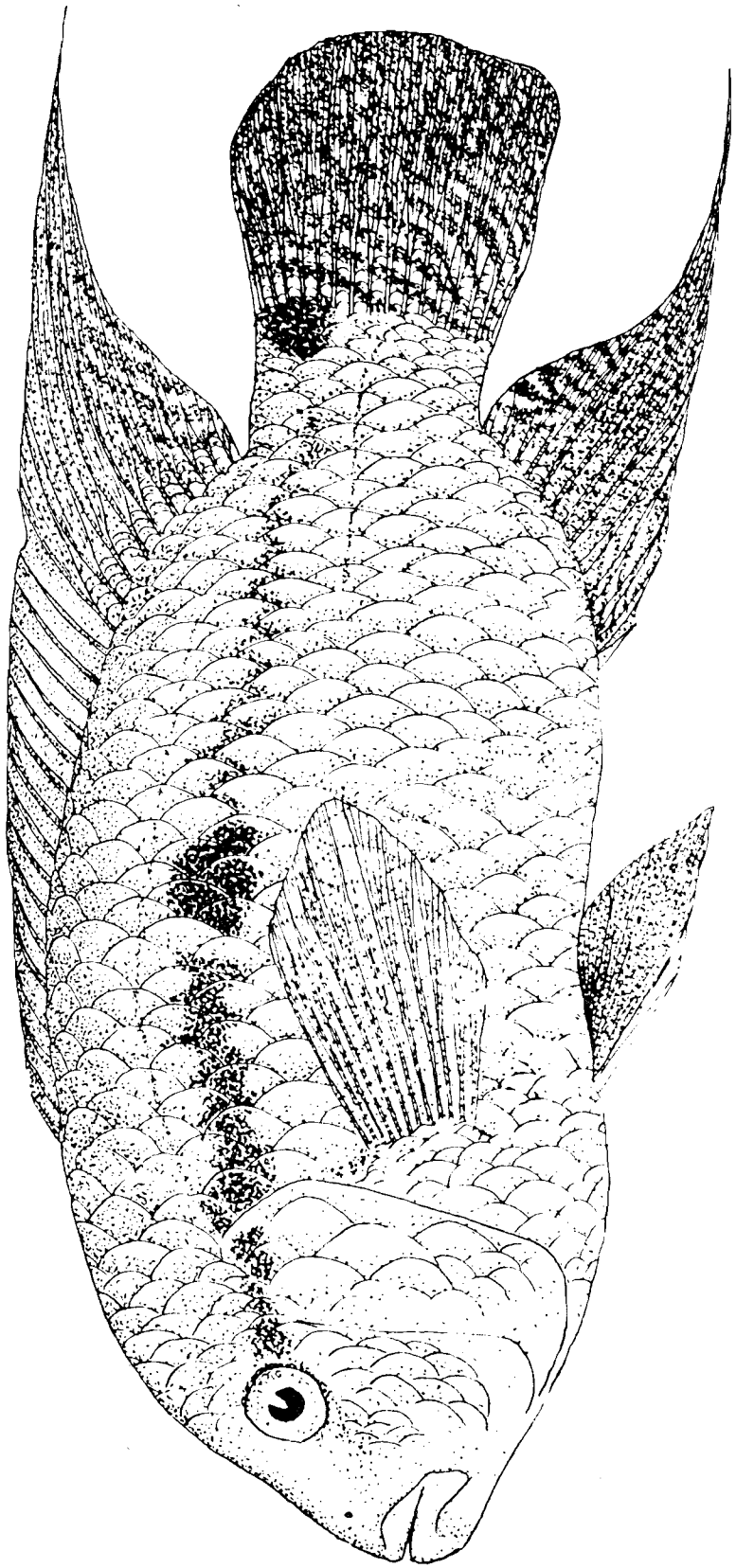
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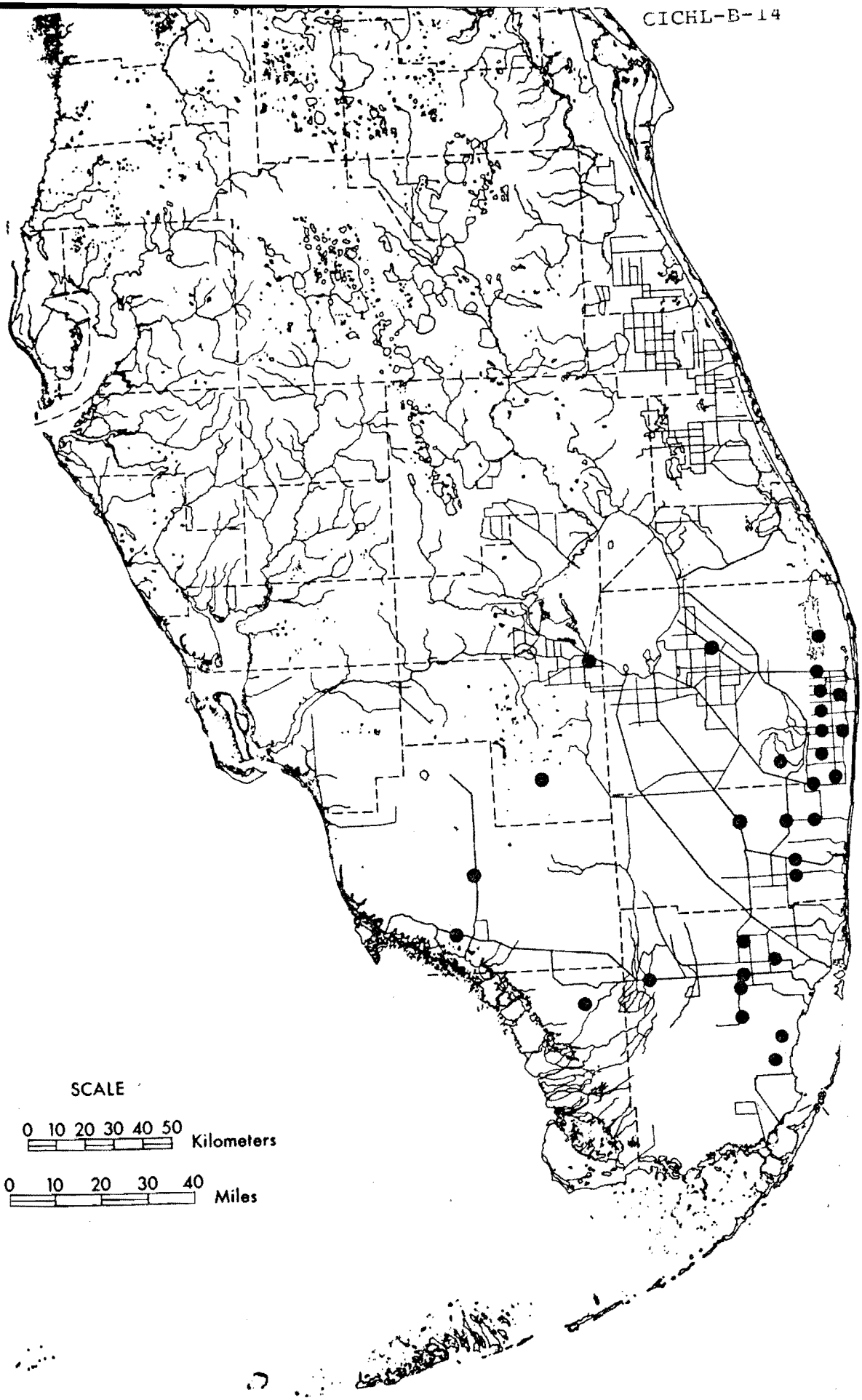
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Compiled by: Dannie A. Hensley




SCALE
0 10 20 30 40 50 Kilometers
0 10 20 30 40 Miles

Order Perciformes
Family Cichlidae

Cichlasoma cyanoguttatum (Baird and Girard)

Rio Grande cichlid

Original description citation: Baird and Girard, 1856. Descriptions of new species of fishes collected in Texas, New Mexico and Sonora, by Mr. John H. Clark, on the U.S. and Mexican Boundary Survey, and in Texas by Capt. Stewart Van Vliet, U.S.A. Proc. Acad. Nat. Sci. Philadelphia, 1854, pp. 25-26.

Type locality: Brownsville, Texas.

Native range: Lower Rio Grande River southward to the Rio Panuco-Tamesi drainage in eastern Mexico (Brown, 1953; Darnell, 1962; Knapp, 1953).

U.S. range: As indicated above. Introduced and established in the Colorado, San Antonio, San Marcos, Guadalupe and Comal rivers in the Edwards Plateau region of Texas (Brown, 1953). Also introduced and established in three counties of Florida: Hillsborough County (Six Mile Creek), Pinellas County (Lake Seminole), and Polk County (phosphate pit in Mulberry). Also reported from Six Mile Creek, Hillsborough County, by Burgess (1958). Reports of this species in Hillsborough County at

Gibsonton, Riverview, and Ruskin by Buntz and Chapman (1970) were based on misidentifications of Cichlasoma octofasciatum (Courtenay et al., 1974).

Sources of introduction: The Rio Grande cichlid was brought to the Guadalupe River basin by the Fish Cultural Station, U.S. Fish and Wildlife Service, at San Marcos, Texas, in 1928 and released into waters on the Edwards Plateau between 1928 and 1941 or 1943 (Brown, 1953).

According to Freddy H. Langford of the Florida Game and Fresh Water Fish Commission (personal communication), the Rio Grande cichlid was first introduced into Florida from Texas stocks about 1941 by a private individual from Mulberry, Polk County. The same individual is reported as having made additional introductions at Mulberry over a period of several years. The source of the introduction at Lake Seminole, Pinellas County, is unknown. A fish farm may have been the source of introduction to Six Mile Creek, Hillsborough County, as this species was cultured as an aquarium fish during the 1940s and early 1950s under the trade name of "Texas bluespot."

Life history: This species is omnivorous (Barlow, 1974; Darnell, 1962). Darnell (1962) reports vegetation (vascular plant matter, filamentous fungi and algae, and occasional benthic diatoms), invertebrates (insect larvae, caterpillars, beetles, water mites, cladocera, and protozoans), detritus,

fish eggs, and fishes in the stomach and associated bursa in Rio Grande cichlids collected in Mexico. Sage and Sélander (1975) found polymorphic populations in the Cuatro Cienegas region of Mexico that fed on snails, others that fed on arthropods, others that fed on algae and detritus, and still others that were piscivorous.

Rio Grande cichlids are ready to spawn in late May in the Rio Tamesi area of Mexico (Darnell, 1962). In the San Marcos River of Texas, spawning occurs from March to August with a peak in April (Buchannan, 1971). The spawning season in Florida is unknown. The species is monogamous with a 1:1 sex ratio and pairs breed more than once per season (Buchannan, 1971). Fontaine (1938) reports between 250 to 300 eggs released by the female with development to hatching in 26 hours at 28.9°C, in 30 hours at 26.7°C, and in 60 hours at 23.9°C. The young remain in a nest hole dug for them for from 24 to 30 hours with the parents alternating in care of the eggs.

In Mexico, this species thrives in shallow lake-like conditions, streams, pools, and backwaters of rivers; juveniles prefer "shallow weedy backwaters" (Darnell, 1962). The Rio Grande cichlid is gregarious and is tolerant of brackish waters.

Hubbs (1951) found the minimum temperature tolerance for this species in the Colorado River at Austin, Texas, to be between 14.2 and 19°C but probably closer to 14.2°C.

Older adults of this species develop a frontal gibbosity (Goldstein, 1970). Average adult size is 80-120 mm SL (Birkhead, in press).

Environmental impress: The environmental impress of the Rio Grande cichlids on native fishes in Florida is unknown. Based on data concerning reproductive periods in Texas and Mexico, we assume that this species has the potential to build large populations in comparison to those of native fishes. Nevertheless, Buchannan (1971) indicates that in the San Marcos River in central Texas, Rio Grande cichlids are not dominant and are almost exclusively herbivorous; he further speculates that this feeding behavior is in response to competition from centrarchids. Goldstein (1970) indicates that Rio Grande cichlids spawn in deeper water and thus do not compete for spawning space with centrarchids.

Darnell (1963) found C. cyanoguttatum in Mexico represented at less than five percent of total fishes collected, except in brackish water where it comprised 36.1 percent of the 45 species collected near Tampico. We found this species to comprise 30.86 percent of the total weight and 33.4 percent of 19 species collected in Six Mile Creek, Hillsborough County; centrarchids taken in this collection comprised seven species representing 34.57 percent of the total weight and 45.72 percent of the total number of fishes collected.

Status: Introduced and established as a transplant in rivers on the Edwards Plateau of central Texas and in waters of three counties of west-central peninsular Florida.

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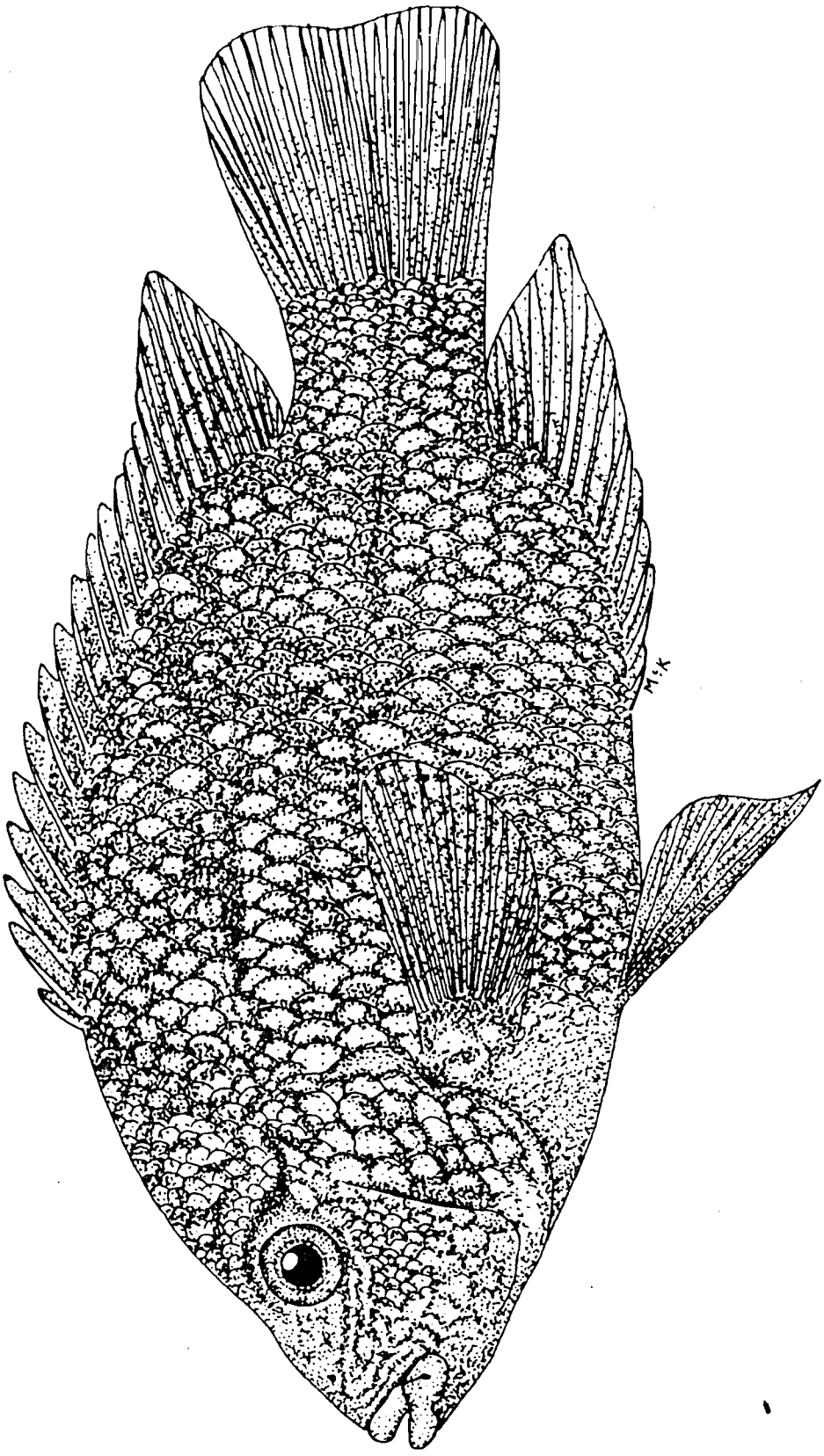
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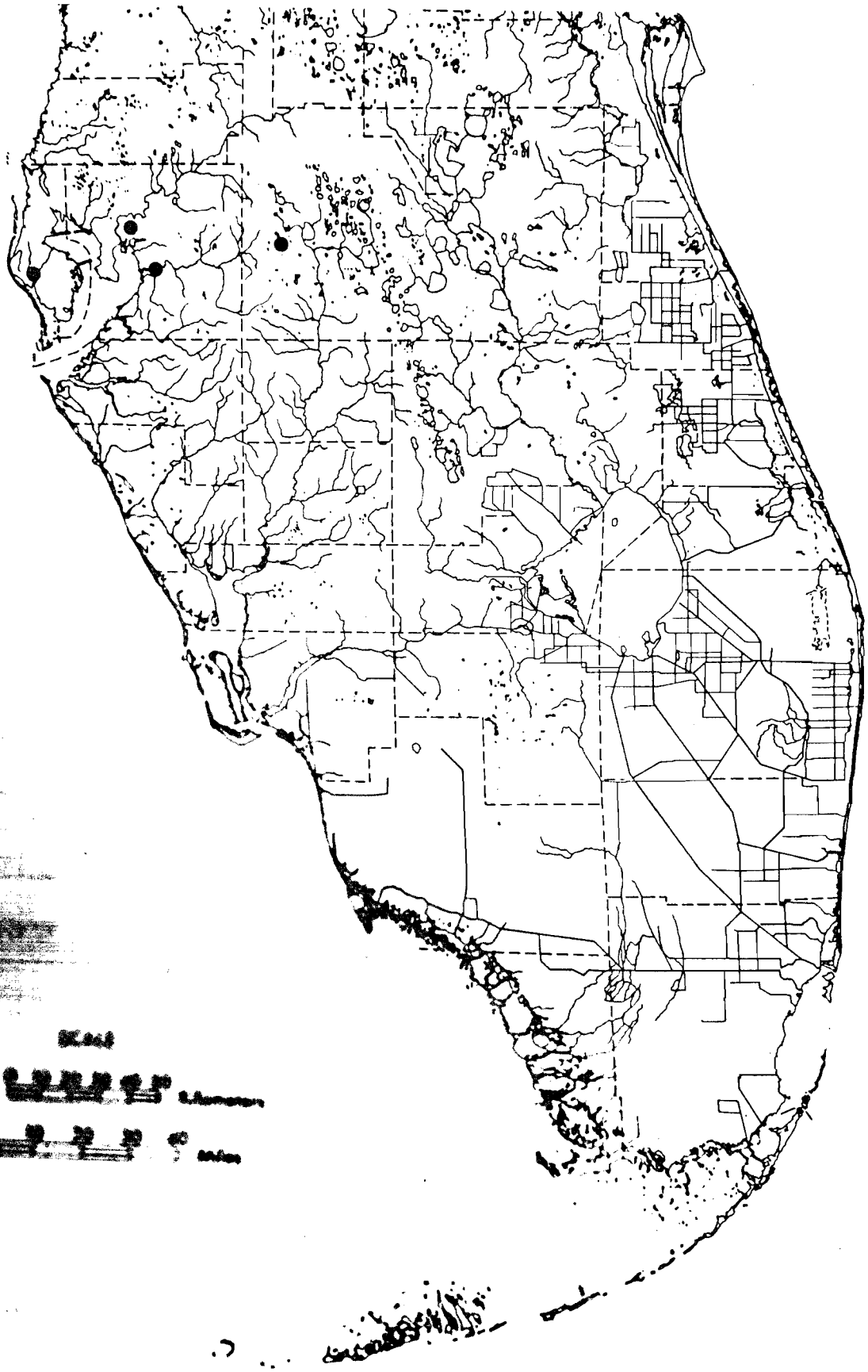
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Compiled by: Walter R. Courtenay, Jr. and Dannie A. Hensley.


M.K



Order Perciformes
Family Cichlidae

Cichlasoma meeki (Brind)

Firemouth cichlid

Original description citation: Brind, 1918. A new subspecies of Thorichthys helleri. Aquatic Life, 3(8): 119-120.

Type locality: Progreso, Yucatan, Mexico.

Native range: Northern part of Yucatan Peninsula, Mexico (Miller, 1966).

U.S. range: C. meeki is established in Dade County, Florida (Rivas, 1965; Hogg, 1976, 1976a). It has been collected in Palm Beach County, Florida, adjacent to a fish farm, but no evidence of reproduction was found at this site (Courtenay, et al., 1974).

Minckley (1973) reported one specimen being collected from a canal in Mesa, Arizona; it is probably not established in this state.

Sources of introduction: There appear to have been at least four separate introductions of C. meeki into Florida. It was reported as established in a rock pit in northwest Miami by Rivas (1965) and in a limestone sinkhole on a private estate

in south Miami by Courtenay et al. (1974). Both of these localities are apparently isolated and introductions there were probably separate. Sources for these introductions are unknown; they were probably releases by local aquarists. Courtenay et al. (1974) collected C. meeki in Palm Beach County in a canal adjacent to a fish farm from where they escaped. Again, no evidence of establishment was found at this locality. The established population in open waters of Dade County appears to have originated from accidental or intentional releases from fish farms within its range (Hogg, 1976, 1976a).

The source for the introduction of C. meeki into Mesa, Arizona is unknown. However, dumping of home aquaria is frequently the source of introductions in such metropolitan areas.

Life history: Based on observations of feeding behavior and morphology, Barlow (1974) classified C. meeki as a substrate sifter. These are Central American Cichlasoma species of the Thorichthys section which are specialized to feed by sifting through sand. In Florida, Hogg (1976a) recorded the following classes of food items for C. meeki: non-filamentous algae, filamentous chlorophyta, molluscan shell fragments, vascular plant fiber, fish eggs, insect parts, cladocerans, chironomid larvae, hirudineans, copepods, fish scales, sand, oligochaetes, fish embryos, and bryozoans. The most important of the classes was non-filamentous algae, followed by filamentous green algae, molluscan shell fragments, vascular plant fiber, fish eggs,

and insect parts. In a trophic gradient from herbivore to carnivore, Hogg found C. meeki to be an omnivore with plant material being more important than animal material. He examined a size series sufficient to show ontogenetic differences in feeding. Fish 60 mm SL and smaller contained less plant fiber and mollusc shells and more filamentous algae than larger fish. Fish above 60 mm TL apparently feed on fish eggs and molluscs more and plant material less than smaller fish. His data also indicate that C. meeki feeds mostly in mid and late afternoon.

In Yucatan, C. meeki occurs in swamps and pools (Hubbs, 1936). Hogg (1976a) found that in Florida it is most commonly found on shallow water shelves along canal banks shaded by overhanging vegetation. Based on his collections and ours, the species appears to show a broad salinity tolerance.

C. meeki spawns in the manner typical of most American cichlids. At the start of the spawning period, holes are dug in sand by use of the mouth and head. In this species, the male does most of this hole digging. Both parents clean an area of substrate where eggs will be deposited. After they are deposited and fertilized, they are guarded and fanned until hatching; in this species the female does most of this incubating.

After hatching, the fry are moved to one of the previously

dug sand pits. The parents continue to guard the young and keep them in a group until this behavior gradually breaks down and the young scatter (Breder and Rosen, 1966).

In Florida, Hogg (1976a) found that C. meeki begins to spawn in February when water temperatures are rising and water levels are falling and continues into September. He recorded spawning at daily maximum water temperatures of 25 and 33°C. He found territories to be very densely clustured in 0.2-0.5 m of water near canal banks. Individuals were observed to make use of man-made as well as natural objects for spawning sites and territorial boundaries. Hogg's data on fecundity indicate that 284-380 ($\bar{X}$ = 306) eggs are laid at each spawning.

In aquaria, C. meeki is reported to mature at 80 mm (probably total length; Sterba, 1966).

Environmental impress: There is little information on the environmental impress of C. meeki in Florida. However, Hogg (1975, 1976a) estimated that it has expanded its range 8 km in two years; it is now quite abundant within its range.

Since cichlids and centrarchids have many similarities in structure and habit (Jordan and Evermann, 1898; Breder and Rosen, 1966), an obvious concern with the establishment of any cichlid in North America is the possibility of it competing with native centrarchids. Species of both families use

shallow-water spawning areas, a limited resource in the canals of southeastern Florida; competition for this resource is possible.

Status: Established in Dade County, Florida.

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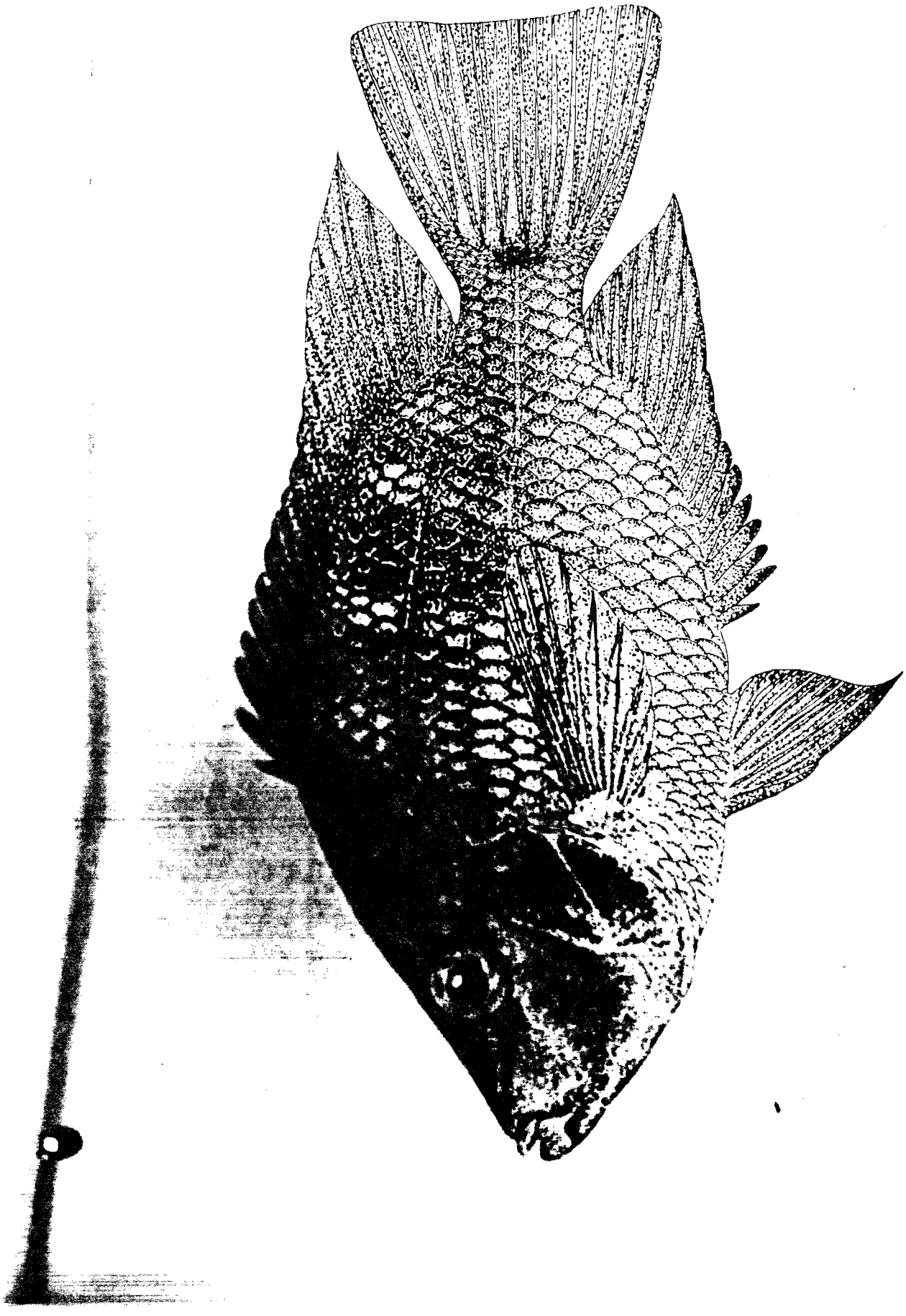
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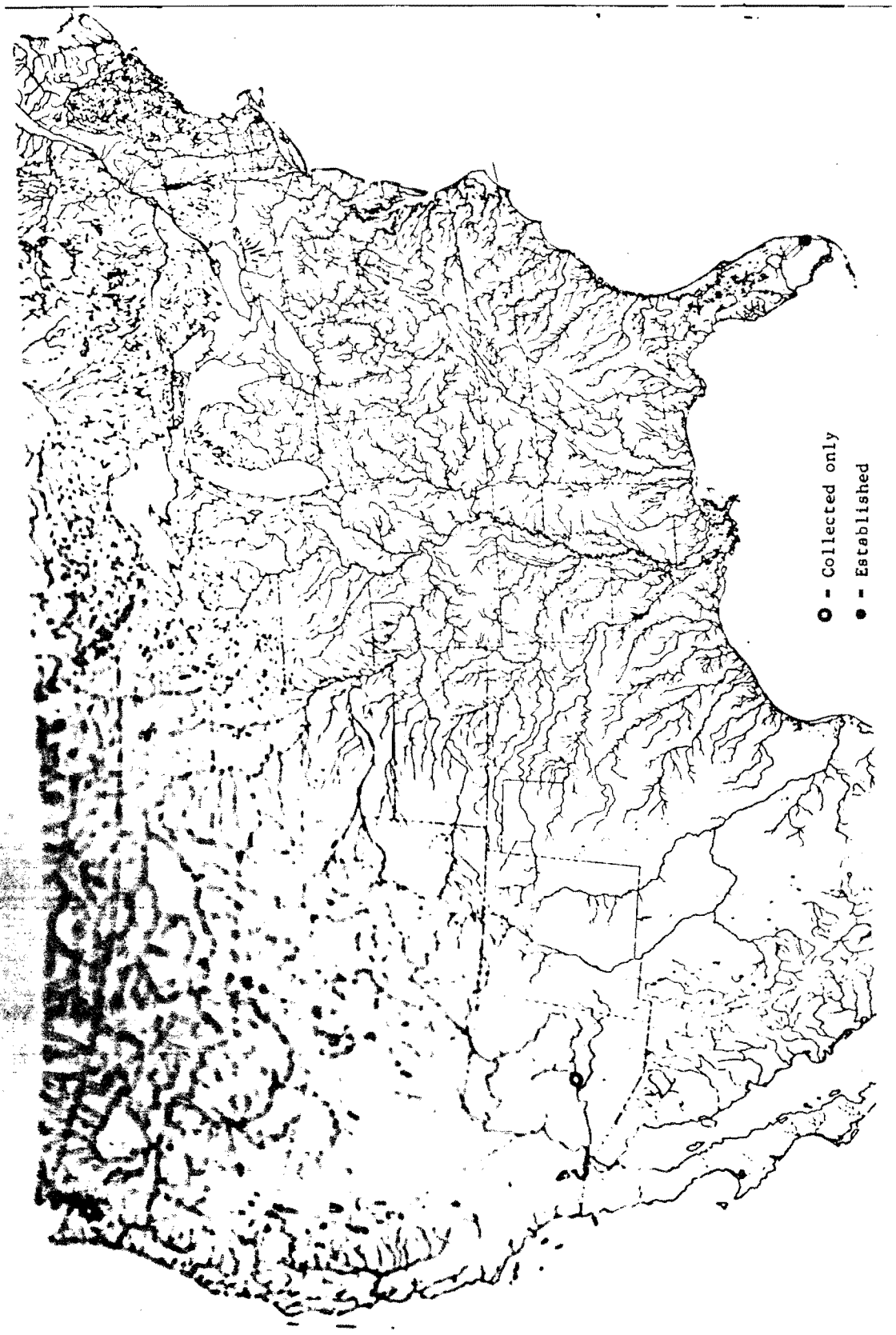
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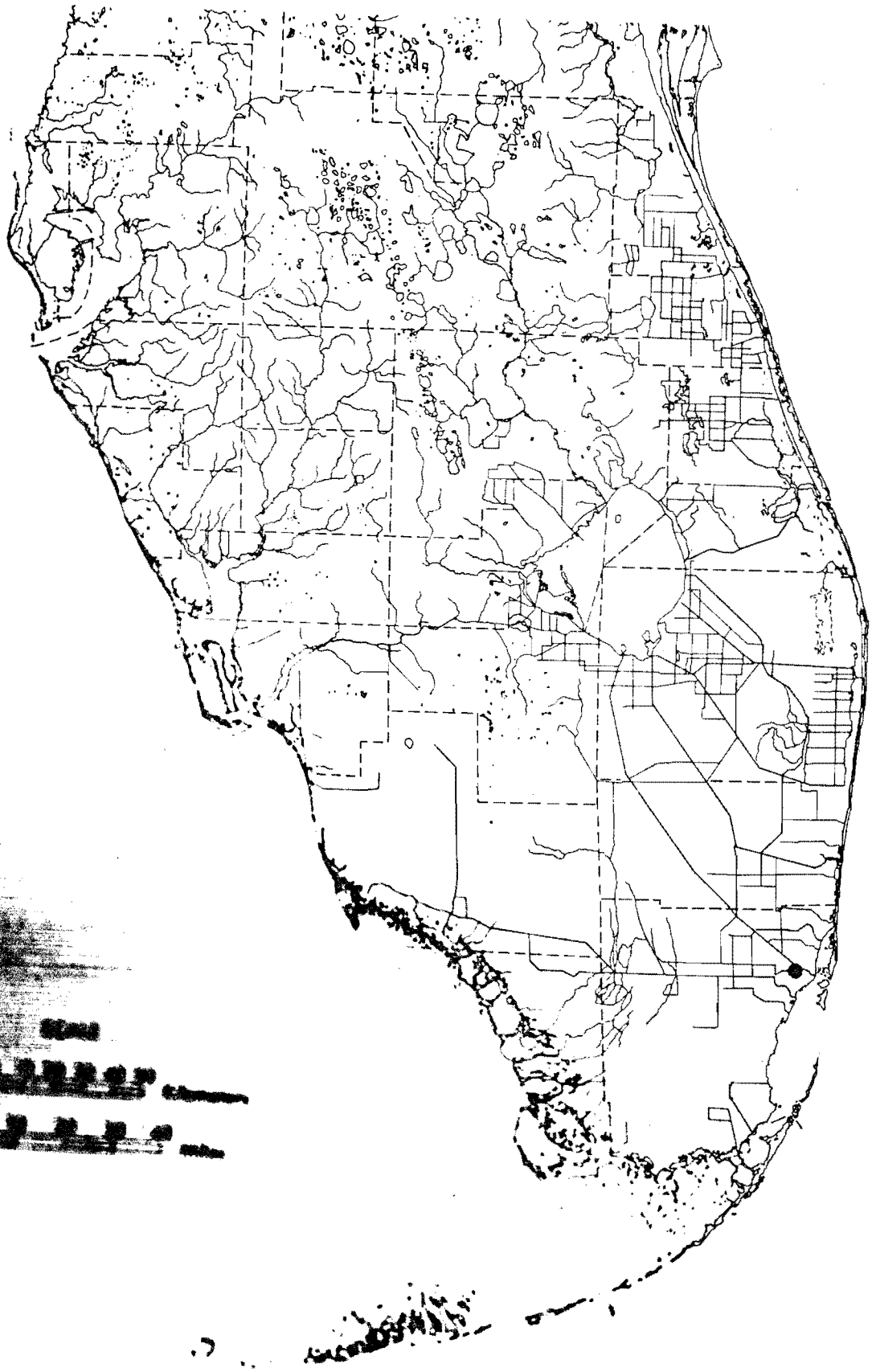
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Compiled by: Dennis A. Hensley




O - Collected only
● - Established



Order Perciformes
Family Cichlidae

Cichlasoma nigrofasciatum (Günther)

Convict Cichlid

Original description citation: Günther, 1869. An account of the fishes of the states of Central America, based on collections made by Capt. J. M. Dow, F. Godman, Esq., and O. Salvin, Esq. Trans. Zool. Soc. London, 6: 452-453.

Type locality: Lakes of Amatitlan and Atitlan, Guatemala.

Native range: Pacific slope of Guatemala to Costa Rica; both slopes of Costa Rica (Miller, 1966).

U.S. range: C. nigrofasciatum is established in Ash Spring, Lincoln County, Crystal Springs, and possibly Rogers Spring, Clark County, Nevada (Deacon, et al., 1964; Hubbs and Deacon, [illegible] Deacon, personal communication).

Minckley (1973) reported two established populations of this species from Arizona. Flooding in 1973 destroyed one population which was established in a borrow pit on the Salt River near the eastern edge of Phoenix. The other population was seen in 1970 in Mesa but it apparently did not survive the winter. Minckley states that single specimens are not uncommon

in canals of the Phoenix area. He predicts that C. nigrofasciatum will become, if it is not already, established in warmer areas of southwestern Arizona.

C. nigrofasciatum was confirmed as established in the outflow of Cave and Basin Hotspring, Banff National Park, Alberta, Canada in 1968 (McAllister, 1969).

Rivas (1965) reported this species established in a rock pit in northwest Miami, Florida. The present status of this population is unknown.

Sources of introduction: The source for the introduction of this species into Nevada is not specifically stated by Deacon et al. (1964) and Hubbs and Deacon (1964). However, these authors imply that many of the introductions and transplants in this area have been made by local residents.

The source for the introduction of C. nigrofasciatum into Arizona is unknown. However, all records for this species have been in or near Phoeniz; dumping of home aquaria is frequently the introduction source in such metropolitan areas.

This species was introduced into Alberta by local aquarists between 1958 and 1967 (McAllister, 1969).

Although no source is given by Rivas (1965) for the introduction of this species into a rock pit in Miami, Florida, releases of tropical fishes by aquarists and fish farmers in southern Florida are common.

Life history: We know of no studies of the food habits of C. nigrofasciatum in its native range. Barlow (1974) has observed that it sometimes moves in groups while feeding, and he lists it as one of the species in which fry are known to graze on mucous on the sides of the parents when food is scarce. The species is probably omnivorous. Minckley (1973) claims it is carnivorous but gives no references.

Gilbert and Kelso (1971), in a study on the Atlantic slope of Costa Rica, found C. nigrofasciatum to be the most common stream-inhabiting species. It appears to be exclusively confined to this habitat. The only exception they noted was one specimen which was obviously a stray that had drifted into an estuary in association with a clump of Eichhornia crassipes. Most of these stream localities where they collected C. nigrofasciatum had soft-mud bottoms, depths of ca. 4 ft, and submerged logs and branches.

Most or all information on reproduction in this species is from aquarium observations and should be viewed with this in mind, since it is possible that confines of aquaria may alter certain spawning characteristics over those present in natural waters. This literature is summarized by Breder and Rosen (1966). As spawning time approaches, both partners participate in scouring the surface of a stone and digging several holes nearby in softer substrate. The female lays a few hundred eggs on the cleaned stone; the male fertilizes them as he

follows her. The eggs are probably guarded and fanned by both parents. They hatch in ca. four days at a temperature of 23.9°C. As soon as hatching occurs, the fry are moved by the parents to one of the holes made previously. They are shifted from one hole to another until ca. four days later when they are able to swim. After this period the parents become occupied in keeping the fry in a group. They do this until the young reach a considerable size. Apparently at this time the young scatter. In aquaria, C. nigrofasciatum has been observed to reproduce at 1.0 - 1.5 years of age. Fish this age are ca. 76 mm in length (probably total length).

It should be noted that C. nigrofasciatum is known to aquarists as one of the most aggressive, pugnacious cichlids. It exhibits a great deal of interspecific as well as intraspecific aggression (Innes, 1955; Breder and Rosen, 1966; Sterba, 1966; Minckley, 1973).

Environmental impress: According to Deacon et al., (1964) C. nigrofasciatum in combination with Poecilia reticulata, P. mexicana, P. latipinna, Gambusia affinis, and Xiphophorus maculatus caused the decline and extermination of a population of the native species Rhinichthys osculus near the Overton arm of Lake Mead. It was the establishment of C. nigrofasciatum in Rogers Spring and the disruption this species could possibly cause to the sport fishery in the adjacent Lake Mead that prompted Hubbs and Deacon (1964) to attempt to remove all

exotic fishes from this spring. However, some of the exotics escaped. A particular concern regarding the potential spread of C. nigrofasciatum to Lake Mead is the possibility that it could enter into competition with centrarchids for spawning sites. It should be emphasized here that C. nigrofasciatum is considered to be an exceptionally pugnacious cichlid and one which shows a great deal of interspecific aggression. As in all cichlids the peak of aggressive behavior is during spawning activities. It is very doubtful that the behavioral repertoire of any centrarchid contains aggressive elements to such a degree that they could successfully compete with C. nigrofasciatum if spawning sites become a limited resource required by both.

An additional concern with the presence of this species in Nevada is the possibility of its spread by humans to other areas, many of which have localized endemic species or subspecies. C. nigrofasciatum was first collected from Rogers Spring in March 1963 by Deacon et al., (1964). Fifteen months later, this species was found in Ash Spring, ca. 115 km NNW of Rogers Spring. Collecting in Ash Spring in 1963 indicated the only non-native fish present was G. affinis (Hubbs and Deacon, 1964). There are no permanent connections between these two localities. Apparently someone had transferred this species as well as P. mexicana and P. latipinna from Rogers Spring to Ash Spring during the intervening 15 months. In

addition, C. nigrofasciatum is now established in Crystal Springs, ca. 40 km ESE of Hiko, Lincoln County (Deacon, personal communication). Concern over the spread of this species or any exotic or non-native fish in the American Southwest is due to the damage they can do to the depauperate ichthyofaunas there. The native fishes there are components of very simple ecosystems which do not have the buffering capacities of larger, more complex ones, and the risk of extermination of native species in these areas is particularly high.

Status: Established in springs in Lincoln and Clark counties, Nevada, and Cave and Basin Hotspring, Banff National Park, Alberta, Canada; possibly established in or near Phoenix, Arizona; reported as established in Dade County, Florida, but current status is unknown.

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Barlow, George W. 1974. Contrasts in social behavior between Central American cichlid fishes and coral-reef surgeon fishes. Amer. Zool., 14: 9-34.

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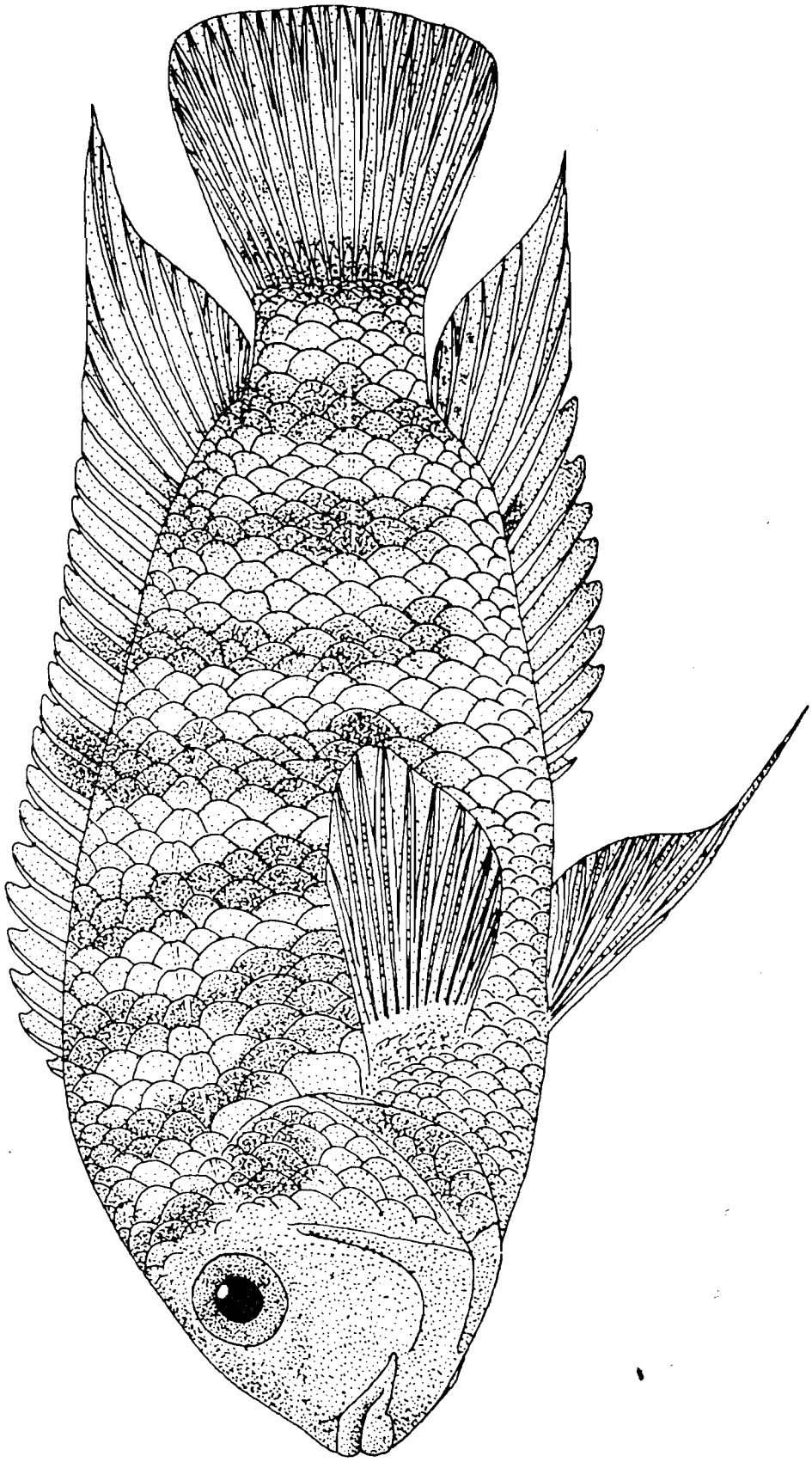
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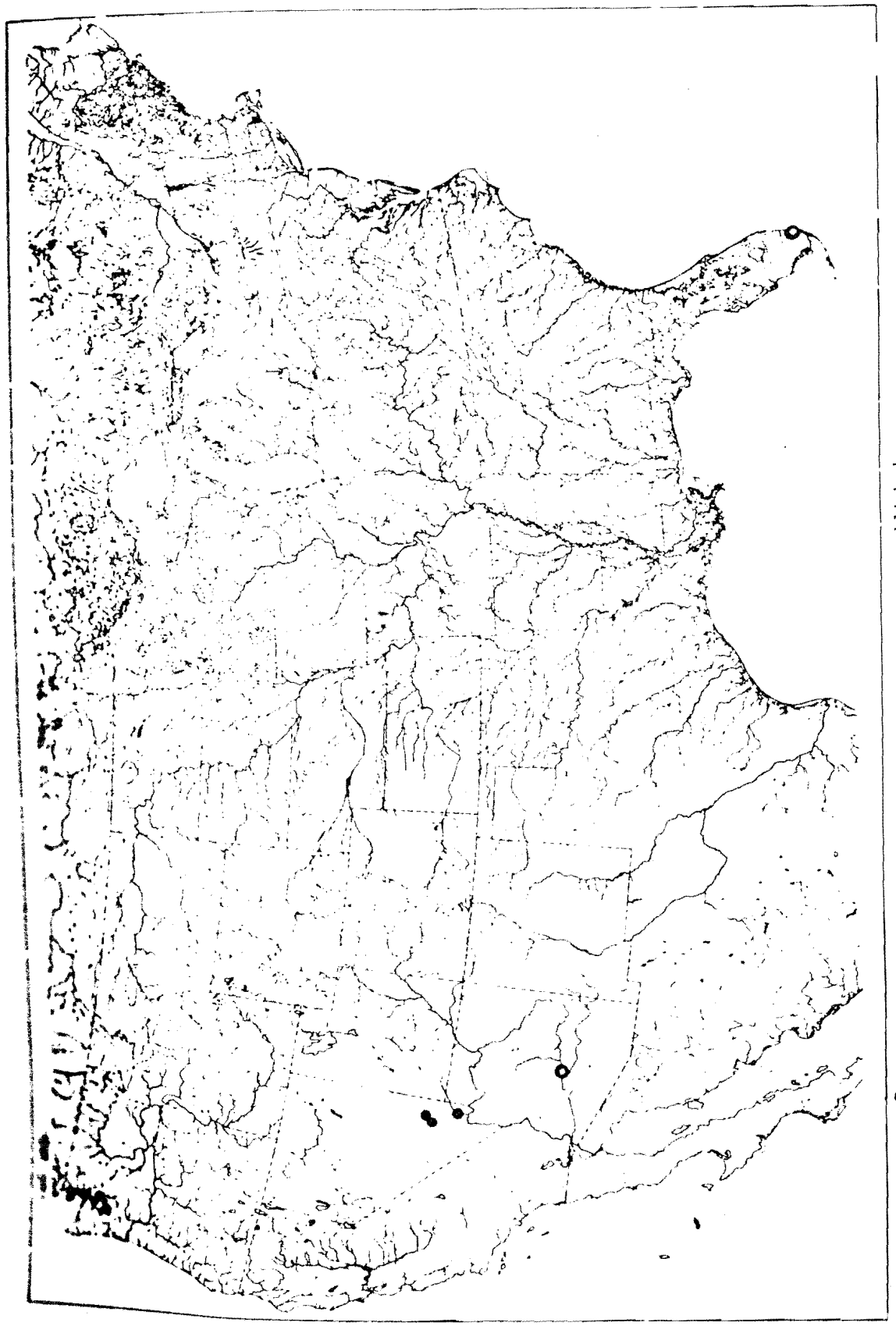
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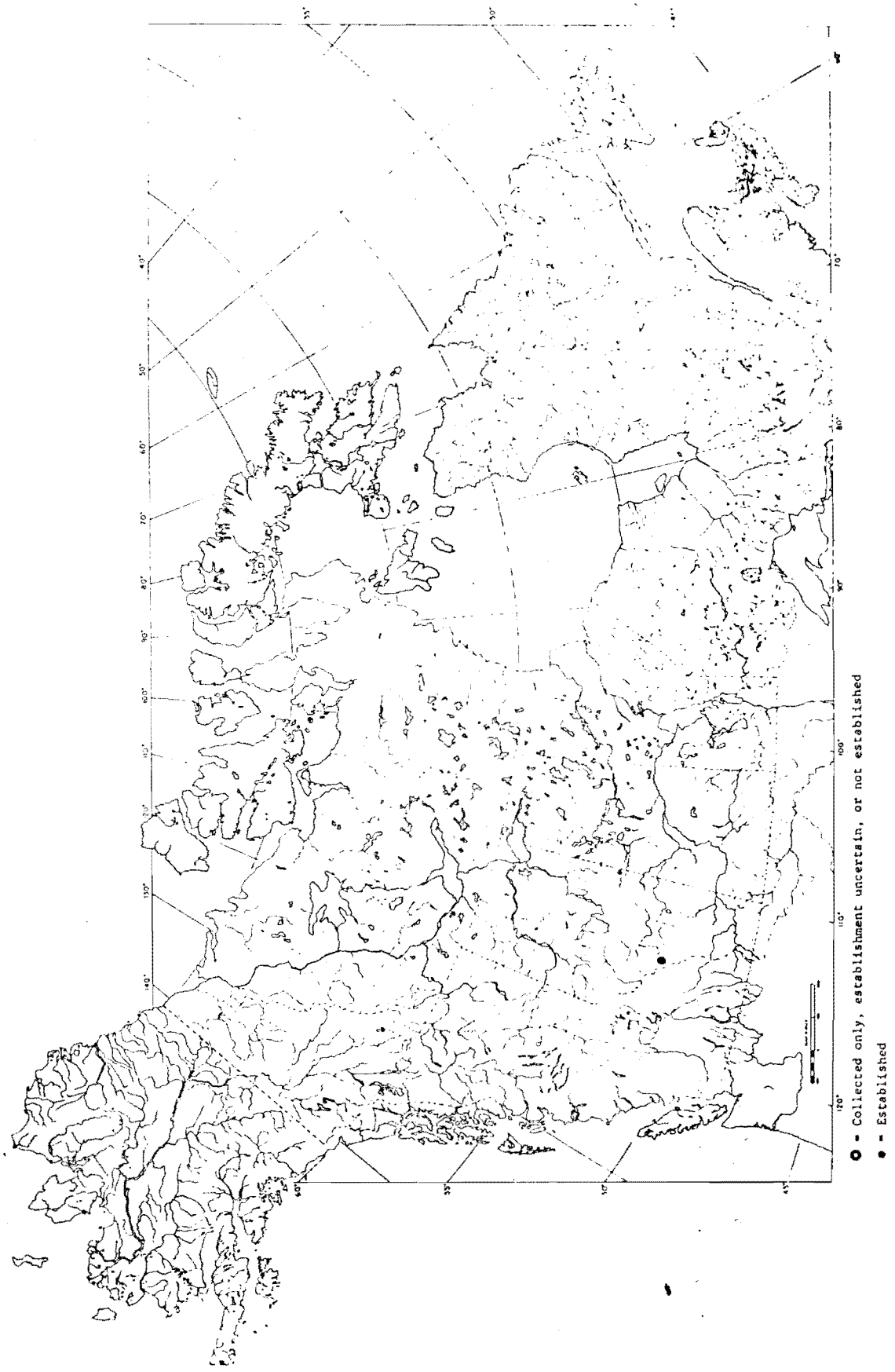
Compiled by: Dannie A. Hensley





O = Collected only, establishment uncertain, or not established

● = Established


O - Collected only, establishment uncertain, or not established
● - Established

Order Perciformes
Family Cichlidae

Cichlasoma octofasciatum (Regan)

Jack Dempsey

Note on systematics: In much of the literature, this species has been called C. biocellatum. This species was described by Regan (1909) from a specimen supposedly from Manaus, Brazil. However, this species has apparently never been captured again from Brazil; thus, the locality is suspect. Regan (1903) described C. octofasciatum from a specimen from Mexico. Comparisons of C. octofasciatum from Central America with Regan's (1909) description of C. biocellatum and aquarium specimens going under this name fail to show any differences (R. M. Bailey, personal communication). Although Regan's types should be examined, for the present C. biocellatum should be considered a junior synonym of C. octofasciatum.

Original description citation: Regan, 1903. Descriptions de poissons nouveaux faisant partie de la collection du Musée d'Histoire Naturelle de Genève. Revue Suisse Zool., Genève, 11: 417-418, pl. 13, fig. 1.

Type locality: Mexico.

Native range: Atlantic slope of Central America from Veracruz, Mexico to the Rio Ulua basin, Honduras (Miller, 1966).

U.S. range: Courtenay et al. (1974) found established populations of C. octofasciatum near fish farms in Palm Beach and Hillsborough counties, Florida. In our 1978 survey we found the species still present at a Hillsborough County locality but not in Palm Beach County. The Hillsborough County locality is within ca. 100 m of a fish farm. Although many specimens of all sizes can be collected here, they may be escapees from the fish farm. Hogg (1976, 1976a) found this species established at the eastern end of Snapper Creek in Dade County, Florida. A collection made in Snapper Creek in 1977 included C. octofasciatum. A recently discovered established population in Levy County, Florida, was eradicated (Daniel Levine, personal communication).

Sources of introduction: Introductions in Palm Beach, Hillsborough, and Dade counties were due to intentional or accidental releases from fish farms (Courtenay et al., 1974; Hogg, 1976, 1976a). Dumping of home aquaria was probably responsible for introduction into Levy County.

Life history: Based on observations of feeding and morphology, Barlow (1974) classified C. octofasciatum as an omnivore. Hogg (1976a) examined only four stomachs from the Dade County population; he recorded the following classes of food items:

filamentous chlorophyta, crayfish exoskeletons, molluscan shell fragments, insect parts, and bryozoans. Filamentous green algae comprised ca. 80% of the contents by weight.

Little or no information is available on habitat requirements for C. octofasciatum. Hogg (1976a) noted that within its range in Dade County, it occurs with C. bimaculatum; habitat requirements are probably similar for these species.

C. octofasciatum spawns in the manner typical of most American cichlids. At the start of the spawning period, holes are dug in the substrate by use of the mouth and head. Both parents clean an area of substrate where eggs will be deposited. Eggs deposited may number several hundred. After fertilization, the parents guard and fan the eggs until hatching. Incubation times have been given as four days at 23.9°C and 52 hours at 27°C. After hatching, the fry are moved to one of the previously dug pits. The parents continue to guard the young and keep them in a group until this behavior gradually breaks down and the young scatter (Breder and Rosen, 1966; Hogg, 1976a). Hogg (1976a) observed young of 10 mm SL in Dade County swimming with no attendant parents.

There is no information available on spawning periodicity or temperatures for this species in its native range or Florida. Hogg (1976a) observed only one pair of C. octofasciatum cleaning a rock for spawning in water 0.5 m deep in Dade County.

According to the data of Hubbs (1936), sexual maturity is attained at ca. 50-55 mm SL.

Environmental impress: C. octofasciatum is not very abundant in Snapper Creek Canal, the canal in which it is established in Dade County. Hogg (1976a) made a collection of fishes from this canal within the range of C. octofasciatum. His sample appears to have been a good representation of the fishes present. C. octofasciatum ranked as one of the lowest species in weight, numbers, and a calculated importance value. Although it is not abundant in Dade County, Hogg (1976, 1976a) estimates that it has dispersed ca. 8 km since 1972.

Since cichlids and centrarchids have many similarities in structure and habit (Jordan and Evermann, 1898; Breder and Rosen, 1966), an obvious concern with the establishment of any cichlid in North America is the possibility of it competing with native centrarchids. Species of both families use shallow-water spawning areas, a limited resource in the canals of southeastern Florida; competition for this resource is possible.

Status: In Florida, the Jack Dempsey established in Dade and possibly Hillsborough counties; has been collected but is not established in Palm Beach County.

References:

Barlow, George W. 1974. Contrasts in social behavior between Central American cichlid fishes and coral-reef surgeon fishes. Amer. Zool., 14: 9-34.

Breder, Charles M., Jr. and Donn Eric Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, N.Y. 941 pp.

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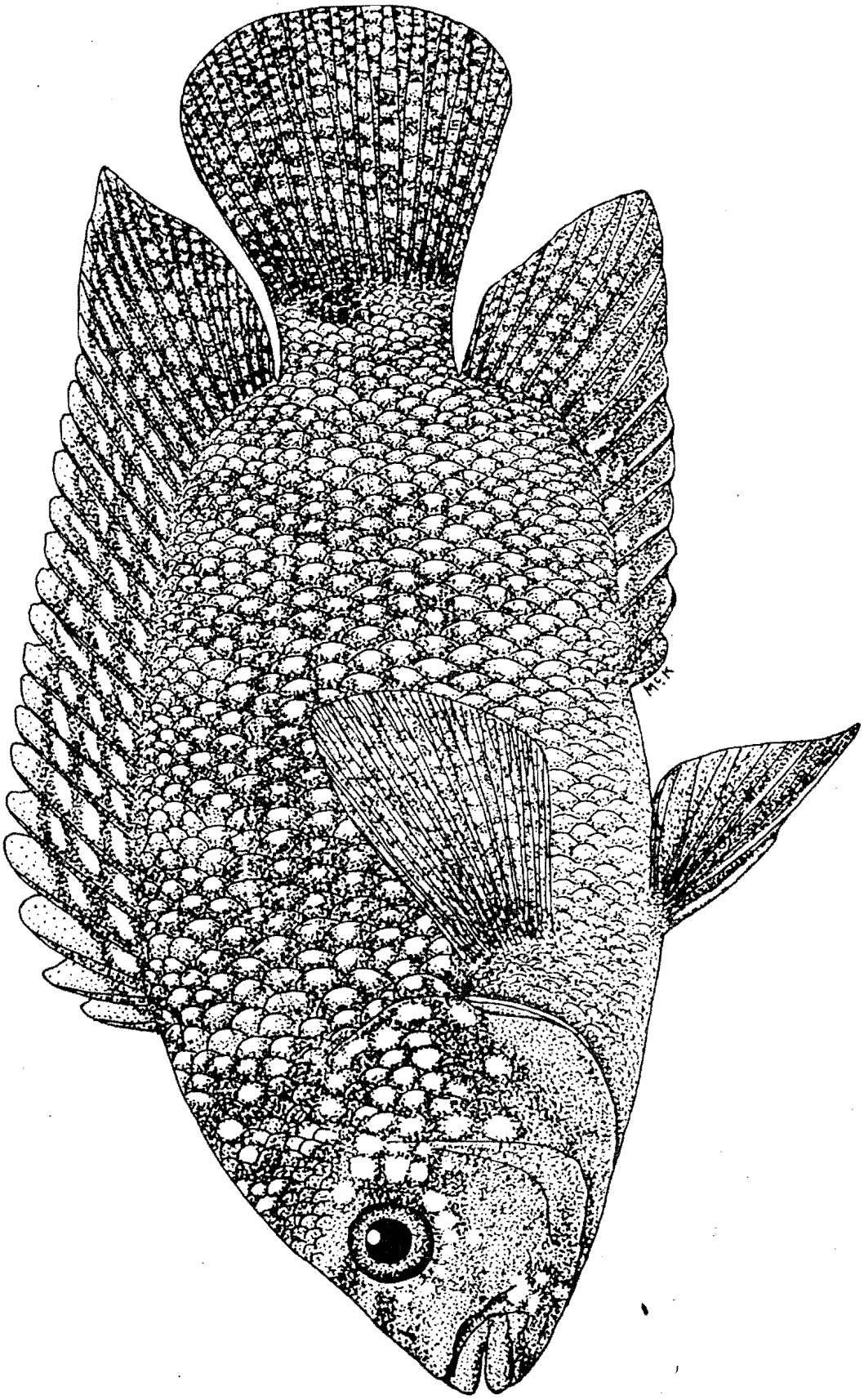
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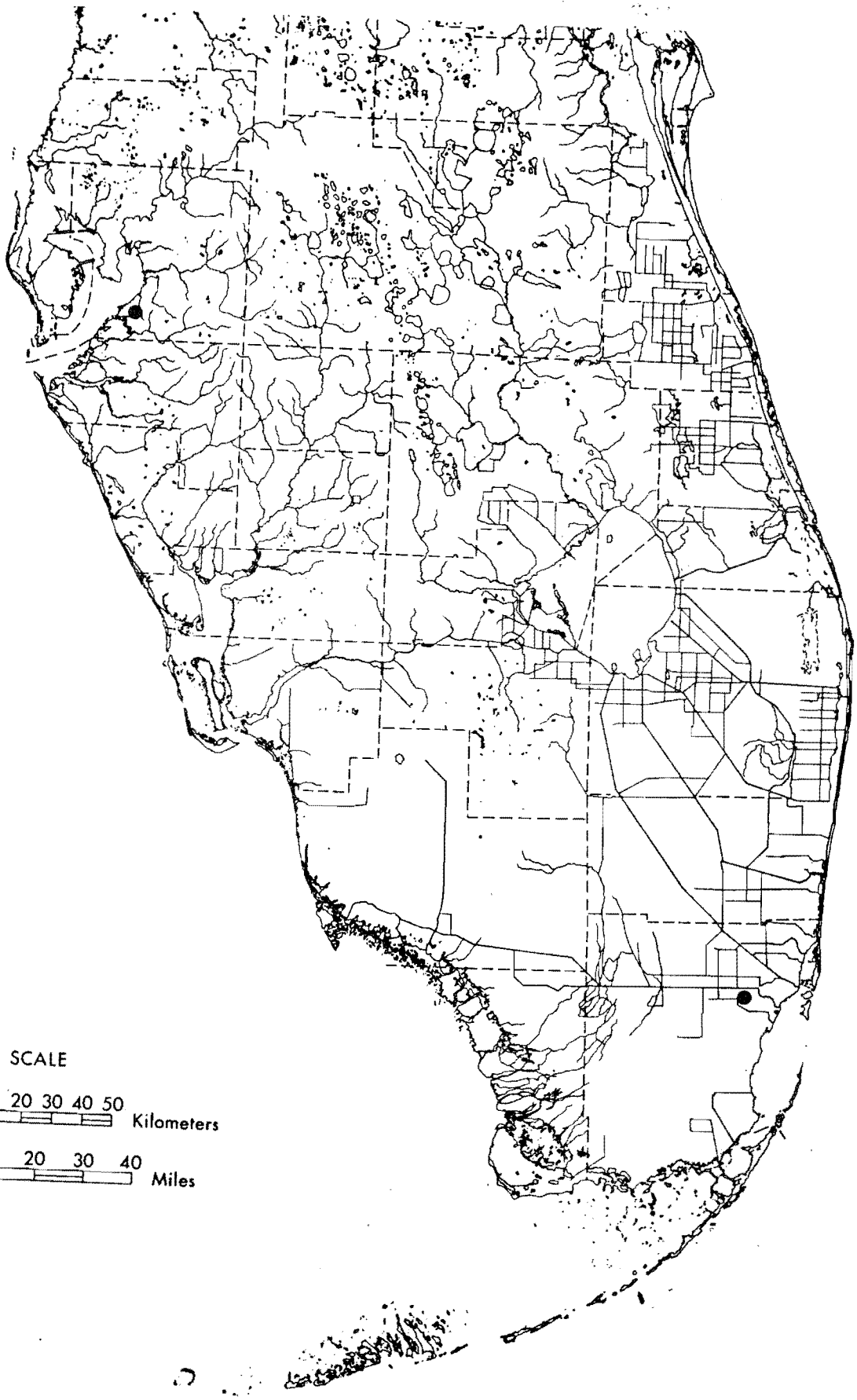
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Regan, C. Tate. 1909. Descriptions of three new freshwater fishes from South America, presented to the British Museum by Herr J. Paul Arnold. Ann. Mag. Nat. Hist., 8(3): 234-235.

Compiled by: Dannie A. Hensley


M.K


SCALE
0 10 20 30 40 50
Kilometers
0 10 20 30 40
Miles

Order Perciformes
Family Cichlidae

Cichlasoma severum (Heckel)

Banded cichlid

Original description citation: Heckel, 1840. Johann Natterer's neue Flussfische brasilien's nach den Beobachtungen und Mittheilungen des Entdeckers beschrieben. Erste Abtheilung, die Labroiden. Ann. Wiener Mus. Natur., 2: 362-364.

Type locality: Rio Negro, near Marabitanas, Brazil.

Native range: Brazil, Surinam, Guyana, French Guiana, and southern and eastern Venezuela (Regan, 1905).

U.S. range: C. severum was introduced into Rogers Spring, Clark County, Nevada. An attempted eradication was probably not totally successful (Hubbs and Deacon, 1964).

Sources of introduction: The source for the introduction of this species is not specifically stated by Hubbs and Deacon (1964). However, these authors imply that many of the introductions and transplants in this area have been made by local residents.

Life history: In Amazonian Brazil, Knöppel (1970) recorded the following classes of food items from C. severum: fruits (granulous, solid fruits or seeds, not of aquatic origin),

detritus, decapods, cladoceran ephippia, algae, sand, and fishes. Of these, fruit and detritus were the most important. Lowe-McConnell (1969) found in Guyana that this species feeds on green algae and other vegetable matter during the rainy season, when food is most plentiful. In the dry season, when food is scarce, specimens collected from drying ponds contained only gritty bottom debris, sand, and bits of dead plant material and chiton. She observed that the occurrence of fat deposits in C. severum indicated the main feeding time for this species is during the wet season.

C. severum has been recorded from floodplain lagoons (varzea lakes), savanna ponds, creeks, and small lakes lateral to river channels in the Amazon system (Lowe-McConnell, 1964, 1969; Knöppel, 1970). It is a characteristic species of large floating islands of vegetation (floating meadow biotope) in varzea lakes (Lowe-McConnell, 1975). There is evidence that at the beginning of the wet season, C. severum makes lateral migrations from permanent water bodies out onto flooded savannas. Again, it apparently feeds predominately during this time, when food is plentiful. As the dry season approaches, it moves back toward main river areas. However, some individuals become isolated in savanna ponds. These fish are subjected to intense predation pressure and crowding, and frequently severe oxygen depletion and desiccation.

In its native range, C. severum probably breeds immediately before or during the wet season. It spawns in the manner

typical of most American cichlids. At the start of the spawning period, holes are dug in the sand by use of the mouth and head. Approximately 400-700 eggs are deposited on the substrate some distance away from these holes. Both parents guard the eggs. After hatching the young are carried by mouth to one of the previously prepared holes where they remain until capable of swimming. Both parents continue to guard the young until they are a considerable size (Lowe-McConnell, 1969; Breder and Rosen, 1966). Lowe-McConnell (1964, 1969) estimated that C. severum matures at ca. 125-130 mm SL. In her 1964 paper, she presents some limited growth data and states that it is possible that this species matures in one year, although severe environmental conditions may cause a delay of one year.

Environmental impress: No information is available on the environmental impress of C. severum in Nevada. Although it is possibly established in only one spring, a concern should be that this spring may serve as a source for transfer of this species by humans to other bodies of water. Human transfer of exotics between springs has been shown to be an important factor in the spread of these species in southern Nevada (Hubbs and Deacon, 1964). The introduction and establishment of exotic fishes in the American southwest is cause for great concern. Many areas there contain depauperate ichthyofaunas composed of localized endemic species. These fishes are part of very simple ecosystems which do not have

the buffering capacities of larger, more complex ones, and the risk of extermination of native species following the introduction of exotic or other non-native species in these areas is particularly high. In addition, Rogers Spring is adjacent to Lake Mead. This should cause concern over the possibility that C. severum could become established in the lake and be a threat to sport fishes (Hubbs and Deacon, 1964). In particular it is possible that C. severum could compete with Lake Mead centrarchids for spawning sites.

Status: Possibly established in Rogers Spring, Clark County, Nevada.

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Breder, Charles M., Jr. and Donn Eric Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, N.Y. 941 pp.

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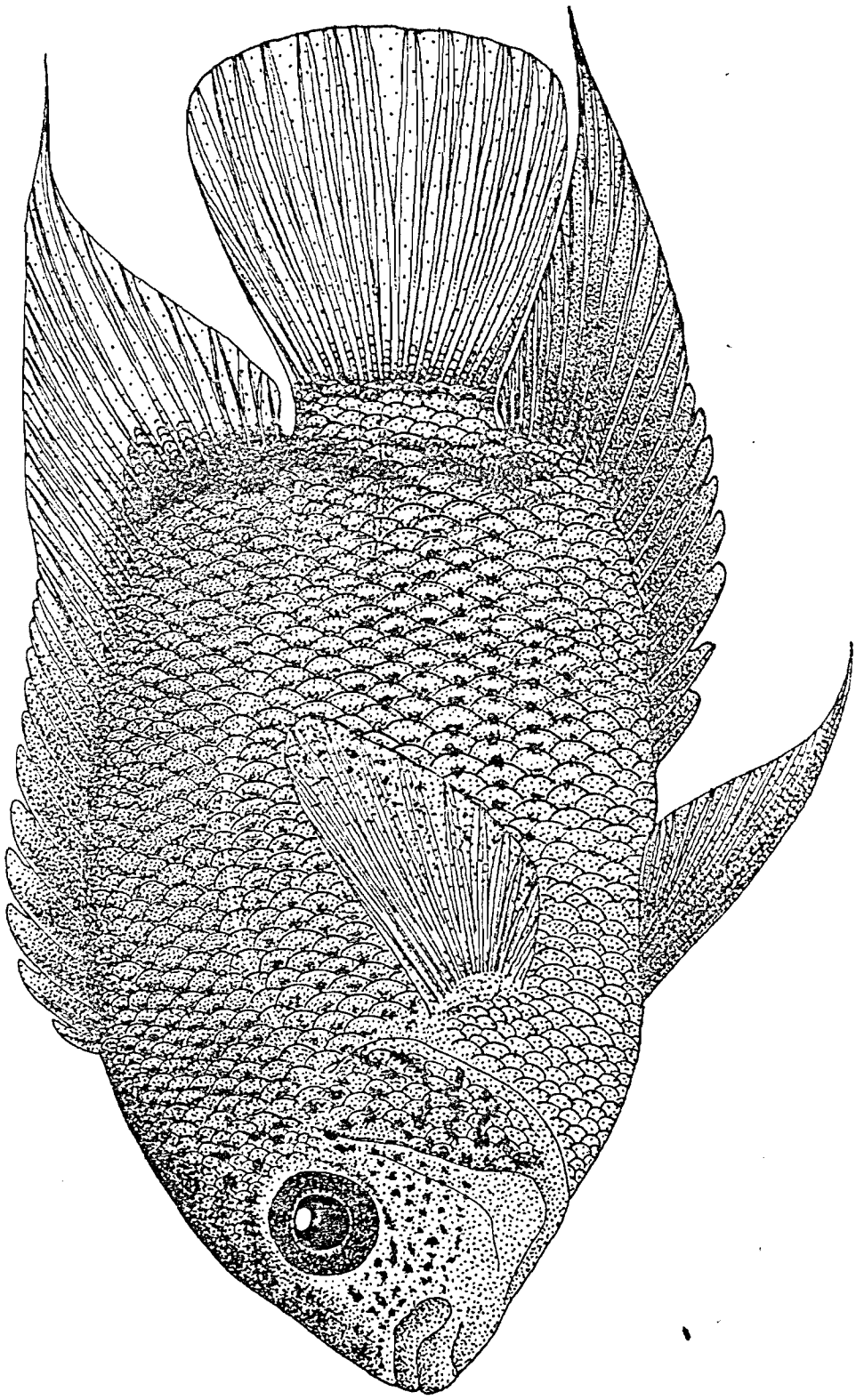
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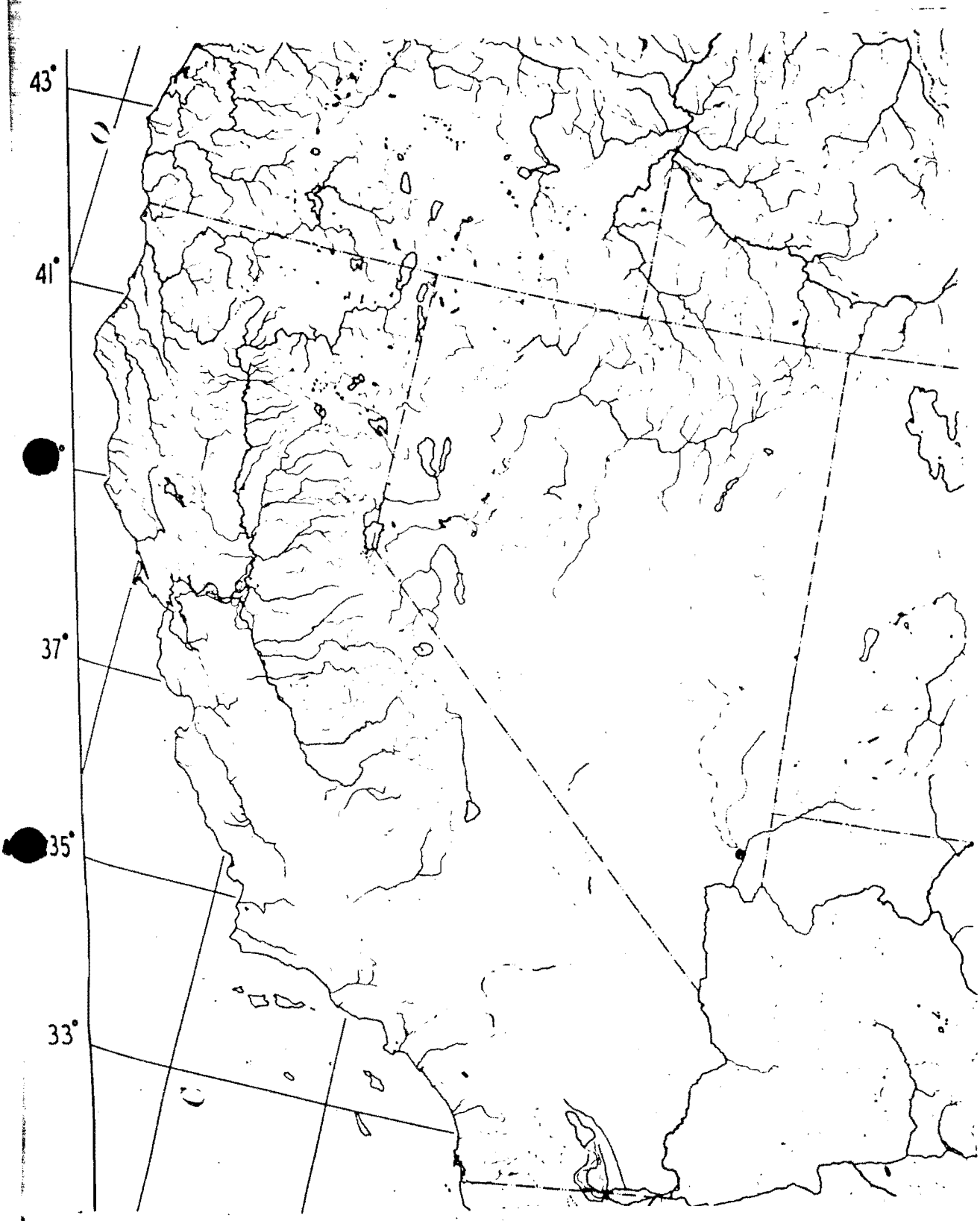
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Compiled by: Dannie A. Hensley




43°
41°
37°
35°
33°

Order Perciformes
Family Cichlidae

Hemichromis bimaculatus Gill

Jewelfish

Original description citation: Gill, 1863. On the west African genus Hemichromis and descriptions of new species in the museums of the Academy and Smithsonian Institution. Proc. Acad. Nat. Sci. Philadelphia, 1862: 137-139.

Type locality: Unknown, probably Liberia.

Native range: North and west Africa (Boulenger, 1899).

U.S. range: H. bimaculatus is established in the Hialeah Canal-Miami River canal system and Comfort Canal, Dade County, Florida (Rivas, 1965; Courtenay and Robins, 1973; Courtenay et al., 1974; Hogg, 1976, 1976a). It is possibly established in Eureka Springs, Hillsborough County, Florida (Courtenay et al., 1974), but this record needs confirmation.

Sources of introduction: The source for the introduction of this species is unknown. Its distribution in Dade County is centered around the Miami International Airport, and one strongly suspects that it may have been released from there. This airport is one of only two points of entry in Florida for tropical fishes.

Life history: In Africa, H. bimaculatus is considered a carnivore (Lowe-McConnell, 1975). In his study of food habits in the Dade County population, Hogg (1976a) recorded the following classes of food items: non-filamentous chlorophyta, filamentous chlorophyta, Cichlasoma bimaculatum fry, insect parts, vascular plant fibers, oligochaetes, fish eggs, cladocerans, copepods, fish scales, chironomid larvae, and molluscan shell fragments. The most important of the classes was non-filamentous green algae, followed by filamentous green algae, C. bimaculatum young, and the insect parts. Among the identifiable remains, plant material was slightly more important than animal material. At least in Florida, H. bimaculatus should more correctly be termed an omnivore.

In its native range H. bimaculatus is most commonly found in forest streams (Lowe-McConnell, 1975): Based on collections and observations in Florida, the species appears to show a broad salinity tolerance (Hogg, 1976a; personal observation).

This species is a substrate spawner. Both parents clean an area of substrate on which the eggs will be deposited. The eggs are ovoid, and estimates of the number laid at one spawning range from 300 to 700. After deposition and fertilization, they are fanned and cleaned until hatching. Apparently the female does most of the incubating in this species. Just before hatching occurs, the parents dig holes in the sand nearby. After the fry hatch, they are picked up by mouth,

usually by the female, and moved to one of these sand pits. The fry begin to swim when about three or four days old. They swim in a tightly packed shoal, guarded by the parents. At night the parents return them to one of the sand pits. The guarding and shoaling behavior gradually breaks down and the young disperse (Breder and Rosen, 1966; Fryer and Iles, 1972; Hogg, 1976a).

In Florida, Hogg (1976a) found that H. bimaculatus begins to spawn in February when water temperatures are rising and water levels are falling, and continues through at least part of the summer months. He recorded spawning at daily maximum water temperatures of 26°C and 33°C. It has been reported to reach sexual maturity at ca. 60-70 mm (probably total length; Sterba, 1966; Goldstein, 1970).

Environmental impress: There is little information available on the environmental impress of H. bimaculatus in Florida. However, this species has expanded its range since first reported from the Hialeah Canal by Rivas (1965). Courtenay et al. (1974) found it in the Miami River Canal in 1971 and reported it as common in borrow canals adjoining the Hialeah Canal. In 1976, it was found to have expanded its range ca. 5 km southward into the Comfort Canal (Hogg, 1976, 1976a).

Since cichlids and centrarchids have many similarities in structure and habit (Jordan and Evermann, 1898; Breder and

Rosen, 1966), an obvious concern with the establishment of any cichlid in North America is the possibility of it competing with native centrarchids. Species of both families use shallow-water spawning areas, a limited resource in the canals of south-eastern Florida; competition for this resource is possible.

Status: Established in Dade County, Florida.

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Boulenger, George A. 1899. A revision of the African and Syrian fishes of the family Cichlidae - Part II. Proc. Zool. Soc. London, 1899: 98-143.

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Hogg, Randall G. 1976a. Ecology of fishes of the family Cichlidae introduced into the fresh waters of Dade County, Florida. Ph.D. dissertation, University of Miami, Coral Gables. 142 pp.

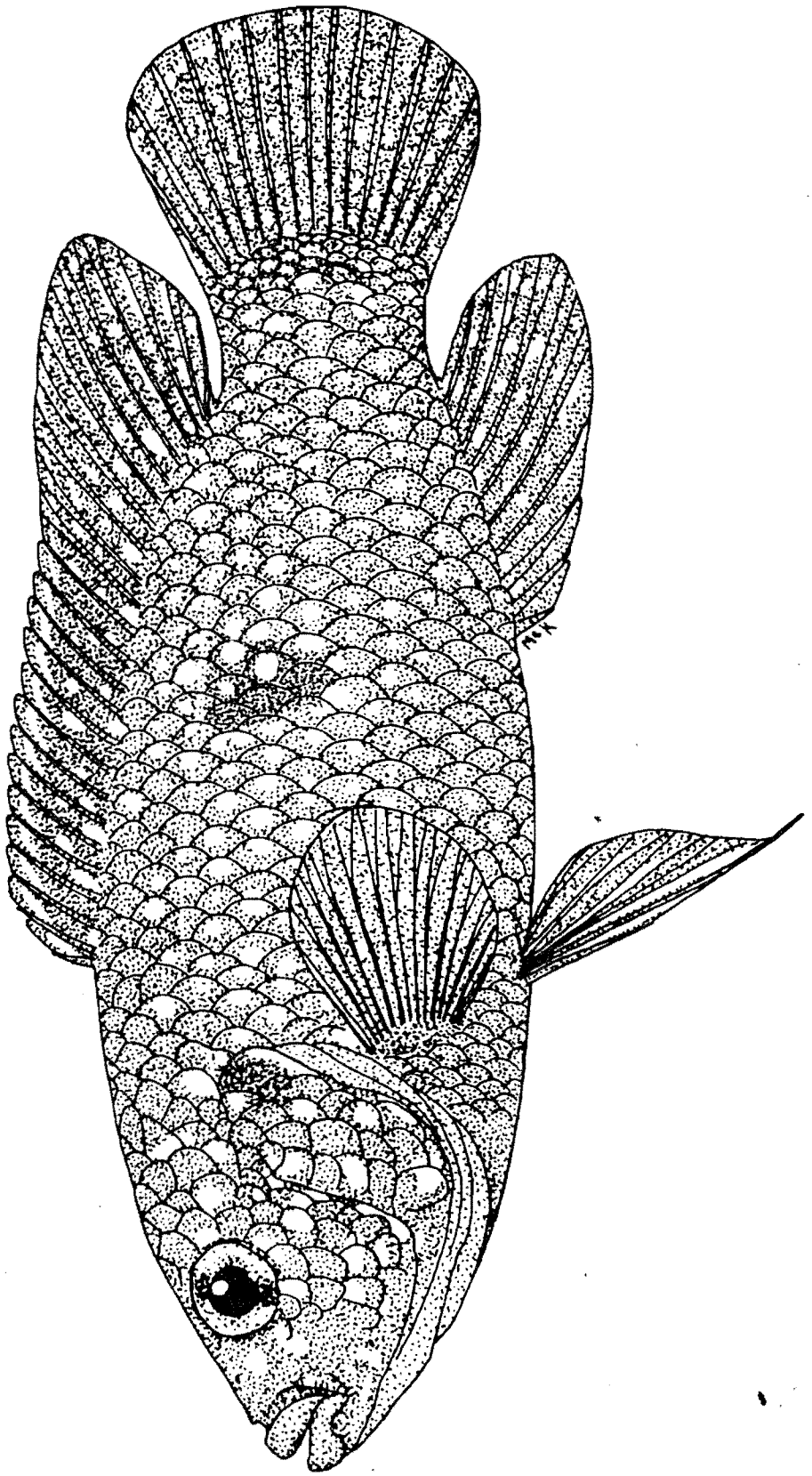
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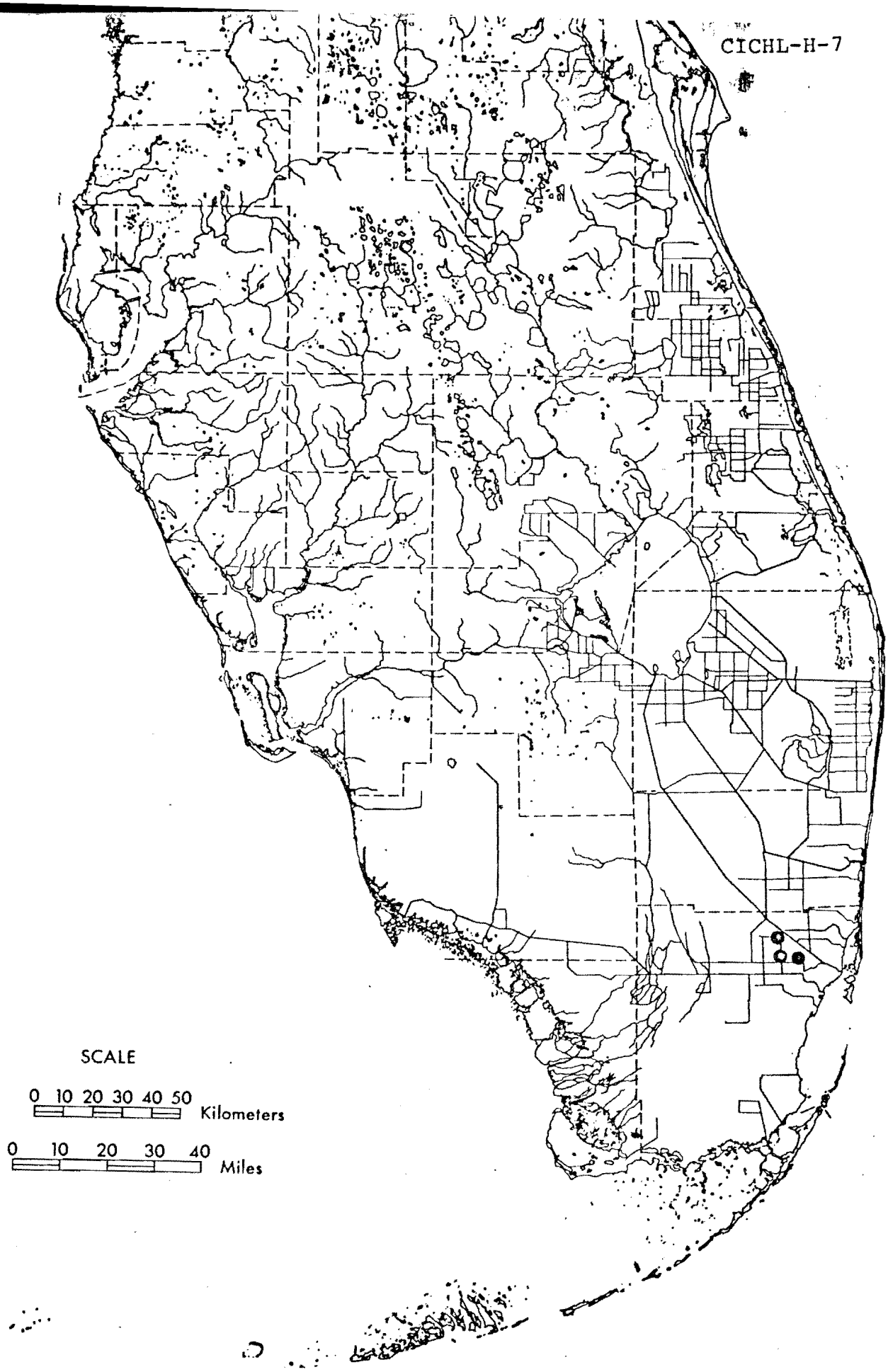
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Compiled by: Dannie A. Hensley.



CICHL-H-7



Order Perciformes
Family Cichlidae

Tilapia aurea (Steindachner)

Blue tilapia

Note on systematics: The origin of the U.S. stocks of T. aurea was Israel (William Smith-Vaniz, personal communication). This species was imported as T. nilotica which also occurs in Israel but only on the Mediterranean slope (Fishelson, 1966). Trewavas (1966) distinguished T. aurea from T. nilotica and Smith-Vaniz (1968) recognized the U.S. stocks of "T. nilotica" as being T. aurea. As far as we know, all citations of T. nilotica in the U.S. refer to T. aurea.

Trewavas (1973) has elevated the group of species containing T. aurea to generic status, i.e. Sarotherodon. We prefer to follow Thys van den Audenaerde (1968) in recognizing this group as one within the genus Tilapia. Recent references (ex: Hubbs et al., 1978) to Sarotherodon aureus are to this same species.

Original description citation: Steindachner, 1864. Ichthyologische Mitteilungen. VII. Verh. Zool. Bot. Geo. Wein, XIV, pp. 229-230, pl. 8, fig. 5.

Type locality: West Africa.

Native range: Senegal, middle Niger, Benue River (?), Tchad, lower Nile, Jordan River system, and hot pools at Ein Fashkha (Thys van den Audernaerde, 1968).

U.S. range: Tilapia aurea is established in the following 18 counties of Florida: Alachua, Brevard, Dade, De Soto, Hardee, Hernando, Hillsborough, Lake, Manatee, Marion, Orange, Osceola, Palm Beach, Pinellas, Polk, Sarasota, Seminole, and Volusia. Foote (1977) also records this species from Broward (an error), Charlotte, Glades, and Pasco counties; we are unaware of any records from these last three counties; she does not record T. aurea from Brevard County.

Tilapia aurea is established in Texas in Braunig Reservoir (Bexar County), Canyon Reservoir (Comal County) on the Guadalupe River (Hubbs et al., 1978), Lake Nasworthy (Tom Green County), and Amistad Reservoir(Val Verde County) on the Rio Grande River (Hubbs, 1976). It was established in Trinidad Lake (Henderson County; Noble et al., 1976) but has been extirpated there (Hubbs et al., 1978; Noble, 1977).

Tilapia aurea has been established since about 1975 in Arizona (W. L. Minckley, personal communication via Robert R. Miller). Alban Essbach (personal communication) reports that this species was used several years ago in an irrigation district in the Gila Bend area for algal control.

This species was established in the North Canadian River,

northwest of Harrah, Oklahoma in 1977 with a confirmed range of 383 km from Lake Overholser to Lake Eufaula (Pigg, 1978). This population apparently died out during cold weather in late 1977 and early 1978.

Robert Behnke (personal communication) reports that T. aurea (identification unconfirmed) is raised commercially on a hog farm in Alamosa, San Luis Valley, Colorado. There are warm springs in the San Luis Valley. This species is marketed as "Colorado panfish." Behnke also comments that this probably represents "an altitudinal record" for Tilapia in the U.S. (above 2.3 km above sea level).

Tilapia aurea was purposefully introduced into Skyland Lake (now Lake Julian), south of Asheville (Buncombe County), North Carolina. It was introduced with T. mossambica which apparently "survived to the exclusion of other species" (J. H. Cornell, personal communication via Reeve Bailey). The stocking of Lake Julian was done in 1965 and T. aurea was still extant there as recently as 1972 (Reeve Bailey, personal communication). Hayden Ratledge (personal communication) reports that to his knowledge T. mossambica is the only species of Tilapia now in Lake Julian.

Smith-Vaniz (1968) reports that T. aurea is stocked annually in ponds in Alabama. He also reports (personal Communication) that this species overwintered successfully in outdoor ponds at Auburn University in 1971.

Tilapia aurea was stocked in Iowa to test growth potential in ponds. Although this species reporduced there, it did not overwinter (Pelgren and Carlander, 1971).

We also have as yet unconfirmed reports that T. aurea may have been sotcked in some golf course ponds at Sea Island and St. Simons Island (Glynn County), Georgia.

Sources of introduction: To our knowledge, all U.S. stocks of T. aurea came from Israel. The first U.S. introduction appears to have been into ponds in Alabama by fisheries personnel at Auburn University (Swingle, 1960). The first shipment to Auburn arrived there on 4 January 1954; it was sent by the late Earl Herland of the Steinhart Aquarium, San Francisco, California. Stocks used by Auburn in pond studies conducted from 1956 to 1959 were obtained by S. Tal from Israel (Swingle, 1960).

Swingle (1960) stated that the "Nile tilapia", T. nilotica (=T. aurea, as noted earlier) grew to a larger size in less time than T. mossambica stocked in Alabama ponds but was a "less readibly caught" species, with a catch per harvestable stock of less than 10 percent. Despite this published warning, the Florida Game and Fresh Water Fish Commission apparently decided to import this fish for experimental purposes as a potential biological control for pest aquatic plants under the guise of a potential new sport species.

In August 1961, the Florida Game and Fresh Water Fish Commission introduced 3,000 T. aurea into a series of research ponds (phosphate pits) at Pleasant Grove, Hillsborough County, to examine the ability of this fish to control aquatic vegetation (Courtenay and Robins, 1973; Courtenay et al., 1974; Harris, 1978). These stocks of blue tilapia were obatined from Auburn University. Apparently because Florida's studies were being conducted with Dingell-Johnson funding (Project F-14, Florida), T. aurea was also to be examined for its sport fishing potential. Crittenden (1962) provided the first report on these studies. In 1964, it was recommended that T. aurea not be stocked in Florida because sport fishing success was low, the species could overwinter in northern Florida, and the addition of another "forage species would serve no useful purpose" (Barkaloo, 1964); interestingly, no comment was made on the ability (or lack thereof) of T. aurea to control aquatic vegetation in Florida in that report.

Despite the recommendation made in 1964 against further stocking of T. aurea in Florida, it was too late. Several sportswriters had earlier portrayed T. aurea as a new sport species. It is reported that fishermen actually removed young blue tilapia from nests within the experimental ponds and moved them to other waters (F. G. Banks, Vernon Ogilvie, Forrest Ware, personal communication; Buntz and Manooch, 1969). Some fish were actually given to "friends" for stocking (Buntz and Manooch, 1969). Other fish, "incapacitated in cold

weather ... could be easily picked up with dipnets by fishermen and transferred alive to rivers, lakes, and private ponds" (Barkaloo, 1964); this apparently happened. By the time the negative recommendation was made, T. aurea had been moved by citizens to waters outside of the experimental areas. Buntz and Manooch (1969) documented the rapid spread of T. aurea in a report compiled only seven years after the initial introduction; Foote (1977) updated the status of T. aurea in Florida as did Harris (1978), based in part on Foote's report.

In 1972, the Florida Game and Fresh Water Fish Commission permitted haul seining for T. aurea and subsequently permitted cast netting for this species. T. aurea gained some acceptance in commercial markets and the whole sale price went from $0.11 to a stabilized (1978) price of $0.15 per pound (about $0.49 per pound whole and $1.89 per pound as fillets in retail markets) (Harris, 1978); Harris (1978) feels that commercial fishermen are now transplanting T. aurea into "new" waters in Florida for the purpose of opening up new commercial fishing; there may not be factual evidence for this at present, but considering how the initial introductions into open waters of Florida occurred, Harris' conjecture is fully plausible.

The northernmost record for establishment of T. aurea in Florida is Lake Alice on the University of Florida campus in Gainesville. It has been established there since 1969 and perhaps earlier. Burgess et al. (1977) indicate that this

was a "local introduction" but fail to indicate a possible source of introduction.

The populations of T. aurea in southern Dade and east-central Palm Beach counties of Florida originated as escapes or releases from aquaculture operations. The northeastern Dade County population is in ponds in a large condominium complex, possibly introduced there for the purpose of aquatic vegetation control.

The reason(s) for the introduction of T. aurea is (are) unclear. What is clear is that this species was touted widely, particularly by fishery biologists at Auburn University, as a species that "bids fair to usurp this position [the position of Cyprinus carpio as the 'foremost pondfish in worldwide culture'] in tropical countries" (Swingle, 1960). Also during the 1960s, interest in pond culture of warmwaters fishes, such as the native channel catfish, Ictalurus punctatus, grew rapidly. Apparently, power companies became interested in using so-called "tropical fishes" for food or sport in heated effluent ponds, used to cool effluents from both fossil fuel - fired and nuclear generating plants, where temperatures often became too high to support populations of native fishes. We suggest that the initial introductions of T. aurea to Texas were made into such cooling reservoirs of power plants as satellite operations. Stickney (1979) supports this suggestion.

Hubbs (1972) did not record T. aurea in Texas but did report T. mossambica as new to the fauna. In 1976, Hubbs cited T. aurea as introduced in an area of eastern south-central, southern, and north-central Texas. The blue tilapia is cited as having been "inadvertently introduced" into one cooling - water reservoir in Texas (Trinidad Lake) "in the late 1960s" (Noble et al., 1976).

Hubbs et al. (1978) emphasize that exotic fishes can best become established and compete with native Texas fishes "in stenothermal springs (Hubbs, 1971) and power plant reservoirs (Thompson et al., 1977)"; they also stess that the steno-thermal springs have endemic fishes and that the reservoirs are "newly constructed environments." Braunig Reservoir is an example in the latter category. Hubbs et al. (1978) also report an established population of T. aurea in Canyon Reservoir on the Guadalupe River that may have resulted (although this was not stated) from release of juvenile T. aurea, often sold as bait in Texas (Clark Hubbs, personal communication), much as the goldfish, Carassius auratus, is used for the same purpose and has adapted to the waters of many states. Hubbs et al. (1978) suggest that T. aurea has either adapted to thermal conditions in Canyon Reservoir or may have found refugia in thermal springs in that area of central Texas. We do not know enough about the history and status of established populations of T. aurea in Lake Nasworthy or Amistad Reservoir to establish possible rationale for introductions there.

Tilapia aurea was apparently introduced to irrigation systems in the Gila Bend area of Arizona for control of algae (Alban Essbach, personal communication). While we have no knowledge of the effectiveness of this introduction, W. L. Minckley (personal communication via Robert R. Miller) states that T. aurea has been established in Arizona since about 1975.

Pigg (1978) only hints that an aquaculture experiment conducted by Oklahoma Gas and Electric Company in an effluent pond near Harrah, Oklahoma from 1972 to 1976 may have been the source of the T. aurea introduction into the North Canadian River that occurred probably in the spring of 1977. Without further knowledge of that introduction, we suggest that Oklahoma Gas and Electric Company's aquaculture experiment, when it was terminated, is the most probably source of this release that extended to about 383 river km before the population died from cold weather in late 1977 and early 1978.

As an Instructor in the Department of Zoology at Duke University in 1963-64, the senior author of this report learned that the State of North Carolina was planning to introduce "Nile perch" into that state. This was reported to C. Richard Robins in 1964 who, in turn, reported the proposed introduction to Sherman Minton, chairman of the Committee on Noxious and Venomous Animals of the American Society of Ichthyologists and Herpetologists. There was an inquiry made by Dr. Minton that was replied to by J. H. Cornell; the reply, somewhat overstated

in our opinion, indicated that North Carolina found this tilapia to be "neither noxious nor venomous." Before the North Carolina introduction in the mid-1960s, Florida had already reported and filed a negative report on T. aurea as a sport fish; North Carolina was planning its introduction of T. aurea as a sport species in Skyland Lake, now called Lake Julian, south of Asheville.

Lake Julian is a cooling reservoir of the Carolina Power and Light Company. In 1972 correspondence to Reeve Bailey, J. H. Cornell recounted the history of this introduction. Some 3,000 fingerlings of both T. aurea and T. mossambica were stocked in Lake Julian in 1965. This reservoir is high in the mountains and is surrounded by streams of trout quality, a most inhospitable habitat by temperature alone for Tilapia spp. Cornell admits that T. aurea proved "difficult to take on hook and line." He also states that Lake Julian is a small reservoir that reaches such high temperatures during summer months "that only a few centrarchids survive," that T. aurea has provided "a lot of recreation for a lot of people, they could be completely eradicated if we found it desireable to do so, and they are filling a niche which none of our domestic species could survive." Thus, T. aurea, which is not venomous, nor is any species of Tilapia, did not prove to be noxious in Lake Julian. What apparently proved to be noxious or detrimental to the point of extirpation of T. aurea in Lake Julian was T. mossambica.

Other introductions of T. aurea into a warm springs area of Colorado were for aquaculture purposes; into Iowa ponds to test growth potential during summers; and, if the Georgia records are valid, apparently for algal control purposes. We seriously question the proven effectiveness of any species of Tilapia in either algal or rooted aquatic vegetation control in North America.

Life history: Foote (1977) provides an ample listing of "useful references" on T. aurea. These references include information on life histories, diseases, growth (primarily in pond culture), etc. All references that she lists are in the library of the Florida Game and Fresh Water Fish Commission's Fishery Research Library at Eustis, Florida. The following is in part a summary of the life history of T. aurea in Lake Parker (Polk County), Florida as reported by Foote (1977) with some additonal data from other sources and from our project personnel.

Foote (1977) established that a majority of the T. aurea population sampled in Lake Parker produced an annual ring in March and April. She then examined scales from 242 specimens and found annuli on scales of 165 individuals. "Average back calculated total lengths for combined year classes at annuli I to IV were 160, 276, 311, and 313 mm respectively." She compared these data with those obtained in Israel (Ben-Tuvia, 1959), Syria (El Bolock and Koura, 1961), and Trinidad Lake

in Texas (Gleastine, 1974) and concluded that the growth rate for T. aurea in Lake Parker is greater than that for this species in Israel and Syria but less than those from Trinidad Lake.

Numerous pond studies on growth rates of T. aurea have been made, particularly in Alabama, and are not treated nor summarized here. Many of these references can be found in Foote (1977).

Adult blue tilapia (above 150 mm TL) show a dietary preference for phytoplankton (Foote, 1977, and others). They will also consume detritus (Vernon Ogilvie, personal communication, and Foote, 1977). Yashouv and Chervinski (1961) and McBay (1962) found a preference for zooplankton (including rotifers, copepods, cladocerans, and ostracods) in juvenile T. aurea less than 50 mm TL and chironomid larvae at lengths of between 50 and 150 mm TL.

Foote (1977) reports literature references of other food items ingested by T. aurea; these include insects, detritus, Pithophora, Potomogeton, Hydrilla, Eleocharis, and Najas. We note that although these items may be ingested, they do not appear to be preferred food items.

In T. aurea from Lake Parker, Foote (1977) found colonial and filamentous algae in the stomachs of 89 percent of 196 specimens examined, sand in four percent, and chironomid larvae in three

percent.

Yashouv (1958) and Pelgrin and Carlander (1971) treat reproductive habits of T. aurea. Nests are built by males. In an Iowa pond, Pelgrin and Carlander (1971) observed a male construct a nest 12 cm deep and 35 cm wide. Phil Chapman (personal communication) reports much larger nests, up to 60 cm wide, made by T. aurea in Polk County, Florida. The female deposits eggs in the next and the male fertilizes them. The female is a mouthbrooder.

Leibman (1933) reports counting about 1,300 embryos from the mouth of a female T. aurea from Lake Tiberias in Israel. Ben-Tuvia (1960) records age at sexual maturity at two years in Lake Tiberias and cites a maximum age of about 5+ years. This species exhibits male growth superiority (Fryer and Iles, 1972).

Tilapia aurea in the U.S. afe found in fresh water in Arizona, Florida, and Texas. This species shows a preference for eutrophic waters in Florida (Buntz and Manooch, 1969). This species can also be found in clear springs (personal observation).

In recent years, however, T. aurea has invaded coastal waters in Pinellas County, Florida; this species now occurs in Frenchman's Creek, Bayboro Harbor, Booker Creek, and Salt Creek in St. Petersburg. It has also been observed below the St. Petersburg pier in 1978. Hensley first learned of specimens

observed or collected in the Bayboro Harbor area in January and February 1976 and he collected T. aurea in Salt Creek in May 1978. The salinity in Booker Creek where T. aurea was collected was 29.6 o/oo (Larry Chako, personal communication). T. aurea has been observed nesting at Bayboryo Harbor. T. aurea in western Tampa Bay appears to have entered the Bay from Lake Maggiore, St. Petersburg, where this species has been established for several years.

George Reid (personal communication) has sampled the Chapel Pond on the Eckerd College campus every years since the pond was constructed in 1964. He first found T. aurea in that pond in August 1976. The only route into that pond is from Boca Ciega Bay.

Environmental impress: There has been no major attempt to measure environmental impress of T. aurea in Florida. Nevertheless, some preliminary data are available. Courtenay et al. (1974) report some dramatic populational increases by T. aurea. One example occurred in Lake Effie at Lake Wales in Polk County; sampling there revealed T. aurea at 0 percent of the total fish biomass in 1966; 0.66 percent in 1968; and 93.26 percent in 1972. There is little doubt that such increases create competition for spawning sites, space, and food.

Horel (1969) reports that in 1968-69 sampling in Lake Parker at Lakeland, Polk County, two years following the introduction

of T. aurea, showed this species to comprise 5 percent of the total fish biomass and the native gizzard shad, Dorosoma cepedianum, 60 percent. In 1972, another survey was made there; T. aurea comprised 68 percent of the fish biomass and gizzard shad 5 percent (Babcock and Chapman, 1973).

In a study of food habits of T. aurea, gizzard shad, and threadfin shad, Dorosoma petenense, in Trinidad Lake, Texas, Hendricks and Noble (in press) found these three species to generally consume the same food items, suggesting potential food competition. These food items were, in descending order, detritus, green algae, blue-green algae, and diatoms. Germany (1977) found that shad populations in Trinidad Lake declined as the T. aurea population increased. Hubbs et al. (1978) suggest that T. aurea "may well be the dominant fish in Braunig Reservoir - even out competing gizzard shad."

In the winter of 1975-76, the Texas Power and Light Company generating plant at Trinidad Lake was shut down for repair and the water temperature dropped to levels lethal to T. aurea. A massive and apparently total mortality of T. aurea in Trinidad Lake occurred (Noble, 1977). Prior to this kill, studies were conducted there on the interactions between T. aurea and largemouth bass, Micropterus salmoides. What was found was that there was a 33 percent decline in the population of M. s. salmoides between 1972 and 1975 in the presence of T. aurea. Florida largemouth bass, M. s. floridana, were

tested in ponds with T. aurea densities essentially equivalent to those in Trinidad Lake (about 2,000 lbs./acre) and the bass failed to spawn; at T. aurea densities of 1,000 lbs./acre, some limited bass spawning was observed. Bass reproduction in Trinidad Lake ceased when T. aurea densities reached 2,000 lbs./acre. Gonosomatic indices indicated that bass retained their eggs at high densities of T. aurea (Noble et al., 1976).

Trinidad Lake monitoring continued after the kill of T. aurea. What was found in 1977 was no T. aurea, successful spawning by largemouth bass, carp (Cyprinus carpio), and the smallmouth buffalo (Ictiobus bubalus). Moreover, it was also noted that during the period in which T. aurea densities were high, white crappie (Pomoxis annularis) populations had declined to "very low levels"; white crappie levels appeared to be increasing in 1977 (Noble, 1977).

From these data, it is clear that the introduction of T. aurea can have an adverse impact on fishes of the same trophic level. There is also strong evidence that high densities of T. aurea, a predictable result when virtually any species of Tilapia is introduced and becomes established in suitable habitat, can have adverse impact on reproduction of sport fishes such as bass and crappies. We strongly caution against further introductions of Tilapia spp. into open waters of the U.S. except, perhaps, into situations such as exist at Lake Julian in North Carolina; even Lake Julian-type stockings,

however, invite unauthorized moving of live individuals into suitable environments elsewhere.

Status: Established in 18 counties of Florida, several reservoirs in Texas, and the Gila Bend area of Arizona; formerly established and now extirpated in Oklahoma, one reservoir in Texas, and in Lake Julian, North Carolina. May be established in warm springs in the San Luis Valley, Colorado.

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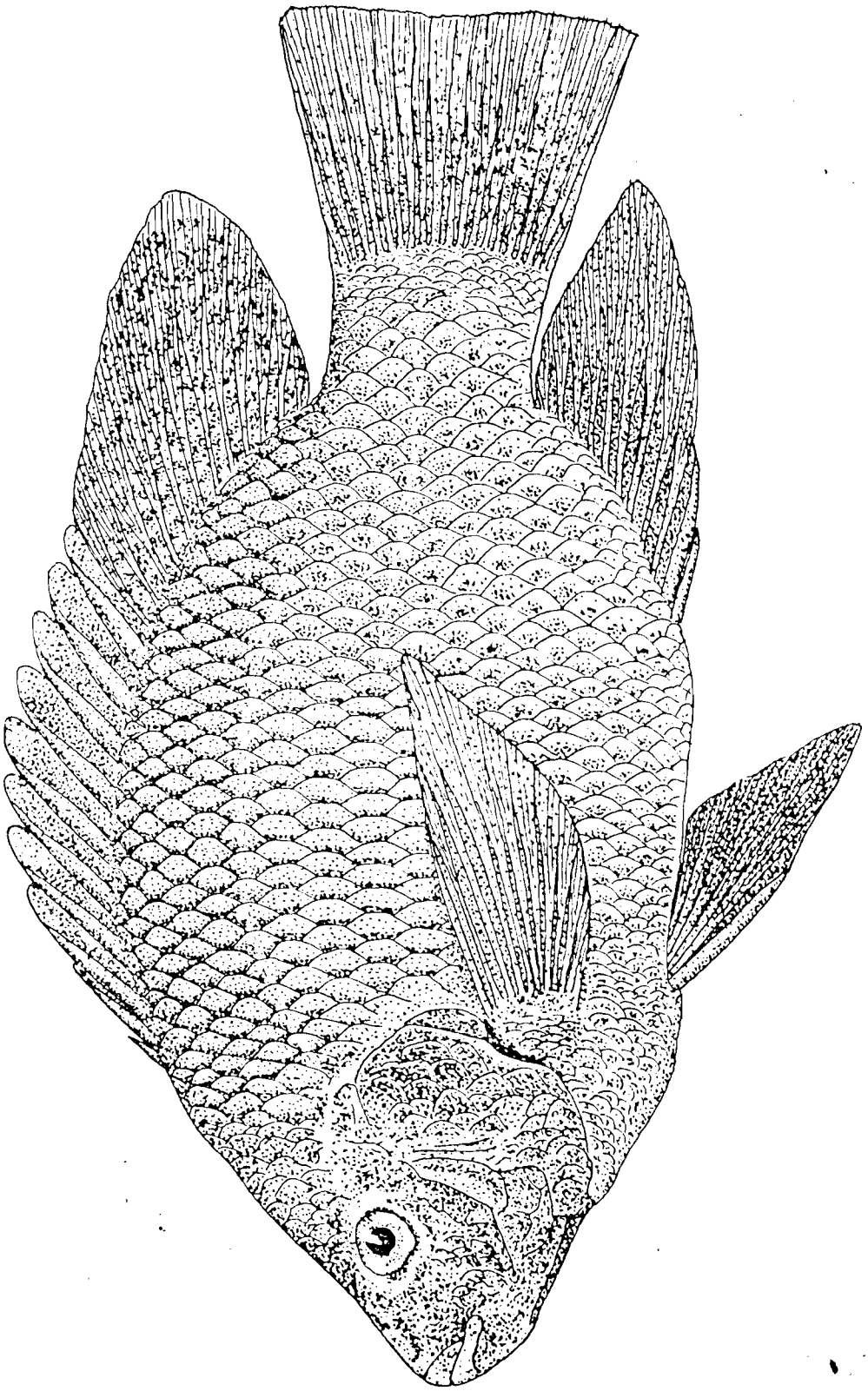
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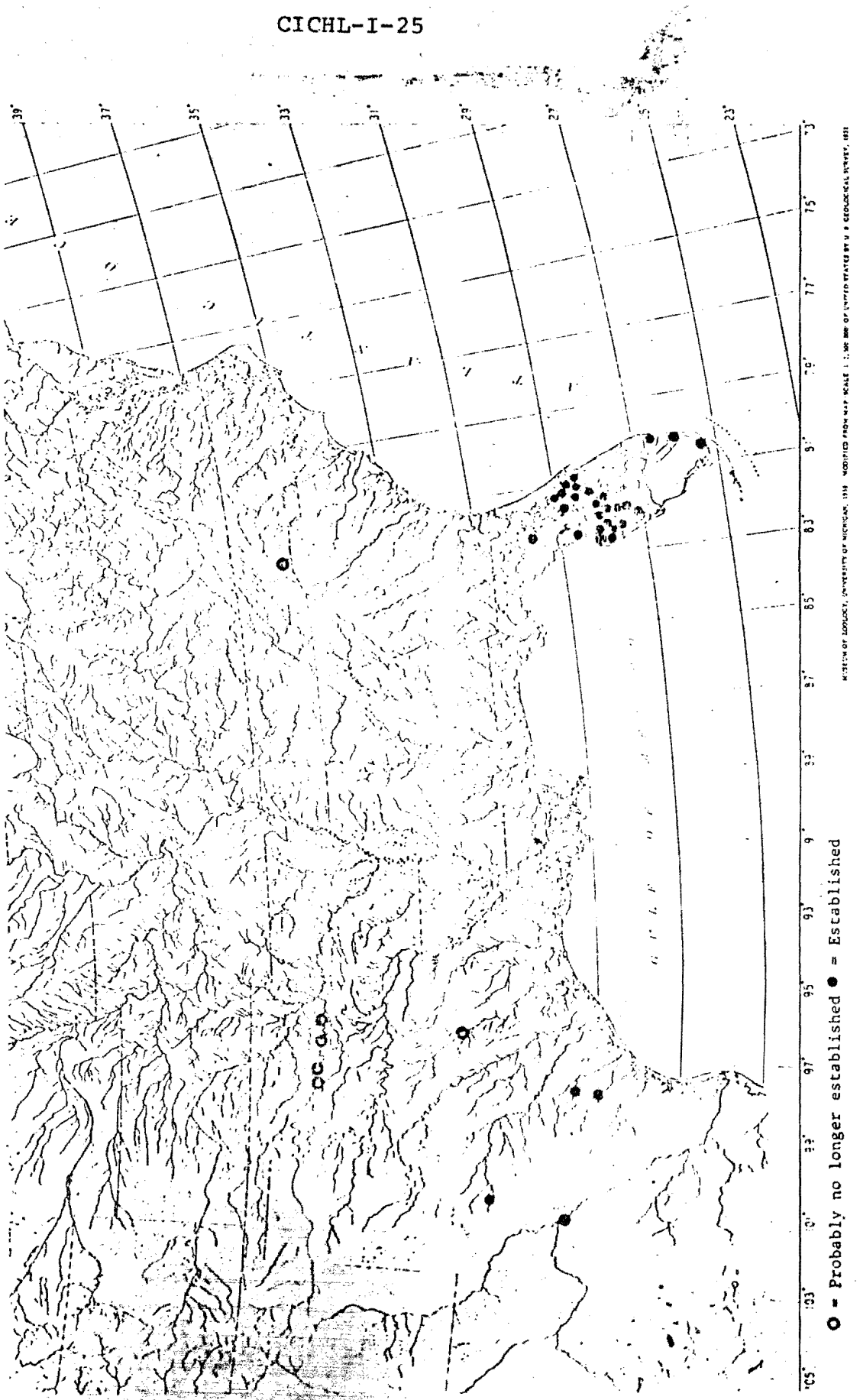
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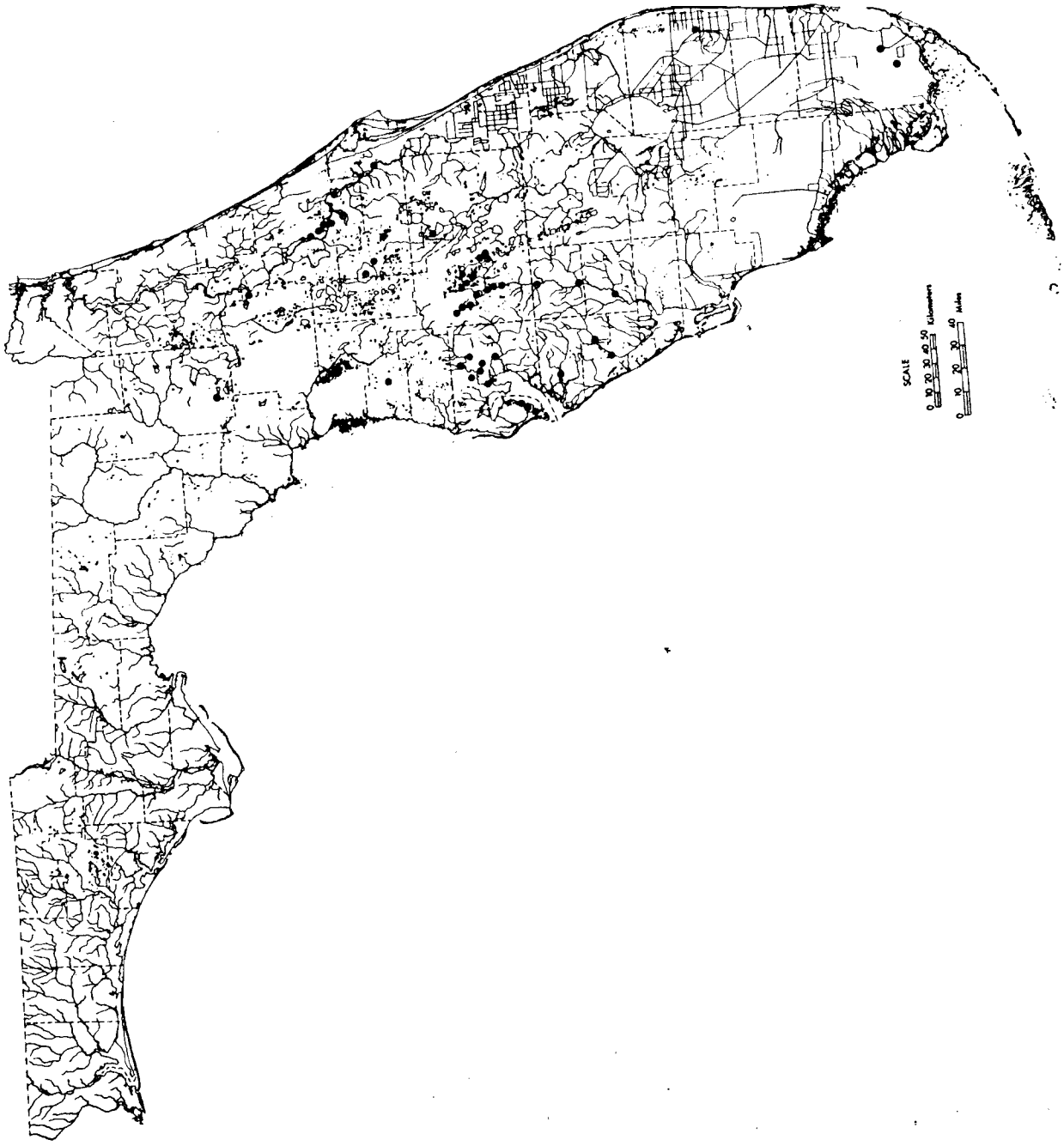
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Order Perciformes
Family Cichlidae

Tilapia mariae Boulenger

Spotted tilapia

Original description citation: Boulenger, 1899. A revision of the African and Syrian fishes of the family Cichlidae, Part II. Proc. Zool. Soc. London, 1898: 122, pl. XI, fig. 1.

Type locality: Azumine Creek, Opobo River, Niger Delta.

Native range: From middle Ivory Coast to southwestern Ghana and from southeastern Dahomey to southeastern Cameroon (Thys van den Audenaerde, 1966, 1968; Trewavas, 1974).

U.S. range: T. mariae is established and spreading rapidly in southeastern Florida. It is now found in Dade, Broward, and Collier counties (Courtenay and Hensley, 1979).

Minckley's (1973) fig. 122, labeled "Tilapia nilotica", appears to be T. mariae. He states that although this species has not been collected in open waters in Arizona, it was present at the state'e Page Springs Hatchery in 1964 and has been experimentally introduced into some areas of southern Arizona.

Sources of introduction: The distribution of T. mariae in Dade County, Florida, when it was first found in 1974, indicated it was introduced by accidental or intentional releases from

fish farms (Hogg, 1974, 1976; Courtenay and Robins, 1975).

Introduction into Arizona was made by the Arizona Game and Fish Department (Minckley, 1973).

Life history: Based on morphology of the jaw teeth, shape of the lower pharygeal bone, and number of gill rakers, T. mariae appears to be intermediate between the herbivorous and microphagous (i.e., phytoplankton- or bottom-feeding) species of Tilapia (Thys van den Audenaerde, 1966). In Lagos Lagoon, Nigeria, it was found to feed on algal filaments and diatoms (Fagade, 1971). Phytoplankton is its main food source in Lake Kotto, Cameroon (Trewavas, 1974). Hogg (1976a) studied the food habits of T. mariae in the canals of Dade County, Florida and recorded the following catagories of food items: filamentous and non-filamentous green algae, vascular plant fiber, bryozoans, cladocerans, fish scales, chironomid larvae, insect parts, fish, bone, seeds, and a type of material resembling tapioca pudding with no discernable microscopic structure. Green algae and the latter unidentifiable material were by far the most important catagories of the diet. Of identifiable remains, plant material was ca. five times as important as animal material. Most of the filamentous and non-filamentous green algae found in the stomachs resembled material collected from submerged pilings or rocks in the canals, although some of the genera of non-filamentous green algae eaten by T. mariae were also collected in plankton samples. Hogg also examined

differences in diet with growth. Specimens less than or equal to 129 mm TL use far less green algae in their diets but more vascular plant fibers and bryozoans. Larger fish become more reliant on filamentous green algae. His data and general observations indicate the species feeds throughout daylight hours but not after sunset.

In its native range T. mariae inhabits coastal lagoons and small rivers in lowland coastal forests (Thys van den Audenaerde, 1966, 1968). In Florida, it prefers the altered habitats of canals and appears to have broad salinity and temperature tolerances (Hogg, 1976a; Courtenay and Hensley, 1979; personal observation).

T. mariae is a substrate spawner, and the general characteristics of its spawning behavior are the same as those of T. zillii (see account of that species). The preferred site for oviposition in T. mariae is the undersurface of rocks. Hogg (1976a) observed the species spawning on the rocky surfaces of canal walls and shelves in Dade County, Florida. The eggs are ca. 1.8 mm in diameter and turquoise blue; 200-469 are laid at each spawning. Both parents guard and aerate the eggs. About two days after the eggs have been laid, the female picks out those that are fertile and moves them by mouth to a newly constructed pit. Hatching occurs a few hours later. For a short period after hatching, the larvae remain attached to the substrate by mucous threads produced by glands on the head. Parents guard

the young until they are ca. 2 cm TL. Young continue to show schooling behavior until ca. 10 cm TL (Fryer and Iles, 1972; Hogg, 1976a; Courtenay and Hensley, 1979).

Juveniles differ markedly from adults in coloration, having seven to nine dark vertical bars on the body and caudal peduncle and two on the head. The five or six dark blotches on the sides of the body and caudal peduncle in adults form in the pale interspaces between these dark bars. The change from the barred to the blotched color pattern appears to be correlated with sexual maturity (Thys van den Audenaerde, 1966; Trewavas, 1974). Maturation apparently occurs within one year (Hogg, 1976a).

Hogg (1976a) found T. mariae spawning throughout the year in Dade County, Florida, with the greatest intensity occurring in spring months.

Environmental impress: Quantitative data on the environmental impress of T. mariae in southeastern Florida are few. However, the extremely rapid spread and increase in abundance of this species has been documented and should be cause for a great deal of concern and additional study.

T. mariae was first reported in 1974 from Dade County by Hogg (1974). He found what appeared to be two separate populations,

one in the Snapper Creek area (including Snapper Creek and Tamiami canals and the Coral Gables Waterway) and the other in the Little River - Biscayne - Opa Locka canal system. In 1976, he estimated that T. mariae had spread 8-16 km to the north, west, and south in the Snapper Creek area and 8 km north and 8-16 km west in the Little River - Biscayne - Opa Locka canal system from the sites of introduction. This species was not present in collections made in the Snapper Creek area during 1970-1972 (Courtenay et al., 1974). In 1978 we made a survey to determine exotic fish distributions in Dade County. The range of T. mariae was found to have expanded 18 km to the north and south of the limits found by Hogg (1974, 1976), i.e., it now occurs from near Homestead in southern Dade County to the South New River Canal in southeastern Broward County. In addition, we have a record of this species having been collected from a pond in Collier County near Carnestown. In 1978, we made two collections from the Tamiami Canal in Collier County at localities east of Carnestown but collected no T. mariae. Thus, the Collier County record should not be considered the western distributional limit until the species has been collected in intervening areas. However, this locality is very near the Tamiami Canal, suggesting range expansion through this canal. The spread of Clarias batrachus into the Big Cypress Swamp, Everglades National Park, and Collier County was via this route (Courtenay, 1978). If T. mariae has spread as far as Carnestown, this represents a range expansion of ca. 95 km

beyond the western distributional limit found by Hogg (1976).

Hogg (1976, 1976a) noted an increase in abundance of T. mariae in the Snapper Creek Canal area. In 1975, he made a collection near the eastern end of Snapper Creek Canal using block nets and antimycin A (Hogg, 1976a). Of 24 fish species he collected, T. mariae ranked third in percent by number (16.7%) and fourth in percent by weight (11.4%). The Dade-County collections we made in 1978 cannot be considered truly quantitative and strict comparisons between our collections and Hogg's cannot be made. However, many of our collections were made using a variety of collecting methods, and, within certain limitations, probably reflect on a gross level the actual quantitative composition of the ichthyofauna. Of 30 collections made in Dade County, T. mariae occurred in 23. We consider 14 of these collections containing T. mariae to have been made in such a manner that they can offer rough indications of the relative importance of this species at these localities (Table 1). T. mariae showed a mean of 53.8% of the samples by weight and 45.7% by number. Obviously, this species is an abundant and important component of the Dade County ichthyofauna.

Cichlids and centrarchids have many similarities in structure and habit (Jordan and Evermann, 1898; Breder and Rosen, 1966), and an obvious concern with the establishment of any cichlid in North America is the possibility of it competing with native centrarchids. Species of both families use shallow-water

spawning areas, a limited resource in the canals of south-eastern Florida. Hogg (1976a) found T. mariae and Lepomis macrochirus occurring together in these shallow-water areas during spawning; competition here is possible.

There appears to have been a shift in dominance between Cichlasoma bimaculatum and T. mariae in the canals of Dade County in recent years. In collections made there in 1970-72 and 1974-75, C. bimaculatum was the most abundant cichlid (Courtenay et al., 1974; Hogg, 1976, 1976a). However, collections made in 1978 showed T. mariae to be more important than C. bimaculatum in terms of percent biomass and numbers at most localities in Dade County (Table 1). It is possible that these species are competitors in these canals for food and spawning sites. Although Hogg (1976a) found C. bimaculatum to be more omnivorous than T. mariae in Dade County, both species feed predominately on filamentous algae. Both species spawn in the shallow-water habitat of canals, and observations indicate direct competition between these species for this resource (Courtenay and Hensley, 1979).

There is a unique opportunity in Dade, Broward, and Collier counties to use quantitative sampling techniques to document the further spread and environmental impress of T. mariae. In our 1978 survey, we were able to outline the distributional limits of this species fairly precisely. Near Homestead, the southern distributional limit, T. mariae was in very low abundance

compared to the Miami metropolitan area (Table 1). The same is true at the northern limit. In both areas, and possibly to the west in the Tamiami Canal leading into Collier County, T. mariae is in low abundance because these are areas of recent arrival. Due to the general uniformity of environmental conditions in the canal systems of southeastern Florida, it is probable that within a very short period of time, population densities of T. mariae at these localities will reach those found in the Miami metropolitan area. If quantitative sampling stations are set up soon near these present distributional limits, a great deal of important information on environmental impress could be obtained as these population increases occur. However, due to the extremely rapid spread of this species, sampling must begin within a few months.

Status: Established in Dade, Broward, and possibly Collier counties, Florida; appears to have been experimentally introduced into southern Arizona.

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Compiled by: Dannie A. Hensley and Walter R. Courtenay, Jr.

Addendum: T. mariae was recently (17 September 1979) collected in southeastern Brevard County. Sixty-four juvenile specimens were collected with a 10 ft. seine (Michael Clark, personal communication). The species appears to be established at this locality. The Micco-Fellsmere area has several large fish farms; this introduction was probably due to escapes from one or more of these operations.

Table 1. Contributions of *T. mariae* and *C. bimaculatum* to collections from Dade County, Florida.[1]

Collection Methods	Total Sample Weight (g)	Total Sample Number	*T. mariae* % Weight	*C. bimaculatum* % Weight	*T. mariae* % Number	*C. bimaculatum* % Number
Rotenone	3059.7	415	< 0.1	11.0	0.2	7.5
Seine and dip nets	3098.6	129	78.0	2.2	45.0	2.3
Seine and cast net	8088.4	143	80.0	0.4	60.8	1.4
Seine and cast net	1376.8	47	95.8	0.0	31.9	0.0
Seine and cast net	2576.4	260	80.6	8.0	54.2	7.3
Cast net	570.4	27	49.6	5.8	63.0	11.1
Rotenone and antimycin A	4046.5	274	70.3	7.7	60.6	6.9
Cast net and shocker	899.5	54	18.2	12.3	11.1	14.8
Rotenone and cast net	1063.2	309	28.6	0.0	81.6	0.0
Cast net	2621.8	121	69.0	2.4	62.8	0.8

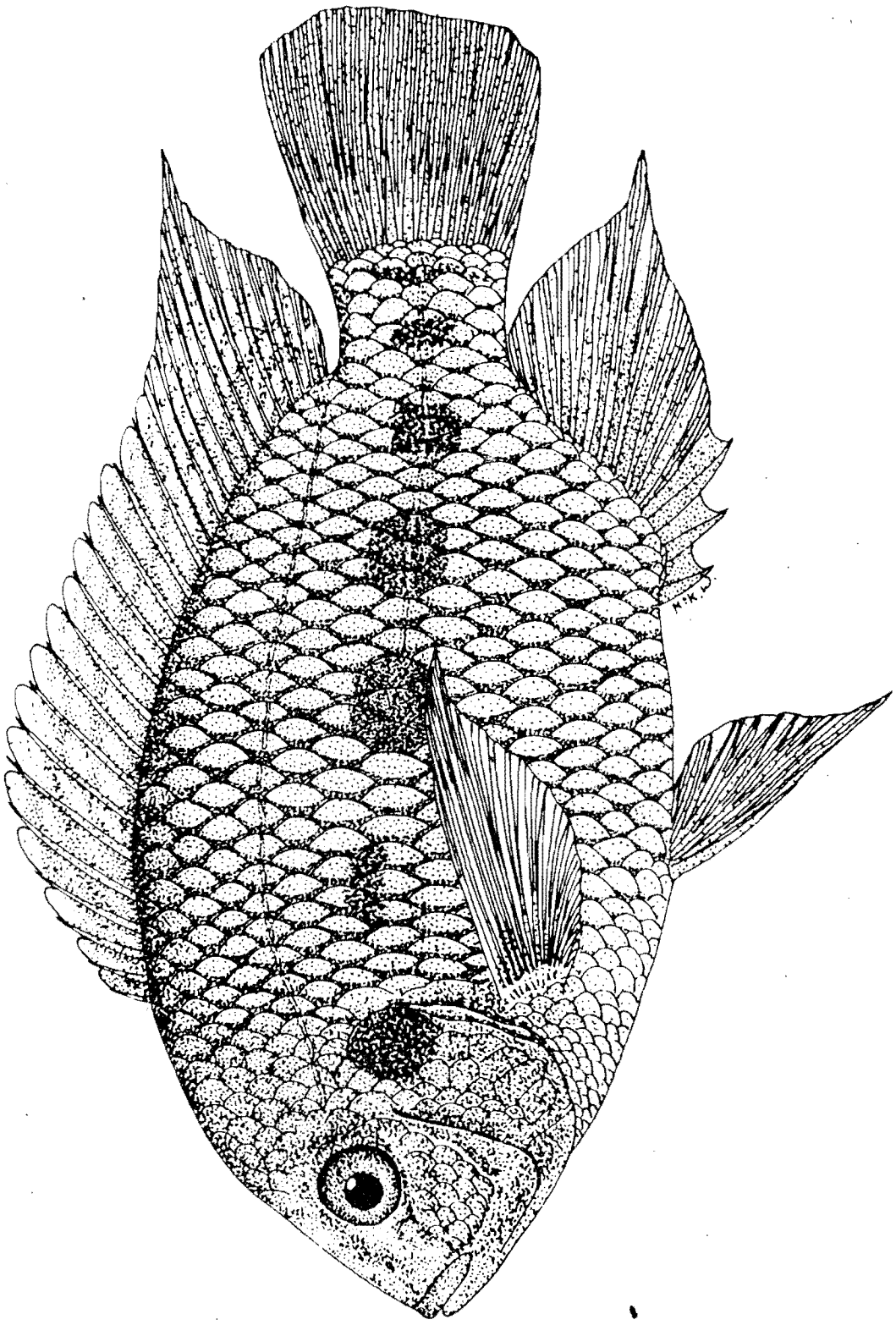
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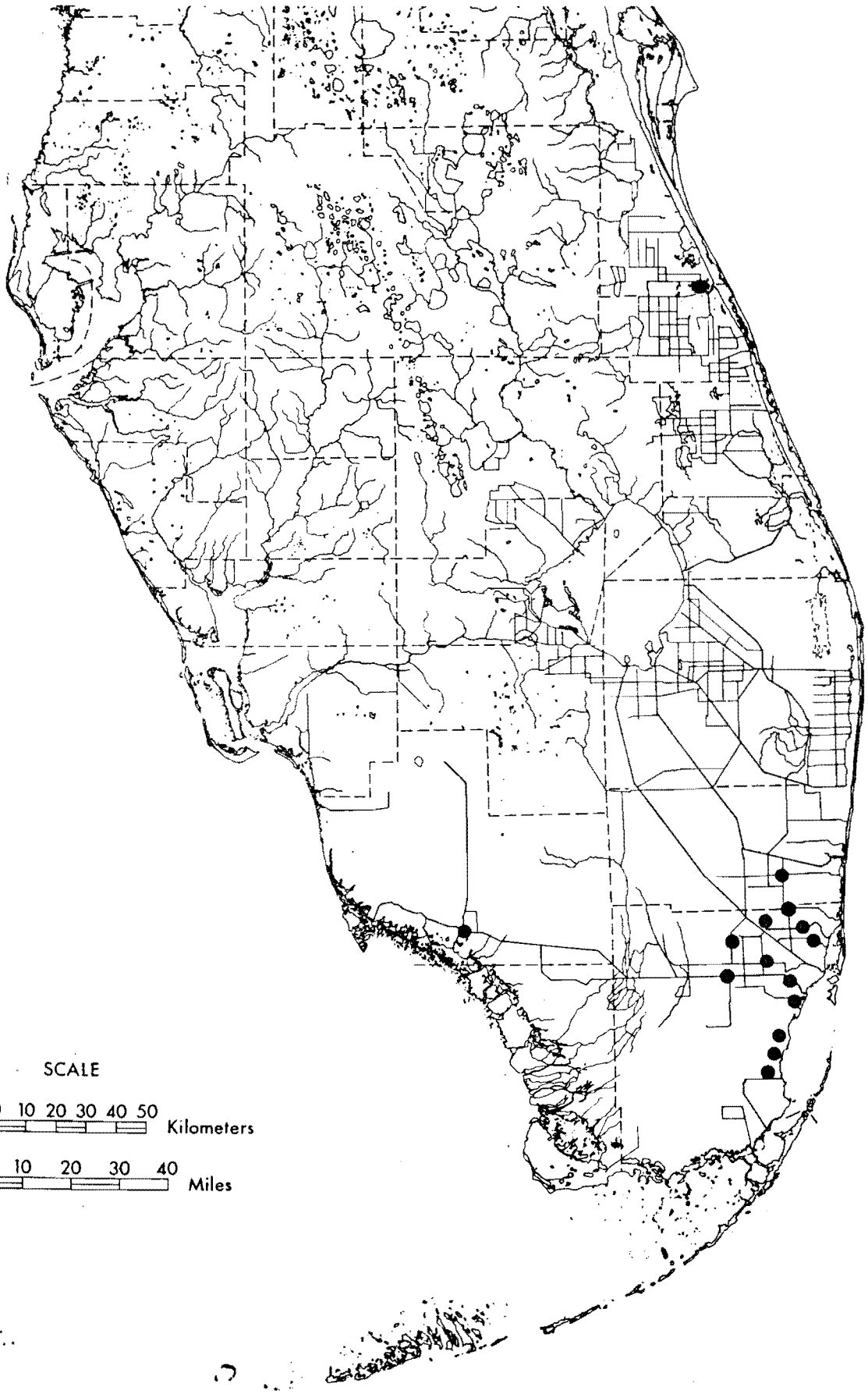
Table 1 - Continued

Collection Methods	Total Sample Weight (g)	Total Sample Number	T. mariae % Weight	C. bimaculatum % Weight	T. mariae % Number	C. bimaculatum % Number
Rotenone and cast net	2931.5	130	58.3	9.0	43.1	15.4
Seine and cast net	728.6	181	35.4	28.4	54.1	1.1
Seine and cast net	743.2	210	85.0	2.3	67.6	0.5
Antimycin A and cast net	5534.8	301	4.9	7.3	3.0	7.6
			$\bar{X}$=53.8	$\bar{X}$=6.9	$\bar{X}$=45.7	$\bar{X}$=5.5

[1] Collections arranged geographically north to south. Northernmost and southernmost collections were made near the distributional limits of T. mariae.

CICHL-J-13




SCALE
0 10 20 30 40 50
Kilometers
0 10 20 30 40
Miles

Order Perciformes
Family Cichlidae

Tilapia melanotheron (Rüppell)

Blackchin tilapia

Note on systematics: In the original literature dealing with the establishment of this species in Florida (Springer and Finucane, 1963; Finucane and Rinckey, 1964), it was identified as Tilapia heudelotii Dumeril. However, Thys van den Audenaerde (1968) identified this species as T. melanotheron. It should be noted that T. macrocephala (Bleeker) is a junior synonym of T. melanotheron (Thys van den Audenaerde, 1968, 1971). Trewavas (1973) has elevated the group of species containing T. melanotheron to generic status, i.e. Sarotherodon. However, we prefer to follow Thys van den Audenaerde (1968) in recognizing this group as one within the genus Tilapia.

Original description citation: Rüppell, 1852. Verzeichniss der in dem Museum der Senkenbergischen naturforschenden Gesellschaft aufgestellten Sammlungen. Vierte Abteilung: Fische und deren Skelette. Frankfurt a. M., p. 21.

Type locality: Gold Coast (=Ghana).

Native range: From middle Liberia to south Cameroon (Thys van den Audenaerde, 1971).

U.S. range: T. melanotheron is established on the eastern side of Tampa Bay and in the Alafia River, Hillsborough County, Florida (Springer and Finucane, 1963; Finucane and Rinckey, 1964; Lachner et al., 1970; Courtenay and Robins, 1973; Courtenay et al., 1974). It should be noted that collections made in Tampa Bay in 1978 showed T. melanotheron to have approximately the same distribution within the bay as that found by Springer and Finucane (1963) and Finucane and Rinckey (1964), i.e., along the east side of Tampa Bay between the mouths of the Little Manatee and Alafia rivers; it is not found throughout the bay as was previously reported by Courtenay et al., (1974). However, T. melanotheron has expanded its range up the Alafia River to Lithia Springs (Buntz and Manooch, 1969; Courtenay et al., 1974).

Sources of introduction: The first confirmed record of T. melanotheron was in 1959. However, an owner of a local seafood market stated they were first noted in gill net catches during 1958. The species probably escaped or was released from one of the numerous fish farms along the eastern side of Tampa Bay (Springer and Finucane, 1963).

Life history: In a study in Lagos Lagoon, Nigeria, T. melanotheron was found to feed on the following classes of food items: filamentous algae, diatoms, hydroid polyps, crustacean appendages, copepods, ostracods, other crustaceans, gastropods, gastropod eggs, bivalves, fish scales, fish eggs, sewage, sand grains, and unidentifiable organic matter (detritus).

Algal filaments, diatoms, sand grains, and detritus were the most important items. The high proportions of sand grains and detritus indicate a great deal of bottom feeding. The species possibly uses the dark organic coatings on sand grains as a nutrition source (Fagade, 1971). The food habits of T. melanotheron in Tampa Bay are similar to those in Lagos Lagoon. Finucane and Rinckey (1964) found this population feeding on detritus, sand, diatoms, armored dinoflagellates, filamentous algae, and insects. In their quantitative analysis, they found it was feeding predominately on detritus and phytoplankton. They found no evidence of feeding on fishes, crustaceans, or molluscs in Tampa Bay estuaries. However, in aquaria it readily consumed Poecilia latipinna and caridean and penaid shrimp. In the freshwater habitat at Lithia Springs on the Alafia River, T. melanotheron is known to feed on green and blue-green algae (Courtenay et al, 1974), and great numbers can be seen grazing on the rocks in the springs (personal observation). No ontogenetic changes in food habits were discerned in the Lagos Lagoon or Tampa Bay studies.

Thys van den Audenaerde (1971:213) gave the general habitat of this species in its native range as "in brackish water and along [the] seacoast." Aronson (fide Finucane and Rinckey, 1964) reports T. melanotheron as having been collected in its native range from waters with salinities near that of sea water. In our 1978 exotic fish survey in Florida, we collected specimens

where salinities ranged from 0.0 o/oo (Lithia Springs) to 22.0 o/oo (Tampa Bay estuary). T. melanotheron has survived several severe winters in Florida. Springer and Finucane (1963) report on a cold kill of this species in Tampa Bay in December 1962. A local seafood dealer reported receiving 1,553 lbs of T. melanotheron from Bullfrog Creek, Hillsborough County during 13-17 December 1962. A water temperature of 9.6°C was recorded in Old Tampa Bay on 13 December 1962. In spite of this cold kill, living individuals were seen swimming in Bullfrog Creek during the same period of time. A similar cold kill occurred during 21-22 December 1975 near the mouth of the Alafia River (personal observation). Water temperatures at this locality were 11°C and 13°C on 22-23 December, respectively. Approximately 30,000 dead or sluggish individuals were present at this locality (David Sherman, personal communication). Fagade (1971) found that T. melanotheron did not occur in water more than 2 m deep in Lagos Lagoon. The species occurs most consistently at similar depths in Tampa Bay estuaries (Finucane and Rinckey, 1964). In a comparison between two collecting stations in Tampa Bay, Finucane and Rinckey (1964) found the species to be more abundant at the station with higher primary production and greater detrital component to the sediment. This is probably due to greater food availability.

In contrast to most congeners, T. melanotheron is a paternal mouth brooder. At spawning time, the male makes and defends a

nest, i.e., a depression in the sand. In aquarium studies, nests average 13.2 cm in diameter and 2.6 cm in depth. As the female deposits eggs in the nesting area, the male fertilizes them and picks them up in his mouth a short time later. About 50 eggs are deposited at one spawning. Incubation time ranges from 6 to 29 days but is usually ca. 14 days (Breder and Rosen, 1966; Fryer and Iles, 1972; references in Finucane and Rinckey, 1964).

Length-frequency and length-weight data for the Tampa Bay population are presented by Finucane and Rinckey (1964). These workers found that individuals there seldom live beyond two years.

In west Africa, spawning in this species reaches a peak in December and January. Finucane and Rinckey (1964) examined spawning periodicity and its correlation with environmental parameters in the Tampa Bay population. They found that spawning occurs from April or May to December. Spawning in Tampa Bay during winter months is probably inhibited by cold water, as a minimal temperature of 25°C is required. The optimal temperature for breeding is 26.7-32.2°C. These workers observed them spawning in brackish waters with a mean salinity of 13.06 o/oo. They were not successful in breeding the species in aquaria when salinities were greater than 34 o/oo. However, it has been spawned in seawater aquaria by Aronson (fide Finucane and Rinckey, 1964).

Environmental impress: Springer and Finucane (1963) and Finucane and Rinckey (1964) found no reason to expect T. melanotheron to be in trophic competition with native estuarine species in Tampa Bay. However, enough case histories of detrimental effects from the establishment of exotic organisms have been documented to warn that competition for food should not be the only concern; other more subtle, dynamic factors may be involved. These workers were not aware that T. melanotheron was distributed up the Alafia River to Lithia Springs. Within these springs T. melanotheron is clearly the dominant fish species, aquatic vegetation appears to be markedly reduced, probably due to grazing by this species, and native centrarchids are in very low abundance compared to expectations (Courtenay et al., 1974; personal observation). It has not been observed spawning in Lithia Springs or the Alafia River, but an obvious concern should be the possibility that it will compete with centrarchids for spawning sites.

This species is of sufficient abundance within estuaries on the east side of Tampa Bay to support a small commercial fishery (18,000 kg in 1968; Buntz and Manooch, 1969). An exotic fish that is so successful in estuaries should be of concern in Florida because of the large expanses of this habitat available, and any deleterious effects it may have could become spread over large areas used as nursery grounds by native marine species. However, it is quite enigmatic that the coastal range of this species has not expanded since first discovered in 1959.

Status: Established on the east side of Tampa Bay and in the Alafia River to Lithia Springs, Hillsborough County, Florida.

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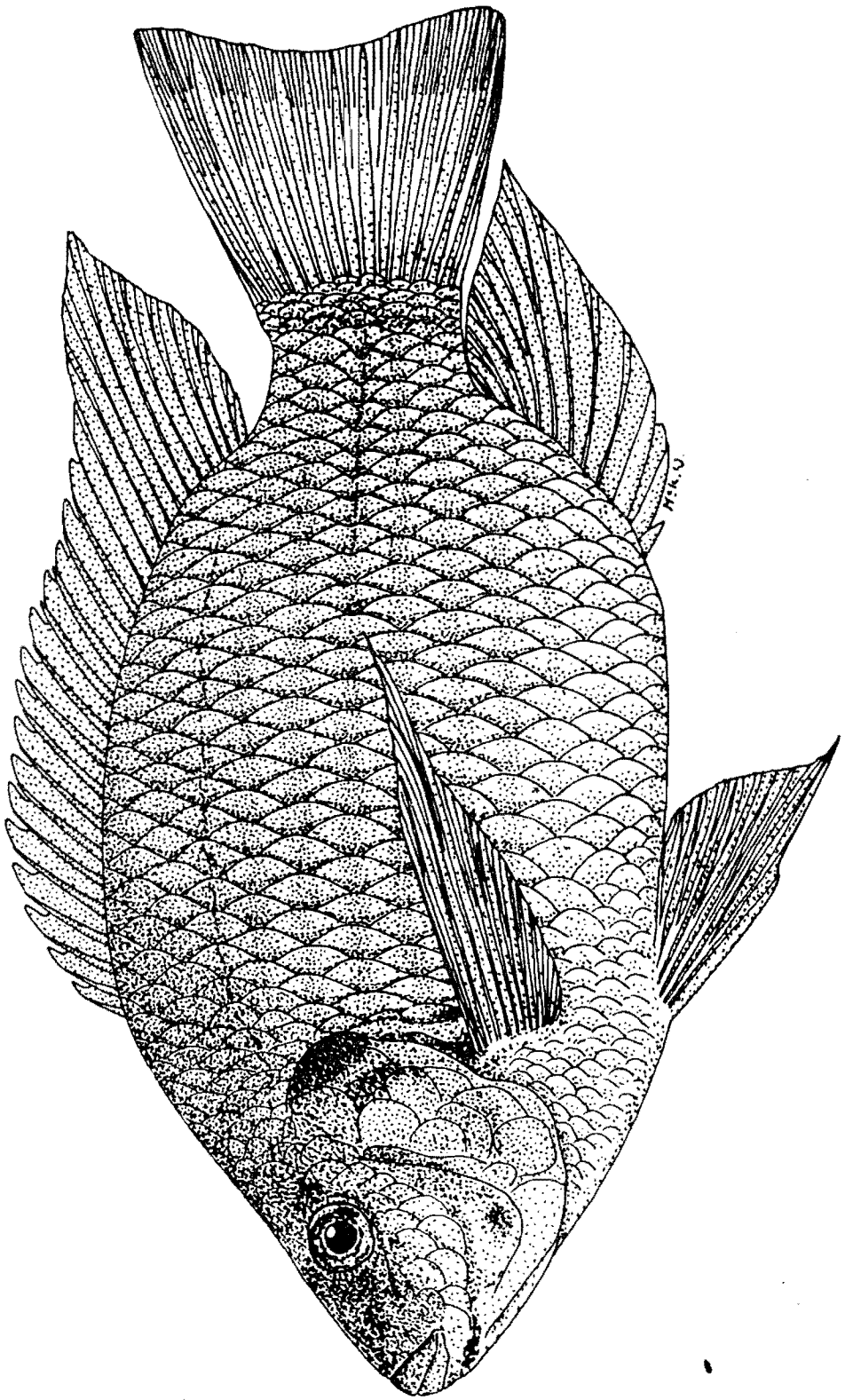
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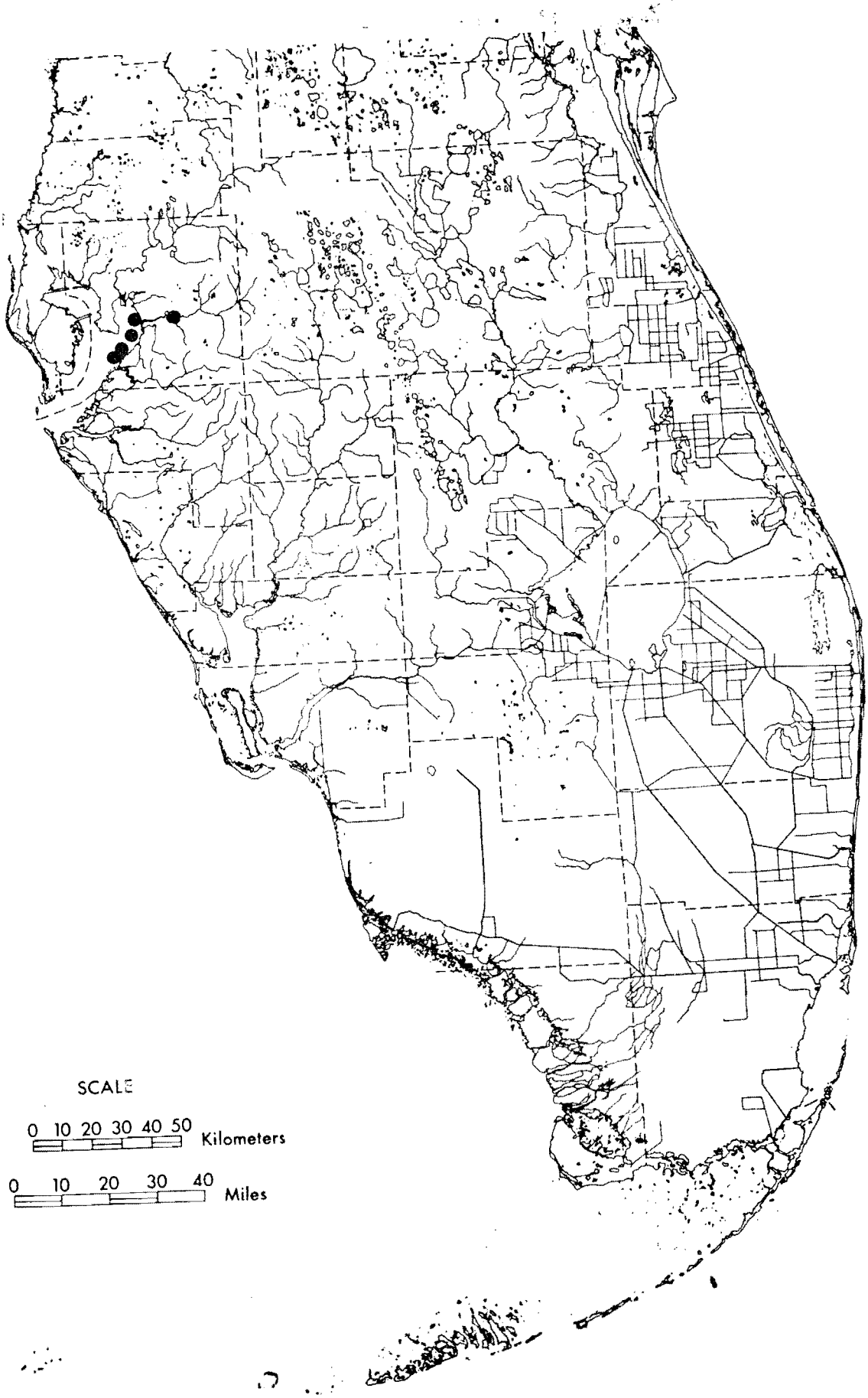
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Compiled by: Dannie A. Hensley



CICHL-K-10



Order Perciformes
Family Cichlidae

Tilapia mossambica (Peters)

Mozambique tilapia

Note on systematics: It should be noted that *T. natalensis* (Weber) is a junior synonym of *T. mossambica* (Thys van den Audenaerde, 1968). Trewavas (1973) has elevated the group of species containing *T. mossambica* to generic status, i.e. *Sarotherodon*. However, we prefer to follow Thys van den Audenaerde (1968) in recognizing this group as one within the genus *Tilapia*.

Both *T. mossambica* and the closely related *T. hornorum* were authorized for use in aquatic weed control in 1971 by the California Department of Fish and Game. Experimental work has been done in California using *T. hornorum* (Moyle, 1976), and the species appears to have been released into open waters in the southeastern area of the state (Pelzman, 1973). These two species can be easily hybridized in ponds, and F_1 hybrids backcross with either parental species (Fryer and Iles, 1972). It is possible that some tilapia in open waters of southeastern California are *T. hornorum*, *T. mossambica* x *T. hornorum* hybrids, or backcrossed individuals.

Original description citation: Peters, 1852. Diagnosen von neuen Flussfischen aus Mossambique. Verhandl. König. Preuss. Akad. Wiss. Berlin, 1852, p. 681.

Type locality: Mozambique (Tette, Sena, Quellimane, Lumbo, Inhambane, Querimba).

Native range: Lower Zambezi River, lower Shire River, and from the Zambezi Delta to Algoa Bay (Thys van den Audenaerde, 1968).

U.S. range: T. mossambica has been collected from five counties in Florida (Courtenay et al., 1974; Hogg, 1976, 1976a; personal observation). Courtenay et al. (1974) listed this species as established in the south fork of the Miami River, Dade County, in an area near Fellsmere, Indian River County, and in Six-Mile Creek, Hillsborough County, and they hypothesized that it was established in the Banana River, Brevard County. The population near Fellsmere apparently is no longer established (personal observation). The records from Six-Mile Creek were probably based on misidentifications of T. aurea. T. mossambica is established in the canals of Dade County (Hogg, 1976, 1976a; personal observation). Establishment in the Banana River was recently confirmed (David Cox, personal communication).

T. mossambica has been established in a power-plant cooling basin (Skyland Lake) near Asheville, North Carolina, since 1965 (J. H. Cornell and Hayden Ratledge, personal communication).

This species is established in Texas in the San Marcos River, San Marcos, Hays County and in the headwaters of the San Antonio River, San Antonio, Bexar County (Brown, 1961; Hubbs et al., 1978).

Since the early 1960s, T. mossambica has been established in the lower Colorado River. It now occurs from Phoenix, along the Gila River, to Yuma. A population was established at Warm Springs, on the San Carlos River, but was apparently destroyed by flooding. The species is probably present in cattle tanks and other waters in southern Arizona, but most precise localities are unknown (Minckley, 1973). It was present in the Salt River in Tempe, but flooding in 1965-1966 apparently extirpated the population (Minckley and Deacon, 1968).

T. mossambica is established in Imperial County, California in a pond and tributary on the eastern side of the Salton Sea, in drainage canals near Bard, and in the lower Colorado River (St. Amant, 1966; Hoover and St. Amant, 1970; Moyle, 1976). It was introduced into tributaries of the San Gabriel and Santa Ana rivers in 1973, and is now known to be established in estuarine areas of the San Gabriel River and Long Beach, Los Angeles County. Specimens have been taken from marine waters at Seal Beach, Orange County and Long Beach (Knaggs, 1977). There have been attempts to establish T. mossambica in the San Diego area, but these have so far been unsuccessful (Moyle, 1976).

Four specimens of T. mossambica were collected by Brown and Fox (1966) during 1962-1963 from a spring-fed pond in Bearmouth, Granite County, Montana. This pond was later destroyed by highway construction (Brown, 1971).

Smith-Vaniz (1968) states that T. mossambica is annually stocked in numerous farm ponds and a few state-owned lakes. Apparently, it is not established in that state.

T. mossambica was stocked for experimental purposes in Arrowhead Pond at Allerton Park of the University of Illinois, near Monticello, Illinois, during the spring months of 1962-1965. The species reproduced during these experiments, but was moved indoors during winters (Childers and Bennett, 1967).

A commercial catfish farm at Hooper, San Luis Valley, Colorado maintains T. mossambica in its raceways for aquatic weed control (Robert Behnke, personal communication).

It should be noted that a species of Tilapia (mossambica or aurea) is reported to be established on Sea Island and St. Simons Island, Georgia (Paul Shafland, personal communication). The status and identification of this species still needs to be ascertained.

Sources of introduction: Introductions of T. mossambica into Florida were probably due to escapes from fish farms and releases by aquarists (Courtenay et al., 1974).

T. mossambica was introduced into Skyland Lake, North Carolina in 1965 by the North Carolina Wildlife Resources Commission (J. H. Cornell, personal communication).

Introduction of this species into the San Marcos River, Texas were due to escapes from the A. E. Wood State Fish Hatchery during 1958-1959 and the Fish Culture Station of the U.S. Fish and Wildlife Service during 1960-1961. Introduction into the San Antonio River occurred in 1956 when ca. 40 juveniles escaped from a rearing pen at the San Antonio Aquarium (Brown, 1961).

This species was introduced into southern Arizona in the early 1960s by the U.S. Fish and Wildlife Cooperative Fisheries Unit at the University of Arizona and the Arizona Game and Fish Department (Minckley, 1973).

Introduction of T. mossambica into a pond and tributary on the eastern side of the Salton Sea, California was probably due to escapes from a nearby fish farm which had been culturing the species (St. Amant, 1966). The presence of this species in the drainage canals of Bard and the lower Colorado River is due to introductions into the Yuma canal system made by the Arizona Game and Fish Department in the early 1960s. The species spread into California waters from the Yuma area by natural dispersal or unauthorized transplants (Hoover and St. Amant, 1970). The California Department of Fish and Game introduced T. mossambica into tributaries of the San Gabriel and Santa Ana rivers in 1973 (Knaggs, 1977).

The source of the introduction of T. mossambica into the pond in Bearmouth, Montana is not mentioned by Brown and Fox (1966).

The annual stocking of T. mossambica into Alabama waters is by the Alabama Department of Conservation (Smith-Vaniz, 1968).

The species was stocked into the experimental pond near Monticello, Illinois by the Illinois Natural History Survey (Childers and Bennett, 1967).

Life history: T. mossambica has been widely introduced and studied for pond culture. It now has an essentially circum-tropical distribution. Most of its popularity is due to the ease with which it can be cultured, its potential for high production, and its rapid growth (Brock, 1954; Swingle, 1960). In addition, it has been advocated for use in aquatic weed and mosquito control and as a game fish (e.g., Kelly, 1957; Swingle, 1960; Childers and Bennett, 1967). As a result of these interests, most studies of T. mossambica have been carried out in ponds and aquaria where the diversities of foods available and coexisting fishes have been minimal. Thus, using the information from these studies to predict or make judgements about its ecology when released into open waters with complex ecosystems requires a great deal of caution. Although T. mossambica has been considered to be primarily herbivorous (Kelly, 1957), it should more properly be considered an omnivore. It has been recorded to feed on the following types of food: filamentous and non-filamentous algae, rooted aquatic vegetation, dead vegetation, soy beans, rice bran,

crustaceans, bryozoans, larval and adult insects, small fishes, oligochaetes, and chopped meat (Kelly, 1957; Childers and Bennett, 1967; Fryer and Iles, 1972; Hogg, 1976a; Moyle, 1976). In addition, its value as a sport fish rests on the fact that it can be caught on artificial and natural baits, including earthworms, flying insects, and small fishes (Swingle, 1960; Jubb, 1967; Minckley, 1973). It is probably at least partially due to the omnivorous food habits of T. mossambica that it has not been particularly effective in controlling aquatic weeds, except in experimental ponds (Moyle, 1976). Although this species has been reported to feed heavily on phytoplankton and other aquatic plants, there is some doubt as to how much of this material is actually digested. T. mossambica does not produce cellulase, and cellulose-walled algal cells have been shown to pass through its digestive tract unharmed (Fryer and Iles, 1972). This species probably shows ontogenetic changes in feeding, but published statements on these changes are contradictory. Thus, small juveniles have been reported as feeding on diatoms and plankton, but becoming more omnivorous with growth, feeding on crustaceans, insect larvae, dead vegetation, and small fishes (Anon., 1962; fide Hogg, 1976a). Minckley (1973) also implies that this species becomes more carnivorous with growth. However, Vaas and Hofstede (1952; fide Kelly, 1956) and Moyle (1976) state that aquatic invertebrates are more important in the diet of juveniles than adults.

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T. mossambica seems to prefer still or slow-moving waters such as ponds, canals, and river backwaters. In the lower Colorado River they are most abundant in areas influenced by warm, saline irrigation water (Moyle, 1976). It is a euryhaline species. At the southern end of its native range, T. mossambica is more common in estuaries than in fresh waters (Jubb, 1967; Allanson et al., 1971). According to Lowe-McConnell (1955) this species has been collected some distance out to sea off of Kenya. Brock (1954) spawned T. mossambica in sea water and was able to transfer adults and juveniles directly from sea water to fresh water without significant loss, although some losses occurred when juveniles spawned in fresh water were put directly into sea water. In Florida, this species is established in the brackish Miami River in Dade County (Courtenay et al., 1974; Hogg, 1976, 1976a) and in the Banana River in Brevard County (David Cox, personal communication), where salinities range from 9.3 to 34.5 o/oo ($\bar{X}$ = 21.8 o/oo; Gilmore, 1977). In California, T. mossambica has been found breeding and larvae have been collected in waters with salinities as high as 34.5 o/oo (Knaggs, 1977). In fresh water, this species can survive temperatures as low as 5-9°C for short periods of time, but over long periods it is not able to survive temperatures below ca. 11-13°C (Childers and Bennett, 1967; Allanson et al., 1971; Moyle, 1976; Knaggs, 1977). However, Allanson et al. (1971) have shown that the lower lethal temperature for T. mossambica is salinity dependant. These workers found that in fresh water this fish

went into a secondary chill coma after prologed exposure to 11°C, but in water with a NaCl concentration of 5 o/oo, it showed no signs of cold stress at this temperature. Failure of T. mossambica to survive in fresh water of low temperature is associated with osmoregulatory collapse and subsequent ion loss. Saline water allows the species to retain near normal sodium and chloride ion concentrations at low temperatures. At the southern limit of the native range of T. mossambica, temperatures of 12°C have been recorded. However, it is in this area that the species occurs more frequently in estuarine than freshwater habitats. Allanson et al. (1971) suggest that its restriction to estuaries in this area is related to the prevention of osmoregulatory failure during winter months.

T. mossambica is a maternal mouthbrooder. When conditions are unfavorable for spawning, adults travel in schools and both sexes are of a greyish color. At spawning time, males assume the reproductive color pattern, where the body and upper areas of the head turn black, the lower part of the head white, and the pectoral fins and borders of the dorsal and caudal fins bright red. These males leave the school, establish territories, and dig pits in the sandy substrate using their mouths. In Florida, Hogg (1976a) has observed that these pits are large (0.5 m in diameter and 0.2 m deep) and that adjacent pits are never closer than 5-10 m. Once males have established territories and dug these pits, they begin to court passing

females with invitational displays. A receptive female follows a male back to the pit, which they circle for some time, the male following the female. While the female swims over the surface of the pit, she releases a number of eggs. The female turns and picks up the eggs in her mouth. The male ejects milt over the area where the eggs were laid. The water containing the milt is also taken into the female's mouth. She makes mumbling movements with her jaws, thoroughly mixing the eggs and milt. This behavior continues until all eggs are laid, at which time the female leaves the territory. The male begins courting other females. The female carrying eggs remains secluded for 10-12 days while incubating the eggs. Juveniles are well developed by the end of this time, when they are released by the female. They form a school which follows the female. For the first four or five days after release of the young, the female will attack intruders. If these attacks do not drive intruders away, the female will call the young to her mouth with special movements. After this period, the young continue to school but become dis-associated from the parent (Baerends and Baerends-Van Roon, 1950).

The number of eggs laid at each spawning depends upon the size of the female. Baerends and Baerends-Van Roon (1950) found that a female 150 mm in length (TL?) lays 200 - 300 eggs. Although no size is given, Hogg (1976a) examined the ovaries of one specimen in Florida which contained 1095 eggs. Eggs

are opaque (Baerends and Baerends-Van Roon, 1950). Hogg (1976a) made counts of the number of young being guarded by two females in Florida; the mean for these counts was 550.

It should be noted that the territoriality exhibited by breeding male T. mossambica probably accounts in part for the fact that wild populations rarely reach densities necessary for effective aquatic weed control (Moyle, 1976).

Most studies on growth and maturation rates of T. mossambica have been carried out in ponds; both rates in natural populations are probably much lower (Lowe-McConnell, 1975). In one series of pond studies, T. mossambica grew from means of 73 - 77 to 162 - 169 mm TL in 18 weeks (Kelly, 1956). Fryer and Iles (1972) present growth data from pond studies in Egypt and South Africa; some examples of these data are total lengths of 82 - 149, 165 - 296, and 227 - 348 mm at ages of one, four, and six years, respectively. In ponds this species breeds when only 2 - 6 months old (Swingle, 1960; Childers and Bennett, 1967; Moyle, 1976). Although Baerends and Baerends-Van Roon (1950) state that growth of young T. mossambica is better in brackish water than fresh water, Brock (1954) found no significant difference in growth rates between juveniles raised in sea water and fresh water. Males develop a concave profile and enlarged mouth and have a faster growth rate than females (Lowe-McConnell, 1975).

In the tropics, T. mossambica spawns during the summer months;

a female may spawn three or four times in one season (Swingle, 1960; Jubb, 1967; Lowe-McConnell, 1975). Males seem to be able to fertilize continuously for many months (Baerends and Baerends-Van Roon, 1950). According to Moyle (1976), T. mossambica will continue to breed as long as water temperatures are above 20°C. In Florida, Hogg (1976a) found spawning in T. mossambica to be strictly seasonal, occurring from February to May. Knaggs (1977) observed this species spawning in coastal areas in southern California during August, September, and October; he saw no spawning activity during observations made in December and January.

Environmental impress: As previously mentioned, virtually all information on the biology of T. mossambica has been obtained from pond and aquarium studies with extremely simple biotas. Most pond studies have been experiments in production (e.g., Kelly, 1956; Swingle, 1960; Childers and Bennett, 1967), where very few food sources were available and there were no coexisting fish species, although one predatory fish species has sometimes been used for population control to reduce stunting in T. mossambica. These studies give little or no information on the subtle, dynamic factors involved when this species is released into open waters with complex ecosystems. This is particularly true in regard to marine and estuarine areas. Unfortunately, information from such studies has apparently been used to justify releases of T. mossambica into open fresh waters, including those connecting directly

with marine waters. Because of our lack of knowledge concerning the ecology of this species under open, more natural conditions, its dispersal should be closely monitored and attempts made to determine its environmental impress where it is established.

Data on the impress of established T. mossambica populations are limited. The estuarine area of the San Gabriel River in southern California, where T. mossambica has been established since 1974, was sampled in 1971. At that time, seven fish species were collected, the most abundant being Fundulus parvipinnis, which comprised 84.0% (1122 individuals) of the sample by number. This area was sampled again in 1976; four species of fish were collected, with F. parvipinnis making up 2.5% (10 individuals) of the sample by number, while T. mossambica comprised 94.0% (376 individuals; Knaggs, 1977). T. mossambica has been established in Dade County, Florida, since the early 1970s (Courtenay et al., 1974). However, in a study of the cichlid fishes of this county during 1974-1976. Hogg (1976a) did not find this species in great abundance. Similarly, in 1978, during a survey of exotic fishes in Florida, we collected T. mossambica only rarely in Dade County; when the species was collected, it usually comprised 5% or less of the sample by number. In contrast, although no quantitative data are yet available, T. mossambica is reported to be the dominant fish in creeks connecting with the Banana River on Merritt Island, Florida (David Cox, personal communication). During reclamation of an irrigation canal in

the Lower Colorado River area of Arizona, an estimated 45360 kg of T. mossambica were collected over a 13.2 km length of the canal (Alban Essbach, personal communication). In light of such reports, the failure of T. mossambica to become a dominant species in the canals of Dade County, Florida, is curious.

The ability of T. mossambica to become estalbished in estuarine and possibly marine waters is cause for great concern. We know nothing of the potential effects this species may have in these waters. Of immediate concern here is the possibility of detrimental effects in estuaries, which are important nursery areas for commercially important fishes. Secondly, this species is capable of using marine waters as dispersal routes between estuaries and river systems. This method has probably accounted for much of the natural dispersal of T. mossambica along the east coast of Africa (Jubb, 1967). Thirdly, although the lethal lower temperatures for this species in saline water are unknown, we do know that it can survive lower temperatures in saline water than fresh water (Allanson et al., 1971). Thus, it has the potential to spread farther in coastal areas than data from fresh water temperature tolerance studies would indicate. In such freshwater tests on T. mossambica conducted by the California Department of Fish and Game, total mortality occurred at 12.8^{o}C. Knaggs (1977), using this temperature as the lower lethal limit and water temperatures from various marine

localities in southern California, found that total mortality of T. mossambica would probably occur at these localities in most years. However, at the southernmost locations, overwintering could occur during some years. Knaggs' use of 12.8°C as the lower lethal temperature probably causes a conservative estimate for the potential range of this species in coastal waters. Allanson et al. (1971) found no signs of cold stress in this species at 11°C in water of 5 o/oo NaCl concentration. Knaggs (1977) also presents the number of days water temperatures below 11.1°C were recorded at several southern California marine localities. Using 11°C as the lower lethal temperature in the marine environment, T. mossambica could probably become established as far north as Santa Monica. In addition, Knaggs has warned of the possibility that this species could disperse along the coast in warm months and overwinter in heated effluent water from coastal electric generating plants. He concludes that T. mossambica is already established in the estuarine areas of the San Gabriel River and appears to be slowly spreading along the coast. In Florida, a major concern is the established population of T. mossambica in the Banana River and the fact that the species now has the opportunity to spread throughout the entire Intracoastal Waterway, the major estuarine area of eastern Florida.

Although we have no information to even attempt predictions of the effects of T. mossambica in estuarine and marine

environments, an obvious concern with the establishment of any cichlid in fresh waters of North America is the possibility of it competing with native centrarchids. These families have many similarities in structure and habit (Jordan and Evermann, 1898; Breder and Rosen, 1966). Species of both families use shallow-water spawning areas. This can be a limited resource in many areas, particularly in canals, irrigation systems, and channelized rivers.

Status: Established in Florida, North Carolina, Texas, Arizona, and California; possibly established in Georgia; annually stocked in ponds and lakes in Alabama; has been collected but is not established in Montana; has been used in pond experiments in Illinois; maintained on a commercial fish farm in Colorado.

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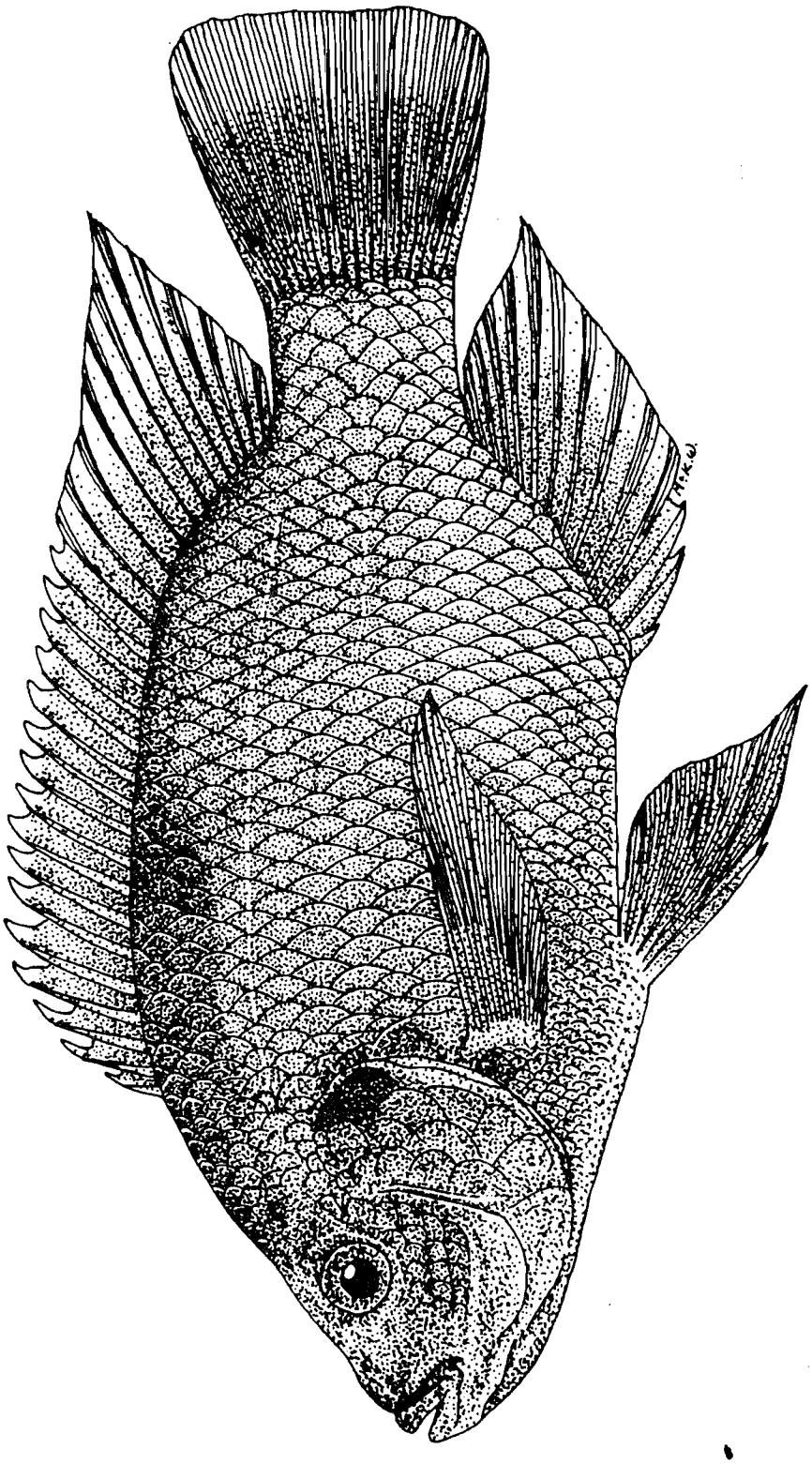
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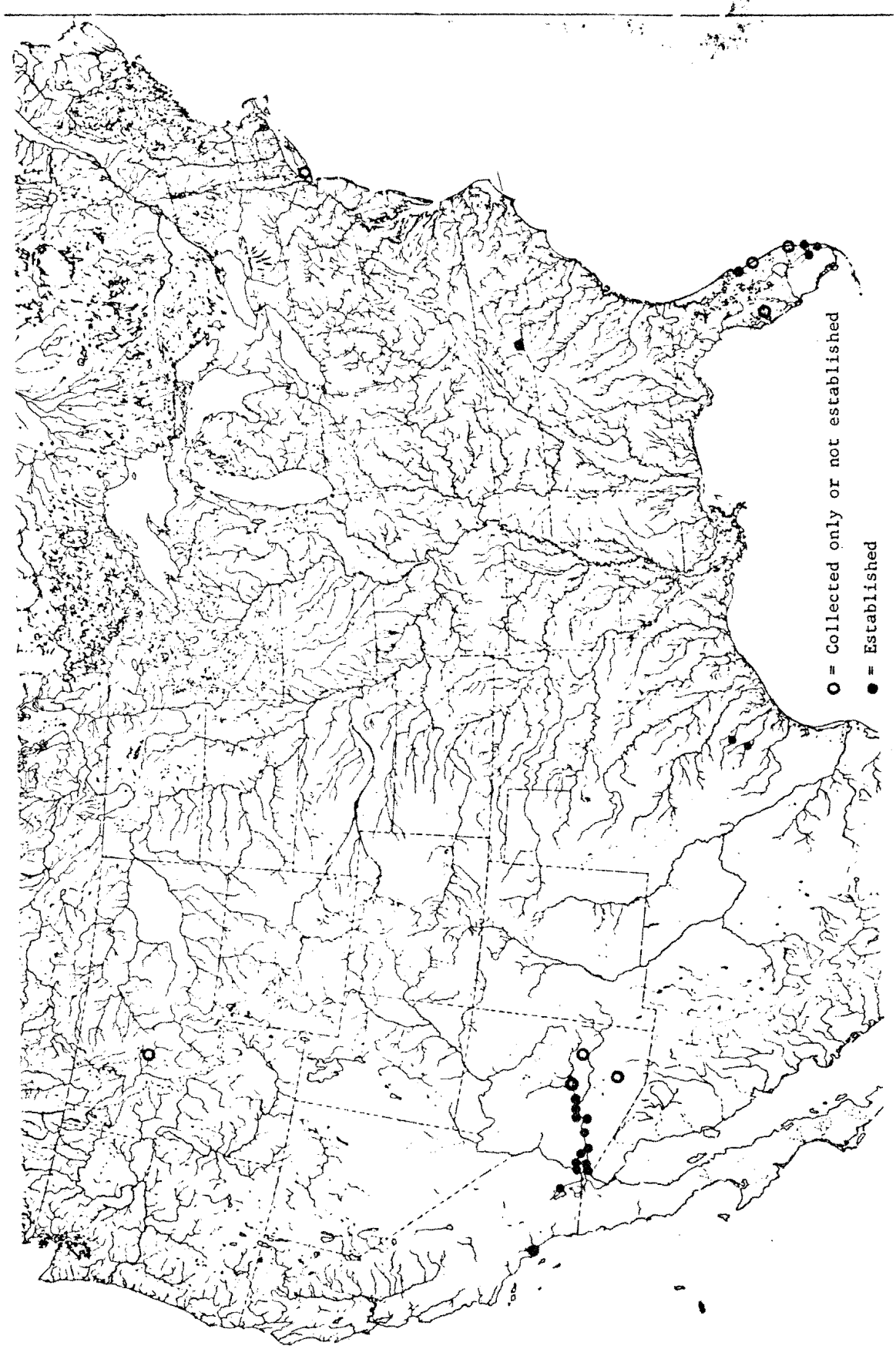
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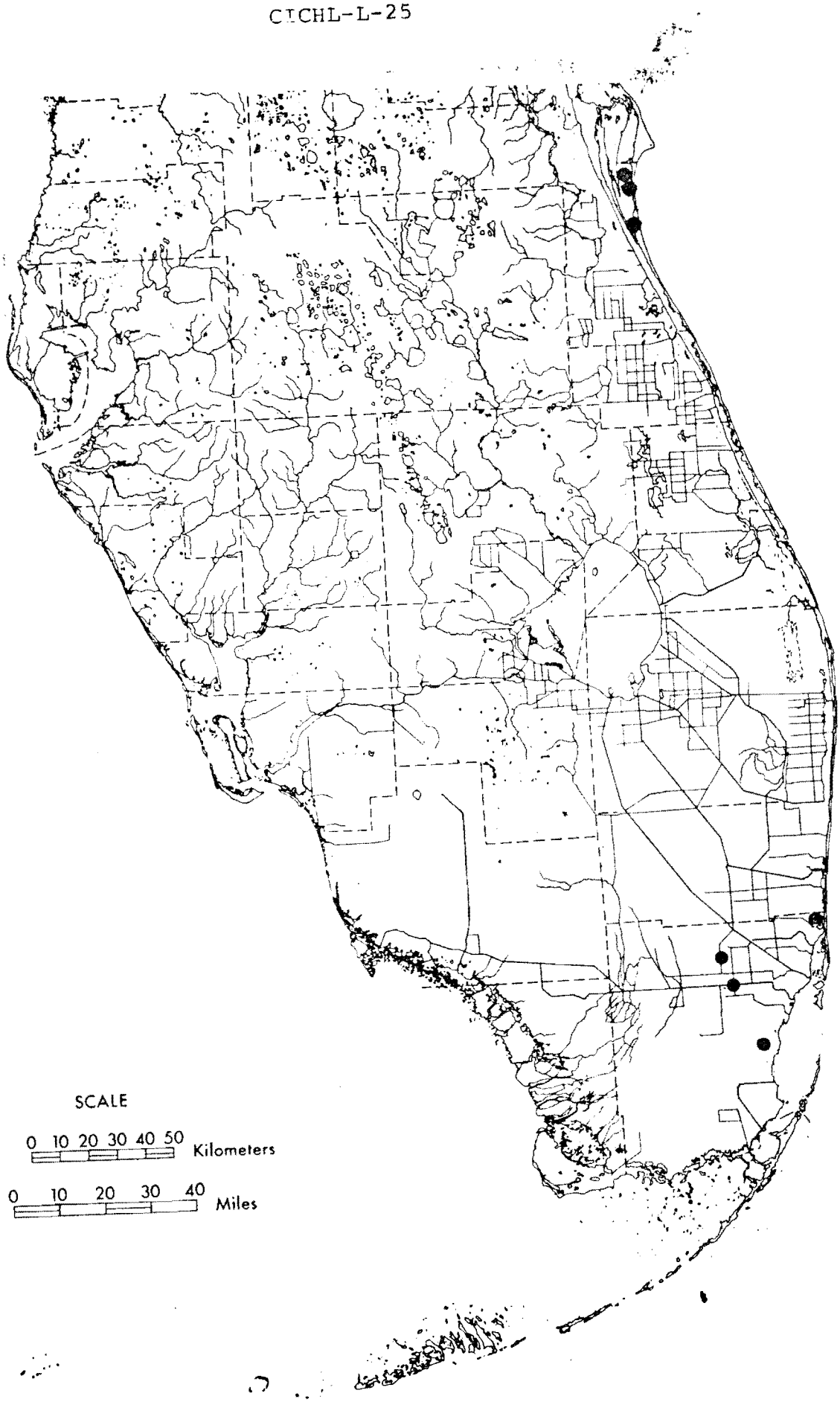
Compiled by: Dannie A. Hensley

Addendum: Philip Briggs (personal communication) recently informed us that on adult T. mossambica was seined from a pond in West Hempstead, Nassau County, New York in 1976. This fish was probably released from a home aquarium.




O = Collected only or not established
● = Established

CICHL-L-25



Order Perciformes
Family Cichlidae

Tilapia zillii (Gervais)

Redbelly tilapia

Note on systematics: In literature dealing with the introduction of this species into Alabama (Smith-Vaniz, 1968) and Florida (Buntz and Manooch, 1969; Phillippy, 1969; Courtenay et al., 1974), it has been referred to as T. melanopleura Dumeril. Thys van den Audenaerde (1968, 1968a) has shown T. melanopleura to be a junior synonym of T. zillii. In the following account we have treated all references to T. melanopleura in the U.S. as T. zillii.

In general the systematics and nomenclature involved in this genus are extremely complex. In many cases proper identification requires examination of specimens by specialists. However, specialists often have great difficulty identifying introduced populations. Such is the case with the identification of T. zillii in the U.S. There is some doubt about this identification, but it is based on the most learned opinions and reflects our current state of knowledge. It is not unlikely, however, that future research may show the species established in this country to be the closely related T. guineensis or T. rendalli, or that more than one species or perhaps even hybrids are involved.

Original description citation: Gervais, 1848. Sur les animaux vertébrés de l'Algeria, envisagés sous le double rapport de la géographie zoologique et de la domestication. Ann. Sci. Nat., 3° ser., Zool., 10:203.

Type locality: Tuggurt, Algeria.

Native range: North and central Africa to Jordan (Thys van den Audenaerde, 1968, 1968a, 1971).

U.S. range: California is the only state in which the establishment of T. zillii is certain. It was released in 1972 near Calexico, Imperial County (Hauser, 1975) and in 1973 into tributaries of the San Gabriel and Santa Ana rivers (Knaggs, 1977). It is now well established in irrigation systems in the Imperial Valley and is probably established in the Palo Verde and Coachella valleys, including the Salton Sea and lower Colorado River (Pelzman, 1973; Moyle, 1976; James St. Amant, personal communication). Although it has been introduced or reported from Kern, Santa Clara, Los Angeles, Orange, and Riverside counties, populations in these counties do not appear to be permanently established or their status is unknown (Moyle, 1976). It should be noted that T. zillii has been collected twice from marine coastal areas in Orange County, but does not appear to be established there (Knaggs, 1977). The species was introduced into Napa County where it survived two winters but died during the third (Pelzman, 1973).

T. zillii was introduced into a canal in Mesa, Maricopa County, Arizona in 1973, and it has been introduced into areas in the southern part of the state. Some of these introductions may have led to established populations (Minckley, 1973).

The species is annually stocked in numerous farm ponds and lakes in Alabama (Smith-Vaniz, 1968). Apparently, it is not established in any open waters of the state.

Experiments were conducted with T. zillii in Polk and Lake counties, Florida. These stocks were destroyed in 1970 (Courtenay et al., 1974). Hogg (1976) collected six specimens of this species from a quarry in Dade County; it was eradicted at this locality (Paul Shafland, personal communication). The species was reported established in an enclosed body of water on a fish farm in Brevard County (Courtenay, et al., 1974). However, it is not known to occur or be established in any open waters of Florida.

Sources of introduction: Nearly all introductions of T. zillii into the U.S. were made to determine its value in aquatic weed control and were carried out by governmental agencies, i.e., California Department of Fish and Game (Pelzman, 1973; Hauser, 1975); Cooperative Fisheries Unit, University of Arizona (Minckley, 1973); Alabama Department of Conservation (Smith-Vaniz, 1968); Florida Game and Fresh Water Fish Commission and U.S. Soil Conservation Service (Buntz and Manooch, 1969; Courtenay et al., 1974). The source for the introduction of

this species in Mesa, Arizona is not specified by Minckley (1973). Its introduction into Dade County, Florida probably resulted from escapes from local fish farms (Hogg, 1976).

Life history: T. zillii has been widely proclaimed as a herbivore with a preference for higher plants (Lowe-McConnell, 1955, 1975; Thys van den Audenaerde, 1964; Fryer and Iles, 1972; Hauser, 1975). The dentition of this species is well adapted for cutting and mastication of leaves (see description in Fryer and Iles [1972] and plates of dentition in the closely related T. rendalli in Thys van den Audenaerde [1964]). There is no doubt that T. zillii will eat higher plants. It has been quite effective in controlling weeds and is widely used in pond culture because it will eat terrestrial plant material such as garden refuse. In both of these uses, however, population densities are usually high; under less crowded conditions, it is more selective in the plants it eats (Moyle, 1976). Labelling this species as being herbivorous on higher plants has been a gross oversimplification not only due to the fact that its herbivorous tendencies are much broader, but also stomach analyses have indicated that it should be considered an omnivore. Buxton (1922; fide Pelzman, 1973) reported T. zillii feeding on diatoms, volvocales, ostracods, vorticellids, rotifers, copepods, cladocerans, hydrachnids, and insects. In studies at the University of California, Davis, it was found that T. zillii is basically herbivorous but will consume dead or weakened fish of its own species, live frog

larvae, and dead or injured Gambusia affinis (Pelzman, 1973). Hogg (1976a) examined two stomachs from specimens collected in Dade County, Florida and found vascular plant fibers, a lizard, crayfish exoskeleton parts, molluscan shell fragments, and insect parts. Quantitative food analyses in Lake Quarun, Egypt by Abdel-Malek (1972, 1972a) and Al-Kholy and Abdel-Malek (1972) showed that the species feeds on the following: diatoms, blue-green, red, and brown algae, higher plants, flagellates, polychaetes, ostracods, copepods, amphipods, gastropods, bivalves, mysidaceans, insects, arachnids, fish eggs and larvae, fish remains (scales), and detritus. In these studies plant material usually accounted for about 46-99% of the stomach contents; approximately 11-50% of the stomach contents were composed of diatoms, 9-30% of blue-green algae, 9-46% of red algae, < 1-13% of brown algae, and 0-14% of higher plants. It should be noted that brown algae and higher plants were the least important plant constituents of the diet. Animal material usually accounted for about 1-50% of the stomach contents. In a one-months sample, Abdel-Malek (1972a) found that 65% of the diet was composed of the polychaete Nereis and the amphipod Gammarus. Lake Quarun is saline (19-31 o/oo; see below), and an argument can be raised that the food available to T. zillii there is not typical of that found in less saline waters within the native range of the species. This is probably true. It is also likely that T. zillii does feed to a larger extent on higher plants in less

saline waters. However, the Lake Quarun studies definitely indicate that this species is much more omnivorous than most authors have alluded to, and it can maintain large populations even in areas where, apparently, higher plants are not readily available food sources.

T. zillii juveniles have been reported to pass through a phase where they feed on benthic algae and the associated microfauna before developing the adult habits of eating higher plants (Fryer and Iles, 1972). Thus, juveniles have been considered to be more carnivorous than adults (Moyle, 1976). These statements, like those characterizing the food habits of adults, are probably oversimplifications. Abdel-Malek (1972) found that T. zillii in Lake Quarun became more carnivorous with age. Again, the Lake Quarun population may be atypical with respect to feeding habits of the species. In Lake Victoria, juveniles apparently do feed more benthically than adults (see "Environmental impress" below).

T. zillii inhabits large rivers and lakes in its native range. Its salinity and temperature tolerances are broad. Chervinski and Zorn (1974; fide Knaggs, 1977) reported it living and reproducing in salinities as high as 45 o/oo. Prior to 1920 Lake Quarun supported a large freshwater fish fauna. Beginning in about 1920 the lake started to increase in salinity and by the 1950s it fluctuated seasonally between 19 and 29 o/oo. Al-Kholy and Abdel-Malek (1972) report that recent salinities

have been as high as 31 o/oo in some regions of the lake. Most of the freshwater ichthyofauna disappeared with this salinity increase, and today only two freshwater species remain, T. zillii and another Tilapia species (T. nilotica or T. aurea). In the 1920s the latter species made up ca. 90% of the total fish harvest from the lake. With the rise in salinity, these positions became reversed, and by 1933 T. zillii accounted for nearly the entire fishery. Some marine fishes have been introduced into Lake Quarun and are flourishing, and yet, nearly 40% of the yearly catch is still comprised of T. zillii. Obviously this species can reproduce and maintain large populations in waters with high salinities, and indeed, in Lake Quarun it became more successful with a salinity increase (El-Zarka, 1956; Fryer and Iles, 1972). In ponds in Napa County, California, T. zillii survived two winters with temperature drops to 10°C but died during the third when temperatures dropped lower for an extended perios (Pelzman, 1973; Moyle, 1976). In temperature tolerance studies, first mortality occurred at 11.1°C and total mortality at 7.2°C (Knaggs, 1977); it has withstood 8.3°C for 18 hours (Pelzman, 1973).

T. zillii is a substrate spawner, not a mouth brooder as it has been considered by some workers (see references in Breder and Rosen, 1966). At spawning it builds several nests in the substrate that are 20-25 cm in diameter and 5-7 cm in

depth. These nests are merely depressions made by the courting pair by removing sand with their mouths. They are usually made on sloping banks in shallow water. The term "nest" here is somewhat of a misnomer, since the female frequently (usually ?) lays eggs at another location. The nest building activity is probably an important stimulus in courtship behavior. Eggs are laid in a cluster on the substrate. They are olive green, oblong (0.8-1.4 x 1.1-2.0 mm), and adhesive. Both parents guard the eggs. As hatching time approaches, the parents dig new holes in the substrate. Hatching occurs in about 48-74 hours. For a short period after hatching, the larvae remain attached to the substrate by mucous threads produced by glands on the head. As soon as the larvae are able to swim freely, they move to the new depressions built by the parents. Parents guard the larvae while they are in transit and pick up any strays by mouth and return them to the depressions. Within about five days after hatching, the young begin swimming in schools but remain in close proximity to the parents. This schooling behavior lasts about five more days, then the young begin to scatter as their close association with the parents gradually breaks down (Lowe-McConnell, 1955; El-Zarka, 1956; Thys van den Audenaerde, 1964; Fryer and Iles, 1972).

Growth data for African populations are presented by Fryer and Iles (1972). Under crowded conditions, this species will

exhibit stunting and will breed when less than a year old at sizes as small as 7 cm TL. Under less crowded, more natural conditions, it breeds at two or more years of age and at sizes over 100 mm TL (Lowe-McConnell, 1955; Fryer and Iles, 1972). In California, T. zillii grows exceptionally fast, reaching an average of 16.4 cm TL in the first year and 24.9 cm TL in the second. This growth rate has been attributed to low population densities and an abundant food supply and is not likely to be maintained as population densities increase (Hauser, 1975).

T. zillii begins to spawn when water temperatures are above 20°C. Based on ovarian egg counts, it can probably lay as many as 7000 eggs at one spawning. However, the usual number laid is probably between 1000 and 6000. Under semi-natural and aquarium conditions, it has been observed to produce successive broods at intervals of 23-78 days. It apparently has the potential to breed throughout the year if temperatures are favorable (El-Zarka, 1956; Fryer and Iles, 1972; Pelzman, 1973). In southern California, breeding probably only occurs for less than six months (Moyle, 1976).

Environmental impress: The decisions to introduce T. zillii into the U.S. for aquatic weed control were ill-advised, being based on poor knowledge of this species' broad ranges of feeding abilities and salinity and temperature tolerances. As is the case in so many purposeful introductions, proponents

have had a very simplistic view of the ecology of the species. Tilapia species are extremely adabtable, and T. zillii appears to be one of the most adabtable of the genus. To use the label of "herbivorous on higher plants" as a justification for the introduction of this species for aquatic weed control shows an obvious lack of knowledge of the dynamics of populations and feeding strategies. Suprisingly little information is available on the environmental impress of this species in the U.S. Enough was known about various aspects of its biology before introduction to have warranted not only extreme caution in any plans for its introduction, but also rigorous monitoring of its environmental impress after introduction.

Again, T. zillii has been shown to be effective in controlling some aquatic weeds in the U.S. (Buntz and Manooch, 1969; Phillippy, 1969; Moyle, 1976). This control is best achieved with high population densities, the species becoming more selective in the plants eaten under less crowded conditions. One concern here is with crowding and competition for spawning sites between T. zillii and native species, particularly centrarchids, if high population densities of T. zillii are maintained for effective weed control. If low population densities are maintained, and it is more selective in its feeding habits, the sole effect may be a change in the composition of the aquatic flora with no change in plant density (Moyle, 1976). Phillippy (1969), in a series of tests on the aquatic plants

Cyprinidae
Cobitidae

preferred by T. zillii in Florida, found that Najas guadalupensis, Chara sp., Ruppia maritima, and Utricularia vulgaris ranked second through fifth in order of preference, while Hydrilla verticillata and Eichornia crassipes, the plants it was hoped would be controlled by T. zillii, ranked seventh and eighth. These five species that were preferred by T. zillii are important plants in fish and waterfowl habitats. When T. zillii was stocked in a high density into a pond in Polk County, Florida, Buntz and Manooch (1969) reported "nearly all vegetation, including water lillies, has been annihilated in the pond, the only higher aquatic left was a reed."

The studies on the T. zillii population in Lake Quarun, Egypt by Abdel-Malek (1972, 1972a) and Al-Kholy and Abdel-Malek (1972) have very important implications for any discussion of the potential environmental impress of this species in the U.S. These authors have clearly shown that within that water body, T. zillii does not conform to the simplistic label of "herbivorous on higher plants," but rather exhibits a great deal of adabtability in its feeding and should be considered an omnivore. Any argument that Lake Quarun is now an atypical body of water for this species is irrelevant; any habitat into which this species is to be introduced will obviously be atypical. The concern here is with what other organisms will be eaten by this species in localities where it is introduced.

The factor of shifts in food habits with growth typically has been given very little regard when a species is proposed for introduction. Usually only the food habits of adults are considered. However, an increasing number of studies are indicating that feeding habits change with development in many, if not most, fishes. Although the results differ, studies in Lake Quarun, Egypt (Abdel-Malek, 1972) and Lake Victoria (Fryer and Iles, 1972) show that feeding habits of T. zillii juveniles are different than those of adults. T. zillii was introduced into Lake Victoria in 1951-1953. The situation here is very interesting because it illustrates the great dangers involved in introductions when little is known about the biology of the species and simplistic concepts of ecological processes are adopted. The justification for introducing T. zillii into Lake Victoria was that the "leaf chopping niche" was unexploited by the indigenous fishes, and this species would fill this niche and convert the unexploited submerged macrophytes into protein usable by man. T. variabilis occurs naturally in Lake Victoria. Since this species is a deposit feeder and a mouth brooder, no competition with T. zillii for food or spawning sites was anticipated. However, soon after the introduction of T. zillii, it became apparent that only a few of the dimensions of these two species' niches had been studied, and the actual ecological interactions between them were much more subtle and complex than expected. It was found that T. zillii juveniles in this lake feed on benthic

algae and the associated microfauna, the same food sources utilized by T. variabilis juveniles. In addition, both species were found to use the same nursery areas. T. zillii appears to have competitive superiority in these interactions. It became very well established in Lake Victoria and now makes significant contributions to commercial catches. However, there have been declines in T. variabilis catches (Fryer and Iles, 1972; Lowe-McConnell, 1975).

T. zillii was introduced into California under the assumption that it would not survive winters there. It has since been realized that this species has the potential, in regard to temperature and salinity tolerances, to become established in northern California and in the state's marine waters (Pelzman, 1973). Although it has overwintered in central California and is established in the southern areas of the state, Moyle (1976) reports large numbers of T. zillii are killed during winters in the warm Imperial Valley. However, it should not be assumed that this indicates the species will not remain established there or that it cannot spread and become established in more northern areas. Heavy cold kills of Tilapia melanotheron and Clarias batrachus have occurred in Florida without noticeably restricting their distributions, and in the case of C. batrachus, without stopping additional range expansion (Courtenay, 1978, 1979; personal observation). In California, T. zillii may be capable of

living at least as far north as the San Joaquin Valley (Moyle, 1976). In this regard, Pelzman (1973) expressed concern over the possibility of this species becoming established in the rice fields of this valley. The species has had access to marine waters in California via the San Gabriel and Santa Ana rivers. In spite of this access and its ability to live and reproduce in seawater, specimens have only been collected twice near the mouths of these rivers. It does not appear to be established in these areas (Knaggs, 1977). However, its potential for establishment and dispersal along the coast should continue to be a matter of concern. Based on marine water temperatures, Knaggs (1977) estimated that T. zillii has the potential to become established anywhere in the marine waters of California south of Port San Luis, San Luis Obispo County. In addition, California has a number of coastal power plants using marine water for cooling. The heated effluents from these could serve as overwintering refugia and further facilitate coast range expansion.

Species of Tilapia are adaptable, aggressive, and show a high degree of competitive ability under many conditions. The precise definitions of these characteristics and their component causes are frequently difficult to state. However, no one who has worked with this genus would doubt that as general characteristics they typify Tilapia species; certainly T. zillii is no exception. T. zillii has now spread to the Salton Sea

and is displacing the only native fish there, Cyprinodon macularius (James St. Amant, personal communication). Because of concern over its potential for disruption of aquatic ecosystems and its wide salinity and temperature tolerances, T. zillii has been prohibited in California except in six of its southern counties (Moyle, 1976, 1976a). It is unfortunate that such concern was not shown before its introduction. It is to the credit of the Florida Game and Fresh Water Fish Commission that their stocks of T. zillii were destroyed after experiments indicated the species was a threat to important native species of aquatic plants.

Status: Established in California; has been introduced and is possibly established in Arizona; is annually stocked in ponds and lakes in Alabama; stocks in Florida were destroyed.

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Gobiidae

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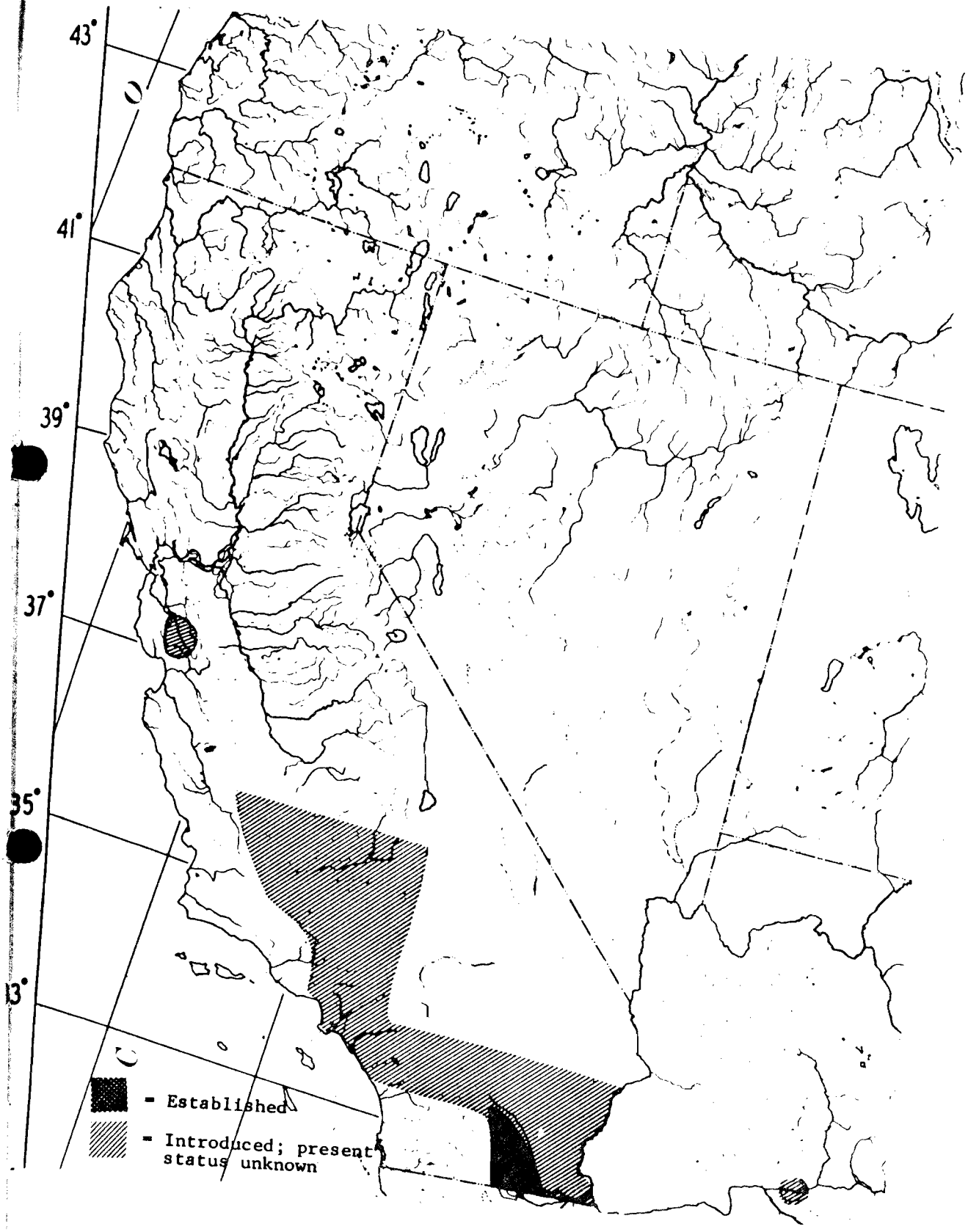
Compiled by: Dannie A. Hensley

Cyprinidae

Cobitidae

Addendum: Although unconfirmed, we have heard that T. zillii is being cultured as a food fish in Idaho and adjacent to a power plant in South Carolina.

Cyprinidae


43°
41°
39°
37°
35°
13°
- Established
- Introduced; present status unknown

CLARIIDAE
Airbreathing catfishes

Clarias batrachus [CLARI-A] FL

Order Siluriformes
Family Clariidae

Clarias batrachus (Linnaeus)

Walking Catfish

Original description citation: Linnaeus, 1758. Systema Naturae, Vol. 1, p. 305.

Type locality: Asia and Africa; name later restricted to Asian species.

Native range: From Sri Lanka through eastern India to the Malay Archipelago (Sterba, 1966).

U.S. range: Established in 20 counties of peninsular Florida: Brevard, Broward, Charlotte, Collier, Dade, DeSoto, Glades, Hendry, Highlands, Hillsborough, Indian River, Lee, Manatee, Martin, Monroe, Okeechobee, Palm Beach, Polk, Sarasota, and St. Lucie (Courtenay, 1978, 1979).

This species has been collected at two localities in California, in All American Canal in the southeastern end of the state (Minckley, 1973) and in the San Joaquin River (Brittan, personal communication). It has also been collected in the Flint River in Georgia (Courtenay and Miley, 1975) and in some reservoirs in Nevada (Deacon, personal communication). There is no evidence for establishment outside of Florida.

Sources of introduction: The first release of Clarias into southeastern Florida appears to have occurred between 1964 and 1966. The source of escape appears to have been an aquarium fish farm in northern Broward County (Courtenay and Miley, 1975) or from a truck in Broward County transporting fish to an aquarium fish farm (Courtenay, 1979). A subsequent introduction in Hillsborough County, Florida, may have resulted from intentional releases by aquarium fish farmers (Courtenay and Miley, 1975).

The sources of introduction outside of Florida are unknown; some, however, may have been intentional releases by individual aquarists.

Life history: This species is omnivorous; in southern Florida, the diet changes seasonally (Courtenay, 1975; Courtenay and Miley, 1975).

Spawning occurs during the wet season. Adhesive eggs are laid in a nest of submerged vegetation. The nest is guarded by the male. Breder and Rosen (1966) have summarized the literature on reproduction.

In southern Florida, newly-hatched young grow to approximately 1500 mm SL in one year and become sexually mature. The largest individuals collected are about 400 mm SL.

There is evidence that this species can survive brief periods of it ing in wet mud or sand and in almost full-strength seawater.

Environmental impress: This species becomes piscivorous during drought conditions in southern Florida (Courtenay and Miley, 1975). The rapid northward range expansion of Clarias in peninsular Florida suggests large population increases to the south and spatial competition with native fishes. Moreover, this species, unlike most native fishes, has an extended breeding period (late April or early May to late October) in southern Florida, also indicating the potential for massive population buildup. Such a potential already may have been realized since this species is now dominant in several portions of the Big Cypress Swamp (Courtenay, 1978).

Status: Established in 20 counties of peninsular Florida.

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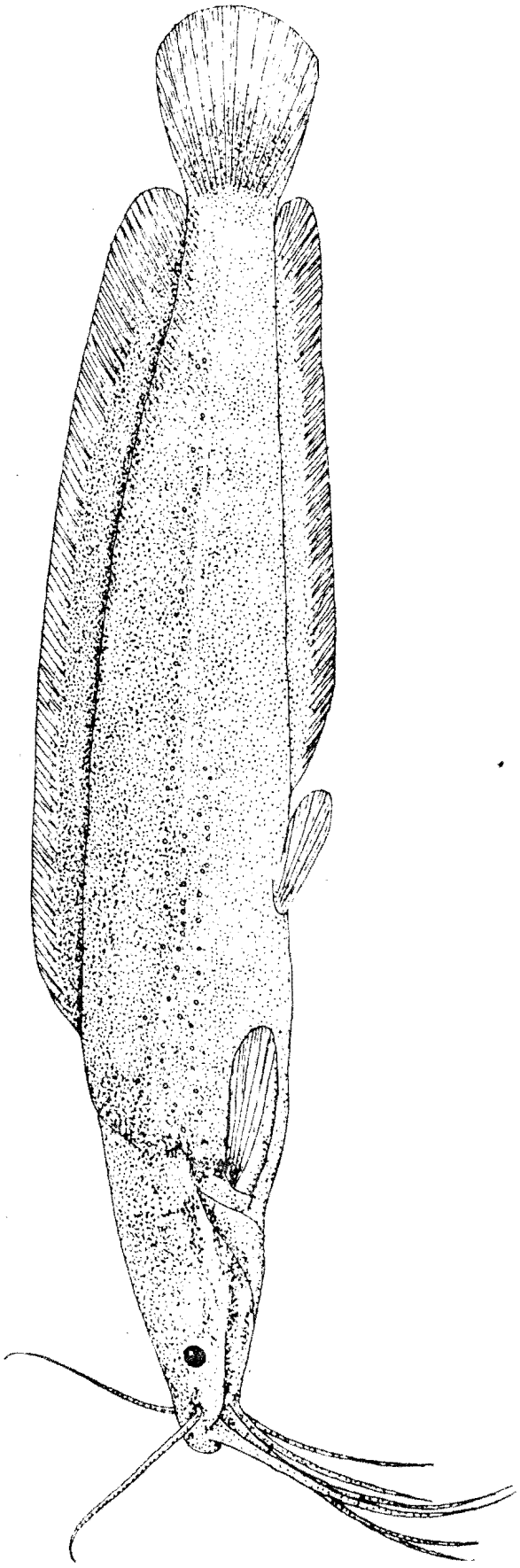
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Compiled by: Walter R. Courtenay, Jr. and Dannie A. Hensley.

Cyprinidae

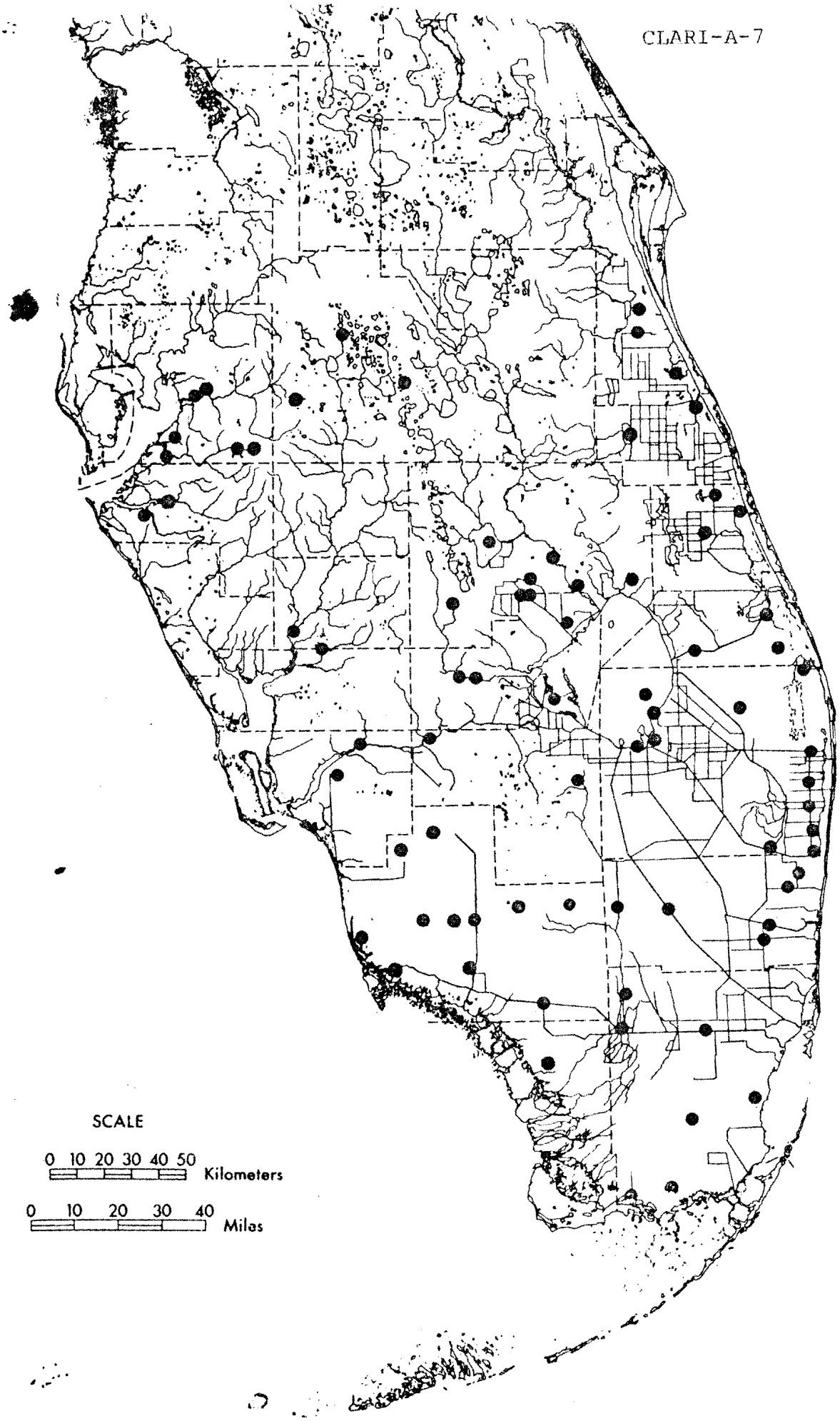
Cobitidae

Addendum: In 1971 a specimen of C. batrachus was caught by a fisherman in Waldo Lake, Brockton, Massachusetts (Halliwell, 1979. Massachusetts fish list. Fauna of Mass., Ser. 4, 13 pp.).



Cyprinidae

Cobitidae


SCALE
0 10 20 30 40 50
Kilometers
0 10 20 30 40
Miles

COBITIDAE
Loaches

Misgurnus anguillicaudatus [COBIT-A] CA, MI

Order Cypriniformes
Family Cobitidae

Misgurnus anguillicaudatus (Cantor)

Oriental weatherfish

Original description citation: Cantor, 1842. General features of Chusan, with remarks on the flora and fauna of that island. Ann. Mag. Nat. Hist., 9: 485.

Type locality: Chusan, China.

Native range: Eastern Asia (Berg, 1949).

U.S. range: M. anguillicaudatus is established in the headwaters of the Shiawassee River, Michigan and several flood control canals in Orange County, California (Schultz, 1960; St. Amant and Hoover, 1969).

Sources of introduction: In Michigan introduction was due to escapees from an aquarium supply company in the area in about 1939 (Schultz, 1960). In California the species escaped from a goldfish farm next to the Westminster flood control channel in the 1930s (St. Amant and Hoover, 1969).

Life history: In the aquarium literature M. anguillicaudatus is reported to be omnivorous (Sterba, 1966).

M. anguillicaudatus prefers habitats with soft substrate. A behavioral characteristic of the species is its habit of

burrowing into the substrate until only the head protrudes (Sterba, 1966).

The eggs of M. anguillicaudatus are reddish and adhesive and are deposited about the bases of water plants. They are reported to hatch in 8-10 days at 21°C. The young bury themselves into the substrate. The closely related M. fossilis may produce as many as 100,000 eggs at each spawning (Breder and Rosen, 1966).

M. fossilis and presumably M. anguillicaudatus have the hindgut modified into an accessory respiratory organ and are thus able to live in waters of low oxygen content due to aerial respiration (Johansen, 1970).

Environmental impress: This species is not known to be a pest or competitor in U.S. waters. However, its burrowing behavior and ability for aerial respiration make it difficult to eliminate this species once established. St. Amant and Hoover (1969) state that it is reportedly being used as bait in other waters. This could cause dispersal and establishment in other areas.

Status: Established in limited areas of California and Michigan.

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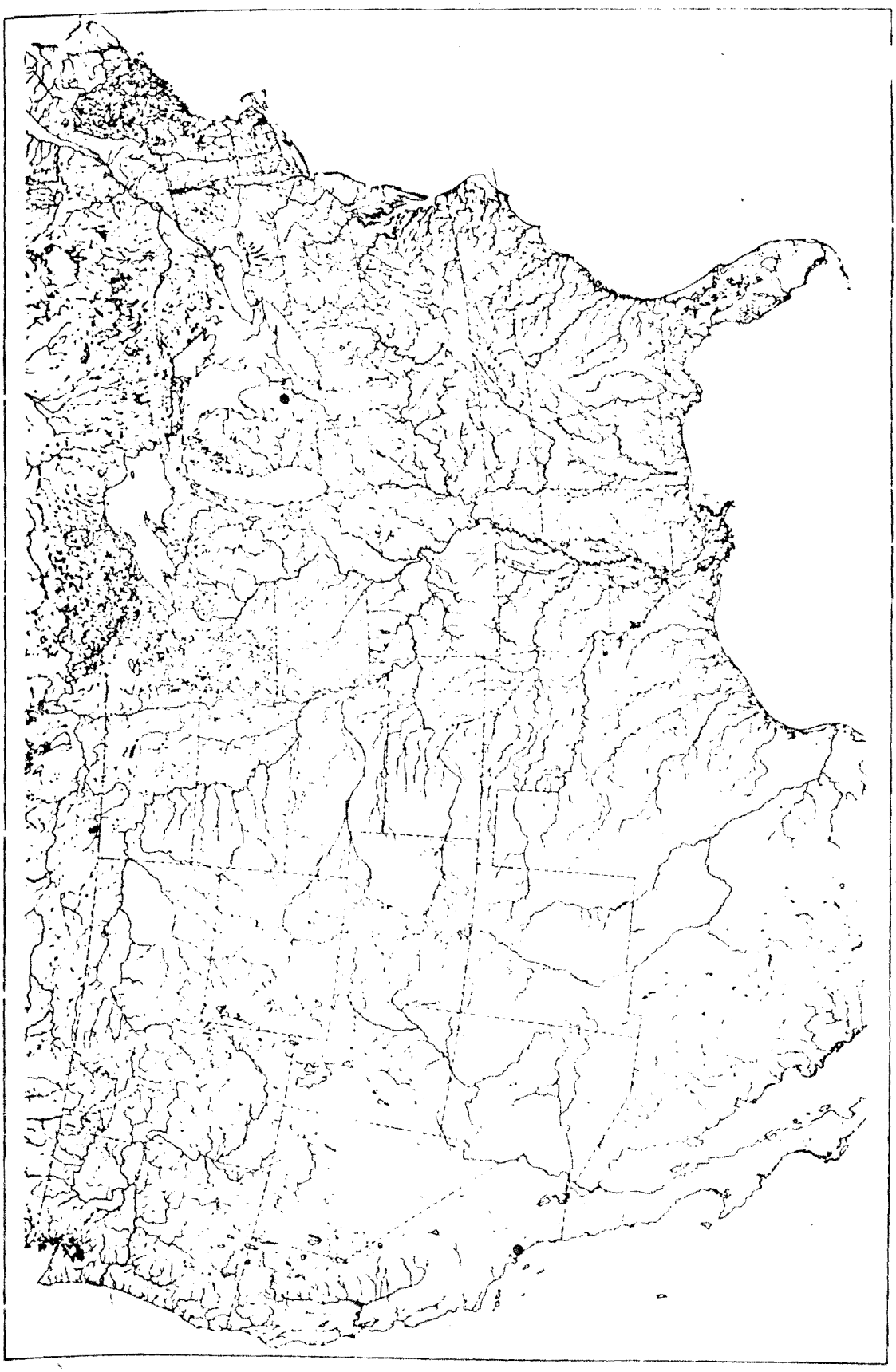
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Cyprinidae

Cobitidae

Cyprinodontidae



Cyprinidae

CYPRINIDAE

Carps and minnows

Carassius auratus	[CYPRI-A]	most states; three provinces
Ctenopharyngodon idella	[CYPRI-B]	see text
Cyprinus carpio	[CYPRI-C]	most states; several provinces
This species not included in report		
Leuciscus idus	[CYPRI-D]	CT
Rhodeus sericeus	[CYPRI-E]	NY
Scardinius erythrophthalmus	[CYPRI-F]	possibly NJ, NY, WI
Tinca tinca	[CYPRI-G]	CA, CO, CT, ID, NM, OR, WA: Brit. Col.

Order Cypriniformes
Family Cyprinidae

Carassius auratus (Linnaeus)

Goldfish

Original description citation: Linnaeus, 1758. Systema naturae, Vol. I, p. 322.

Type locality: China and Japan (introduced in Japan).

Native range: Eastern Europe to China (Wheeler, 1969).

U.S. range: C. auratus has been recorded from all of the continental United States (Table 2). Accounts of this species are in nearly every ichthyofaunal work for a particular state or drainage system. It is known to occur in British Columbia, Alberta, and Ontario, Canada. Although C. auratus has not been reported from Manitoba, it is expected to enter this province from the Cheyenne River, North Dakota (Scott and Crossman, 1973).

Several statements can be made concerning the status and distribution of C. auratus in North America: 1) It has not been as successful as its relative Cyprinus carpio in becoming and remaining established. 2) Occurrences of the species are often sporadic. In many areas this may reflect continued releases and escapements rather than established populations. Continued

introduction of this species results from its widespread use as an ornamental and bait fish and its culture in many hatcheries for these purposes. Consequently, in many localities it is very difficult to determine the status of this species, i.e., whether its occurence is due to an established population or merely releases and escapements. 3) Some previously established populations are no longer present. 4) At present, it is very well established in some areas. 5) It can be expected to occur in any fresh waters that are sufficiently warm (spawning requires temperatures of 15-23°C [Moyle, 1976]), primarily those that are lentic and often oxygen deficient with thick vegetation.

Sources of introduction: There is some doubt about when C. auratus was first brought to North America. De Kay (1842) claims it was probably introduced into the U.S. in the 17th century. In the last quarter of the 19th century, the U.S. Fish Commission raised the species and was responsible for distributing it to many of the states.

Subsequent distribution of C. auratus has been due to escapement from hatcheries, bait hooks, and outdoor ponds, dumping of unused bait, release of aquarium fish, and purposeful introductions.

Life history: C. auratus is omnivorous with a preference for phytoplankton, although it is known to occasionally eat insects and small fishes. Young-of-the-year fish tend to feed more on zooplankton and insect larvae (Moyle, 1976).

In California spawning begins in April or May and usually occurs several times per season. The eggs are adhesive and are laid in shallow water over submerged vegetation (Moyle, 1976). Larval development is illustrated by Mansueti and Hardy (1967) and Jones, Martin, and Hardy (1978).

It hybridizes in the wild with Cyprinus carpio. In the Lake Erie area hybrids outnumber either parental species (Trautman, 1957).

Information on fecundity, maturation, growth, and ecology of the species in California is given by Moyle (1976). Breder and Rosen (1966) have reviewed the extensive literature on reproduction.

Environmental impress: Little is known about the ecology of the goldfish in North America. In most states it is not considered a "pest species", this term generally referring to species whose populations become very large and highly visible to the public. This species has the potential to produce large populations in North America. Although the size of the pond is not given, Schwartz (1963) reports that nearly seven tons of 11-12 inch C. auratus were removed from Urieville Pond near Chestertown, Maryland in 1962. However, most large established populations appear to be in the vicinity of western Lake Erie (Hubbs and Lagler, 1949; Scott, 1954; Slastenenko, 1958; Carl, Clemens, and Lindsey, 1959) and California (Moyle, 1976). Like Cyprinus carpio,

large populations of C. auratus can severely disrupt gamefish habitats (Moyle, 1976).

In one area of the U.S., introduction and establishment of C. auratus has had very visible and detrimental effects on a native fish species. Deacon, Hubbs, and Zahuranec (1964) documented the original decline in the only population of Empetrichthys latos latos at a spring-fed pool on Manse (Bowman) Ranch, Pahrump Valley, Nye County, Nevada. E.l. latos is the only remaining subspecies of three which were endemic to Pahrump Valley. They found that the original decline of this population was correlated with the introduction and establishment of C. auratus. Goldfish were introduced into the pool in late fall 1961, had reproduced by July 1962, and were of sufficient size by late fall 1962 to possibly be competing with adult E.l. latos and eating their young. These authors admit that there were three possible causes for the decline in the E.l. latos population: collection of adults by biologists, removal of most of the submerged vegetation between 10 May and 24 July 1962, and introduction and establishment of C. auratus. Although the decline probably was a result of all three factors, it appeared to be most closely correlated with the goldfish introduction. This pool went dry in 1975; E.l. latos exists now only in refugia outside of Pahrump Valley (Soltz and Naiman, 1978).

Status: Although the present status of this species in particular regions is difficult to determine, it appears to be

established in 25 states and three Canadian Provinces (Table 2).

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Table 2

States and Canadian provinces where Carassius auratus has been recorded, its status, and references

State or Canadian Province	Status	Reference
Alabama	Establishment uncertain	Smith-Vaniz (1968)
Alberta	Established	Paetz and Nelson (1970)
Arizona	Establishment uncertain	Minckley and Deacon (1968); Minckley (1973)
Arkansas	Establishment undertain	Buchanan (1973)
British Columbia	Established	Carl, Clemens, and Lindsey (1959)
California	Established	Wales (1962); Kimsey and Fisk (1964); St. Amant and Hoover (1969); Moyle, Fisher, and Li (1974); Moyle (1976, 1976a)
Colorado	Establishment uncertain	Ellis (1914)
Connecticut	Establishment uncertain	Whitworth, Berrien, and Keller (1968)
Delaware	Established	Lee et al. (1976)

Table 2 (continued):

State or Canadian Province	Status	Reference
Florida	Not established	Courtenay et al. (1974); unpublished records
Georgia	Established	Dahlberg and Scott (1971)
Idaho	Established	Linder (1963); Gebhards (personal communication)
Illinois	Established	Meek (1908); Smith (1979)
Indiana	Established	Blatchley (1938); Nelson and Gerking (1968)
Iowa	Establishment uncertain	Harlan and Speaker (1956)
Kansas	Establishment uncertain	Cross and Collins (1975)
Kentucky	Established	Clay (1962)
Louisiana	Establishment uncertain	Douglas (1974)
Maine	Not established	Kendall (1914)
Maryland (including Washington, D.C.)	Established	Bean (1893, 1904); Smith and Bean (1899); Bean and Fowler (1929); Schwartz (1963); Musick (1972); Lee et al. (1976)

Table 2 (continued):

State or Canadian Province	Status	Reference
Massachusetts	Established	Storer (1839); Courtenay (personal observation)
Michigan	Established	Hubbs and Lagler (1949); Scott (1954); Slastenenko (1958); Carl, Clemens, and Lindsey (1959)
Minnesota	Establishment uncertain	Eddy and Surber (1947); Eddy and Underhill (1974)
Mississippi	Establishment uncertain	Cook (1959)
Missouri	Not established	Pfliegger (1975)
Montana	Establishment uncertain	Brown (1971)
Nebraska	Established	Jones (1963); Morris et al. (1974)
Nevada	Established	Miller and Alcorn (1943); La Rivers (1962); Deacon, Hubbs, and Zahuranec (1964); Deacon (personal communication)
New Hampshire	Established	Scarola (1973)

Table 2 (continued):

State or Canadian Province	Status	Reference
New Jersey	Establishment uncertain	Fowler (1906, 1952)
New Mexico	Establishment uncertain	Koster (1957)
New York	Established	De Kay (1842); Bean (1904); Eddy and Surber (1947)
North Carolina	Establishment uncertain	Fowler (1945)
North Dakota	Establishment uncertain	Scott and Crossman (1973)
Ohio	Established	Trautman (1957)
Oklahoma	Established	Miller and Robison (1973)
Ontario	Established	Dymond (1922, 1955); Dymond, Hart, and Pritchard (1929); Hubbs and Lagler (1949); Scott (1954); Slastenenko (1958); Carl, Clemens, and Lindsey (1959); Scott and Crossman (1973)
Oregon	Establishment uncertain	Schultz (1929)
Pennsylvania	Established	Bean (1893)
Rhode Island	Established	Stolgitis (personal communication)

Table 2 (continued):

State or Canadian Province	Status	Reference
South Carolina	Established	Loyacano (personal communication)
South Dakota	Established	Churchill and Over (1933); Bailey and Allum (1962)
Tennessee	Established	Kuhne (1939)
Texas	Established	Knapp (1953); Hubbs (1958)
Utah	Not established	Sigler and Miller (1963)
Virginia	Established	Smith and Bean (1899); Musick (1972)
Vermont	Not established	Hall (personal communication)
Washington	Established	Chapman (1942)
West Virginia	Not established	Denoncourt *et al.* (1975)
Wisconsin	Established	Cahn (1927)
Wyoming	Establishment uncertain	Simon (1946)



CYPRI-A-21

Order Ostariophysi
Family Cyprinidae

Ctenopharyngodon idella Valenciennes

Grass carp

Original description citation: Valenciennes, in: Cuvier and Valenciennes, 1844. Histoire Naturelle des Poissons, 17. P. Bertrand, Paris, p. 362.

Type locality: China.

Native range: Rivers, lakes, and ponds of the Amur Region of Siberia (about 50°N) and Manchuria southward through China to the Canton River (about 23°N) (Berg, 1949; Greenfield, 1973; J. E. Darovec, personal communication). This species has been introduced for pond culture or biological control purposes into Taiwan, Malaysia, Japan, Viet Nam, Thailand, Hong Kong, Sri Lanka, India, Israel, Great Britain, eastern Europe (including USSR), Germany, Holland, Mexico, Puerto Rico, and the U.S. (Greenfield, 1973; Provine, 1975; Stroud, 1975).

U.S. range: As of 1977, specimens of grass carp had been collected in the wild in the following states: Alabama, Arkansas, Florida, Georgia, Illinois, Iowa, Kentucky, Louisiana, Mississippi, Missouri, Nebraska, and Tennessee (Guillory and Gasaway, 1978). Unconfirmed reports indicate the presence of this species in the Mississippi River in Wisconsin and

Minnesota and in the Missouri River in Kansas and Nebraska as far north as the Gavins Point Dam near Yankton, South Dakota. Guillory and Gasaway (1978) list grass carp as having been imported from private hatcheries for stocking in 32 states. James Malone, an Arkansas fish farmer, reported to the senior author in 1972 that he had shipped grass carp to individuals and/or agencies in 45 states.

Sources of introduction: The decision to import grass carp into the United States was made at a meeting held in 1962 at Stuttgart, Arkansas (Sneed, 1972). The fish was imported in November 1963 to the Fish Farming Experimental Station at Stuttgart by the U.S. Fish and Wildlife Service (Guillory and Gasaway, 1978; Stevenson, 1965). Auburn University also received a shipment of grass carp in 1963 (Guillory and Gasaway, 1978). The Fish Farming Experimental Station later distributed grass carp to the Arkansas Game and Fish Commission.

The first stocking of grass carp into open waters in the U.S. apparently was undertaken for aquatic weed control in December 1971 at Lake Conway, Arkansas by personnel of the Arkansas Game and Fish Commission. Prior to this stocking, the species had been released into isolated ponds in Alabama, Arkansas, and Arizona (Greenfield, 1973; Guillory and Gasaway, 1978).

Grass carp were first found in the wild in the White River, Arkansas, by commercial fishermen in 1970 (Bailey, 1972).

In February 1971, the species was collected in the Mississippi River in Illinois (Greenfield, 1973). Since records show the first stocking into open waters of the U.S. to have occurred in December 1971, and the wild-caught specimens in Arkansas and Illinois were of the 1966 age class, one could conclude that these wild-caught fish were either escapees from or were otherwise released by the Fish Farming Experimental Station of the U.S. Fish and Wildlife Service or perhaps from the Arkansas Game and Fish Commission's Lonoke hatchery (Guillory and Gasaway, 1978) or both. These agencies had fish that were spawned by the U.S. Fish and Wildlife Service in 1966. It is not known, however, if one or more Arkansas fish farms might also have been the source of introduction or, indeed, if any of these farms even had grass carp in 1966.

It appears that the major source of introduction (which is continuing) is the Arkansas Game and Fish Commission (Pflieger, 1978).

Life history: Age of grass carp at sexual maturity appears to vary with latitude. Hickling (1967) reports sexual maturation in 15 to 20 months in Malacca while Stott (1967) states that this species requires nine to ten years in the Amur River. Courtship and mating are polyandrous (Breder and Rosen, 1966; Lin, 1935). Preferred spawning sites in the native range are those having "a current of from 12,000 to 20,000 feet per hour" (roughly one to two meters/sec.) and spawning occurs at or near

the surface (Breder and Rosen, 1966). Preferred spawning temperatures are reported as 20° to 30°C. The eggs are demersal (Lin, 1935; Stott, 1967) (Berg, 1949, says eggs are pelagic) and maximum hatching success is stated to occur on a bottom substrate of gravel. Berg (1949) and Lin (1935) state that a female grass carp may release between 100,000 to more than 800,000 eggs. The eggs are about 4.2 mm in diameter (Breder and Rosen, 1966). There are no records of natural spawnings in ponds. John Stanley (personal communication and in Leon County, Florida, Circuit Court, under oath) has observed hatching of grass carp eggs on a substrate of cotton in a petri dish.

Hora and Pillay (1962) report that grass carp grow to lengths greater than 1.2 meters and Konradt (1964) reports weights of over 30 kg. Berg (1949) records a specimen of 1.1 m in length that weighed 15 kg. Optimum growth is reported to occur at 21°C (Bardach et al., 1972; Schneider, 1969). Provine (1975) says that grass carp can live for at least 13 years.

As is often the case with fishes, young grass carp show a different diet than do the adults. Up to 30 mm in length, grass carp feed on crustaceans, rotifers, chironomid larvae and other small animal matter. Beyond 30 mm in length, this species shows a decided preference for macrophytes that has prompted many to state that it is an herbivore. Hora and Pillay (1962) and Lin (1935), however, state that this fish is omnivorous,

feeding (in the wild) on such things as "grass, leaves of trees, water plants, small fishes, earthworms, silkworm pupae, beef, insects, and even decayed cloth and shoes" (Lin, 1935). These reports, however, may be based on analyses of the stomach contents of young grass carp.

Adult grass carp are preferential herbivores, although Hora and Pillay (1962), Lin (1935) and Stevenson (1965) indicate the species to be an omnivore. Chinese fish culturists consider grass carp to be highly destructive of rice plants and recommend that they be kept out of rice paddies (Roberts et al., 1973). Tang (1970) suggests that when an adequate supply of macrophytes is low and when competition is absent, grass carp will feed on materials other than aquatic plants. Conversely, Kilgen and Smitherman (1974) indicate that when macrophytes are absent in ponds, grass carp fed on terrestrial plants along the pond margins.

Compared to most other "herbivorous" fishes, the length of the digestive system in grass carp is relatively short. About 50% of the food material ingested is passed as feces (Hickling, 1966; Stroganov, 1963). Hickling (1966) reported that food can pass completely through a grass carp in less than eight hours at temperatures of 28° to 30°C. Stroganov (1963) stated that the feces of grass carp promotes vigorous growth of plankton.

The majority of cyprinid fishes cannot tolerate saline waters and are, therefore, typically referred to as "primary freshwater fishes". Maceina and Shireman (1979) found no mortalities in fingerling grass carp exposed to salinities of 14 0/00 for 96 hours. Cross (1970) found that adult grass carp can tolerate salinities of 17.5 and 10.5 0/00 for 5 hours and 24 days, respectively.

Environmental impress: As noted earlier in this account, the first record of an official release of grass carp in open waters of the United States was undertaken in 1971. Nevertheless, the first wild-caught specimens were of the 1966 year class and were caught prior to the official release in 1971.

To date, there are no records of detrimental effects to native fishes or to fish habitat in the open waters of the U.S. that can be attributed to grass carp. Courtenay (1979) points out, however, that in several cases detrimental effects caused by the introduction of exotic species may require several decades before they are first noted. Studies in certain lake and pond situations, however, have shown grass carp to be detrimental to sport fishes (W. M. Bailey [1978]; and Ware and Gasaway [1976].

Courtenay (1979), Courtenay and Robins (1973; 1975), Greenfield (1973), Lacher et al. (1970) and others have cautioned that should grass carp reproduce in North America, the potential for detrimental effects to native fishes, waterfowl, and their

respective habitats exists. This remains a serious concern to biologists throughout the U.S. to the point that the importation, possession, or release of grass carp is now illegal in more than two-thirds of the states. Grass carp have reproduced outside of their native range in the Tone River near Tokyo, Japan (Inaba et al., 1957); near the Ah Kung Tian Reservoir in Formosa (Tang, 1963); in the Syr Dar'ya River, Kara Kuma Canal System, Volga River, Kuban River, and Ili River of Russia (Stanley et al., 1978), and in Mexico (Stroud, 1975). Stanley (1976) predicts that grass carp will reproduce in the U.S.

Status: Introduced as early as 1966 and possibly reproducing as indicated by several sources (personal communication) and particularly by Smith (1979): "At this time commercial fishermen [in Illinois] report that the grass carp is taken with regularity."

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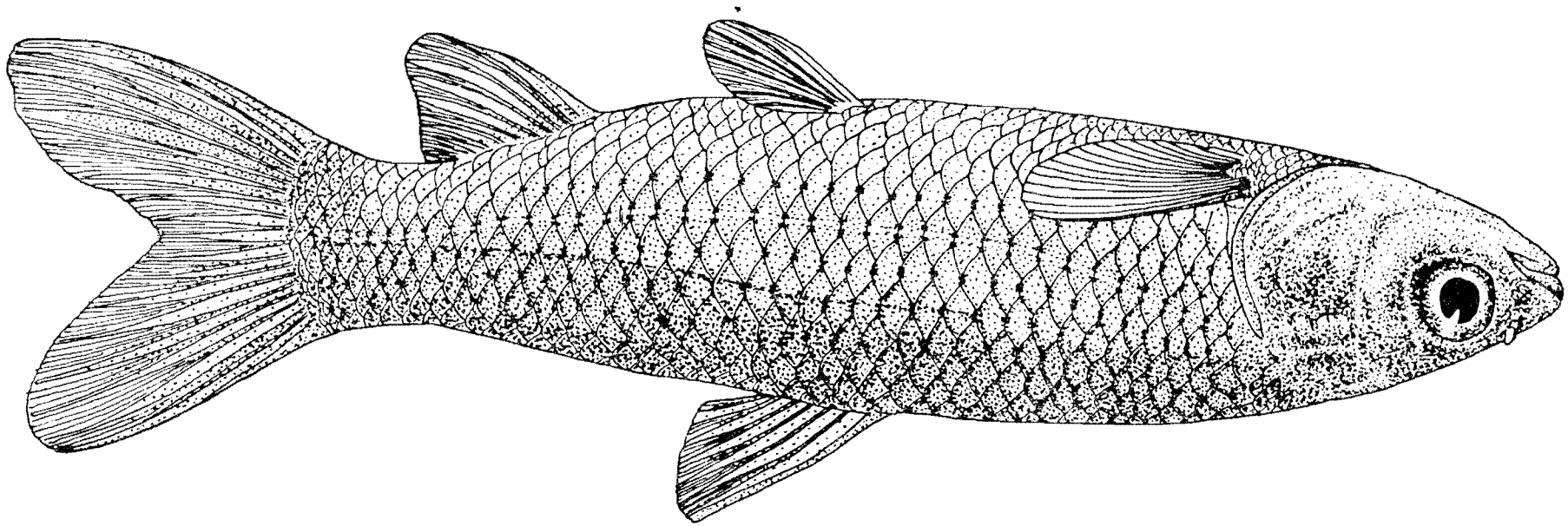
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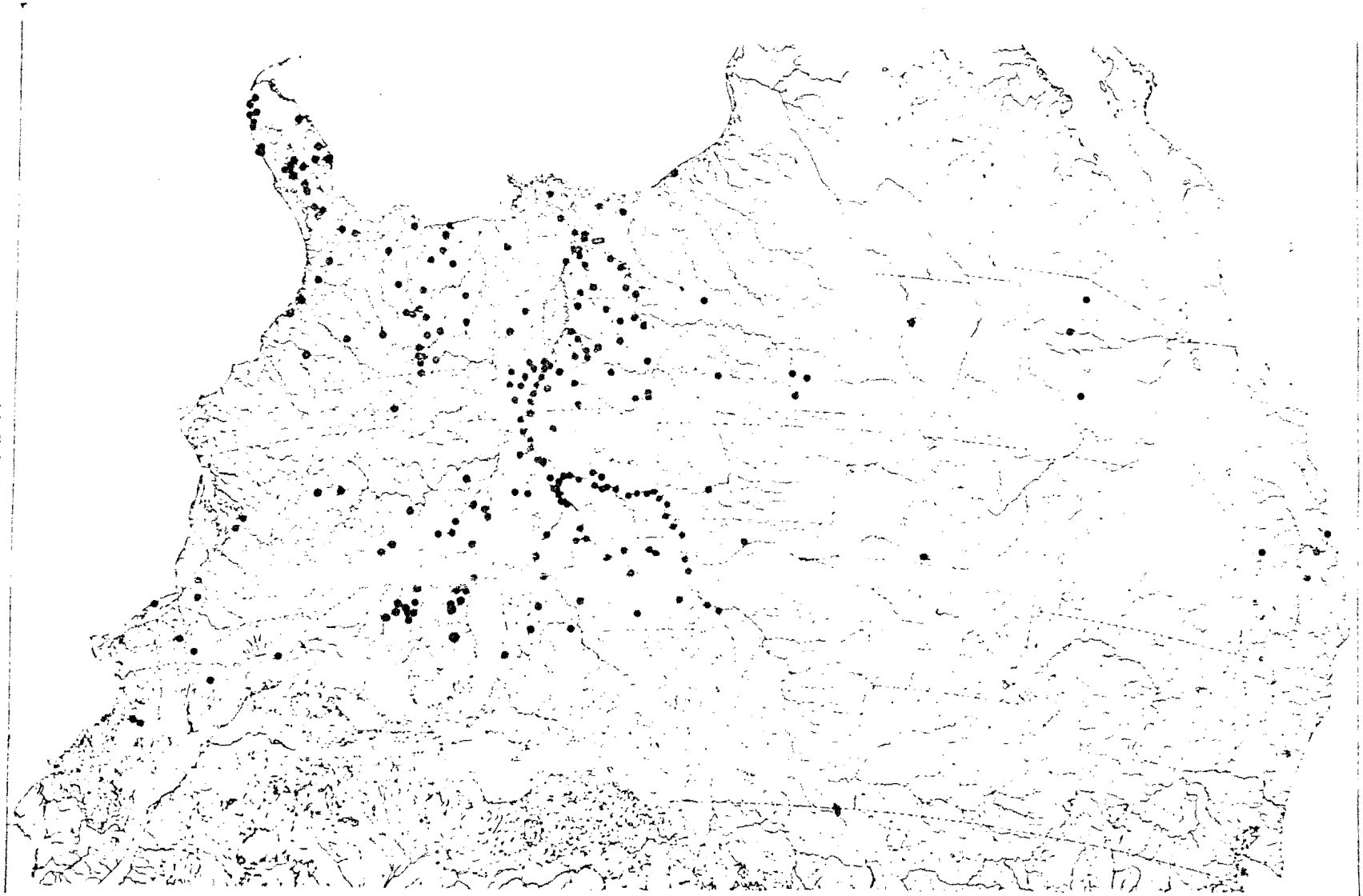
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Compiled by: Walter R. Courtenay, Jr.



CYPRI-B-13



CYPRT-B-14

Order Cypriniformes
Family Cyprinidae

Leuciscus idus (Linnaeus)

Ide

Original description citation: Linnaeus, 1758. Systema Naturae, Vol. I, p. 324.

Type locality: Freshwaters of Europe

Native range: Europe, from the Rhine eastward, and the Aral Sea basin (Berg, 1949).

U.S. range: A population of L. idus has maintained itself in one small pond in Connecticut since 1962 or 1963 (Whitworth et al., 1968).

The species has been introduced and collected in Long Island, New York (Bean, 1901, 1904). Apparently, there have been no recent collections of the species from this area; establishment in the state is doubtful.

It has been introduced and collected in the Potomac River drainage (Smith and Bean, 1899; Bean and Fowler, 1929; Schwartz, 1963). Although it has been included in recent lists of species from this drainage (Jenkins, et al., 1972; Lee et al., 1976), it is doubtful that it still occurs in this area (Musick, 1972).

Specimens were collected from a pond in York County, Pennsylvania in 1961 (Edwin Cooper, personal communication). One population was eradicated in Delaware County, Pennsylvania in about 1967 by Clark Shiffer. It is possible that it can still be found in some private waters of the state (Clark Shiffer, personal communication).

Sources of introduction: The golden variety of this species is a popular ornamental fish. Some "goldfish" in pet stores are L. idus (Schwartz, 1963). Although Lachner et al., (1970) state that introduction into the U.S. was probably made through private stocks, governmental agencies have been responsible for at least some introductions.. Releases in Long Island, New York, were made from stocks at the state's Cold Spring Harbor Hatchery (Bean, 1901), and at least one introduction in the Potomac River was made when the species escaped from U.S. Fish Commission ponds (Smith and Bean, 1899). Another introduction into the Potomac River drainage may have been due to escapees from commercial ponds in Thurmont, Maryland, going into the Monocacy River (Schwartz, 1963). Introduction into Pennsylvania was apparently due to pond suppliers who have produced this species for years (John Ramsey, personal communication).

Life history: In its native range, this species feeds mainly on insects and benthic invertebrates, and to some extent on spawn of other fish species, diatoms, and filamentous algae (Berg, 1949; Wheeler, 1969).

In its native range, it spawns from April to early June in weedy and sandy areas (Berg, 1949; Wheeler, 1969). The eggs are adhesive and become attached to submerged stones and plants. Information on growth rates and maturation in its native range is given by Berg (1949) and Wheeler (1969).

Environmental impress: No information available.

Status: Established in Connecticut; possibly established in Pennsylvania; establishment in New York and the Potomac River drainage is possible but improbable.

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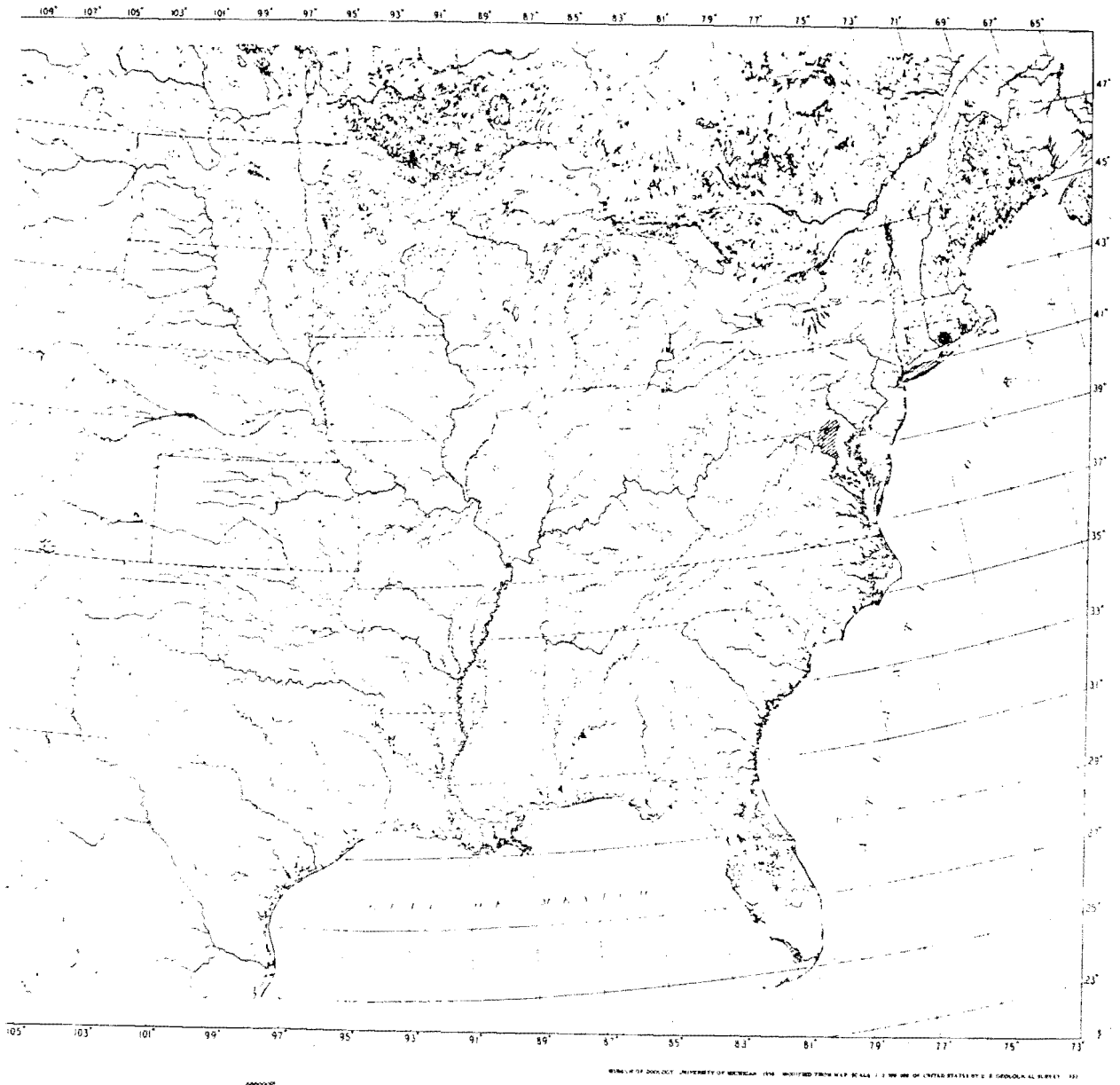
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Compiled by: Dannie A. Hensley


= Established
= Present status uncertain

Order Cypriniformes
Family Cyprinidae

Rhodeus sericeus (Pallas)

Bitterling

Original description citation: Pallas, 1776. Reise durch verschiedene Provinzen des russischen Reiches, Vol. III, pp. 208, 704.

Type locality: Onon River.

Native range: Europe, from France eastward, Asia Minor, and northern China (Berg, 1949).

U.S. range: In 1923 or earlier, R. sericeus was introduced and became established in the Saw Mill River, near Tarrytown, Westchester County, New York (Dence, 1925; Myers, 1925; Bade, 1926; Greeley, 1937). Although Breder (1933) claimed it disappeared at this locality shortly after 1925, specimens have been collected there as recently as the 1940s (C. Lavett Smith, personal communication). In August 1979, 10 or 11 specimens were collected in the Bronx River, Bronxville, New York by Dr. Robert Schmidt of Fordham University (C. Lavett Smith, personal communication).

Sources of introduction: Myers (1925) states that the species was often imported into New York City as an aquarium fish.

Introduction into the Saw Mill River was probably due to releases of aquarium fish.

Life history: In its native range, this species feeds mainly on phytoplankton (Berg, 1949).

In its native range, spawning occurs from April to July. During spawning, the female develops a long ovipositor. This is introduced into the excurrent syphon of a freshwater mussel and eggs are deposited. The male ejects sperm into the incurrent siphon of the mussel where fertilization occurs. The eggs hatch inside the mussel and the larvae remain there until free swimming. Breder (1933) showed that R. sericeus will use the American mussels Anodonta cataracta and Unio complanatus for breeding. The literature on reproduction for the species is reviewed by Breder and Rosen (1966).

Environmental impress: No information available.

Status: Possibly established in Saw Mill River, New York; established in Bronx River, New York.

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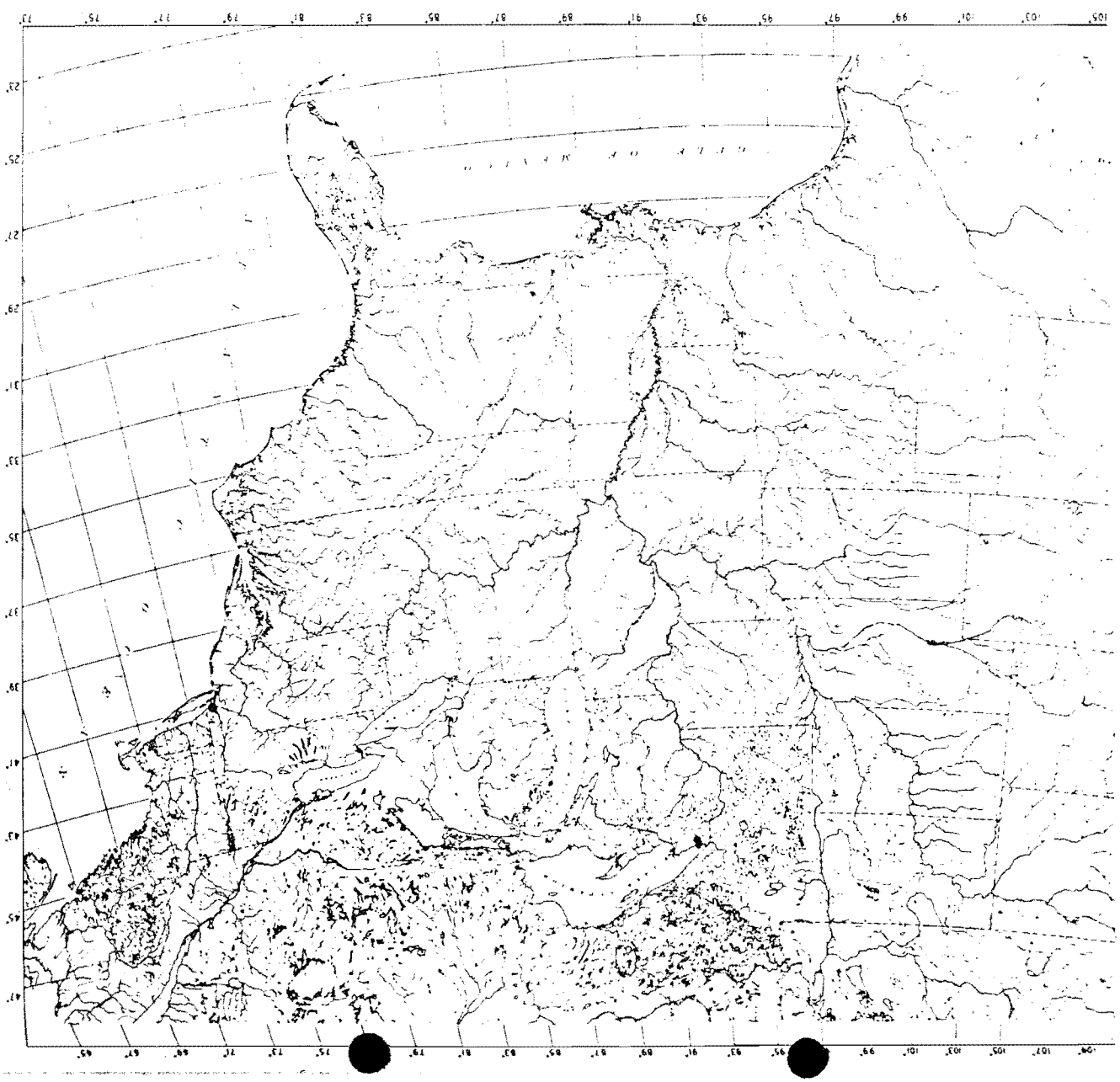
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Compiled by: Dannie A. Hensley and Walter R. Courtenay, Jr.



Order Cypriniformes
Family Cyprinidae

Scardinius erythrophthalmus (Linnaeus)

Rudd

Original description citation: Linnaeus, 1758. Systema naturae, Vol. I, p. 324.

Type locality: Northern Europe.

Native range: Europe, Ural River, Emba River, Asia Minor, southern coast of the Caspian Sea, and the Aral Sea basin (Berg, 1949).

U.S. range: This species was established in New York; Greeley (1937) reported it from the Roeliff-Jansen Kill, a tributary of the Hudson River, Columbia County, and Myers (1925) reported it from Central Park Lake, New York City. It was introduced into several other localities from the population in Central Park Lake (Myers, 1925). C. Lavett Smith (personal communication) has looked for the species once, apparently at the Roeliff-Jansen kill, and did not find it. There are no recent reports of its presence in New York; its status in this state is uncertain.

Myers (1925) reports the species well established in the lake in Hudson County Park, Jersey City, New Jersey. There are apparently no recent records of it from the state; its status here is uncertain.

S. erythrophthalmus was introduced into Oconomowoc Lake, Wisconsin in 1917, and was reported as becoming established (Cahn, 1927; Greene, 1935). Its present status is unknown.

Sources of introduction: Sources for the New York introductions are unknown. The species was introduced into New Jersey by private citizens, apparently from the New York City population (Myers, 1925), and into Wisconsin by the state's conservation department (Cahn, 1927; Greene, 1935).

Life history: In its native range, adults feed mainly on surface or aerial insects; the young eat diatoms, algae, and copepods predominantly. Large adults are known to occasionally eat fish (Wheeler, 1969).

In its native range, spawning takes place from April to July. The eggs are adhesive and are laid in submerged vegetation near shore. Information on fecundity, maturation, growth rates, and spawning behavior is given by Berg (1949), Breder and Rosen (1966), and Wheeler (1969).

Environmental impress: No information available.

Status: Possibly established in New York, New Jersey and Wisconsin.

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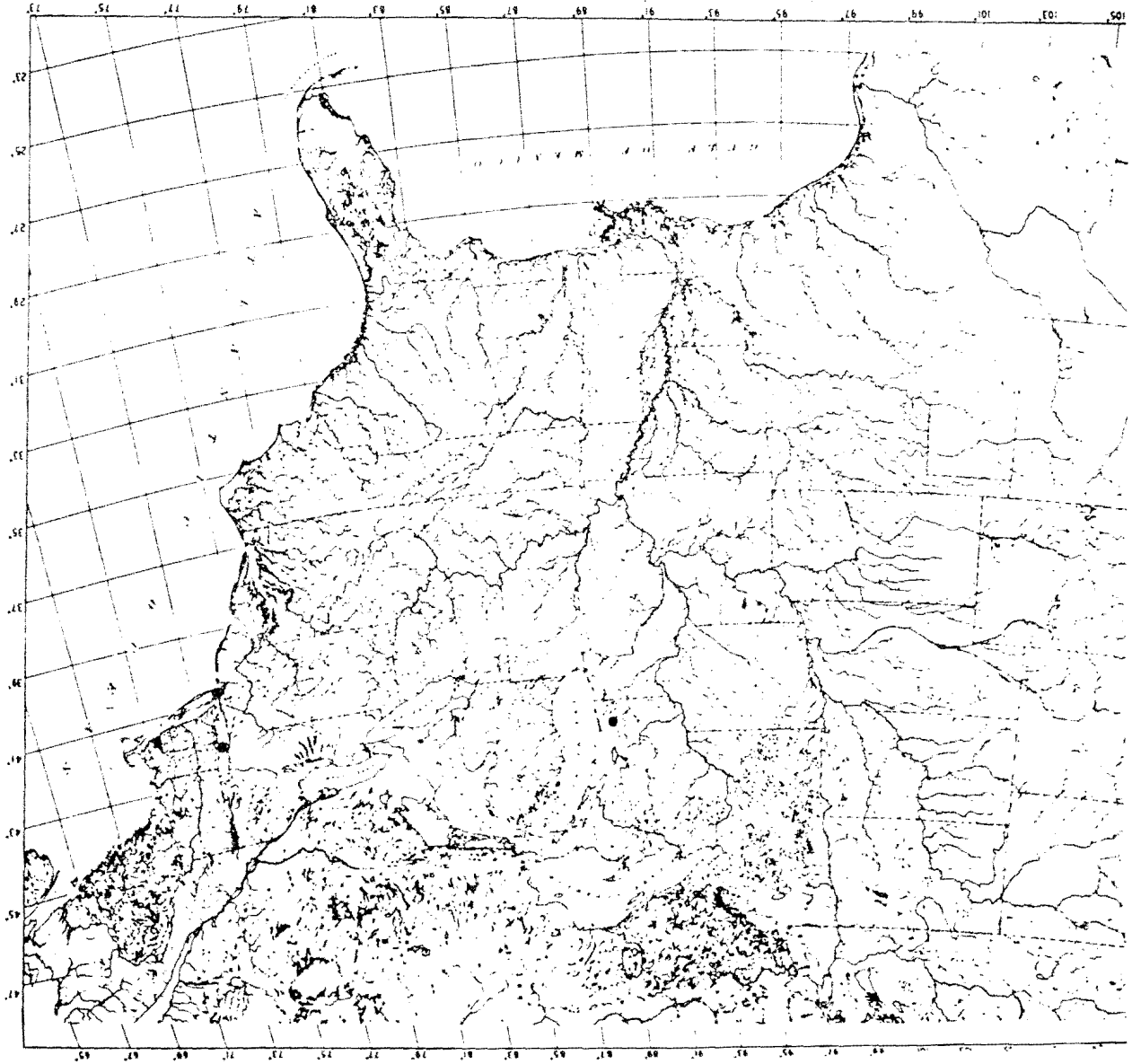
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Compiled by: Dannie A. Hensley



CYPRI-F-5

Order Cypriniformes
Family Cyprinidae

Tinca tinca (Linnaeus)

Tench

Original description citation: Linnaeus, 1758. Systema naturae, Vol. I, p. 321.

Type locality: Europe.

Native range: Western Europe, eastward to the Ob and Yenisei basins and Lake Baikal (Berg, 1949).

U.S. range: T. tinca is established in British Columbia (Dymond, 1936; Carl et al., 1959; Scott and Crossman, 1973), Washington (Smith, 1896; Schultz and De Lacy, 1935; Dymond, 1936; Chapman, 1942; Baughman, 1947; Moore, 1968), Oregon (Smith, 1896; Schultz and De Lacy, 1935; Baughman, 1947), California (Marr, 1940; Shapovalov, 1944; Baughman, 1947; Kimsey and Fisk, 1964; Moore, 1968; Moyle, 1976, 1976a), Idaho (Smith, 1896; Baughman, 1947; Linder, 1963; Moore, 1968; Stacey Gebhards, personal communication), Colorado (Baughman, 1947; Beckman, 1952; Moore, 1968; Robert Behnke, personal communication), New Mexico (Baughman, 1947; Koster, 1957), and Connecticut (Webster, 1942; Baughman, 1947; Whitworth et al., 1968; Cole Wilde, personal communication).

It was introduced into and collected from New York (Bean, 1904; Baughman, 1947). However, there are apparently no recent records of the species from the state; its current status is unknown.

Many tench were released into the Potomac River in the late 1800s. Apparently, the species originally became well established in Maryland (Baughman, 1947). In the 1890s it was becoming common and beginning to appear in markets (Smith and Bean, 1899). However, the species started to decline. There is a discrepancy in the literature as to when this occurred. Baughman (1947) states that, apparently as late as the 1940s, the tench was considered a nuisance in some Maryland waters, and yet Schwartz (1964) claims the last known wild-caught specimen was collected in 1911. There is considerable doubt that T. tinca still exists in Maryland (Schwartz, 1964; Musick, 1972). However, Schwartz (1964) feels they may still be found in some creeks in Frederick County, where they are reared for sale as "goldfish", and in the Potomac River (Schwartz, 1963). The species was included in the recent lists of fishes of Maryland and the Potomac River drainage of Jenkins et al. (1972) and Lee et al. (1976).

T. tinca was introduced into Delaware (Baughman, 1947) and is listed by Lee et al. (1976) as occurring there. However, Musick (1972) has expressed doubt that it still exists in the area.

It was introduced into Missouri and specimens were collected there (Baughman, 1947). However, they are apparently no longer established as they are not included in the work of Pflieger (1975).

Baughman (1947) records that the species was introduced into Arizona, and it has been collected in the state (Robert R. Miller, personal communication). However, it does not appear to be established and is not included in the work of Minckley (1973).

Sources of introduction: Baughman (1947) reviewed the history of introductions of T. tinca into North America, and attempted to determine their success. He found that between 1886 and 1896, the U.S. Fish Commission was responsible for distributing the species to 36 states, the District of Columbia, and Mexico. This agency distributed tench to all of the states mentioned under "U.S. range" except California and Connecticut. It was introduced privately into a reservoir on a ranch in San Mateo County, California in 1922 from stocks obtained in Italy. Later it was spread to other waters in California by ranchers (Shapovalov, 1944). The source for its introduction into Connecticut is unknown. Populations in British Columbia originated from Washington by way of the Columbia River (Dymond, 1936, 1955; Carl et al., 1959; Scott and Crossman, 1973).

Life history: In its native range, T. tinca adults feed mainly on benthic invertebrates; the young eat substantial quantities of algae (Wheeler, 1969).

Spawning occurs during May through August in its native range (Berg, 1949; Wheeler, 1969). The eggs are adhesive and become attached to submerged plants (Breder and Rosen, 1966; Wheeler, 1969).

Information on growth rates, maturation, and fecundity is presented by Berg (1949) and Wheeler (1969). Breder and Rosen (1966) review the literature on secondary sexual characters of the species.

In severe winters, the tench is reported to overwinter by lying dormant in bottom mud. It has the ability to live in poorly oxygenated water (Wheeler, 1969).

Environmental impress: Little information is available for this species. In the 1940s, T. tinca was reported to be a nuisance in certain localities in Maryland, and to be established in commercial quantities and a serious control problem in Kootenai County, Idaho (Baughman, 1947). As previously mentioned under "U.S. range", there is serious doubt that the species still occurs in Maryland. Although still established in Idaho, the tench is no longer considered a problem and there are no commercial or significant sport fisheries for the species in the state (Stacey Gebhards, personal communication).

Interestingly, Baughman (1947) presents evidence to indicate that centrarchids may have prevented more widespread establishment of T. tinca. He also presents a report claiming that plantings of Micropterus salmoides into one Maryland lake reduced a previously very large population of tench.

Status: Established in British Columbia, Washington, California, Oregon, Idaho, Colorado, Connecticut, and New Mexico; possibly established in New York, Maryland, and Delaware; specimens have been collected from Missouri and Arizona, but the tench is apparently not established in these states.

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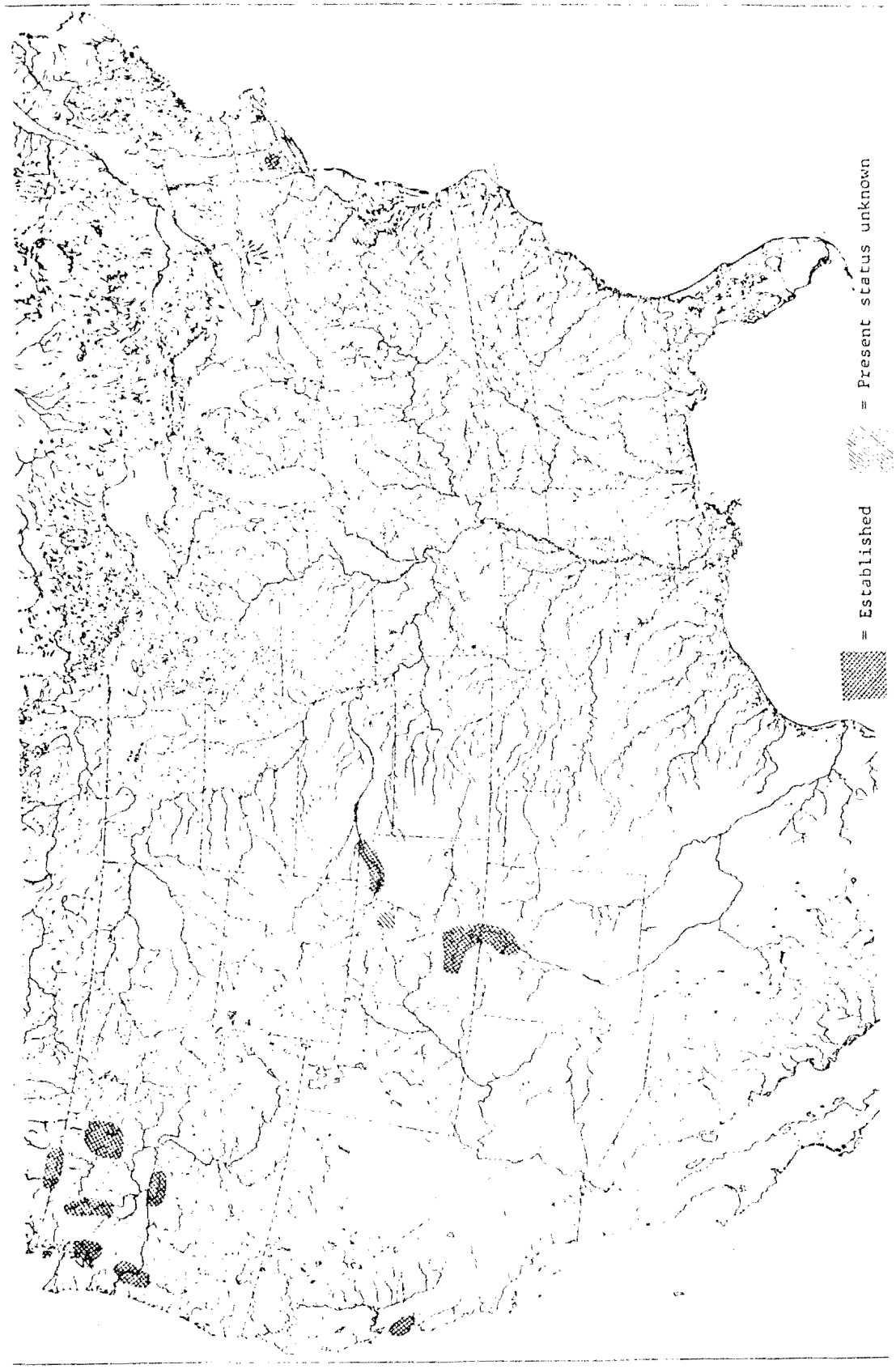
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Compiled by: Dannie A. Hensley


= Established
= Present status unknown

GOBIIDAE
Gobies

Acanthogobius flavimanus	[GOBII-A]	CA
Tridentiger trigonocephalus	[GOBII-B]	CA

Order Perciformes
Family Gobiidae

Acanthogobius flavimanus (Temminck and Schlegel)

Yellowfin goby

Original description citation: Temminck and Schlegel, in: Siebold, 1845. Fauna Japonica, pp. 141-142, pl. LXXIV, fig. 1.

Type locality: Nagasaki Bay, Kyushu, Japan.

Native range: Southern Japan, Korea, and coastal waters of China (Masuda et al., 1975).

U.S. range: This species is established in San Francisco, San Pablo, and Suisun bays, the Sacramento-San Joaquin Delta, Delta-Mendota Canal, San Luis Reservoir, and coastal areas from Tomales Bay to Elkhorn Slough (Brittan et al., 1963, 1970; Miller and Lea, 1972).

Sources of introduction: This species may have arrived in the San Francisco Bay area in the sea-water system of ships which were partially clogged with fouling organisms (Brittan et al., 1963). Although most of the spread of this species in the area is probably due to its own dispersal abilities, some spread may be due to its use as a bait fish (Brittan et al., 1970).

Life history: In Japan, adults of A. flavimanus feed mainly on a variety of crustaceans and small fishes (Okada, 1961).

Larvae feed on zooplankton, mainly copepods (Dotu and Mito, 1955).

In California, the spawning season extends from January to March (Brittan et al., 1970), coinciding with that in Japan (Dotu and Mito, 1955; Okada, 1961). At spawning, a Y-shaped, vertical burrow with two entrances is made in bottoms composed of mud and coarse sand. Eggs are attached to a wall of the burrow by filaments. Larvae are pelagic for an unknown period of time, and settle to the bottom when 15-20 mm in length (Dotu and Mito, 1955). The embryonic and larval development is illustrated by Dotu and Mito (1955) and Okada (1961).

The yellowfin goby has wide temperature and salinity tolerances (Brittan et al., 1970). Although the larval stages are usually spent in salt water, the large numbers of this species in the San Luis Reservoir, Merced County, probably indicate that it can complete its life cycle in fresh water (Moyle, 1976).

At least one predator of this species in the San Francisco Bay area is known; great blue herons, Ardea herodias, have been observed feeding A. flavimanus to their young in a rookery near Reedwood City, San Mateo County (Brittan et al., 1970).

Environmental impress: The spread of A. flavimanus in the San Francisco Bay area has been called "explosive" by Brittan et al. (1970). The authors estimate that this species was originally introduced three or four years previous to 1963, when the first

two specimens were collected. By 1966, specimens were being collected in increasing numbers at widely separated localities in the Bay area. In 1967, a fish kill occurred in the San Luis Reservoir, which receives fresh water from the Sacramento-San Joaquin River Delta. About half of the approximately 10,000 fishes killed in this incident were A. flavimanus. Since the work of Brittan et al. (1970), the species has become one of the most abundant benthic fishes in San Francisco Bay and the Sacramento-San Joaquin River Delta, has been collected along the California coast from Elkhorn Slough, Monterey County to Tomales Bay, Marin County, and is continuing to expand its range (Miller and Lea, 1972; Moyle, 1976).

The rapid range expansion and population increase exhibited by this species should cause great concern for possible effects on the native fauna, but little information is available in this regard. The tremendous increase in population size in the San Luis Reservoir, a recent man-made structure, was possibly due to a lack of competition from other benthic fishes, e.g., no catfishes were found in the 1967 fish kill (Brittan, et al., 1970). However, Brittan et al. (1970) reported that at one San Francisco Bay locality, A. flavimanus heavily outnumbered the native Leptocottus armatus, formerly the most common benthic fish at this site. Moyle (1976) has warned of the possibility that competition and predation by A. flavimanus could eliminate populations of the native tidewater goby Eucyclogobius newberryi, a species which has shown a serious decline since 1950 and

should be considered a rare or threatened species.

Status: Established in California in The San Francisco Bay-Delta region and on the coast from Tomales Bay, Marin County to Elkhorn Slough, Monterey County.

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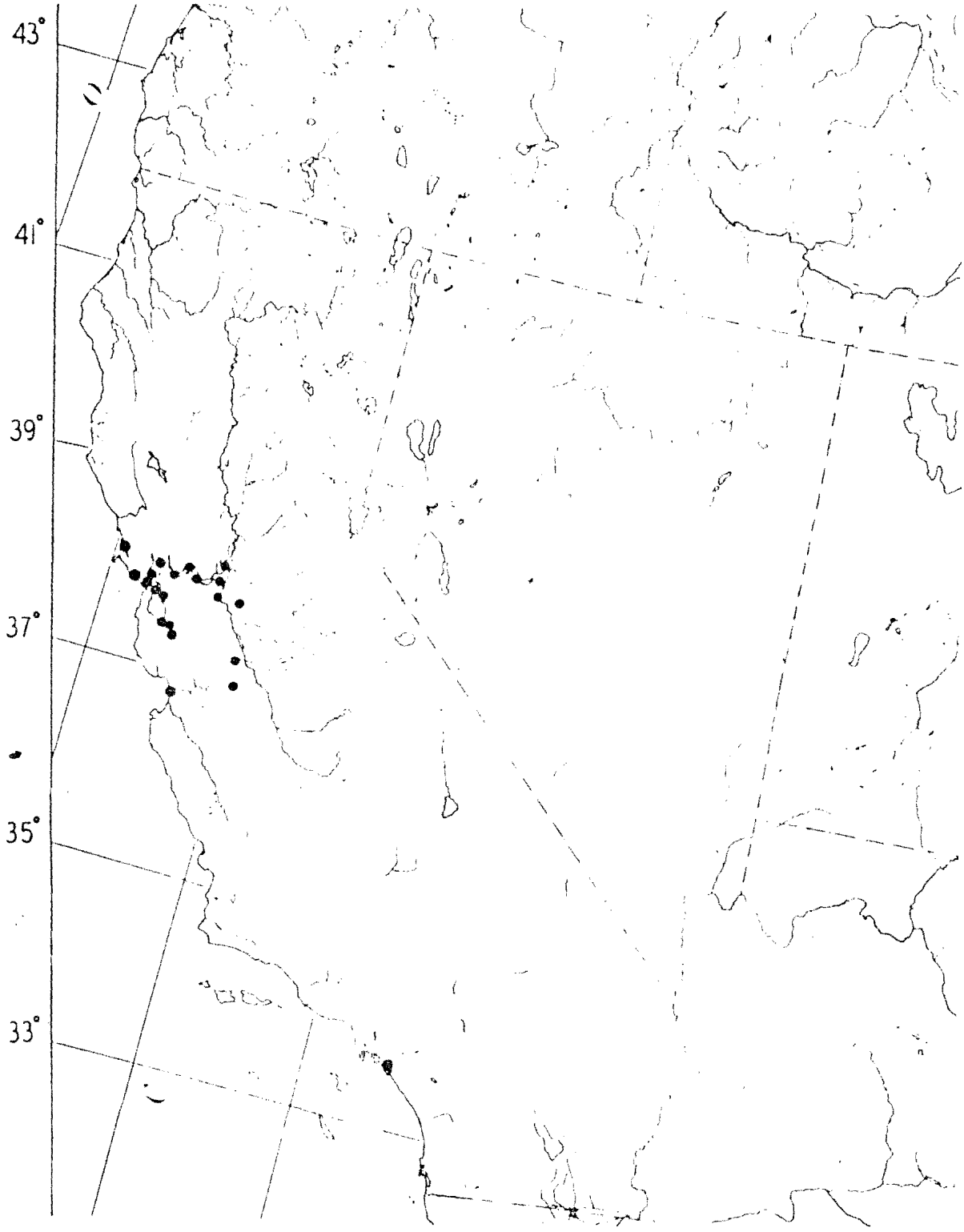
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Okada, Yaichiro. 1960. Studies on the freshwater fishes of Japan. Pref. Univ. Mie, Tsu. 860 pp.

Compiled by: Dannie A. Hensley.

Addendum: In a recent paper Haaker (1979. Bull. Southern Calif. Acad. Sci., 78(1): 61-67) reported A. flavimanus established in Newport Bay, Orange County, California, and probably established in Los Angeles and Long Beach harbors, the San Gabriel River, and near the mouth of the Los Angeles River, Los Angeles County. It was first seen in Los Angeles Harbor on 22 September 1977, and appears to be rapidly extending its range south from this area. This is reminiscent of the rapid spread of this species in the San Francisco Bay-Delta region reported by Brittan et al. (1970). As in northern California, a major concern in these southern areas is the possibility that A. flavimanus might cause elimination of the rare or threatened Eucyclogobius newberryi, and displacement of Leptocottus armatus. Haaker has expressed an additional concern. In southern California, Gillichthys mirabilis is collected in back bays and sloughs for use as bait in local lakes, the Salton Sea, Lake Mead, and the Colorado River. If A. flavimanus is collected with this bait species, it could become established in these other areas. A. flavimanus was probably transported to the Los Angeles and/or Long Beach harbors on fouling organisms on ships.

The stomachs of five specimens of A. flavimanus from southern California were examined and found to contain a crab, ostracods, amphipods, copepods, and a large amount of unidentifiable material.


43°
41°
39°
37°
35°
33°

Order Perciformes
Family Gobiidae

Tridentiger trigonocephalus (Gill)

Trident goby

Original description citation: Gill, 1858. Prodromus descriptionis familiae Gobioidarum duorum generum novorum. Ann. Lyceum Nat. Hist., N.Y., 7:18-19.

Type locality: Hong Kong.

Native range: Eastern Siberia, China, Korea, and Japan (Dotu, 1958).

U.S. range: Established in brackish-water areas of San Francisco Bay and Los Angeles Harbor, California (Hubbs and Miller, 1965; Brittan et al., 1970; Brittan, personal communication; Miller and Lea, 1972; Moyle, 1976).

Sources of introduction: Hubbs and Miller (1965) hypothesize that it was introduced into San Francisco Bay as egg stages on the introduced Pacific oyster, Crassostrea gigas, and into Los Angeles Harbor among fouling organisms on a ship.

Life history: The trident goby spawns from April to June in Ariake Sound, Kyushu, Japan. Eggs are attached to empty oyster shells by filaments and are guarded by the male. Larvae are pelagic (Dotu, 1958).

Environmental impress: No information available.

Status: Established in San Francisco Bay and Los Angeles Harbor, California.

References:

Brittan, Martin R., John D. Hopkirk, Jerrold D. Conners, and Michael Martin. 1970. Explosive spread of the oriental goby Acanthogobius flavimanus in the San Francisco Bay-Delta region of California. Proc. Calif. Acad. Sci., 38(11): 207-214.

Dotu, Yosie. 1958. The bionomics and life history of two gobioid fishes, Tridentiger undicervicus Tomiyama and Tridentiger trigonocephalus (Gill) in the innermost part of Ariake Sound. Sci. Bull. Fac. Agric., Kyushu Univ., 16(3): 343-358.

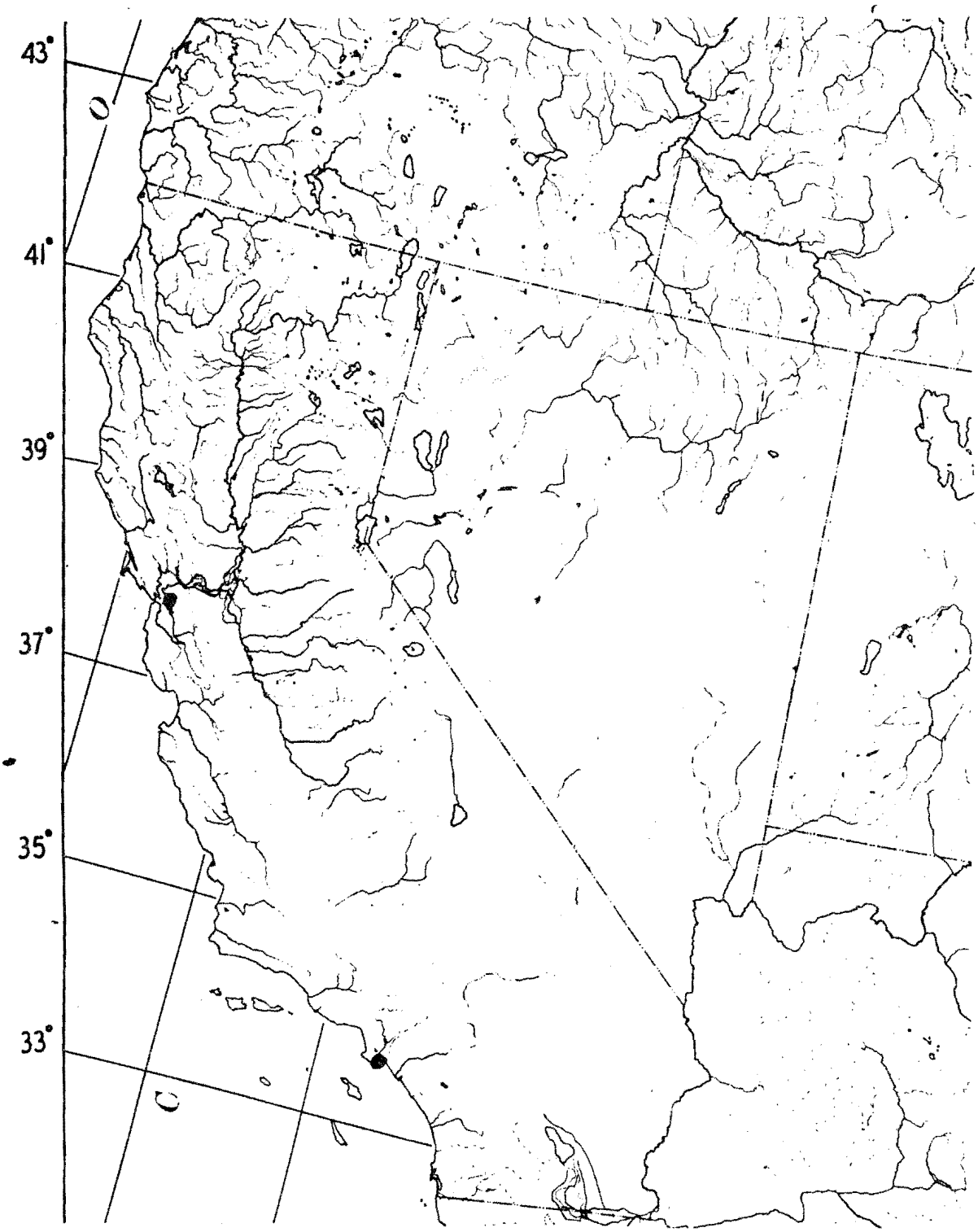
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Moyle, Peter B. 1976. Inland fishes of California. Univ. Calif. Press, Berkeley. 405 pp.

Compiled by: Dannie A. Hensley

Addendum: Haaker (1979. Bull. Southern Calif. Acad. Sci., 78(1): 61-67) made several observations on Tridentiger trigonocephalus in Los Angeles Harbor. He examined gut contents of 15 specimens and found the following classes of food items in order of decreasing frequency: crustaceans (gammarid and caprellid amphipods, copepods, isopods, and ostracods), polychaetes, gastropods, and fish eggs. Most specimens were found in discarded bottles and cans. In September he found a 78 mm SL male and a 66 mm SL female with a clutch of 300 eggs in an aluminum beer can.


43°
41°
39°
37°
35°
33°

LORICARIIDAE
Armored catfishes

Hypostomus spp. [LORIC-A] FL, NV, TX

Order Siluriformes
Family Loricariidae

Hypostomus spp.

Armored catfishes

Note on systematics: Systematics of this genus are in great need of revision. At present it is impossible to correctly identify or ascertain the number of species established in the U.S.

We have followed Boeseman (1968) in using the generic name. However, the name Plecostomus is frequently used by other workers.

Native range: (generic) From Rio de la Plata to eastern Ecuador and Costa Rica (Gosline, 1945; Bussing, 1966).

U.S. range: Species of this genus have become established in Indian Springs, Clark County, Nevada (Minckley, 1973; James Deacon, personal communication), the San Antonio River, San Antonio, Texas (Barron, 1964; Hubbs et al., MS), and Hillsborough and Dade counties, Florida (Burgess, 1958; Rivas, 1965; Courtenay et al., 1974).

Sources of introduction: In Nevada and Florida, introductions were probably due to releases of fish from home aquaria and fish farms.

The population in Texas originated from the San Antonio Zoological Gardens, where a species was introduced into a pool for control of algae (Barron, 1964).

Life history: Hypostomus species are mainly nocturnal algal grazers (Lowe-McConnell, 1975). Stomach contents of specimens collected in Florida and Texas have consisted of algae, other plant material, and detritus (Courtenay et al., 1975; Hubbs et al., MS).

During daylight hours Hypostomus species hide under logs, rocks, and undercut banks, and are difficult to see or collect (Lowe-McConnell, 1975; Saul, 1975). In the San Antonio River Hubbs et al. (MS) collected large adults Hypostomus from swift waters, often under large boulders, and juveniles from waters with slow to moderate currents and heavy vegetation.

Species of this genus lay eggs in holes in banks, where they are guarded by one or both parents (Breder and Rosen, 1966; Lowe-McConnell, 1975). They are small brood spawners. Based on the number of ova ripening at one time in the ovaries, one species (H. plecostomus) appears to lay 115-118 eggs per spawning (von Ihering et al., 1928; fide Lowe-McConnell, 1975). Breder (1927) reported that ovarian eggs from H. plecostomus are 2.40-2.55 mm in diameter. Hubbs et al. (MS) found ovarian eggs to be 3.25 mm in diameter in a specimen from the San Antonio River population. Eggs of H. plecostomus require ca. 7-8 days before

hatching (Breder and Rosen, 1966). Due to an even size distribution in the San Antonio River population, Hubbs et al. (MS) suggested that this population has a prolonged breeding season. These authors found females maturing at 116-181 mm (SL?) and males at 130-180 mm.

Hypostomus species have the stomach modified for aerial respiration and are able to use this organ for survival in poorly oxygenated waters and making short terrestrial migrations. Aerial respiration in these species is accessory (Carter, 1935; Johansen, 1970; Lowe-McConnell, 1975).

Environmental impress: Because Hypostomus species feed primarily by grazing algae and detritus from submerged objects, it has generally been felt that they pose little competitive threat to native North American fish species (Courtenay et al., 1974). Thus, Hubbs et al. (MS) state that trophic competition with native percids in the San Antonio River is unlikely since these species feed predominantly on arthropods. These authors suggest that if any displacement of native species has occurred there it has most likely involved the cyprinids Campostoma anomalum and Dionda episcopa, both of which are very abundant in central Texas but were absent from samples taken in the area where the Hypostomus species is established. Breder (1927) has pointed out some interesting similarities in feeding behavior, morphology of the mouth and digestive tract, and food utilized between H. plecostomus and generalized anuran tadpoles. To what

degree it is possible that established Hypostomus species are competing with native anuran tadpoles is unknown.

Although no detrimental effects from established populations of Hypostomus species have been documented, some concern is still warranted since subtle factors may be involved of which we are still unaware. These populations should be monitored to determine their densities and expansions. In this regard, the species in the San Antonio River spring run and Six-Mile Creek, Hillsborough County, Florida, are abundant (Hubbs et al., MS; personal observation). In addition, the Tampa Bypass Canal connecting Six-Mile Creek with the Hillsborough River was recently completed, and the population is expected to spread into this river (Courtenay et al., 1974; Derril Moody, personal communication).

Status: Established in Clark County, Nevada, San Antonio, Texas, and Hillsborough and Dade counties, Florida.

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Poeciliidae

Oryziatidae

Gosline, William A. 1945. Catálogo dos nematognatos de água-doce da América do Sul e Central. Bol. Mus. Nac., Zool., Brasil, 33:1-138.

Hubbs, Clark, Thomas Lucier, Gary P. Garrett, Robert J. Edwards, S. Michael Dean, and Edie Marsh. MS. Survival and abundance of introduced fishes near San Antonio, Texas.

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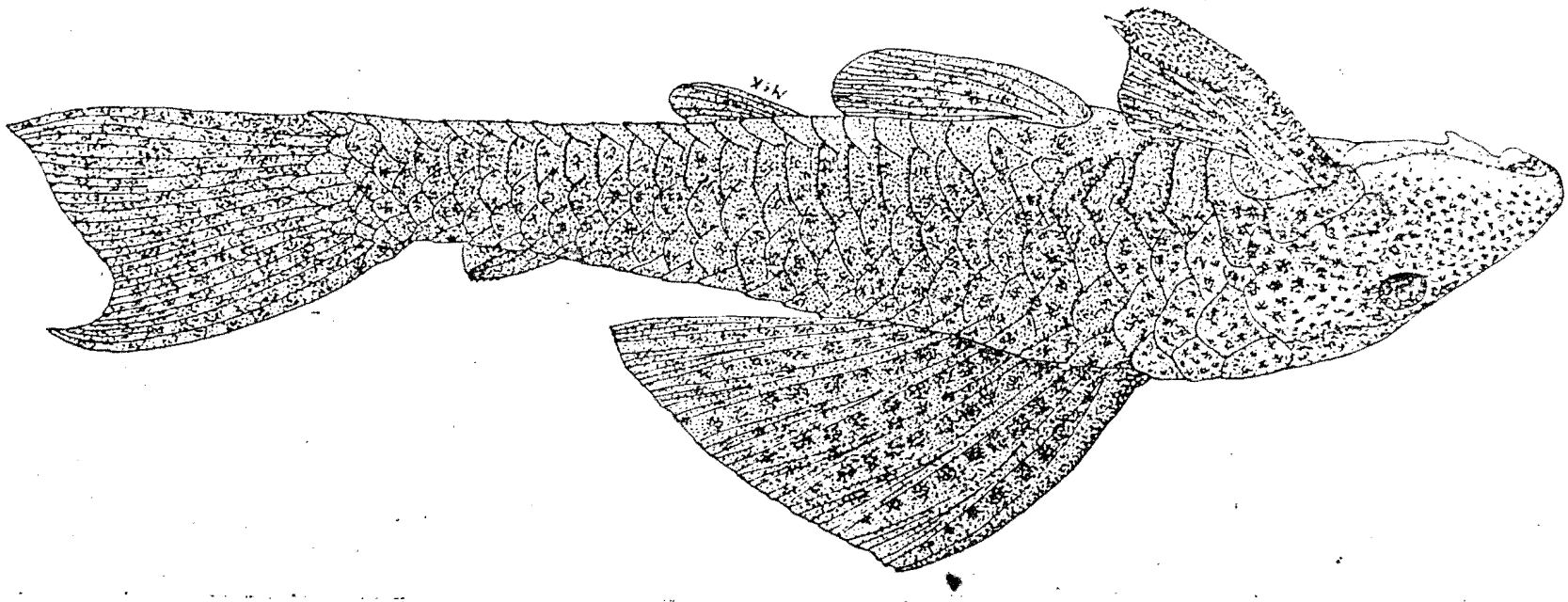
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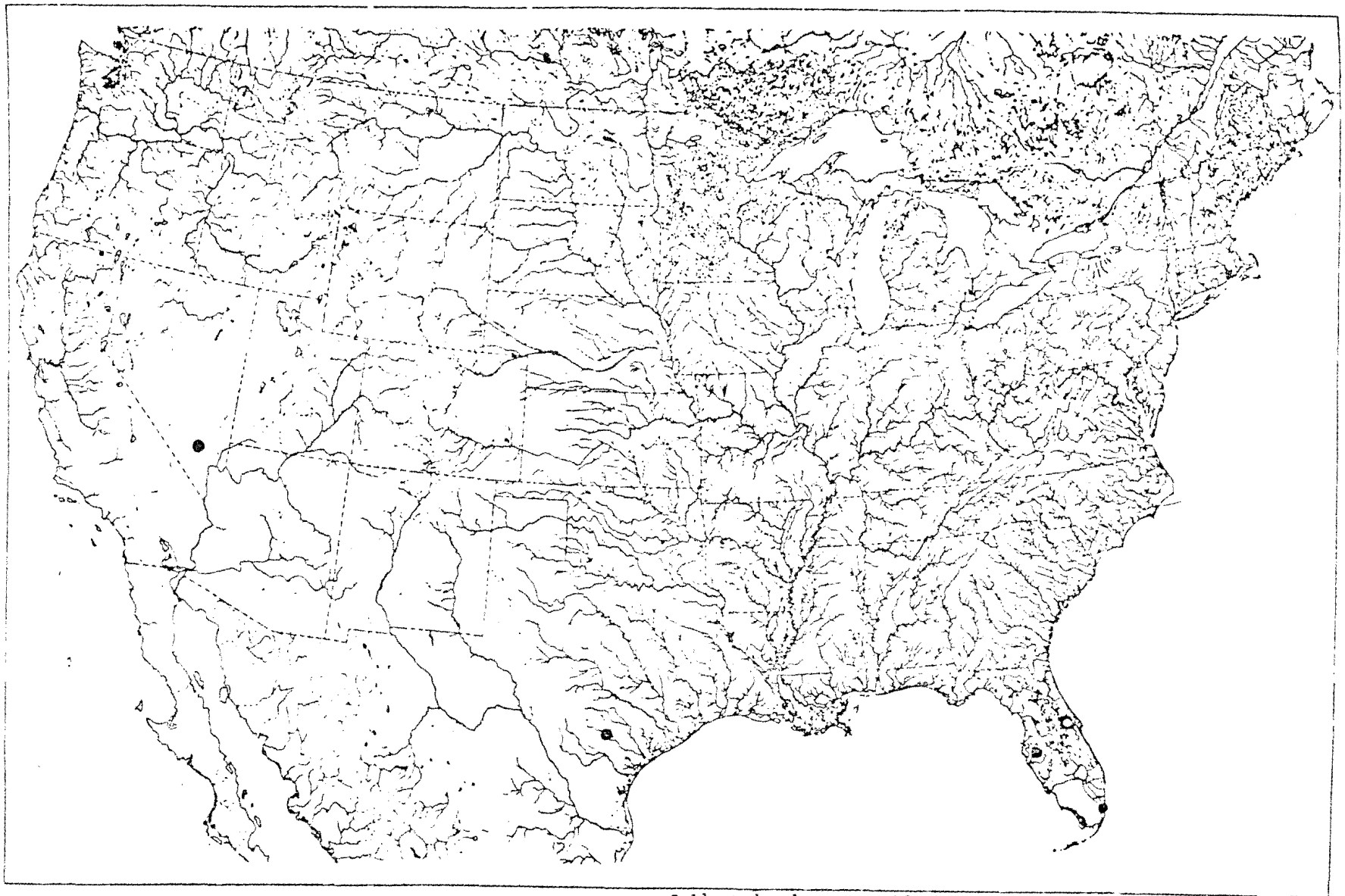
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Cryziatidae

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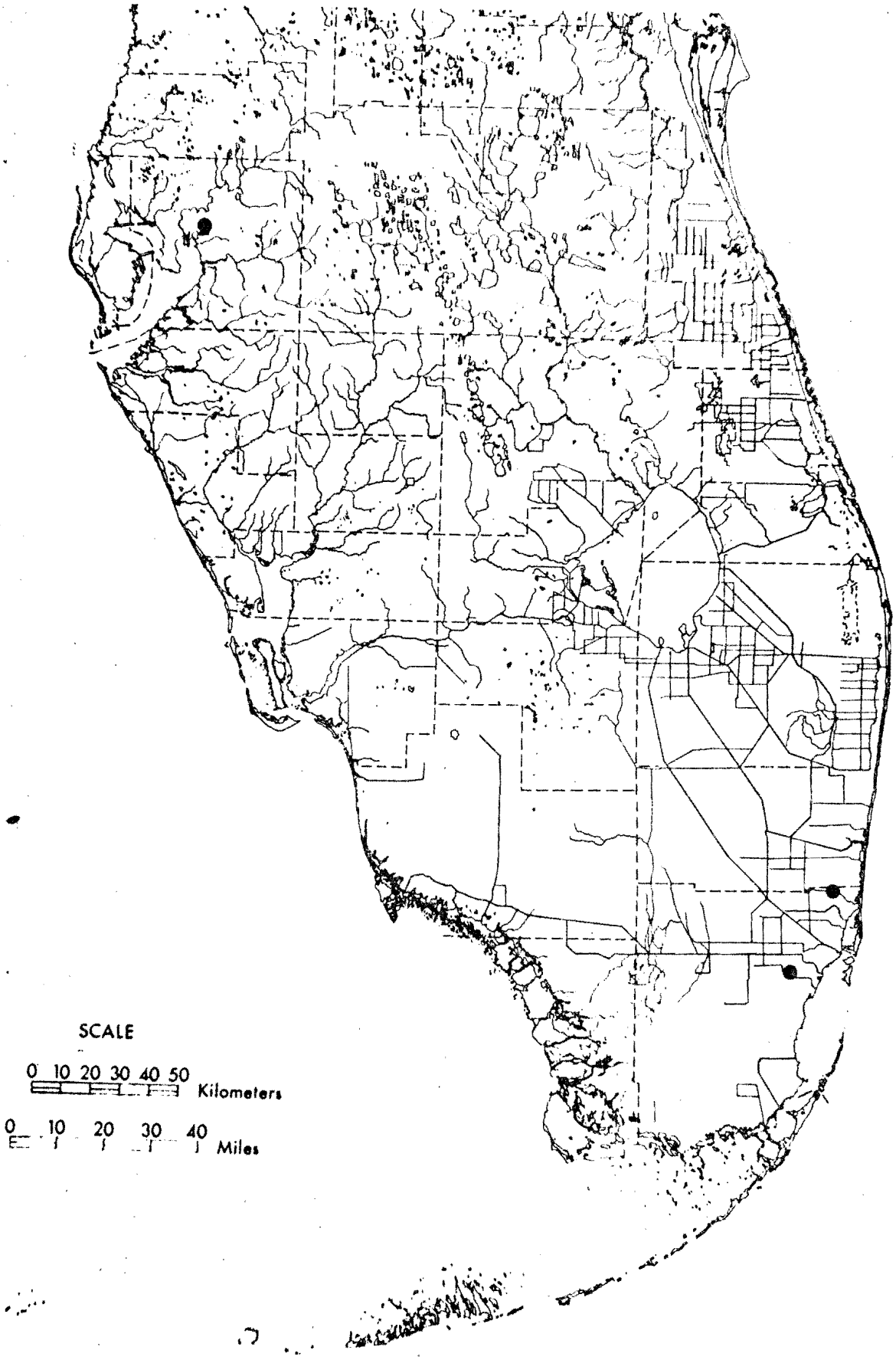
Compiled by: Dannie A. Hensley





= Collected only or establishment uncertain

= Established


SCALE
0 10 20 30 40 50
Kilometers
0 10 20 30 40
Miles

ORYZIATIDAE

Medakas

Oryzias latipes [ORYZI-A] NY

Order Atheriniformes
Family Oryziatidae

Oryzias latipes (Temminck and Schlegel)

Medaka

Original description citation: Temminck and Schlegel in: Siebold, 1846. Fauna Japonica, p. 224, pl. CII, fig. 5.

Type locality: Japan.

Native range: Japan, Korea, southern Manchuria, eastern China, and as far south as Hainan (Briggs and Egami, 1959).

U.S. range: O. latipes was introduced into northern California, and was probably established in San Francisquito Creek, Santa Clara, as late as the 1940s (Shapovalov et al., 1959). Apparently, it is no longer established in this state.

The species is known to have been established for years in permanent ponds in Suffolk County, Long Island, New York. Although these ponds have not been sampled for at least five years, there is no reason to believe that the medaka is not still there, since it has a very wide temperature tolerance (Donn E. Rosen, personal communication).

Sources of introduction: It has been used for many years in the U.S. as an aquarium fish and an experimental animal for reproductive physiology, genetics, behavior, and embryology (Briggs

and Egami, 1959). Its introduction into open waters was due to accidental or purposeful releases.

Life history: This species is at least partially insectivorous.

In Japan, spawning occurs from April to October. During spawning, 20-40 eggs remain attached to the genital opening of the female until they are transferred to a plant. The literature on reproduction is summarized by Breder and Rosen (1966), and a bibliography for the species is presented by Briggs and Egami (1959).

This species has wide temperature and salinity tolerances.

Environmental impress: No information is available for this species.

Due to its wide salinity tolerance, it has the potential to become established in coastal areas (Rosen, 1973).

Status: Established in Suffolk County, New York.

References:

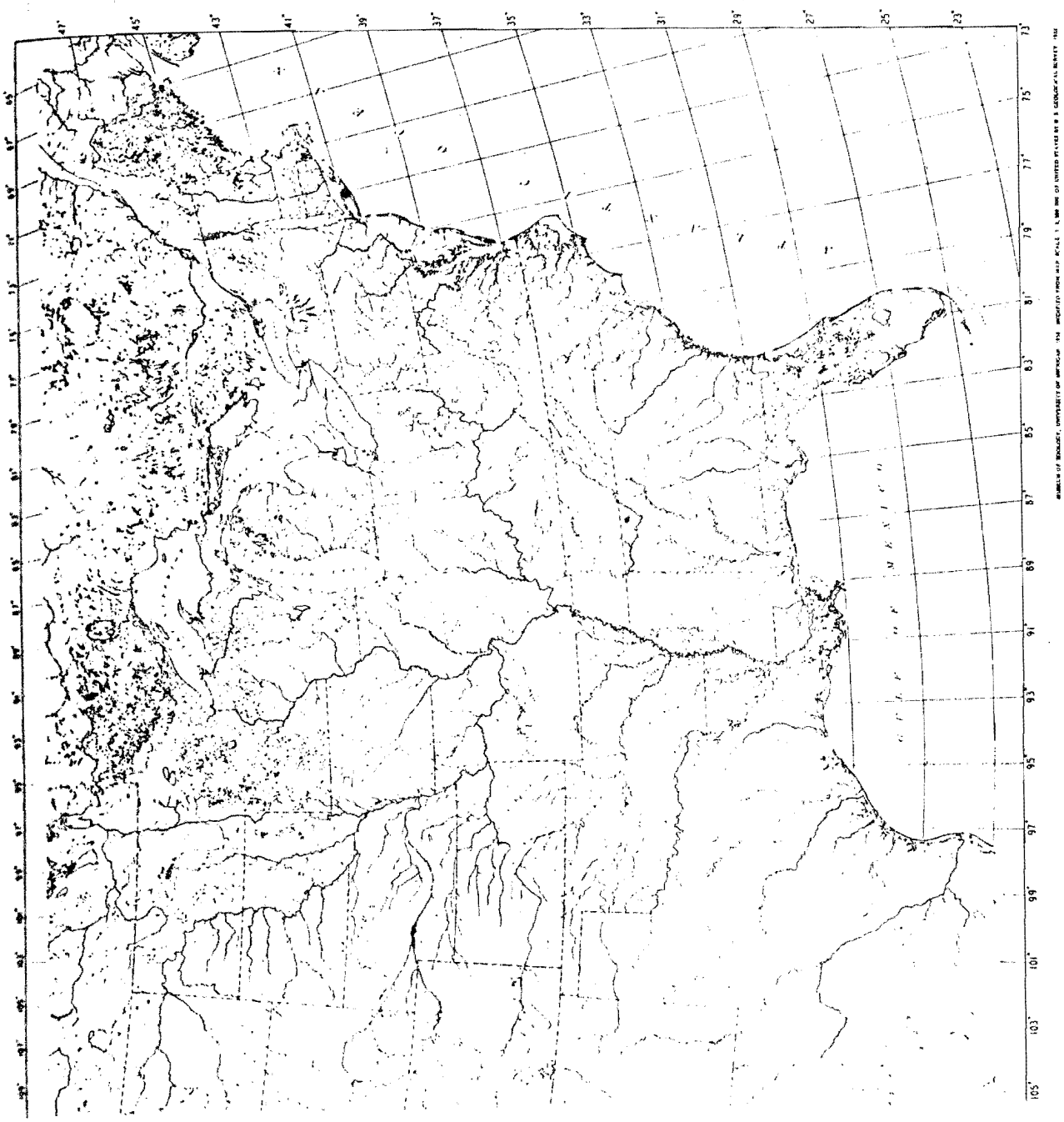
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Rosen, Donn E. 1973. Suborder Cyprinodontoidei. In Fishes of the western North Atlantic. Part six. Mem. Sears Found. Mar. Res., 1: 229-262.

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Compiled by: Dannie A. Hensley



OSMERIDAE

Smelts

Hypomesus transpacificus nipponensis [OSMER-A] CA

Order Salmoniformes
Family Osmeridae

Hypomesus transpacificus nipponensis McAllister

Wakasagi

Original description citation: McAllister, 1963. A revision of the smelt family, Osmeridae. Natn. Mus. Canada Bull., 191: 36-37, fig. 11 (upper inset).

Type locality: southern Onuma, southern Hokkaido, Japan.

Native range: Hikkaido and possibly Honshu, Japan (McAllister, 1963).

U.S. range: In 1959, H.t. nipponensis was introduced into six reservoirs in Lassen, Siskiyou, Humbolt, Nevada, El Dorado, and San Bernardino counties, California. It has since been introduced into other reservoirs. The status of some of these populations is in doubt. However, it is doing well in a number of reservoirs, and can be expected to occur anywhere in the lower Klamath, Sacramento, and other river systems (Wales, 1962; Moyle, 1976).

Sources of introduction: H.t. nipponensis was introduced by the California Department of Fish and Game in an attempt to provide a forage fish for trout in some lakes and reservoirs. It was apparently impossible to collect enough of the native subspecies,

H.t. transpacificus (Sacramento-San Joaquin Delta region), for stocking purposes (Wales, 1962).

Life history: This species is known to feed mainly on zooplankton (Moyle, 1976).

Little is known about the life history of H.t. nipponensis in California. In Japan, this subspecies can have an anadromous or completely freshwater life history. Spawning in both types of life histories occurs in rivers or on shores of lakes in April or May. The eggs are small and adhesive; they become attached to submerged objects. Maturity is attained in one year. Those that are anadromous die after spawning, while those that are strictly freshwater may live up to four years (Hamanda, 1961).

Environmental impress: No information is available on the environmental impress of H.t. nipponensis. Considering the fact that osmerids are highly predaceous, it is surprising that no studies have been done on the introduced populations' effects on zooplankton and fish larvae (Moyle, 1976).

Status: Established in some northern California reservoirs.

References:

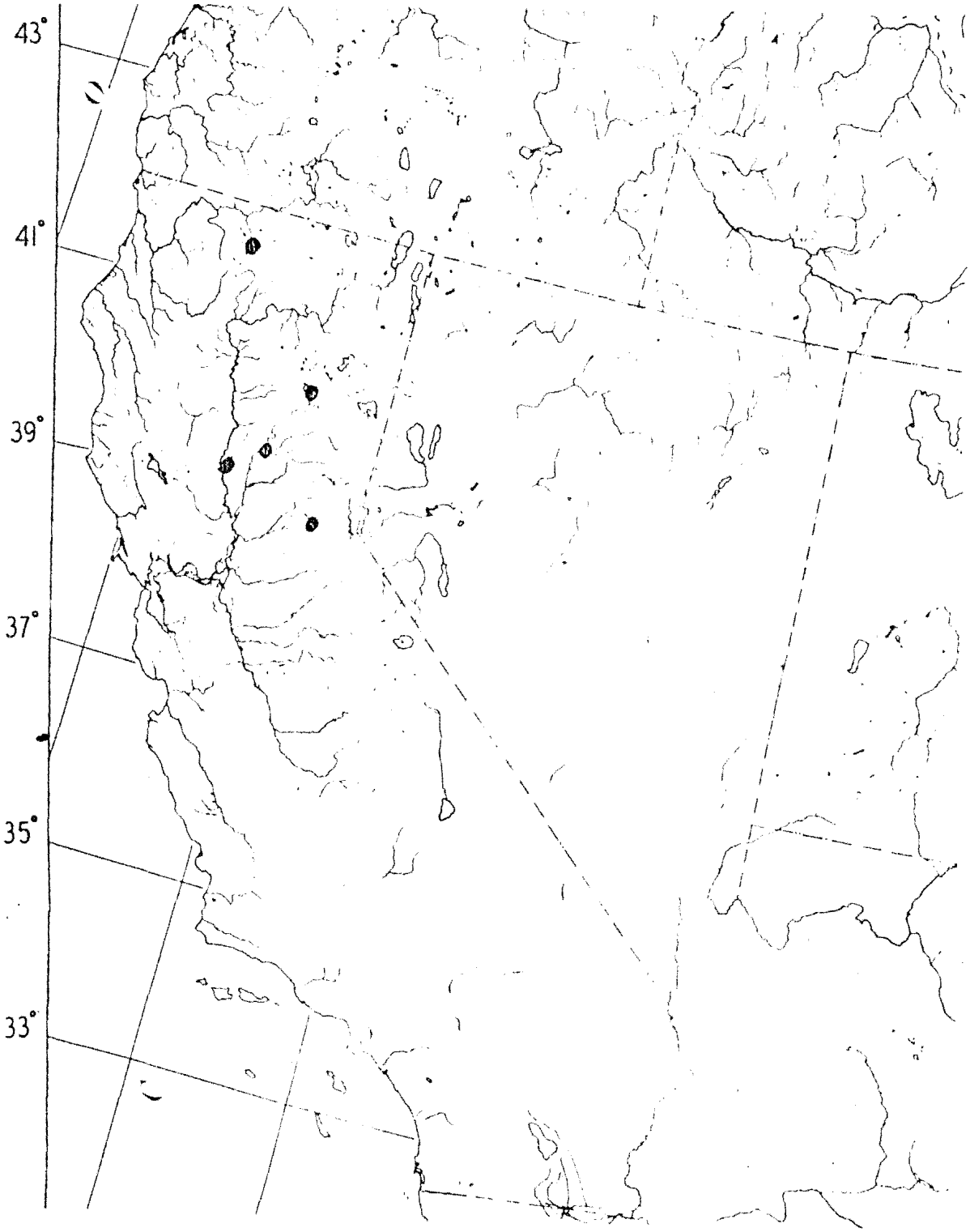
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Compiled by: Dannie A. Hensley



Procellariidae

POECILIIDAE
Livebearers

Belonesox belizanus	[POECI-A]	FL
Poecilia reticulata	[POECI-B]	AZ, NV, TX; Alb., possibly FL
Poecilia sphenops "complex"	[POECI-C]	CA, MT, NV
Poeciliopsis gracilis	[POECI-D]	CA
Xiphophorus helleri	[POECI-E]	FL, MT; Alb.
Xiphophorus maculatus	[POECI-F]	FL, NV
Xiphophorus variatus	[POECI-G]	FL, MT

Order Atheriniformes
Family Poeciliidae

Belonesox belizanus Kner

Pike killifish

Original description citation: Kner, 1860. Über Belonesox belizanus, nov. gen. et spec. aus der Familie der Cyprinodonten. Sitzber. K. Akad. Wiss. Wien, Math. Nat. Cl., 40(10): 419-422.

Type locality: Belize, Belize.

Native range: Atlantic slope of Middle America from Laguna San Julián, northwest of Veracruz City, Mexico, to Costa Rica (Caldwell et al., 1959; Miller, 1966).

U.S. range: B. belizanus is established in canals in southeastern Dade County, Florida (Belshe, 1961; Rivas, 1965; Lachner et al., 1970; Courtenay and Robins, 1973; Courtenay et al., 1974; Miley, 1978).

It has been seen and collected in the San Antonio River in San Antonio, Texas (Barron, 1964). This population is apparently no longer extant (Hubbs et al., MS).

Sources of introduction: B. belizanus was originally imported into Dade County, Florida, for use in research by the Medical Research Unit at the University of Miami. In April or May 1957,

approximately 50 fish were released into a canal near Goulds when they were no longer needed in research (Belshe, 1961). This species is reported to be established on the campus of the University of Miami in Coral Gables (Courtenay et al., 1974). This appears to have been a separate introduction, but the source is unknown. It was possibly due to dumping of home aquaria.

The source of introduction of this species in San Antonio, Texas is unknown. Introductions due to releases by home aquarists are frequent in such urban areas.

Life history: Most published information on the food habits of B. belizanus is found in the aquarium literature (e.g., Innes, 1955; Sterba, 1966; Jacobs, 1971). Although this literature reports the species as feeding on various prey (fishes, oligochaetes, insects, and tadpoles), it is widely known to be primarily piscivorous. Because of this it is not a popular aquarium fish. In Guatemala it has been observed feeding on Astyanax (Hubbs, 1935). Most information on the feeding ecology of B. belizanus has been obtained from the Florida population and is found in the unpublished works of Belshe (1961) and Miley (1978). B. belizanus feeds diurnally. In Florida it has been recorded to feed on the following species: Gambusia affinis, Poecilia latipinna, Lucania parva, L. goodei, Cyprinodon variegatus, Heterandria formosa, Fundulus grandis, B. belizanus, Micropterus salmoides,

Microgobius gulosus, the shrimp Palaemonetes paludosus, and an unidentified insect species. Both Belshe and Miley found B. belizanus to have a strong preference for feeding on native poeciliids and cyprinodontids. An exception to this was in a collection of fishes made by Belshe where 45.9% of the B. belizanus stomachs examined contained P. paludosus, only 15.8% contained fishes, and 3.6% contained both. He hypothesized that this was due to a low availability of prey fishes of the size suitable for B. belizanus. Laboratory experiments by Belshe and Miley, in which shrimp and fishes were offered as prey, support this hypothesis, i.e., a great preference was shown for fishes. In addition, Miley found crustaceans, insects, and molluscs present at a concentration of 5,840 individuals/m^2 at one locality, but stomachs of B. belizanus collected in this area contained 99% fishes. Among the native poeciliids and cyprinodontids, B. belizanus preys most heavily on G. affinis and P. latipinna. Both of these species occur in open water to a greater extent than L. goodei and H. formosa, which tend to remain secluded in refugia (i.e., aquatic plants) and, hence, are not as readily vulnerable to predation. Adult G. affinis are within the normal prey size for B. belizanus. However, this predator apparently can only feed on juvenile P. latipinna which are ca. 40 mm TL or smaller. In experiments Miley found that B. belizanus consumed G. affinis at rates of 2.7 - 3.1 prey/predator/day and has conversion ratios of 20.3 - 32.2%. In a similar set

of experiments using the same prey species, Belshe found a mean consumption rate of 2.9 prey/predator/day, and that the time for a 77 mm SL B. belizanus to digest a ca. 33 mm SL G. affinis is five hours. In aquaria B. belizanus will begin feeding within one or two minutes after birth on newborn Poecilia reticulata, Xiphophorus spp., and G. affinis, pieces of G. affinis, copepods (Cyclops), the branchiopod Daphnia, and enchytraeid oligochaetes (Innes, 1955; Belshe, 1961; Breder and Rosen, 1966; Sterba, 1966; Jacobs, 1971). Belshe had no success in feeding newborn B. belizanus on brine shrimp (Artemia), small beetle larvae, or commercial fish food.

In its native range B. belizanus has been collected in estuaries, small, slow streams, springs, pools, and stagnant water holes in swamps (Meek, 1904; Hubbs, 1935, 1936; Caldwell et al., 1959; Gilbert and Kelso, 1971). It appears to be more common in slow or still waters. It is known from brackish-water areas (Meek, 1904; Caldwell et al., 1959; Rosen and Bailey, 1963; Gilbert and Kelso, 1971). Observations in Guatemala by Hubbs (1935) indicate the species has a high tolerance of oxygen-deficient conditions. In Florida, B. belizanus is most common in narrow canals with abundant marginal vegetation; population densities are much lower in deep, open-water canals (Belshe, 1961; Miley, 1978). In a series of experiments, Belshe (1961) found that the species can tolerate seawater, and that it becomes disabled when temperatures are lowered to 10 - 13°C ($\bar{X}$ = 10.7°C).

Males of B. belizanus are much smaller than females. At spawning 20 - 148 young are produced. However, based on dissections, Belshe (1961) found 48 - 225 ($\bar{X}$ = 93.9) embryos present per female. Young are 13 - 30 mm TL at birth (Meek, 1904; Innes, 1955; Belshe, 1961; Breder and Rosen, 1966; Sterba, 1966; Jacobs, 1971). Breder and Rosen (1966) observed one female produce four broods at intervals of 31 - 37 days. Belshe (1961) found that the time between individual births varied from 0 to 30 min with a mean of 3.7 min. Although Jacobs (1971) gives the minimum temperature for spawning as 25°C, Belshe (1961) successfully spawned the species at 20 - 24°C.

B. belizanus is cannabalistic. Breder and Rosen (1966) and Miley (1978) present observations which indicate morphological and behavioral adaptations in juveniles to reduce parental cannabalism. Juveniles have a broad, black, mid-lateral band. In the presence of either or both parents, they remain motionless at the surface, mimicing floating twigs. When the parents are removed, the juveniles descend and search for food. Under natural conditions, such mimicry probably functions to protect the young against all predatory species.

Jacobs (1971) reports that B. belizanus reaches sexual maturity in six months and is full grown in one year. Females at least as small as 73 mm SL have been found with embryos (Gilbert and Kelso, 1971).

Environmental impress: Belshe (1961) estimated that B. belizanus spread ca. ten square miles in just over three years after its introduction. He warned that temperature and salinity would pose no barriers to the spread of this exotic in southern Florida. However, except for the separate introduction in Coral Gables, there appears to have been no range expansion of this species beyond the limits found by Belshe in 1960 (personal observation). Why it has not become more widely dispersed is unclear.

Although B. belizanus has not become as widely distributed as expected, it remains one of the potentially most detrimental exotic species established in North America. The studies of Belshe (1961) and Miley (1978), using field and experimental data, clearly showed that B. belizanus feeds heavily on native poeciliids and cyprinodontids, particularly Gambusia affinis. The concern here is that this heavy predation probably seriously reduces natural controls on mosquito larvae. In addition, both workers expressed concern that B. belizanus could be competing with native piscivores. Miley examined stomach contents of B. belizanus and the native fishes occurring with it. He constructed a similarity matrix using these data and found that the diet of B. belizanus overlapped those of Micropterus salmoides by 84% and Lepomis gulosus by 40%.

Status: Established in southeastern Dade County, Florida; has been collected but is apparently not established in San Antonio, Texas.

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Meek, Seth E. 1904. The fresh-water fishes of Mexico north of the Isthmus of Tehuantepec. Publ. Field Columbian Mus., Zoöl. ser., 5: 1-252.

Non-established species

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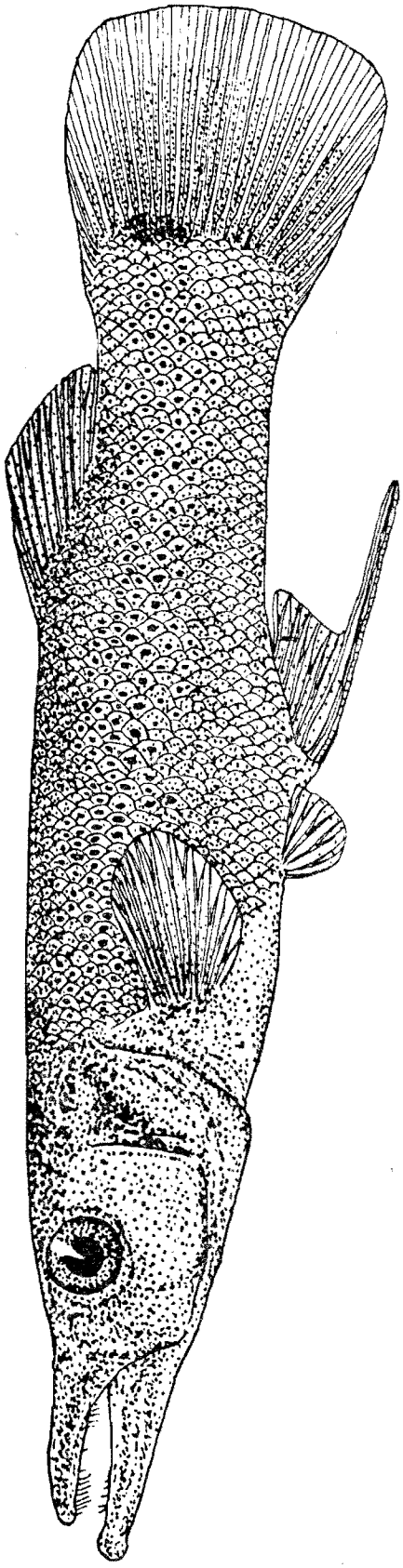
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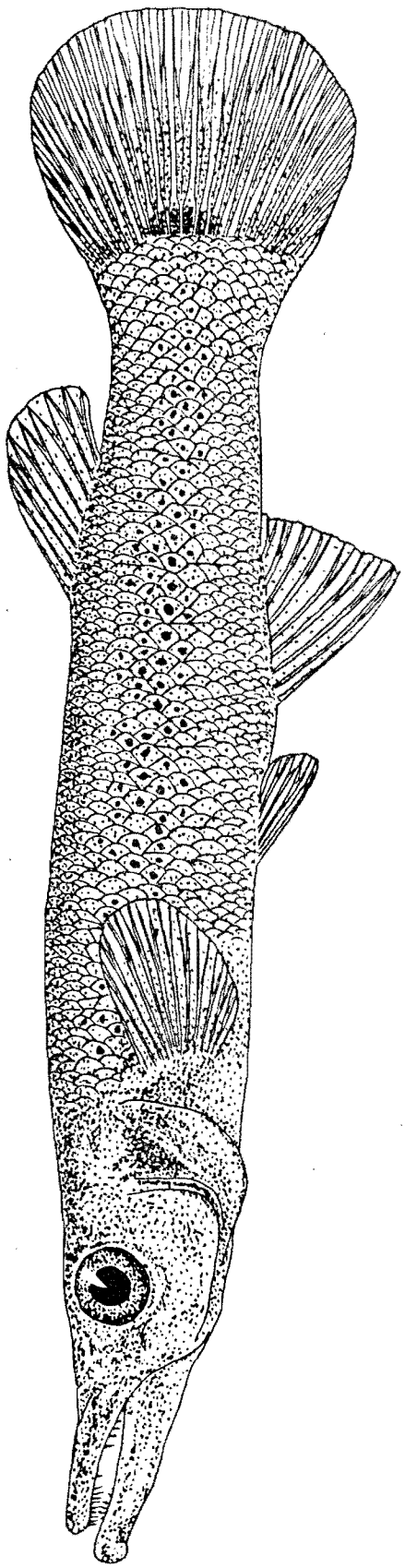
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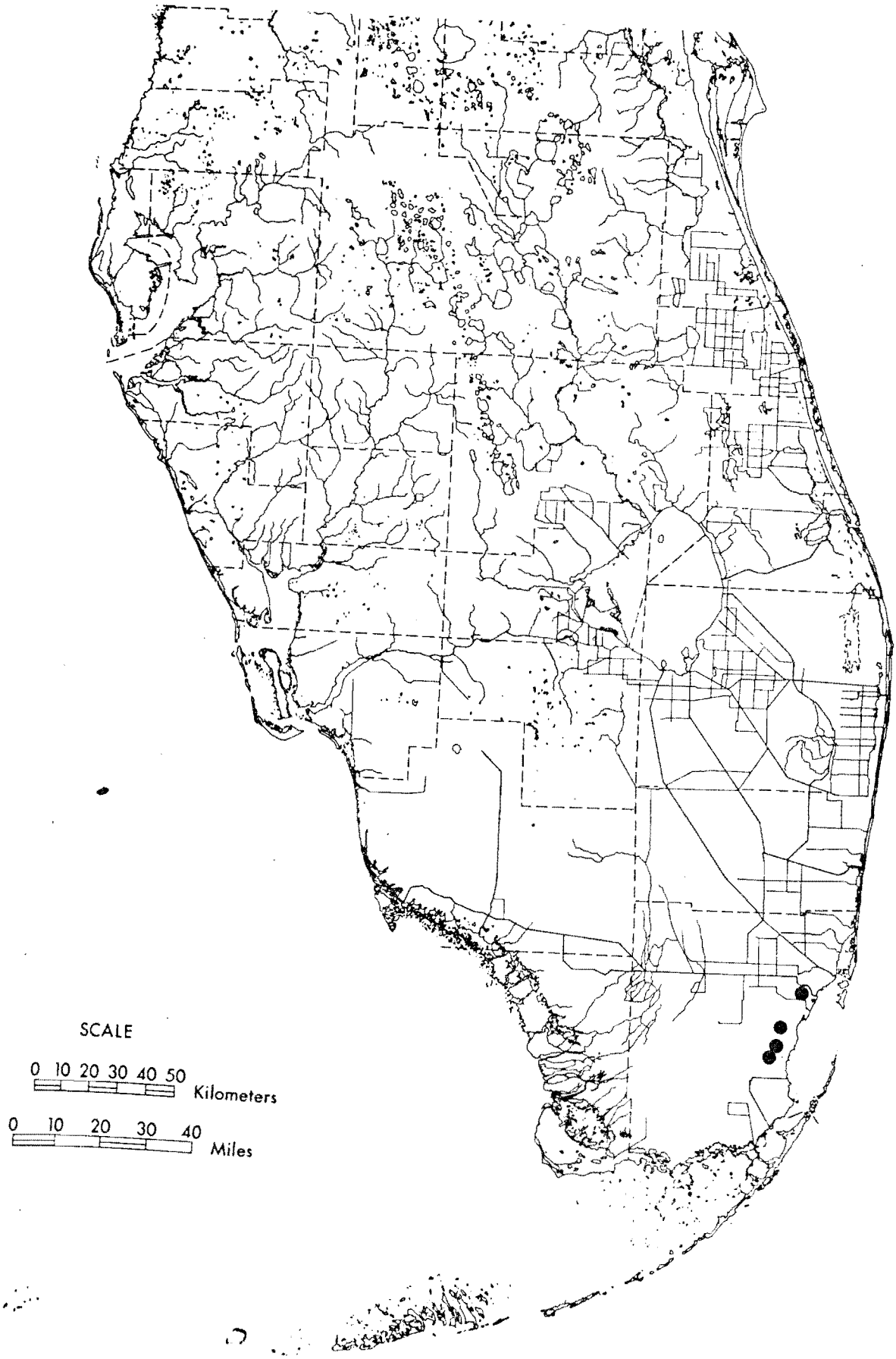
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Compiled by: Dannie A. Hensley

Non-Established Species







Non-established Species

Order Atheriniformes
Family Poeciliidae

Poecilia reticulata Peters

Guppy

Original description citation: Peters, 1859. Hr. W. Peters legte eine neue von Hrn. Jagor im atlantischen Meere gefangene Art der Gattung Leptocephalus vor and fügte Mittheilungen über einige andere neue Fische des zoologischen Museums hinzu. Monatsber. K. Preus. Akad. Wiss., Berlin, p. 412.

Type locality: Caracas, Venezuela.

Native range: Netherlands Antilles and the Venezuelan islands, Trinidad, the Windward (Barbados) and Leeward (St. Thomas and Antigua) Islands, and from western Venezuela to Guyana; records from the Lesser Antilles may be introductions (Rosen and Bailey, 1963).

U.S. range: Established in Alberta, Canada (McAllister, 1969), Nevada (Deacon et. al., 1964; Deacon, personal communication), Arizona (Minckley, 1973), and Texas (Hubbs et al., MS).

Evidence for permanent breeding populations of P. reticulata in California is uncertain. Established populations are occasionally known from sewage-treatment ponds in this state, but no populations are known to be established in natural waters (Moyle, 1976, 1976a).

Courtenay et al. (1974) listed P. reticulata as established in Hillsborough and Palm Beach counties, Florida. The records from Hillsborough County are probably not from reproducing populations. The population in Palm Beach County is no longer extant (personal observation). However, this does not preclude establishment in isolated situations in southern Florida.

Sources of introduction: Sources for introductions of P. reticulata in Nevada, California, and Florida were combinations of escapes from tropical fish farms and releases made by aquarists (Deacon et al., 1964; St. Amant and Hoover, 1969; Courtenay et al., 1974; Moyle, 1976). Introductions into Alberta, Canada and Texas were made by aquarists (McAllister, 1969; Hubbs et al., MS). Although sources for introductions into Arizona are unknown, these were probably due to the dumping of home aquaria.

Life history: P. reticulata feeds mainly on insect larvae and is an important natural control of mosquitos in its native range.

The extensive literature on reproductive physiology, spawning behavior, and genetics for this species was reviewed by Breder and Rosen (1966); more recent literature is cited by Farr (1977).

Environmental impress: Establishment of P. reticulata in Preston Town Spring, White Pine County, Nevada, has caused a reduction in population density of the native cyprinodontid Crenichthys

baileyi (Deacon et al., 1964). P. reticulata was first recorded from this spring in 1961. In 1963, P. reticulata was found to far outnumber C. baileyi in this spring and was present in all habitats within the spring where C. baileyi occurred. Nearby is Preston Big Spring, with its outflow running into Preston Town Spring. However, due to a five-foot drop in the outflow, P. reticulata has not entered Preston Big Spring. Deacon et al. (1964) compared the population densities of C. baileyi in these two springs by sampling with minnow traps. They found that the Preston Town Spring had fewer C. baileyi in the entire spring source area than were captured in a trap set for 15 minutes in a comparable area in the Preston Big Spring.

Status: Established in Alberta, Canada, Nevada, Arizona, and Texas; status uncertain in California and Florida.

References:

Breder, Charles M., Jr. and Donn Eric Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, N.Y. 941 pp.

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Deacon, James E., Clark Hubbs, and Bernard J. Zahuranec. 1964. Some effects of introduced fishes on the

Order Atheriniformes
Family Poeciliidae

Xiphophorus hellerii Heckel

Green swordtail

Original description citation: Heckel, 1848. Eine neue Gattung von Poecilien mit rochenartigen Anklammerungs-Organe. Sitzber. K. Akad. Wiss. Wien, Math. Nat. Cl., 1:291, pl. 8.

Type locality: Orizaba, Veracruz, Mexico; precise locality is probably in error (Rosen, 1960).

Native range: Atlantic slope from Rio Nautla, Veracruz, Mexico to northwestern Honduras (Rosen, 1960; Rosen and Kallman, 1969).

U.S. range: X. hellerii is established in Alberta, Canada (McAllister, 1969), Montana (Brown, 1971), and Florida (Courtenay and Robins, 1973; Courtenay et al., 1974; personal observation).

It was established near Rock Springs, Maricopa County, Arizona, but has not been collected there since flooding in the area in 1965 (Minckley, 1973).

St. Amant and Hoover (1969) have collected this species near a fish farm in Orange County, California; evidence for a permanent breeding population in this state is uncertain (Moyle, 1976).

La Rivers (1962) reported X. hellerii as established in Rogers Spring, Clark County, Nevada. It is possible that La Rivers' record was actually for Blue Point Spring (1 mi northeast of Rogers Spring). However, later collections from both localities did not contain this species (Deacon et al., 1964). It was collected in 1975 from Indian Springs, Clark County (Deacon, personal communication), but its status there is unknown. Establishment of X. hellerii in Nevada should be considered uncertain.

Sources of introduction: Introductions into California and Florida were due to escapes or intentional releases from fish farms (St. Amant and Hoover, 1969; Courtenay et al., 1974; personal observation). In addition, at least one introduction in Florida was probably due to an intentional release by amateur aquarists (personal observation). It was introduced into Alberta, Canada by aquarists (McAllister, 1969).

Although Brown (1971) does not give a source for the introduction of X. hellerii into Trudau Pond, Madison County, Montana, at least one other exotic species, one of the Poecilia "sphenops complex," is known to have been introduced into this pond by a tropical fish dealer. The sources for the introductions of X. hellerii into Arizona and Nevada are unknown.

Life history: We know of no studies of the feeding ecology of X. hellerii either in its native range or the U.S. It should not be assumed that this species is insectivorous as has been

done by some who have advocated its use in mosquito control. X. variatus has also been proposed for this purpose, but Darnell (1962) has shown that in the Rio Tamesí, Mexico, this species does not feed on insects.

In its native range, X. hellerii usually inhabits lotic habitats, although in the southern part of its range it is frequently collected in standing or sluggish waters. Species of Xiphophorus apparently have little or no tolerance for brackish waters (Rosen, 1960).

Reviews of literature on reproduction and secondary sexual structures are found in Rosen (1960) and Breder and Rosen (1966).

Environmental impress: No information is available on the environmental impress of this species in the U.S. and Canada.

Status: Established in Alberta, Canada, Montana, and Florida; previously established population in Arizona is no longer extant; status in California and Nevada is uncertain.

References:

Breder, Charles M., Jr. and Donn Eric Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, N.Y. 941 pp.

Brown, C. J. D. 1971. Fishes of Montana. Big Sky Books, Mont. State Univ., Bozeman. 207 pp.

Courtenay, Walter R., Jr. and C. Richard Robins. 1973. Exotic aquatic organisms in Florida with emphasis on fishes: A review and recommendations. Trans. Amer. Fish. Soc., 102(1):1-12.

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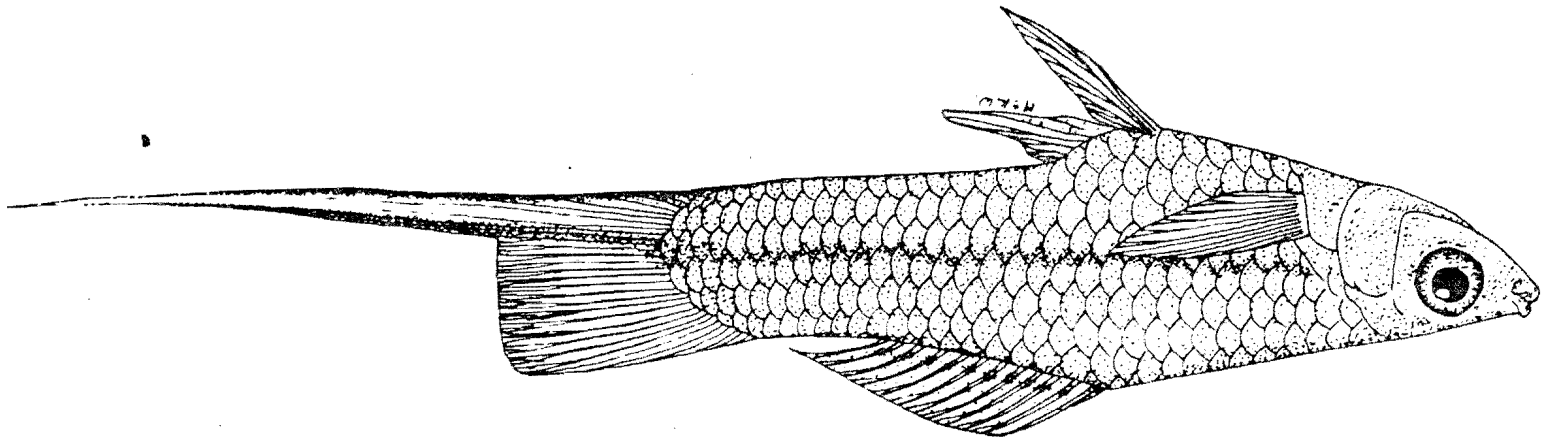
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St. Amant, James A. and Franklin G. Hoover. 1969. Addition of Misgurnus anguillicaudatus (Cantor) to the California fauna. Calif. Fish and Game, 55(4): 330-331.

Compiled by: Dannie A. Hensley

Addendum: X. hellerii was released into a drainage canal near Oasis and has been collected near Mecca, Riverside County, California. It does not appear to be established at either locality (Mearns 1975. Calif. Fish and Game, 61(4): 251-253). Introductions at these localities were apparently due to escapes from nearby fish farms or releases of home aquarium fish.



Salmonidae

Non-Established Species

O - Collected only, establishment uncertain, or not established
● - Established

Order Atheriniformes
Family Poeciliidae

Xiphophorus maculatus (Günther)

Southern platyfish

Original description citation: Günther, 1866. A catalogue of the fishes in the British Museum, Volume 6, pp. 350-351.

Type locality: Mexico.

Native range: Atlantic slope from just south of Veracruz City, Mexico to northern Belize (Miller, 1966).

U.S. range: X. maculatus is established in Nevada (La Rivers, 1962; Deacon et al., 1964) and Florida (Courtenay and Robins, 1973; Courtenay et al., 1974).

It has been collected near a fish farm in Orange County, California (St. Amant and Hoover, 1969). It is not established in this state.

Hubbs (1976) listed X. maculatus as known or suspected of having been released in Texas.

Sources of introduction: Escapes or intentional releases from fish farms account for the introductions of X. maculatus into Nevada, California, and Florida (Deacon et al., 1964; St. Amant and Hoover, 1969; Courtenay et al., 1974). Hubbs (1976) did

native fish fauna of southern Nevada. Copeia, 1964(2): 384-388.

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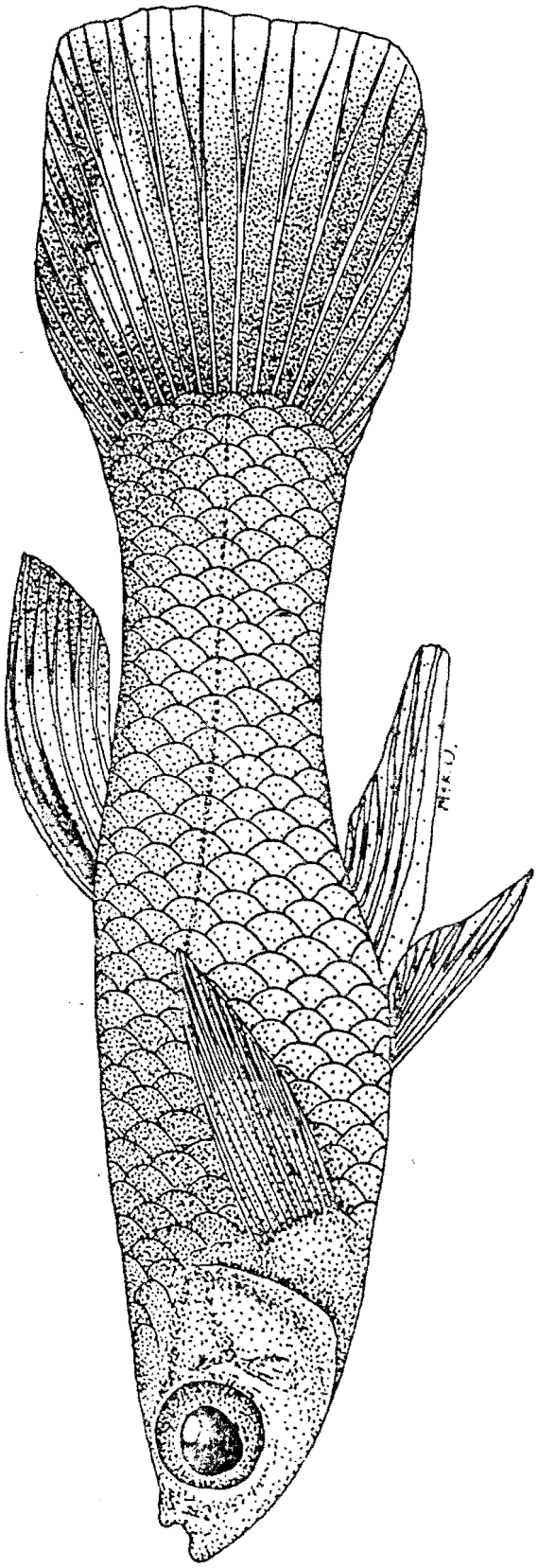
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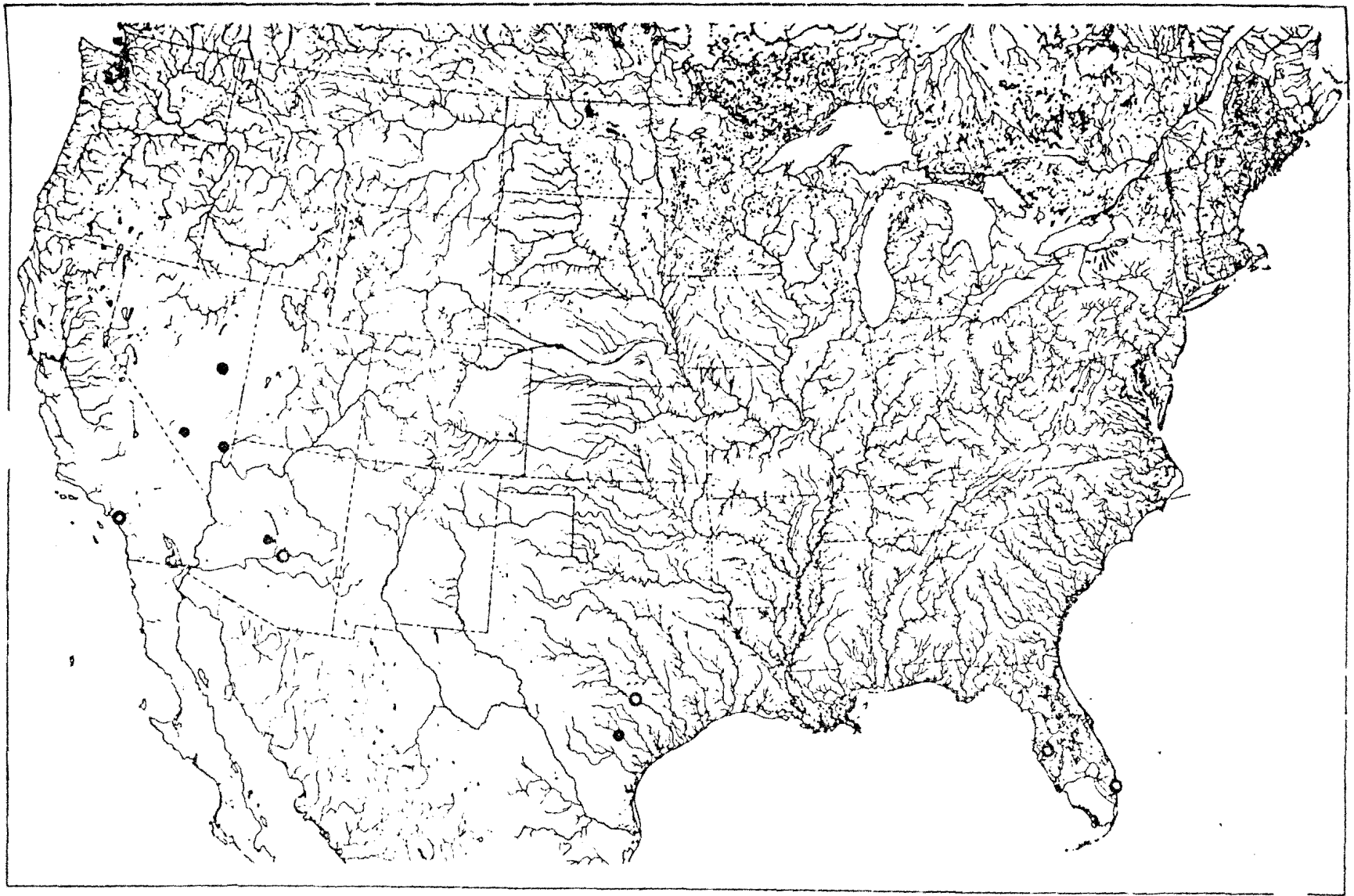
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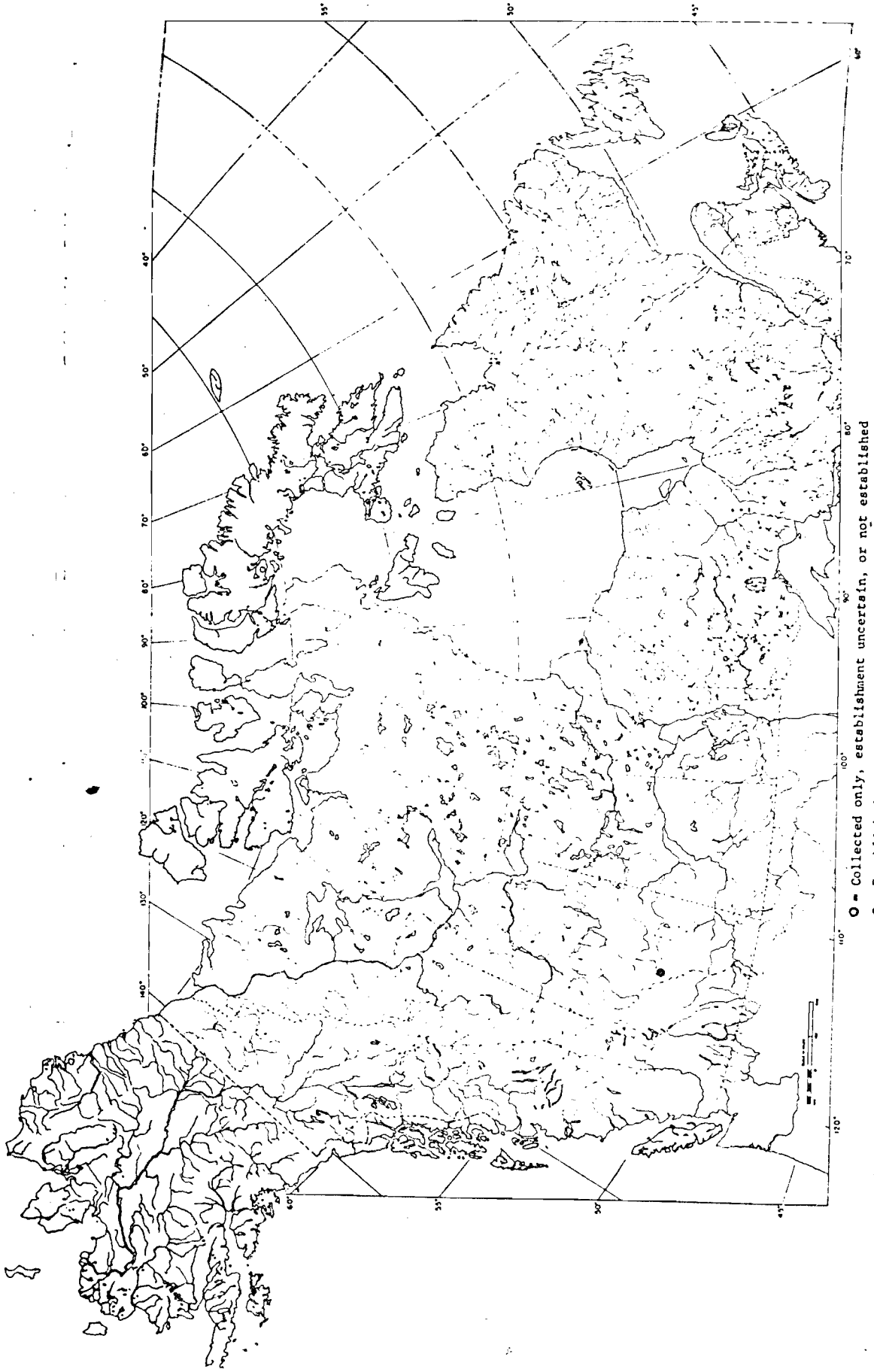
Compiled by: Dannie A. Hensley.





O = Collected only, establishment uncertain, or not established

● = Established


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● = Established

Order Atheriniformes
Family Poeciliidae

Poecilia "sphenops complex"

Shortfin Mollies

Note on systematics: This complex has been variously considered as being composed of one polytypic species with many subspecies or several species (Rosen and Bailey, 1963). Schultz and Miller (1971) showed that the complex is composed of an unknown number of distinct species. Species of this complex that have been collected in the U.S. have been referred to as P. mexicana, P. sphenops, P. latipunctata, P. petenensis, and P. butleri. In view of (1) the subtle morphological differences between species of this complex, (2) the fact that most references to these species in the U.S. were published before the work of Schultz and Miller (1971), and (3) the fact that authors who described these species in regional works for the U.S. failed to mention morphological characters considered important by Schultz and Miller (1971), we feel the identifications of species introduced into the U.S. should be considered questionable until specimens are reexamined by specialists or reexamined with emphasis on the characters used by Schultz and Miller (1971). We are, therefore, not including "original description citations" for this species (P. sphenops) or for other members of the complex.

Type locality: For P. sphenops, near Veracruz, Mexico (Valenciennes in Cuvier and Valenciennes, 1846).

Native range: For species complex, from northern Mexico to the Caribbean slope of Colombia, and the Netherlands and Colombian West Indies (Rosen and Bailey, 1963).

U.S. range: Species of this complex are established in Trudau Pond, Madison County, Montana (Brown, 1971), and several springs and most of the Moapa River in Nevada (Hubbs and Deacon, 1964; Deacon et al., 1964; Deacon, personal communication).

In California, a species has been collected near the Salton Sea (St. Amant, 1966, 1970; St. Amant and Sharp, 1971) and in the Westminster flood control channel, Orange County (St. Amant and Hoover, 1969). However, all of these localities are near tropical fish farms, and the specimens could have been escapees; establishment in this state is uncertain (Moyle, 1976).

One or more species of this complex have been collected in Dade, Palm Beach, Polk, and Hillsborough counties, Florida (Courtenay and Robins, 1973; Courtenay et al., 1974; Pestrak, personal communication). Although Courtenay and Robins (1973) and Courtenay et al. (1974) have considered some species of this complex to be established in Florida, their current status is unknown.

A species was collected once in the metropolitan canal system near Phoenix, Arizona (Minckley and Deacon, 1968; Minckley, 1973); it is not established in this state.

Sources of introduction: Introductions into California and Florida resulted from escapes or intentional releases from tropical fish farms (St. Amant, 1966; St. Amant and Hoover, 1969; St. Amant and Sharp, 1971; Courtenay et al., 1974). At least one introduction in Nevada was due to intentional releases from a tropical fish farm (Deacon, et al., 1964). The species established in Montana was introduced by a tropical fish dealer (Brown, 1971). The source of the introduction into the canal system of Phoenix, Arizona is unknown. However, tropical fish species are frequently introduced into such metropolitan areas as a result of dumping of home aquaria.

Life history: Darnell (1962) found that a population of P. sphenops in the Río Tamesí drainage system of east-central Mexico feeds on detritus, filamentous algae, diatoms, desmids, and bits of vascular plant material. It apparently uses its broad, flat, tooth-covered lower lip as a brush or rasp to clean algae and other accumulated organic material from exposed surfaces of rocks and other objects. P. latipunctata another member of the P. "sphenops complex," is a bottom feeder. A population of this species in the Río Tamesí system was found to feed on bottom ooze, green and blue algae, and diatoms (Darnell, 1962).

Darnell (1962) presents information on spawning times and brood sizes for populations of P. sphenops and P. latipunctata in the Río Tamesí drainage. Breder and Rosen (1966) review spawning behavior for the genus.

Environmental impress: Establishment of a species (referred to as Mollienesia or Poecilia mexicana) of this complex in Nevada has adversely affected two native fishes with very restricted distributions. The endangered relict cyprinid Moapa coriacea is found only in the headwaters of the Moapa River, i.e., the many warm springs and streams in the Warm Springs area of Clark County (La Rivers, 1962). Minckley and Deacon (1968) found that an original population decline in M. coriacea was closely correlated with the introduction and establishment of P. mexicana in the Moapa River. However, after two additional years, the population of M. coriacea showed an increased density. It should be noted that Gambusia affinis and the bullfrog, Rana catesbeiana, were introduced into the Warm Springs area previous to the introduction of P. mexicana (Miller and Alcorn, 1943; La Rivers, 1962), and a major concern regarding M. coriacea is that any additional introductions of non-native species may result in similar population declines from which the species may not recover (Minckley and Deacon, 1968).

Crenichthys baileyi is a cyprinodontid which exists as a number of disjunct populations in warm springs and effluent streams along the pluvial White River drainage in eastern and

southern Nevada (La Rivers, 1962). Some populations of C. baileyi have been severely reduced following the introduction of exotic or non-native fishes. A population at Hiko Springs, Lincoln County, became extinct following the introduction of Micropterus salmoides and P. mexicana (Minckley and Deacon, 1968; Deacon, personal communication).

The population declines in both M. coriacea and C. baileyi apparently resulted from an increase in parasitism and possibly through direct competition with P. mexicana (Minckley and Deacon, 1968). It is possible that the establishment of P. mexicana caused sufficient stress through competition in the M. coriacea and C. baileyi populations to make these species abnormally susceptible to existing parasites or that new parasites were introduced with P. mexicana.

The introduction and establishment of species of the Poecilia "sphenops complex," as well as other exotics, into the American Southwest is cause for great concern. Many of these areas contain depauperate fish faunas composed of localized endemic species. These fishes are part of very simple ecosystems which do not have the buffering capacities of larger, more complex ones, and the risk of extermination of native species following the introduction of exotic or non-native species in these areas is particularly high.

Status: Species are established in Montana and Nevada; establishment in California and Florida is uncertain; a species

has been collected in Arizona but is not established.

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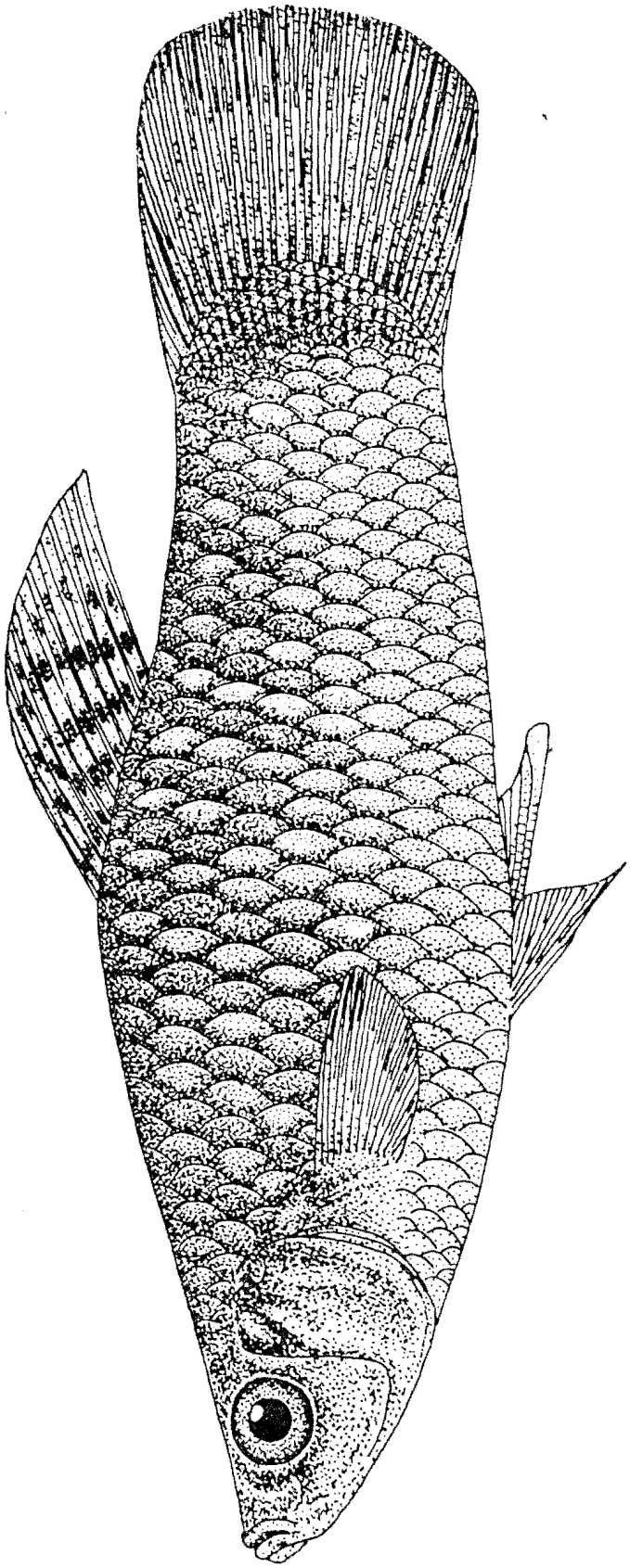
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St. Amant, James A. and Ira Sharp. 1971. Addition of Xiphophorus variatus (Meek) to the California fauna. Calif. Fish and Game, 57(2): 128-129.

Compiled by: Dannie A. Hensley

Addendum: In 1974 Mearns (1975. Calif. Fish and Game, 61(4): 251-253) collected and observed Poecilia mexicana in an irrigation canal one mile south of Mecca, Riverside County, California. He estimated that he observed and collected a total of 99+ specimens of this species there during January, July, and November, and considered it one of the dominant fishes. The specimens observed and collected included juveniles. This species should be considered established in California (Hubbs et al. 1979. Occ. Pap. Calif. Acad. Sci., 133: 1-51). This introduction was probably due to releases by local aquarists or escapes from a nearby fish farm.



Salmonidae

Non-Established Species

Salmonidae

Non-Established Species

Order Atheriniformes
Family Poeciliidae

Poeciliopsis gracilis (Heckel)

Porthole livebearer

Note on systematics: In most previous literature this species has been called Poeciliopsis or Poecilistes pleurospilus (Günther). However, Rosen and Bailey (1963) showed this name to be a junior synonym of P. gracilis.

Original description citation: Heckel, 1848. Eine neue Gattung von Poecilien mit rochenartigen Anklammerungs - Organe. Sitzber. K. Akad. Wiss. Wien, Math. Nat. Cl., 1: 300-302, pl. 9, fig. 3d, e, f, 4.

Type locality: Orizaba Mountains, Veracruz, Mexico.

Native range: Pacific and Atlantic slopes of Central America from southern Mexico to Honduras (Rosen and Bailey, 1963; Miller, 1966).

U.S. range: In 1974, Mearns (1975) collected 16 specimens (8 - 43 mm SL) of P. gracilis from an irrigation canal near Mecca, Riverside County, California. Based on the presence of small juveniles, a wide range of sizes, and observations of additional uncollected individuals, he considered the species established. P. gracilis is still established at this locality (Hubbs et al.,

1979; James St. Amant, personal communication).

Sources of introduction: Introduction of P. gracilis was probably due to releases by aquarists or escapes from a nearby tropical fish farm, and apparently occurred early in 1974 (Mearns, 1975).

Life history: Most information on the biology of P. gracilis has been gathered from aquarium observations. It is reported to be an omnivore (Sterba, 1966; Jacobs, 1971).

Spawning occurs at 25-28°C. As many as 40 young are spawned over a period of up to 10 days. Intervals between broods may be from 10 to 12 days (Breder and Rosen, 1966; Jacobs, 1971).

Environmental impress: There is no information on the environmental impress of P. gracilis. However, it should be noted that this species is only one of four non-native or exotic poeciliids (others are Gambusia affinis, Poecilia latipinna, and P. mexicana) established in the area immediately north of the Salton Sea (St. Amant and Sharp, 1971; Mearns, 1975). Populations of the native Cyprinodon macularius in the Salton Sea area have already become depleted, possibly through trophic competition with G. affinis and P. latipinna (Moyle, 1976). In addition, Tilapia zillii is established in this area and appears to be a factor in these declines (James St. Amant, personal communication). It is very likely that P. gracilis will cause additional stress on the C. macularius populations.

Status: Established in Riverside County, California.

References:

Breder, Charles M., Jr. and Donn Eric Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, N.Y. 941 pp.

Hubbs, Carl L., William I. Follett, and Lillian J. Dempster. 1979. List of the fishes of California. Occ. Pap. Calif. Acad. Sci., 133: 1-51.

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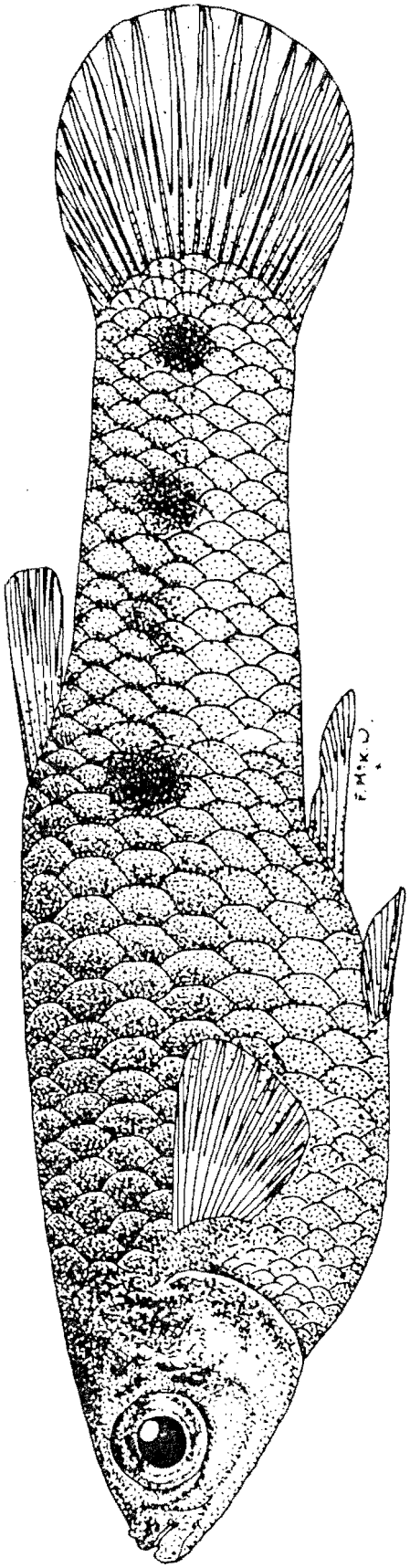
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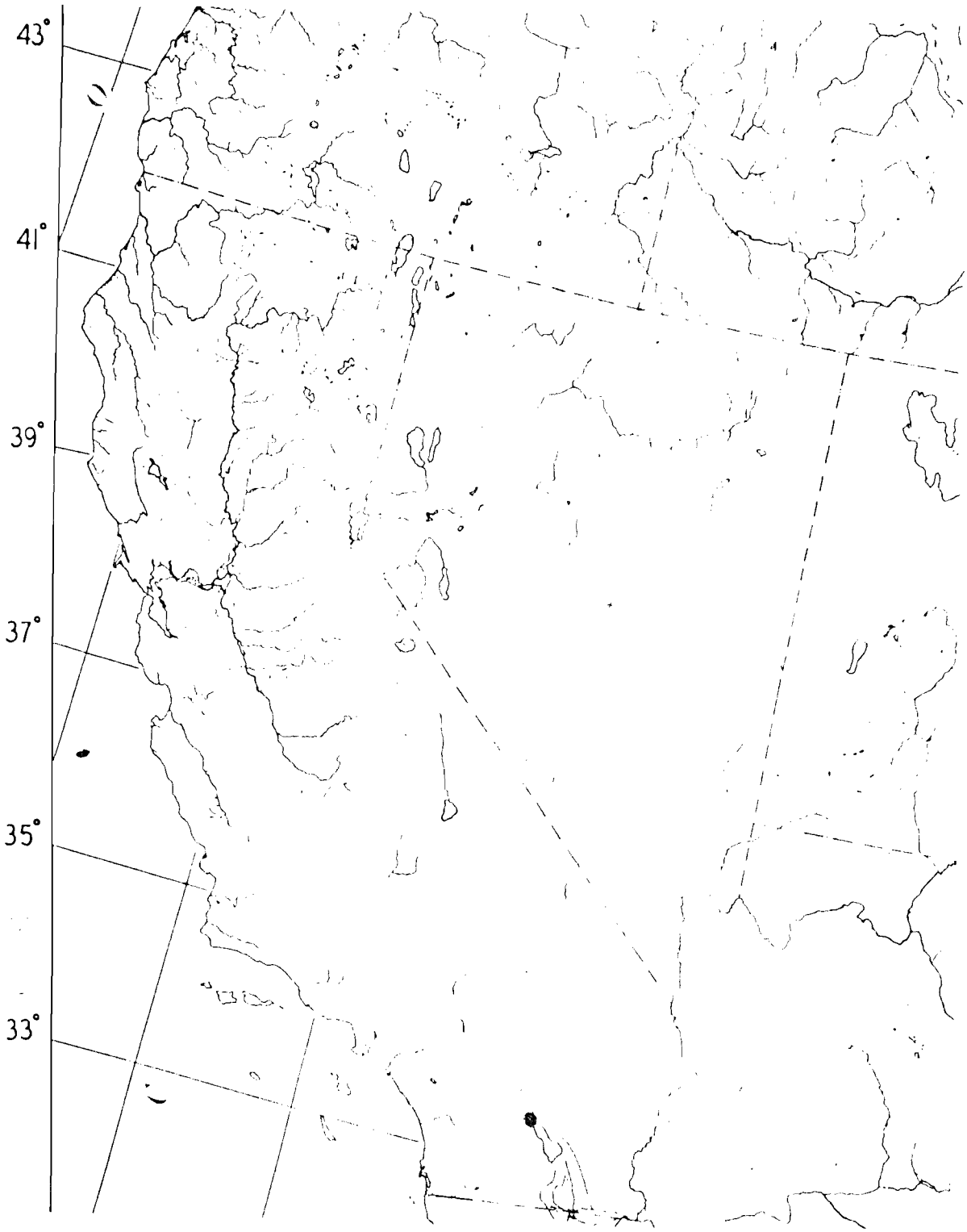
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Compiled by: Dannie A. Hensley



Salmonidae

Non-Established Species


43°
41°
39°
37°
35°
33°

not list a source for the suspected introduction of this species into Texas.

Life history: We know of no studies of the feeding ecology of X. maculatus either in its native range or the U.S. This species, like X. hellerii and X. variatus, has been proposed for use in mosquito control. Assumptions that Xiphophorus spp. are insectivorous appear to rest solely on the fact that they are poeciliids. Such assumptions are not justifiable. For example, Darnell (1962) has shown that in the Rio Tamesi, Mexico, X. hellerii does not feed on insects.

In its native range, X. maculatus usually inhabits lentic habitats. Species of Xiphophorus apparently have little or no tolerance for brackish waters (Rosen, 1960).

The very extensive literature on reproduction, sexual dimorphism, and genetics for this species was reviewed by Rosen (1960) and Breder and Rosen (1966). Borowsky and Kallman (1976) cite more recent literature in a study of mating patterns in natural populations.

Environmental impress: No information is available on the environmental impress of this species in the U.S. Its establishment in Blue Point Spring, Clark County, Nevada should not cause a great deal of concern, since this spring contains no localized endemic species or subspecies and the biota of nearby waters has been drastically changed by the formation of

Lake Mead (Deacon et al., 1964). However, one concern regarding this population should be the possibility that it may serve as a source for transfer of the species by humans to other springs in which localized endemics do occur. Human transfer of exotics between springs has been shown to be an important factor in the spread of these species in southern Nevada (Hubbs and Deacon, 1964).

Status: Established in Nevada and Florida; has been collected but is not established in California; has possibly been introduced into Texas.

References:

Borowsky, Richard and Klaus D. Kallman. 1976. Patterns of mating in natural populations of Xiphophorus (Pisces: Poeciliidae). I. X. maculatus from Belize and Mexico. Evolution, 30(4):693-706.

Breder, Charles M., Jr. and Donn Eric Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, N.Y. 941 pp.

Courtenay, Walter R., Jr. and C. Richard Robins. 1973. Exotic aquatic organisms in Florida with emphasis on fishes: A review and recommendations. Trans. Amer. Fish. Soc., 102(1):1-12.

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

Deacon, James E., Clark Hubbs, and Bernard J. Zahuranec. 1964. Some effects of introduced fishes on the native fish fauna of southern Nevada. Copeia, 1964 (2):384-388.

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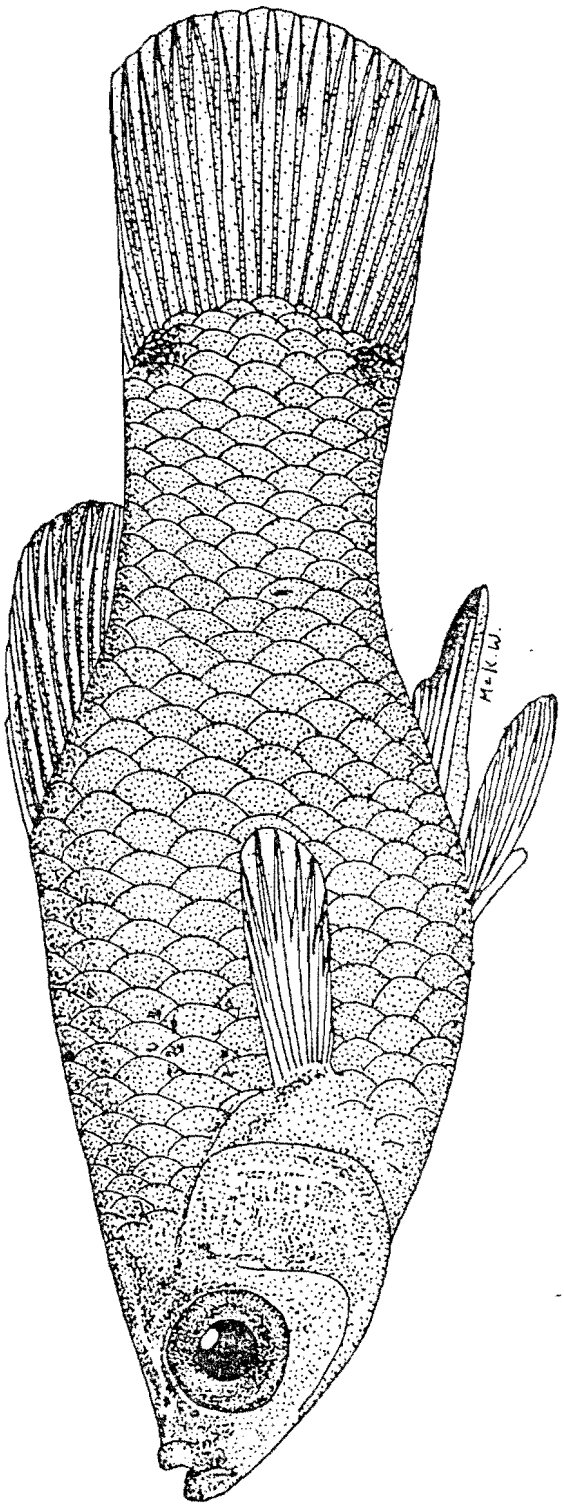
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Rosen, Donn Eric. 1960. Middle-American poeciliid fishes of the genus Xiphophorus. Bull. Fla. State Mus., Biol. Sci., 5(4):57-242.

St. Amant, James A. and Franklin G. Hoover. 1969. Addition of Misgurnus anguillicaudatus (Cantor) to the California fauna. Calif. Fish and Game, 55(4): 330-331.

Compiled by: Dannie A. Hensley



Salmonidae

Non-Established Species

Salmonidae
Non-Established Species
O = Collected only
● = Established

Order Atheriniformes
Family Poeciliidae

Xiphophorus variatus (Meek)

Variable platyfish

Original description citation: Meek, 1904. The fresh-water fishes of Mexico north of the Isthmus of Tehuantepec. Publ. Field Columbian Mus., Zoöl. Ser, 5: 146-147, pl. X.

Type locality: Valles, San Luis Potosi, Mexico.

Native range: Southern Tamaulipas, eastern San Luis Potosi, and northern Veracruz, Mexico (Rosen, 1960).

U.S. range: X. variatus is established in Montana (Brown, 1971) and Florida (Courtenay and Robins, 1973; Courtenay et al., 1974; Burgess et al., 1977).

This species was established in the Salt River at Tempe, Arizona in 1963-1965. In 1965 this river flooded and the population was exterminated (Minckley and Deacon, 1968; Minckley, 1973). It has been reported from Yuma (Minckley, 1973), but apparently is not established there.

X. variatus was possibly established in Orange and Riverside counties, California (St. Amant and Hoover, 1969; St. Amant and Sharp, 1971). However, it is doubtful that it still exists in this state (Moyle, 1976; St. Amant, personal communication).

Sources of introduction: Introductions into California and Florida were due to escapes or intentional releases from fish farms (St. Amant and Hoover, 1969; St. Amant and Sharp, 1971; Courtenay et al., 1974; personal observation). In addition, at least one introduction in Florida was probably due to an intentional release by amateur aquarists (personal observation). It was undoubtedly released into Montana ponds by home aquarists (Brown, 1971). The sources for introductions into Arizona are unknown.

Life history: Darnell (1962) found that X. variatus in the Rio Tamesi drainage, Mexico, feeds during the day, mainly on mud or bottom ooze and to a limited extent on diatoms, desmids, filamentous green algae, and protozoa. Thus, there is little or no support for those who have proposed this species, as well as X. hellerii and X. maculatus, as mosquito control agents.

In its native range, X. variatus is typically found in lentic habitats (Rosen, 1960; Darnell, 1962). Darnell (1962) found it at one locality where the water was low in oxygen (3.2 ppm) and high in carbon dioxide (28.0 ppm). Species of Xiphophorus apparently have little or no tolerance for brackish waters (Rosen, 1960).

Rosen (1960) presents information on genetics and morphological variation in this species. The literature on reproduction, sexual dimorphism, and genetics for the genus is reviewed by

Breder and Rosen (1966). Borowsky and Khouri (1976) cite more recent literature on X. variatus in a study of mating patterns in natural populations.

Environmental impress: No information is available on the environmental impress of this species in the U.S.

Status: Established in Montana and Florida; a previously established population in Arizona is no longer extant; was possibly established in California but no longer occurs there.

References:

Borowsky, Richard and Janine Khouri. 1976. Patterns of mating in natural populations of Xiphophorus II. X. variatus from Tamaulipas, Mexico. Copeia, 1976(4): 727-734.

Breder, Charles M., Jr. and Donn Eric Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, N.Y. 941 pp.

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

Minckley, William L. 1973. Fishes of Arizona. Ariz. Game and Fish Dept., Phoenix. 293 pp.

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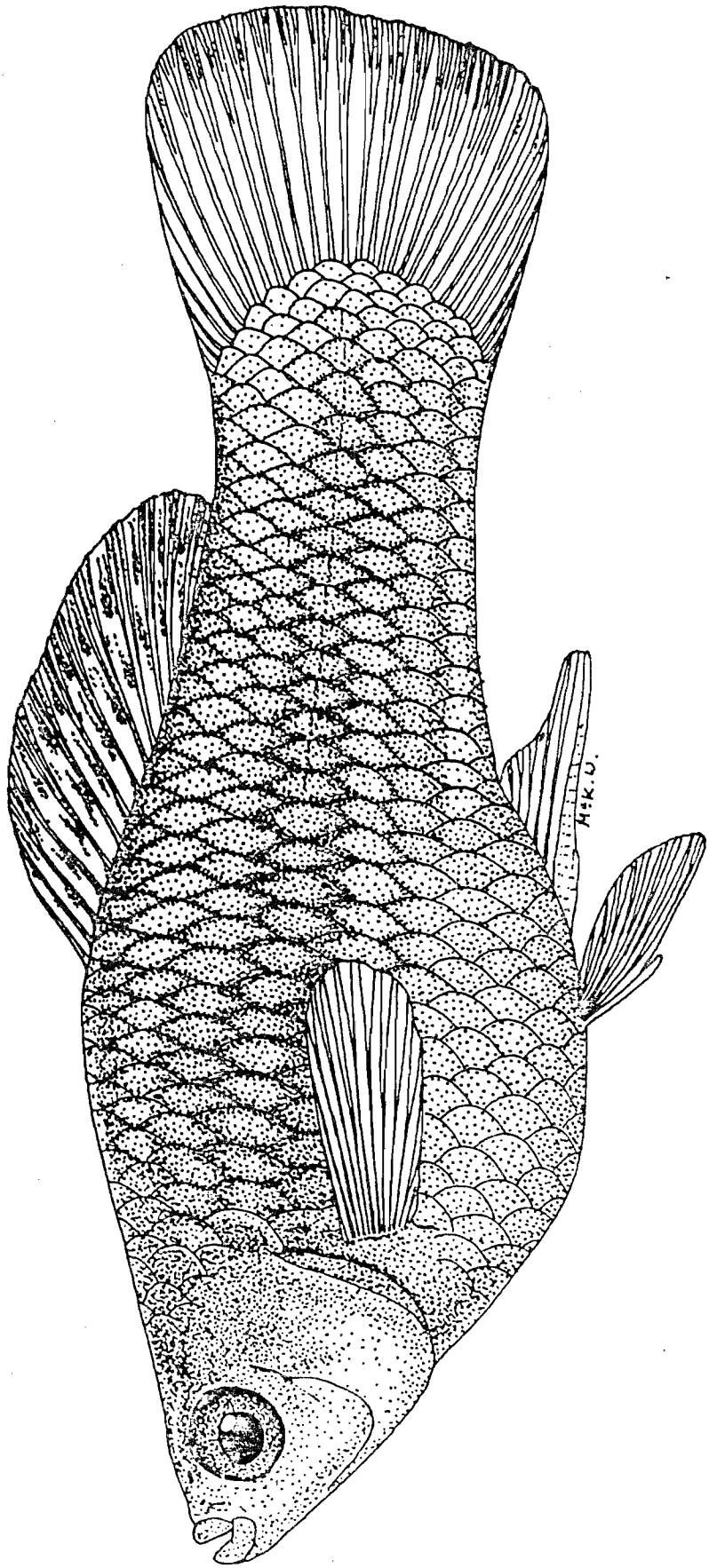
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St. Amant, James A. and Ira Sharp. 1971. Addition of Xiphophorus variatus (Meek) to the California fauna. Calif. Fish and Game, 57(2): 128-129.

Compiled by: Dannie A. Hensley



Salmonidae

Non-Established Species

SALMONIDAE

Salmons and trouts

Salmo trutta	[SALMO-A]	several states and provinces

This species not included in report

APPENDIX A

NON-ESTABLISHED EXOTIC FISHES

The following is an annotated listing of exotic fishes that are known to have been collected or introduced into the waters of North America. Included are reports of exotics collected that are not established in the form of reproducing populations, exotics that were collected but not established in certain states but that have reproducing populations elsewhere in North America and species that were formerly established and that have been extirpated.

A summary listing of the species treated herein appears at the end of this section of the report.

ANABANTIDAE - climbing gouramis

Anabas testudineus (Bloch) Climbing perch

According to Ross B. Socolof (personal communication), this species, native to southern China, Indo-China, Malaya, India, Sri Lanka, the Philippes, and the Indo-Australian archipelago, was established in the late 1960s or early 1970s on and surrounding a fish farm on Piney Point Road in extreme northwestern Manatee County, Florida (Courtenay et al., 1974). We did not collect any specimens during the 1970-72 portion of our Dingell-Johnson project (F-28, Florida) nor have we collected

any in the present study. We assume that the population may have been extirpated, perhaps by cold weather.

Ctenopoma nigropannosum (Reichenow) Twospot ctenopoma

Courtenay et al. (1974) list this species as established in a canal adjacent to the same fish farm from which R. B. Socolof reported *Anabas testudineus*. Specimens of two size classes were collected there during Dingell-Johnson project F-28, Florida. We have not collected any specimens there since 1971 and, therefore, consider this fish to have been extirpated, perhaps by cold weather. This species is native to Africa, from the Niger Delta to the Congo River.

ANGUILLIDAE - freshwater eels

Anguilla anguilla (Linnaeus) European eel

One specimen was collected at the State Delta Fish Protective Facility near Byron, Contra Costa County, California. The source of introduction was probably ship ballast (Skinner, 1971). This fish is native to Europe and North Africa.

ATHERINIDAE - silversides

Chirostoma chapalae Jordan and Snyder
Lake Chapala silverside

Millions of eggs of this and perhaps other species of *Chirostoma* were released into Amistad and Falcon reservoirs on the Rio Grande River by the Mexican government prior to June 1975 (Clark Hubbs, personal communication). The

fish was introduced as a food source for local residents. This species, endemic to Lake Chapala, Mexico, failed to become established in the Rio Grande reservoirs.

BELONTIIDAE - gouramis

Betta splendens Regan — Siamese fightingfish

Specimens of this species were collected in 1969 in Lake Worth Drainage District canal L-15, adjacent to an aquarium fish farm west of Atlantis, Palm Beach County, Florida (Courtenay et al., 1974). The species was not taken at that locality in subsequent years. In December 1975, an established population was found in a canal south of Holmberg Road, northern Broward County, Florida. Subsequent collections there in 1975 reconfirmed establishment as a dominant fish in that canal. The population was killed by extremely cold weather in January 1977. It is likely that isolated populations of this species are established in southern Florida. This species is native to Thailand.

Colisa fasciata (Bloch) — Giant gourami

This species, native to northeastern India, Bangla Desh, Assam, Burma, Thailand, and the Malay peninsula has been collected occasionally in Pennsylvania (Clark Shiffer, personal communication).

Colisa labiosa (Day) — Thicklipped gourami

This species was collected in 1977 in a canal adjacent

to a fish farm at 15th Ave., N.W., Ruskin, Hillsborough County, Florida (Derril Moody, personal communication). It is native to southern Burma.

Colisa lalia (Hamilton-Buchanan) Dwarf gourami

The dwarf gourami has been collected in Lake Worth Drainage District canal L-15, adjacent to a fish farm, Palm Beach County, Florida in 1969 and 1970 (Courtenay et al., 1974). It was collected in 1971 in a canal east of Ruskin (Courtenay et al., 1974) and in another canal at 15th Ave., N.W. in Ruskin, Hillsborough County, Florida, adjacent to a fish farm, since 1977; there is no evidence of reproduction to date. This species is native to India, Bangla Desh, and Assam.

Macropodus opercularis (Linnaeus) Paradisefish

Myers (1940) presented unconfirmed reports of paradisefish breeding in the Everglades, Florida. This species, native to Korea, China, Vietnam, and Taiwan, has been collected in Lake Worth Drainage District Canal L-15, near an aquarium fish farm, Palm Beach County, Florida in 1969 and 1970 (Courtenay et al., 1974) but has not been found there in subsequent collections.

Trichogaster leeri (Bleeker) Pearl gourami

The pearl gourami, native to the Malay peninsula, Thailand, Sumatra, and Borneo, was collected in 1970 in Lake Worth Drainage District canal L-15, adjacent to a

fish farm, Palm Beach County, Florida (Courtenay et al., 1974).

Trichogaster trichopterus (Pallas) Blue gourami

The blue gourami was collected in 1971 in Lake Worth Drainage District canal L-15, adjacent to a fish farm, Palm Beach County, Florida (Courtenay et al., 1974) and in 1978 in an irrigation ditch along South Canal Drive, 1.3 mi. east of the Florida Turnpike, Dade County, Florida. This species is native to the Indo-Australian archipelago, the Malay peninsula, and Indo-China.

CALLICHTHYIDAE - smooth armored catfishes

Callichthys sp. Callichthys

This fish, possibly *Callichthys callichthys*, was collected in the early 1970s in a canal along Jog Road, Palm Beach County, Florida (Vernon Ogilvie, personal communication). One specimen of *C. callichthys* is reported as having been caught in June 1978 in Great South Bay off Copiague, Suffolk County, Long Island, New York (Philip Briggs, personal communication). It is native from Trinidad to Buenos Aires.

CENTROPOMIDAE - snooks

Lates nilotica (Linnaeus) Nile perch

This species, native to the Nile River of Africa, was introduced in 1979 into one or more reservoirs in Texas by the Texas Parks and Wildlife Department (Clark Hubbs,

personal communication). It was introduced for sport fishing.

CHANIDAE - milkfish

Chanos chanos (Forsskal) Milkfish

The milkfish was introduced by the State of California into a stream near Bridgeport, Solano County, California in 1876-77 (Shapavolov et al., 1959). This species, native to the Indo-West Pacific and eastern tropical Pacific, did not become established. This species is cultured in several countries as a food fish (Bardach et al., 1972).

CHANNIDAE - snakeheads

Ophicephalus micropeltes Kuhl and van Hasselt Giant snakehead

Two specimens of the giant snakehead have been collected from the Saco River, Maine (Hugh DeWitt, personal communication) and one from Johnson Pond, Coventry, Rhode Island. All appear to be aquarium releases. This species is native to Indo-China, Malaya, the East Indian islands, Thailand, Burma, and India.

CHARACIDAE - characins

Astyanax fasciatus mexicanus (De Filippi) Mexican banded tetra

This fish is considered by some ichthyologists as *Astyanax mexicanus* rather than as a subsepcies of *A. fasciatus*. It was introduced into California (date and

reason, if any, unknown) but did not become established (Hubbs et al., 1979). The Mexican banded tetra is native to Mexico from the Rio Balsas and Rio Tehuacan to the Rio Grande.

Colossoma sp. Pacu

One specimen of pacu was collected in Waverly Pond, Tallahassee, Leon County, Florida (Ralph Yerger, personal communication; Courtenay et al., 1974). Several specimens were collected from ponds adjacent to an industrial complex in Daytona Beach, Volusia County, Florida (Vernon Ogilvie and William Wegener, personal communication; Courtenay et al., 1974). One specimen was taken in Crescent Lake, St. Petersburg, Pinellas County, Florida (Dannie Hensley, personal communication). We have an unconfirmed report of a pacu having been caught near Vero Beach, Indian River County, Florida in 1979. Brittan (1979) reports the catch of a pacu, tentatively identified as *Colossoma nigripinnis* Cope, in the Sacramento River, near Elkhorn Ferry, Yolo County, California in 1977. One specimen of *Colossoma* sp. was caught in Lake Erie (Stroud, 1976).

Most of the Florida-caught specimens are tentatively identified as *C. bidens* (Spix).

Species of this genus are native to South America.

Gymnocorymbus ternetzi (Boulenger) Black tetra

This species has been collected in considerable numbers in a roadside ditch near a fish farm at the west end of 15th Ave., N.W., Ruskin, Hillsborough County, Florida. There is no evidence of reproduction. This species is native to the Matto Grosso region of the Paraguay River and the Rio Negro.

Hoplias malabaricus (Bloch) Trahira

This fish, native from Panama to northern Ecuador and Buenos Aires, was found to be established in the Little Manatee River, Hillsborough County, Florida (Hensley and Moody, 1975; Hensley, 1976). No specimens have been collected since January 1977 and we presume that it was extirpated by extremely cold temperatures during that month.

Serrasalmus sp. Piranha

Clark Shiffer (personal communication) reports that specimens of one or more as yet unidentified species of piranha are captured occasionally in Pennsylvania.

Serrasalmus nattereri (Kner) Caribe

Three specimens of this species were reported as having been caught in southeastern Florida; one in a canal at the corner of Broward Blvd. and University Drive, west of Ft. Lauderdale, Broward County; another in a borrow pit connected to the Snapper Creek Canal at State Road 826,

West Miami, Dade County (Courtenay et al., 1974); and the third at Lake Mabo, N.W. 6th Ave. and N.W. 6th St., Boca Raton, Palm Beach County.

Courtenay has received approximately 20 reports since 1969 of sightings of piranhas, several reported to be caribes, in the Tamiami Canal near its juncture with Snapper Creek Canal, West Miami, Dade County, Florida. Limited collections in that area of the Tamiami Canal have not contained any piranhas to date.

Reeve Bailey (personal communication) reports a specimen, probably of *S. nattereri*, that was found dead on the shore of a lake near Ann Arbor, Washtenaw County, Michigan. There is another report of two specimens found in Ohio after a young boy was bitten badly (Stroud, 1976) in the Rocky River near London.

This species occurs from the Orinoco basin of Venezuela, in the rivers of Surinam, Guyana, French Guiana, Brazil, the Amazon basin, and the Rio Parana and Rio Paraguay basins to Argentina.

Serrasalmus rhombeus (Linnaeus) White piranha

Serrasalmus rhombeus is treated herein as a species "complex" as it appears that there is more than one species involved (William Fink, personal communication).

Two specimens were collected from an abandoned swimming

pool in South Miami, Dade County, Florida (Courtenay et al., 1974). Personnel of the Florida Game and Fresh Water Fish Commission eradicated an established population at Monkey Jungle, a south Dade County, Florida tourist attraction.

The species complex is native to the Amazon basin, French Guiana, Surinam, and the Orinoco.

CICHLIDAE - cichlids

Aequidens pulcher (Gill) Blue acara

Ross Socolof (personal communication) reported this fish to have been established in the 1960s in canals and ditches around fish farms in the Tampa Bay, Hillsborough and Manatee counties, Florida. It was not collected in that area during 1970-72 under Dingell-Johnson Project F-28, Florida, nor since. This fish is native to Trinidad and northern Venezuela.

Astronotus ocellatus (Cuvier) Oscar

Although this fish is established in southern Florida, specimens have been collected from the waters of Massachusetts (Congamond Pond, Southwick, Hamden County; Halliwell, 1979); Mississippi (Anonymous, 1979); Pennsylvania (Clark Shiffer, personal communication); and Rhode Island (William Krueger, personal communication). All are believed to be aquarium releases.

The oscar is native to the Amazon, Parana, Rio Negro, and Rio Paraguay of South America.

Cichla ocellaris Schneider — Lucanari

Ten thousand juvenile *C. ocellaris* were released in northern Dade County, Florida in 1964 by personnel of the Florida Game and Fresh Water Fish Commission toward establishment for sport fishing purposes. This species, native to northern South America, failed to become established (Courtenay et al., 1974).

Cichlasoma beani (Jordan) — Green guapote

This species is from the lowland streams of Sinaloa and Jalisco, Mexico. It was introduced into California (source, locality, and reason unknown) but failed to establish (Hubbs et al., 1979).

Cichlasoma labiatum (Günther) — Red devil

A single specimen of this fish was collected in Six Mile Creek, under the U.S. highway 301 bridge, Hillsborough County, Florida (Courtenay, 1979). Fish farms are in the vicinity. We have unconfirmed reports of divers having observed other specimens of this highly agressive cichlid at the same locality. This species is native to the Great Lakes of Nicaragua.

Cichlasoma meeki (Brind) — Firemouth

This species is established in southern Florida. Minckley

(1973) states that one specimen of this species was captured in a canal in Mesa, Arizona. This fish is native to northern Yucatan.

Cichlasoma nigrofasciatum (Günther) Convict cichlid

The convict cichlid, native to the Pacific slope of Guatemala and both slopes of Costa Rica, is established in Lincoln and Clark counties, Nevada, and in Cave and Basin Hotsprings, Alberta, Canada. It may still be established near Phoenix, Arizona. Rivas (1965) reports a single specimen from a rockpit in northwestern Miami, Dade County, Florida.

Cichlasoma trimaculatum (Günther) Threespot cichlid

An established population of this cichlid in a lake near Ellenton, Manatee County, Florida was eradicated by personnel of the Florida Game and Fresh Water Fish Commission, This fish is native to the Pacific slope of southern Mexico and Guatemala.

Cichlasoma salvini (Günther) Salvini cichlid

We have information that the salvini cichlid, native to southern Mexico and Guatemala, is established in a small lake at an as yet unknown location in Dade County, Florida. Until we can locate this lake and confirm the status of this fish, we are listing it as non-established. Our report comes from a very reliable source.

Salmonidae
Non-Established Species
O = Collected only, establishment uncertain, or not established
● = Established

Geophagus brasiliensis (Quoy and Gaimard) Pearl cichlid

A single specimen of this eastern Brazilian fish was collected near a fish farm in Lake Worth Drainage District canal L-15, Palm Beach County, Florida (Courtenay et al., 1974).

Pterophyllum sp. Angelfish

St. Amant (1966) and St. Amant and Hoover (1969) reported this South American (Amazon and Orinoco rivers) cichlid from a pond and tributary on the eastern side of the Salton Sea near the Hot Mineral Spa, Imperial County, California and the Westminster flood control channel, Westminster, Orange County, California. Both sites were adjacent to aquarium fish farms. It is also reported by McAllister (1969) from Cave and Basin Hotsprings, Banff National Park, Alberta, Canada, where it does not overwinter. We have had unconfirmed and unsubstantiated reports of angelfish in Lake Worth Drainage District canal L-14, near a fish farm in Palm Beach County, Florida.

Tilapia aurea (Steindachner) Blue tilapia

This species is established in Arizona, Florida, and Texas. It was previously established in North Carolina (Julian Lake, near Asheville) and in Oklahoma (North Canadian River, near Oklahoma City; Pigg, 1978). It is stocked annually in ponds and lakes in Alabama (Smith-Vaniz, 1968). It may be established in ponds at a fish farm in Colorado and in golf course ponds in Georgia. The blue tilapia is native to Senegal, the middle Niger, Benue River (?),

Chad, lower Nile, Jordan River system, and pools at Ein Fashkha.

Tilapia hornorum Trewavas (no common name)

This species was one of three species of *Tilapia* authorized in 1971 as a biological control for aquatic weeds in southern California; the other two are *T. mossambica* and *T. zillii*. It was stocked into irrigation drains in extreme southeastern California, survived for a year or so (Pelzman, 1973), and has apparently died out. This species is native to the eastward-flowing rivers of Africa.

Tilapia mossambica (Peters) Mozambique tilapia

Smith-Vaniz (1968) states that this species is stocked annually in Alabama. It is seasonally stocked in a commercial catfish farm at Hooper, Colorado and is used in raceways there for aquatic weed control (Robert Behnks, personal communication). It was used in experiments in a pond in Illinois. Four specimens were collected from a spring-fed pond at Beavermouth, Granite County, Montana (Brown and Fox, 1966). One adult specimen was collected in Hall's Pond, Hall's Pond Park, West Hempstead, Nassau County, New York in 1976 (Philip Briggs, personal communication). This species is possibly established in Georgia in golf course ponds in Glynn County.

This species is established in Arizona, California, Florida, North Carolina, and Texas. It is native to the lower Zambezi and lower Shire rivers, and from the Zambezi River to Algoa Bay, Africa.

Tilapia sparmanni Smith (no common name)

This fish, a south African species, was reported from Six-Mile Creek, near fish farms in Hillsborough County, Florida by Burgess (1958). No additional specimens have been collected at that locality since.

Tilapia zillii (Gervais) Redbelly tilapia

The redbelly tilapia, established in California and possibly in Arizona, is stocked annually in Alabama (Smith-Vaniz, 1968). An established population in a pond at Perrine Wayside Park, Perrine, Dade County, Florida, was eradicated by personnel of the Florida Game and Fresh Water Fish Commission. We have an unconfirmed report that it is stocked, probably annually, on a fish farm in Idaho. Another unconfirmed report states that this species is being cultured in a reservoir of a power plant in South Carolina.

T. zillii is native to rivers and lakes in north and central Africa to Jordan.

CLARIIDAE - airbreathing catfishes

Clarias batrachus (Linnaeus) Walking catfish

Established in 20 counties of Florida, individual specimens of the walking catfish have been collected in the

All-American Canal, southern California (Minckley, 1973); in Park Lake, North Stockton, Californoa; the Flint River, Georgia (Courtenay and Miley, 1975); Waldo Lake, Brockton, Massachusetts (Halliwell, 1979); and in a reservoir in Nevada (Minckley, 1973); all non-Florida specimens appear to be aquarium releases.

This species is native to southeastern Asia from eastern India to south China.

CYPRINIDAE - carps and minnows

Barbus sp. Tinfoil barb

Courtenay et al. (1974) reported the capture of a tinfoil barb in Lake Worth Drainage District canal L-15, adjacent to a fish farm, Palm Beach County, Florida. The genus *Barbus* is native to India, Sri Lanka, southeast Asia, China, Africa, and one species occurs in Great Britain, western and central Europe.

Barbus conchonius (Hamilton-Buchanan) Rosy barb

A few specimens of the rosy barb were collected in Lake Worth Drainage District canal L-15, near a fish farm, Palm Beach County, Florida (Courtenay et al., 1974). This species is from northern India, Bangla Desh, and Assam.

Barbus gelius (Hamilton-Buchanan) Golden barb

A few specimens of this species were collected from Lake Worth Drainage District canal L-15, near a fish farm, Palm Beach County, Florida in 1969 and 1970 (Courtenay et al (1974). It is native to northeastern and central India.

Barbus tetrazona (Bleeker) Tiger barb

This species, native to Sumatra, Borneo, Thailand, and possibly Cambodia, was collected by Naiman and Pister (1974) from a small stream flowing from Warm Springs Sanctuary in Owens Valley, Inyo County, California. Moyle (1976) considers establishment uncertain and Hubbs et al. (1979) do not consider this fish as established.

Paul Shafland (personal communication) collected a large specimen of this fish at Perrine Wayside Park, Perrine, Dade County, Florida.

Brachydanio rerio (Hamilton-Buchanan) Zebra danio

Courtenay et al (1974) report this species as having been collected in Lake Worth Drainage District canal L-15, Palm Beach County, and in a ditch in Gibsonton, Hillsborough County, Florida. Both sites are adjacent to fish farms. Derril Moody (personal communication) has collected this fish near a fish farm, 0.1 mi. east of U.S. Hwy. 41 on Kraker Ave., Adamsville, Hillsborough County, Florida. St. Amant and Hoover (1969) record this fish from a ditch near a fish farm in the Westminster flood control channel, Westminster, Orange County, California.

This fish is native to eastern India.

Carassius auratus (Linnaeus) Goldfish

Hensley (earlier in this report) cites the goldfish as not established in Florida, Maine, Missouri, Utah,

Vermont, and West Virginia, although the species has been collected in all these states. He also lists establishment as uncertain in Alabama, Arizona, Arkansas, Colorado, Connecticut, Iowa, Kansas, Louisiana, Minnesota, Mississippi, Montana, New Jersey, New Mexico, North Carolina, North Dakota, Oregon, and Wyoming.

This species is native from eastern Europe to China.

Ctenopharyngodon idella (Valenciennes) Grass carp

Although we treat grass carp as established, earlier in this report, it is probably not established outside of the Mississippi-Missouri watersheds in North America at present.

This fish is native to eastern Asia.

Danio malabaricus (Jerdon) Giant danio

This species, native to the west coast of India and Sri Lanka, has been collected by Derril Moody (personal communication) near a fish farm in a canal at western end of 15th Ave., N.W., Ruskin, Hillsborough County, Florida.

Hypophthalmichthys molitrix (Valenciennes) Silver carp

At least four specimens of this fish, native to China from the Amur basin to Canton, have been caught in a creek emptying into the Arkansas River and one into the White River, both localities in Arkansas County, Arkansas (Jon Stanley, personal communication). This species is being cultured in Arkansas.

Tinca tinca (Linnaeus) Tench

Hensley (earlier in this report) cites this specimen of the tench as having been collected in Arizona and Missouri where it is not established. He also treats this native of western Europe as possibly established in Delaware, Maryland and New York.

CYPRINODONTIDAE - tooth carps

Cynolebias bellottii Steindachner Argentine pearlfish

This native of the Rio de la Plata basin of South America was used experimentally in 1964-65 at the University of California at Riverside to determine its use for mosquito control (Bay, 1966). It was later introduced into some ponds in southern California (Moyle 1976, 1976a) and Moyle (1976) considered it to be probably established in Riverside and possibly Los Angeles counties. Hubbs et al. (1979), however, list this species as not established.

Rivulus harti (Boulenger) Trinidad rivulus

St. Amant (1970) reported this fish from a small ditch near a fish farm on the eastern side of the Salton Sea, California, where it was established. Moyle (1976, 1976a) and James St. Amant (personal communication) are doubtful that this species is still established. The Trinidad rivulus is native to Trinidad and possibly to Guyana and northern Brazil.

DORADIDAE - thorny catfishes

Pterodoras granulosus (Valenciennes) (no common name)

One specimen of this South American catfish, native to the Amazon and Paraguay rivers, was found dead in a canal on county road 77, 2.3 mi. north of Brooker Creek near Lake Tarpon, Pinellas County, Florida. Subsequent collecting in that area failed to locate any additional specimens. This probably represents an aquarium release.

ESOCIDAE - pikes and pickerels

Esox reicherti Dybowski Amur pike

Eggs of this species were imported by the U.S. Fish and Wildlife Service and subsequently transferred to the Pennsylvania Fish Commission (Lachner et al., 1970). Fry and fingerlings were stocked into Glendale Lake, 20 mi. northeast of Altoona, Pennsylvania; this is part of the west branch of the Susquehanna River drainage. Stockings were made in 1968 through 1970 and three years since 1971; there has been no evidence of successful reproduction.

Flooding in 1972 following Hurricane Agnes resulted in the escape of some brood fish from a hatchery into upper Spring Creek, approximately five miles south of Bellefonte, Pennsylvania. *Esox reicherti* has been collected from Bald Eagle Creek, a tributary of the west branch of the Susquehanna River near Bellefonte and it is presumed that

these are escapees from the hatchery; no evidence of reproduction has been found in that creek (Robert Butler, personal communication).

The reason for stocking appears to have been the provision of a new sport fish. This species is native to the Amur basin.

HELOSTOMATIDAE - kissing gourami

Helostoma temmincki Cuvier and Valenciennes Kissing gourami

Specimens of the kissing gourami were collected near a fish farm in Lake Worth Drainage District canal L-15, Palm Beach County, Florida (Courtenay et al., 1974). Specimens have recently (1977-78) been collected in numbers near a fish farm in a canal at the western end of 15th Ave., N.W., Ruskin, Hillsborough County, Florida; there is no evidence of reproduction.

This species is native to Java, Borneo, Sumatra, through the Malay peninsula into central Thailand.

ORYZIATIDAE - medakas

Oryzias latipes (Temminck and Schlegel) Medaka

Rosen (1973) reported the medaka as having been introduced into North America. He has confirmed the establishment of this species on Long Island, New York. This fish was introduced and probably became established in San Francisquito Creek, Santa Clara, California

(Shapovalov, 1959); it is no longer established there (Hubbs et al., 1979).

The medaka is used widely as an experimental animal in developmental biology courses and future additional releases are to be expected. This species is native to Japan, Korea, southern Manchuria, and eastern China as far south as Hainan.

PERCIDAE - perches

Stizostedion lucioperca (Linnaeus) European pike-perch

John Nickum (personal communication) reports that this fish, native to central Europe (south to northern Italy, east to Russia, north to the Baltic, and west to the River Werre), has been introduced into central New York. At present, this report is unconfirmed.

PLECOGLOSSIDAE - ayu

Plecoglossus altivelis Temminck and Schlegel Ayu

Hubbs et al. (1979) indicate the ayu to have been introduced into California but that it is not an established species. The ayu is considered a delicacy in eastern Asia where it is cultured (Bardach et al., 1972); this may have been the reason for its attempted introduction in California.

This species is native to Japan, Korea, and China.

POECILIIDAE - livebearers

Belonesox belizanus Kner — Pike killifish

The pike killifish has been seen and collected in the San Antonio River, San Antonio, Texas (Barron, 1964); it may have been established there but is no longer considered as established (Hubbs et al., MS). This species, native to Central America, is established in Texas.

Poecilia reticulata Peters — Guppy

Moyle (1976, 1976a) lists the guppy as occurring in certain sewage treatment ponds in California but indicates that there are no known wild populations in that state. This fish is established in Alberta, Canada, Arizona, Texas and Nevada. Courtenay, et al. (1974) list this fish from Hillsborough and Palm Beach counties, Florida. The Hillsborough County records are probably from non-reproducing a non-overwintering stocks and the Palm Beach County population at Boca Raton was extirpated by drought; this, however, does not preclude establishment of this species in other isolated sites in southern Florida, for which there is a high probability.

The guppy is native to the Netherlands Antilles and the Venezuelan islands, Trinidad, the Windward (Barbados) and Leeward (St. Thomas and Antigua) Islands, and from western Venezuela to Guyana.

Poecilia sphenops Valenciennes Shortfin molly

We are treating this as a species complex. Minckley (1973) refers to a member of this complex as having been collected once in the metropolitan canal system near Phoenix, Arizona. Establishment by members of this complex in California and Florida is unknown at present. Members of the complex are established in California, Montana, and Nevada.

The native range for members of the complex is northern Mexico to the Caribbean slope of Colombia and the Colombian West Indies.

Xiphophorus hellerii Heckel Green swordtail

Minckley (1973) lists this species as having been established near Rock Springs, Maricopa County, Arizona; flooding of that site in 1965 appears to have extirpated the population. Its status near a fish farm in Orange County, California (St. Amant and Hoover, 1969) and in Indian Springs, Clark County, Nevada (James Deacon, personal communication) is uncertain.

This species is established in Alberta, Canada, in Florida, and in Montana. Its native range is from the Rio Nautla, Veracruz, Mexico southward along the Atlantic slope to northwestern Honduras.

Xiphophorus maculatus (Günther) Southern platyfish

The southern platyfish has been collected near a fish farm in Orange County, California (St. Amant and Hoover, 1969) and is know or suspected to have been released in Texas (Hubbs, 1976).

This species is established in Florida and Nevada. It is native from just south of Veracruz, Mexico to northern Belize.

Xiphophorus variatus (Meek) Variable platyfish

This fish was possibly established in Orange and Riverside counties, California (St. Amant and Hoover, 1969; St. Amant and Sharp, 1971) but it is doubtful that these populations are still extant (Moyle, 1976; Hubbs et al., 1979; James St. Amant, personal communication). It was also established in Arizona (Minckley, 1973).

This species, native to southern Tamaulipas, eastern San Luis Potosi, and northern Veracruz, Mexico, is established in Florida and Montana.

PLEURONECTIDAE - righteye flounders

Platicithys flesus (Linnaeus) European flounder

Emery and Teleki (1978) record this species from two specimens collected in Lake Erie. They speculate the source of introduction as ship ballast. This fish is native to the coastal waters of Europe.

SALMONIDAE - salmons and trouts

Hucho hucho (Linnaeus) Danube salmon

Lachner, et al. (1970) cite this species as having been introduced into Quebec, possibly as a sport fish. It did not become established. It is native to the Danube and Prut basins of Europe.

Oncorhynchus masou (Brevoort) Cherry salmon

Cristie (1970) reports the cherry salmon to have been introduced into Westward Lake, Algonquin Park, Ontario, by the Ontario Department of Lands and Forests in July 1966. Mature specimens, some releasing spawn, were collected in 1967 and 1968 (Christie, 1970). Nevertheless, this salmon has not become established.

This species is native from the mouth of the Amur River to Pusan, Japan, Sakhalin Island, and the west coast of Kamchatka.

Salmo letnica (Karaman) Ohrid trout

This species, endemic to Lake Ohrid, Albania/Yugoslavia, has been purposefully introduced into Turquoise Lake, near Leadville, Big Creek Reservoir, and Parvin Lake, Colorado, by the Colorado Game, Fish, and Parks Department in 1969 (Robert Behnke, personal communication); in seven lakes in Minnesota, including Strawberry Lake, Chester Lake, and Big Trout Lake (Behnke, 1971); numerous lakes and reservoirs in Tennessee including

Watauga Lake and Ripshin Lake, stockings done by Tennessee Wildlife Resources Agency (Price Wilkens, personal communication); and Wyoming into Viva Naughton Reservoir on the Hams Fork of the Green River and into lakes near Casper by the Wyoming Fish and Game Department (Robert Behnke, personal communication). There has been no evidence of successful reproduction although spawnings have been observed in Tennessee.

As with the Amur pike, the Ohrid trout was brought into the United States by the U.S. Fish and Wildlife Service and shipped to a federal hatchery in Manchester, Iowa and a state hatchery at Lanesboro, Minnesota (Behnke, 1970, 1971).

Additional Comments on Non-Established Species

The listing above is by no means comprehensive. It is certain that specimens of exotic fishes other than those in this listing have been collected and not reported or published. It is also certain that some exotic species have been found that have been discarded or lost and, therefore, will never be reported; an example of this is an unidentified lungfish, found on Hutchinson Island, Florida, that had to be disposed of after a freezer at a state agency thawed due to a Hurricane David-caused electrical failure in September 1979.

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EXOTIC FISHES COLLECTED IN NORTH AMERICA
(Not established in states
and provinces listed)

		States and Provinces
ANABANTIDAE - climbing gouramis		
Anabas testudineus (Bloch)[1]	Climbing perch	FL
Ctenopoma nigropannosum (Reichenow)[1]	Twospot ctenopoma	FL
ANGUILLIDAE - freshwater eels		
Anguilla anguilla (Linnaeus)	European eel	CA
ATHERINIDAE - silversides		
Chirostoma chapalae Jordan and Snyder[2]	Lake Chapala silverside	TX
BELONTIIDAE - gouramis		
Betta splendens Regan[1]	Siamese fighting-fish	FL
Colisa fasciata (Bloch)	Giant gourami	PA
Colisa labiosa (Day)	Thicklipped gourami	FL
Colisa lalia (Hamilton-Buchanan)	Dwarf gourami	FL
Macropodus opercularis (Linnaeus)	Paradisefish	FL
Trichogaster leeri (Bleeker)	Pearl gourami	FL
Trichogaster trichopterus (Pallas)	Blue gourami	FL
CALLICHTHYIDAE - smooth armored catfishes		
Callichthys sp.	Callichthys	FL, NY
CENTROPOMIDAE - snooks		
Lates nilotica (Linnaeus)[3]	Nile perch	TX

CHANIDAE - milkfish

Chanos chanos (Forsskal)[2]	Milkfish	CA

CHANNIDAE - snakeheads

Ophicephalus micropeltes Kuhl and van Hasselt	Giant snakehead	ME,RI

CHARACIDAE - characins

Astyanax fasciatus mexicanus (De Filippi)	Mexican banded tetra	CA
Colossoma spp.	Pacu	CA,FL,OH
Gymnocorymbus ternetzi (Boulenger)	Black tetra	FL
Hoplias malabaricus (Bloch)[1]	Trahira	FL
Serrasalmus sp.	Piranha	PA
Serrasalmus nattereri (Kner)[5]	Caribe	FL,MI,OH,PA?
Serrasalmus rhombeus (Linnaeus)[6]	White piranha	FL

CICHLIDAE - cichlids

Aequidens pulcher (Gill)	Blue acara	FL
Astronotus ocellatus (Cuvier)[7]	Oscar	MA,MS,PA,RI
Cichla ocellaris Schneider[2]	Lucanari	FL
Cichlasoma beani (Jordan)	Green quapote	CA
Cichlasoma labiatum (Günther)	Red devil	FL
Cichlasoma meeki (Brind)[7]	Firemouth	AZ
Cichlasoma nigrofasciatum (Günther)[8]	Convict cichlid	AZ,FL
Cichlasoma trimaculatum (Günther)[6]	Threespot cichlid	FL
Cichlasoma salvini (Günther)[9]	Salvini cichlid	FL
Geophagus brasiliensis (Quoy and Gaimard)	Pearl cichlid	FL
Pterophyllum sp.	Angelfish	CA
Tilapia aurea (Steindachner)[10]	Blue tilapia	AL,CO,GA, NC,OK
Tilapia hornorum Trewavas	(no common name)	CA
Tilapia mossambica (Peters)[11]	Mozambique tilipia	AL,CO,GA?,IL, MT,NY
Tilapia sparmanni Smith[12]	(no common name)	FL
Tilapia zillii (Gervais)[6,13]	Redbelly tilapia	AL,AZ,FL,ID,NC

CLARIDAE - airbreathing catfishes

Clarias batrachus (Linnaeus)[7]	Walking catfish	CA,GA,MA,NV

CYPRINIDAE - carps and minnows

Barbus sp.	Tinfoil barb	FL
Barbus conchonius (Hamilton-Buchanan)	Rosy barb	FL
Barbus gelius (Hamilton-Buchanan)	Golden barb	FL
Barbus tetrazona (Bleeker)	Tiger barb	CA,FL
Brachydanio rerio (Hamilton-Buchanan)	Zebra danio	CA,FL
Carassius auratus (Linnaeus)	Goldfish	FL,ME,MO,UT,VT,WV
Ctenopharyngodon idella (Valenciennes)	Grass Carp	See Text
Danio malabaricus (Jerdon)	Giant danio	FL
Hypophtalmichthys molitrix Valenciennes	Silver carp	AR
Tinca tinca (Linnaeus)[14]	Tench	AZ,MO

CYPRINODONTIDAE - tooth carps

Cynolebias bellottii Steindachner[15]	Argentine pearl-fish	CA
Rivulus harti (Boulenger)[15]	Trinidad rivulus	CA

DORADIDAE - thorny catfishes

Pterodoras granulosus (Valenciennes)	(no common name)	FL

ESOCIDAE - pikes and pickerels

Esox reicherti Dybowski[2]	Amur pike	PA

HELOSTOMATIDAE - kissing gourami

Helostoma temmincki Cuvier and Valenciennes	Kissing gourami	FL

ORYZIATIDAE - medakas

Oryzias latipes (Temminck and Schlegel)[16]	Medaka	CA

PERCIDAE - perches

Steizostedion lucioperca (Linnaeus)[17]	European pike-perch	NY

PLECOGLOSSIDAE - ayu

Plecoglossus altivelis Temminck and Schlegel	Ayu	CA

POECILIDAE - livebearers

Belonesox belizanus Kner[7]	Pike killifish	TX
Poecilia reticulata Peters[18]	Guppy	CA
Poecilia sphenops Valenciennes[19]	Shortfin molly	AZ
Xiphophorus hellerii Heckel[20]	Green swordtail	AZ,CA,NV
Xiphophorus maculatus (Günther)[21]	Southern platyfish	CA,TX
Xiphophorus variatus (Meek)[22]	Variable platyfish	AZ,CA

PLEURONECTIDAE - righteye flounders

Platichthys flesus (Linnaeus)	European flounder	Ont

SALMONIDAE - salmons and trouts

Hucho hucho (Linnaeus)[2]	Danube salmon	Que
Onchorhynchus masou (Brevoort)[2]	Cherry salmon	Ont
Salmo letnica (Karaman)[2]	Ohrid trout	CO,MT,TN,WY

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[1]species formerly established and apparently extirpated

[2]purposefully released but failed to establish

[3]purposefully released by Texas Department of Parks and Wildlife in 1979

[4]identification tentative; FL specimens examined by Walter R. Courtenay, Jr. do not appear to be *C. nigripinnis* as reported in earlier lists

[5]identification of FL and MI specimens fairly certain

[6]formerly established and subsequently eradicated in FL by Florida Game and Fresh Water Fish Commission

[7]established in FL

[8]established in NV and Alb and possibly in AZ

[9]probably established in a Dade County, FL pond; have not been able to get pond location; identification certain

[10]established in AZ, FL and TX; stocked annually in AL; reported from springs in CO; GA report tentative; purposefully stocked, established, and later died out in Julian Lake, NC; purposefully stocked and failed to establish in OK; also stocked in IA for growth studies

[11]stocked annually in AL; CO report based on springs population; MT report based on stockings on fish farms, probably annually; IL report based on fish stocked for growth studies

[12]reported by Burgess (1958. The Fishes of Six-Mile Creek, Hillsborough County, FL, with particular reference to the presence of exotic species. Proc. a. Conf. SE Game Fish Commn., 12, 8 pp.); possibly a misidentification

[13]established in CA; reported as stocked annually in AL; ID report based on stockings on fish farm, probably annually; may be established in AZ; reared commercially in SC

[14]established in CA, CO, CT, ID, NM, OR, WA, and Brit. Col.; probably established in DE, MD, and NY

[15]purposefully stocked, apparently established, but later died out

[16]established in NY

[17]unconfirmed report from New York Cooperative Fishery Unit, Ithaca

[18]established in AZ, NV, TX, and Alb.; possibly established in FL

[19]treated as a species complex; established in CA, MT and NV; possibly established in FL

[20]established in FL, MT, and Alb

[21]established in FL and NV

[22]established in FL and MT

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prepared by Walter R. Courtenay, Jr. and Dannie A. Hensley

ADDENDUM

On page A-6, reference was made to two specimens of the giant snakehead, *Ophicephalus micropeltes*, as having been collected from the Saco River, Maine. Hugh DeWitt (personal communication) informs us that only one specimen was taken from the Saco River and the other was captured in the Mousam River below the Springvale Dam near Sanford, York County, Maine in the Summer of 1976.

APPENDIX B

ACKNOWLEDGMENTS

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