

ANNOTATED LIST OF
INTRODUCED NON-NATIVE FISHES,
MOLLUSKS, CRUSTACEANS AND
AQUATIC PLANTS IN TEXAS WATERS

by

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ABSTRACT

At least 40 fish species and two hybrids have been reported released in or recovered from Texas waters. Among these species, approximately 68% (28) were originally introduced by state or federal fish and wildlife agencies, with five species apparently from a public aquarium source, six species probably from private aquarists and three species originated from fish farm/live bait sources. Fourteen species are well established in the state and 22 do not appear to maintain reproducing populations or have not been reported in recent years. The status of northern pike (Esox lucius), muskellunge (E. masquinongy), shoal bass (Micropterus sp.) and rudd (Scardinius erythrophthalmus) is uncertain. Hybrid grass carp (Ctenopharyngodon idella x Hypophthalmichthys nobilis) and hybrid corvina (Cynoscion xanthulus x C. nebulosus) are also present in state waters.

Five gastropods and one pelecypod were introduced into state waters from largely undetermined sources. Among these, three snails (Marisa, Thiara and Melanoides) and Asiatic clam (Corbicula) are known to be established; status of the remaining two snails is undetermined. One crustacean, a penaeid shrimp, was taken in state waters, but has not been collected since and does not appear to be established.

Nearly 70 species of aquatic and semiaquatic plants have been introduced in Texas; however, numbers of aquatic plants listed may vary depending upon the reference source. Nearly all are established. The time and origin of many introductions is unknown, or at least uncertain.

INTRODUCTION

Importation and transplantation of non-native fishes to the inland waters of Texas have occurred from at least the mid-1800's and have continued through the present. Original introductions by the U.S. Bureau of Fisheries and the Texas Oyster and Fish Commission ranged from the release of common carp (Cyprinus carpio) to such unusual exotics as Chinook salmon (Oncorhynchus tshawytscha) and American shad (Alosa sapidissima). In the 1950's the Texas Game and Fish Commission began stocking native marine fishes in inland reservoirs and rivers. More recently, Texas Parks and Wildlife Department (TPWD) has studied both marine and freshwater exotic fishes for potential use in reservoirs to enhance sport fishing opportunities and to use abundant forage fish populations.

Both the ornamental/aquarium fish trade and private aquaculturists have also imported non-native fishes, invertebrates and wetland and aquatic plants. Deliberate and accidental releases from these sources have also served to increase the number of exotic species in state waters. Because of environmental problems arising from established species like common carp and blue tilapia (Tilapia aurea), Texas and many other states have enacted state legislation and departmental regulations to restrict or control importation and introduction of exotic fishes, shellfishes and aquatic plants.

This paper presents a preliminary summary of non-native fish, mollusk, crustacean and wetland and aquatic plant species reported from, or introduced into, Texas waters.

MATERIALS AND METHODS

Published literature and agency reports were reviewed for records of stocking and of captures of non-native fishes. This included review of both state and federal stocking reports as well as scientific journal articles. Reports by anglers or state fisheries personnel on several additional species taken in recent years were also included. Many federal stockings were listed in Baughman (undated). Information on marine and estuarine species which were native to Texas coastal waters but which were stocked into inland reservoirs, or species which were transferred from one drainage basin to another within the state was not included. Similarly, records of aberrant strays into state waters or of unverified collections were not included. No formal procedure or individual has been designated within the state to record and catalogue exotic aquatic organisms taken in Texas waters, subsequently some records relied on memories of local biologists. Further, non-native fish populations are not regularly monitored and present status is often unavailable.

Information on gastropod introductions was obtained from Burch (1989) and pelecypods from Burch (1973). TPWD collection records were also studied for both groups and for crustaceans; however, monitoring and recording invertebrate occurrences is even less well documented than for fishes.

The introduced plant list was developed largely from Muenscher (1967), Correll and Correll (1972), Reed (1988a, 1988b) and Hatch et al. (1990) as well as from unpublished state and federal records. The aquatic plant list given herein is exceptionally and often arbitrarily broad because of the

difficulty in defining an aquatic plant. Muenscher (1967) stated: "The concept of aquatic plants is subject to various interpretations. It is difficult to make a definition that can be rigidly adhered to in actual practice. There are too many borderline species that may or may not be included." Therefore, it was deemed preferable to include marginally aquatic and wetland non-aquatic species than to omit certain introduced exotic plants on minor technicalities of differences in habitat. Because this list of introduced exotic plants reflects directly on prohibited exotic plants in Texas, a broadly inclusive list may be used to assist in better protection from undesirable introductions in the future. Further, there are often differences of opinion among botanists as to whether some species are introduced or native; such differences have been indicated.

RESULTS

The following non-native fishes, mollusks, crustaceans and aquatic plants have been introduced into or reported from Texas waters:

Fishes

Family Clupeidae: Herrings

- Blueback herring (*Alosa aestivalis*) were imported from South Carolina, and stocked at Lake Theo, Briscoe County, and another research site in North Texas in 1982 for study as a possible forage species. Although believed still present at these locations, none are known to have spread to other state waters (Guest 1983).
- American shad (*A. sapidissima*) were imported and stocked as a game fish repeatedly by the U.S. Bureau of Fisheries in the 1800's; all such introductions were unsuccessful (Baughman 1950).

Family Cyprinidae: Carps and Minnows

- Common carp (*Cyprinus carpio*) from original introductions by the U.S. Bureau of Fisheries (Baughman 1950) were very successful, and they are now widely distributed throughout the state. Stockings reflected the high regard for the species as a game and food fish in Europe; however, similar public acceptance never developed in North America. More recently, both state and federal hatcheries in Texas have started culturing colored strains of common carp, known as koi, as hatchery forage, and at least one experimental stocking of koi has occurred.
- Goldfish (*Carassius auratus*) from original importation and introduction by the U.S. Bureau of Fisheries were successfully established at many locations around the state. At present, use as a bait fish continues to result in their introduction to new locations in Texas. Note that some authorities (W.R. Courtenay, Jr., Florida Atlantic University, Boca Raton, Florida; pers. comm.) feel that domestic goldfish stocks are actually hybrids between

goldfish and Crucian carp (*C. carassius*), and indeed low gill raker counts in some individuals may appear to support that premise. However, meristic counts often deviate from wild-type norms under culture, and corroborative electrophoretic evidence is generally lacking.

- Grass carp (*Ctenopharyngodon idella*) have been imported legally for experimental study and illegally by fish farmers and private individuals since the 1970's for control of aquatic vegetation. Although escapees have been collected at several locations, no reproducing populations have been identified in state waters. Hybrid grass carp (grass carp x bighead carp, *Hypophthalmichthys nobilis*) were legally imported and sold until 1990 when they were listed as prohibited in Texas.
- Other Chinese carps including bighead carp and silver carp (*H. molitrix*) have been imported and are being reared by state fish farmers, and black carp (*Mylopharyngodon pises*) have reportedly been imported for sale in Houston, Harris County, fish markets for several years. However, none have been taken or reported in field collections, except for a single bighead carp specimen taken from Victor Braunig Reservoir in 1991. Based on its large size (about 4.5 kg) and probable introduction through use as trot-line bait, this specimen could have entered the reservoir at an earlier date.
- Ide (*Leuciscus idus*), also known as golden orfe, were imported several times, but in limited numbers, by the U.S. Bureau of Fisheries in the 1800's. Importation may have reflected minor ornamental, sport or forage interest in the species. These fish appear to have been distributed to private individuals for stocking, and actual introduction sites are largely unrecorded. None appear to have established. Ide are still reared and used as a bait fish in other states and are occasionally sold in the ornamental fish trade; although not reported in Texas since their original introduction and presently prohibited in the state, additional introductions could occur from domestic stocks elsewhere in North America.
- Rudd (*Scardinius erythrophthalmus*) have been imported from Arkansas for use as bait fish for several years, and have been taken from several reservoirs (Howells et al. 1991); however, no established populations have been confirmed. Rudd became prohibited in Texas in 1990.
- Tench (*Tinca tinca*) were imported and introduced in Texas in the 1800's by the U.S. Bureau of Fisheries presumably as a sport species. Introductions were unsuccessful and none are known to be present in state waters at this time.

Family Serrasalminidae (Characidae): Piranhas and Their Relatives

- Pacu (*Colossoma* spp.) of at least two species have been reported from Texas waters including black pacu (*C. macropomum*) and red-bellied pacu (*C. brachypomum*); however, the specific identity of some specimens has not been determined (Howells et al. 1991). Although some records have represented large

individuals, there is no evidence of overwintering or spawning in Texas. All were probably aquarium releases.

- Redbellied piranha (Serrasalmus sp.) was represented by a single specimen (probably S. nattereri) taken from Boerne City Reservoir, Kendall County, in the early 1980's and is apparently the only confirmed record of a piranha from Texas (Howells et al. 1991). This specimen was probably an aquarium release.

Family Loricariidae: Armored Catfishes

- Suckermouth catfish (Hypostomus spp.; often reported as H. plecostomus but species identification is unresolved) were first reported by Barron (1964) and Hubbs et al. (1978) from the spring tributaries of the San Antonio River within the San Antonio Zoo, Bexar County. Collections by TPWD Inland Fisheries Research personnel in 1985-1988 confirmed their presence; they were still present there in 1990. Additionally, "plecostomus" were taken in Comal Springs, Comal County, in 1991 by Southwest Texas State University personnel (B.G. Whiteside; STSU, pers. comm.). These fish probably originated from pet trade specimens.

Family Esocidae: Pikes

- Northern pike (Esox lucius) were stocked as game fish from 1967 through 1981 at many locations around the state by TPWD. Present status of most such introductions has not been examined in recent years.
- Muskellunge (E. masquinongy) were stocked as game fish by TPWD at three locations in 1975 and 1976 (Amistad Reservoir in Val Verde County, Copper Breaks State Park in Hardeman County and Inks Lake in Burnet County). Present status is undetermined.

Family Salmonidae: Trouts and Salmon

- Rainbow trout (Oncorhynchus mykiss) were imported and stocked as a game fish at numerous locations by the U.S. Bureau of Fisheries in the 1800's (Baughman 1950), and stockings have continued on a put-and-take basis through the present.
- Redband trout (Oncorhynchus sp. or O. mykiss ssp.; taxonomic status of redband trout is still unclear) were introduced twice (1983 and 1986) by TPWD in Guadalupe River waters below Canyon Reservoir, Hays County, but have not been monitored for subsequent survival. This trout was imported for study of potentially greater heat tolerance than is typical of rainbow trout.
- Coho salmon (O. kisutch) were introduced in a single stocking in 1974 at Inks Lake, Llano County, when TPWD released 1,245 individuals. These game fish apparently arrived unrequested when other fish were being imported from an out-of-state hatchery. None are believed to have survived.
- Chinook salmon (O. tshawytscha) were imported and stocked as a game fish in the 1800's (Baughman 1950) as California salmon; all

- stocking attempts failed.
- Brown trout (Salmo trutta) were originally imported in the 1800's as a game fish by the U.S. Bureau of Fisheries and more recently by TPWD with probable additional introductions by private individuals and trout clubs. No introductions produced established populations, and recent trout stocking efforts have centered wholly on rainbow trout.
 - Brook trout (Salvelinus fontinalis) were released as a game fish by TPWD in a single stocking in 1981 (6,977 in the Guadalupe River, Canyon Reservoir tailrace), but which was preceded by older U.S. Bureau of Fisheries introductions. None were successful.

Family Poeciliidae: Livebearers

- Pike killifish (Belonesox belizanus) were reported by Barron (1964) from Brackenridge Park in San Antonio, Bexar County; however, Hubbs et al. (1978) were unable to verify its presence, and collections by TPWD Inland Fisheries Research personnel in 1985-1988 likewise found none. Releases probably originated in the pet trade.
- Mexican molly (Poecilia mexicana) were listed by Courtenay et al. (1984) as an introduction in Texas waters; however, taxonomic confusion within the shortfin molly (P. sphenops) complex, including broadspotted molly (P. latipunctata), with various molly hybrids and with Amazon molly (P. formosa), as well as with definition of original native ranges, suggests extreme caution should be used in identifying species in question or concluding that they are indeed from non-native introductions.
- Guppy (P. reticulata) were reported from spring waters in San Antonio (Hubbs et al. 1978), Bexar County, and Austin, Travis County, (Edwards 1976), but the Austin population apparently disappeared shortly after being discovered (Edwards 1976) and no individuals were collected by TPWD Inland Fisheries Research personnel during sampling in San Antonio in 1985-1988. Released specimens probably originated in the pet trade.
- Green swordtail (Xiphophorus helleri) were collected by TPWD Inland Fisheries Research personnel during collections in spring water tributaries of the San Antonio River within the San Antonio Zoo, Bexar County, in 1985-1988, and were still present there in 1990. Although green swordtail commonly hybridize with other xiphophorids raised in aquarium culture, specimens collected in San Antonio were in agreement with wild-type descriptions and demonstrated no phenotypic indication of contamination. These specimens likely originated from pet trade or public aquarium sources.

Family Atherinidae: Silversides

- Mexican silverside or charal comun (Chirostoma jordani) have been reported from Texas-Mexican border waters (Courtenay et al. 1984), probably based on collections by C. Hubbs (G.P.

Garrett, TPWD, Ingram, Texas; pers. comm.). This species probably originated from Mexican introductions as a possible aquacultural food fish.

Family Centropomidae: Snooks and Nile Perches

- Nile perches (Lates spp.) of four species, including L. angustifrons, L. mariae, L. microlepis and L. niloticus, were imported from Africa by TPWD for study as predatory game fishes in 1975 (Howells and Garrett In press). Victor Braunig Reservoir, Bexar County, was stocked with 14 L. niloticus in 1979 and 98 L. mariae in 1984; Coletto Creek Reservoir, Goliad County, received approximately 68,000 L. angustifrons and L. mariae in 1981; and Fairfield Reservoir, Freestone County, was stocked with 1,310 L. mariae in 1983. None of these stockings produced enduring populations. Work with these species ended in 1985 and the remaining 14 individuals (two L. angustifrons, six L. mariae and six L. niloticus) were stocked in Smithers Reservoir, Fort Bend County. A dead individual was found there in 1990 suggesting other specimens could still survive; however, none are otherwise believed present in state waters.

Family Percichthyidae: Temperate Basses

- Striped bass (Morone saxatilis) were reported in the last century from Gulf of Mexico waters along the Texas coast, but no established spawning populations were documented from state waters. Striped bass were imported from South Carolina in 1965 for use as game fish in reservoir stocking programs, and they have been widely stocked since. A reproducing population is established in Lake Texoma on the Oklahoma border, and spawning has been detected elsewhere within the state as well.

Family Centrarchidae: Sunfishes

- Rock bass (Ambloplites rupestris) were originally imported and stocked by the U.S. Bureau of Fisheries in the 1800's, with additional stocking efforts by the Texas Game and Fish Commission in the 1940's, presumably as a game fish. Hubbs (1961) reported it as present in central Texas, and specimens were collected in the San Marcos River, Hays County, and several other water bodies in 1990 by TPWD Inland Fisheries Research personnel indicating continued existence.
- Redbreast sunfish (Lepomis auritus) from the Atlantic coastal drainage were introduced into Texas (Knapp 1953; Lee 1980); importation presumably reflected its importance as one of the larger lepomid pan fishes.
- Smallmouth bass (Micropterus dolomieu) were imported and stocked as a game fish by TPWD in the early 1970's, with numerous introductions since (Guest 1985).
- Shoal Bass (Micropterus sp.) entered the state when a group of 29 individuals were imported and experimentally stocked in a

private pond in Kerr County in 1976 by TPWD; current status is undetermined.

Family Percidae: Perches

- Walleye (Stizostedion vitreum) introductions of this game fish by Texas Game and Fish Commission began in the 1950's, with subsequent stockings by TPWD at numerous locations around the state; populations are well established in several reservoirs and additional stockings have continued.
- Yellow perch (Perca flavescens) releases by TPWD began with introductions in Lake Meredith, Hutchinson County, in 1980, with subsequent stockings in four other smaller water bodies in the Texas panhandle thereafter. Yellow perch are established in Lake Meredith, and possibly elsewhere. Introductions probably represented value as a panfish or game fish to compliment other cooler water species like walleye and smallmouth bass.

Family Sciaenidae: Seatrouts

- Orangemouth corvina (Cynoscion xanthalmus) were obtained from the Salton Sea, California by TPWD for study as a game fish with subsequent introductions in two Texas reservoirs (Victor Braunig and Calaveras reservoirs, Bexar County); its hybrids (with spotted seatrout, C. nebulosus) were also stocked in Calaveras Reservoir (Howells 1991a; Howells and Garrett In press). Although fish are still being taken by anglers, neither reproduction nor escape from these impoundments is likely, and fishing and natural mortalities are expected to eliminate the remaining individuals within the next few years.

Family Cichlidae: Cichlids

- Oscar (Astronotus ocellatus) have been represented by several specimens taken by anglers in recent years; however, no spawning or established populations are known. Field-collected specimens likely represent aquarium releases.
- Peacock cichlids (Cichla ocellaris and C. temensis) were stocked in four Texas reservoirs (1978-1984) as game fish by TPWD, and although some individuals did survive for brief periods, most introductions appear to have failed because of hot or cold temperature extremes; none are presently known to be present in state waters (Garrett 1982; Howells and Garrett In press).
- Blue tilapia (Tilapia aurea) first appeared in state waters in the 1960's apparently from fish farm and bait bucket releases, and have become the most widely established tilapia species in Texas, especially in power-plant reservoirs and other thermally-stable water bodies. (Howells 1991b; Muoneke 1988).
- Mozambique tilapia (T. mossambica) were first found in spring waters within the San Antonio Zoo, Bexar County, in the late 1950's (Brown 1961); although later transferred to the San

Marcos River and to Canyon Reservoir, Comal County, those populations now appear to represent blue tilapia x Mozambique tilapia hybrids (Howells 1991b). The San Antonio Zoo population was still present in 1990. The initial introduction reflected escape of specimens from the zoo aquarium (Brown 1961).

- Redbelly tilapia (*T. zilli*) were first reported from spring waters within the San Antonio Zoo, Bexar County, in 1978 (Hubbs 1982), where they were still present when last examined by TPWD Inland Fisheries Research personnel in 1990. This species has not expanded its range to other locations since its original introduction (Howells 1991b). The source of the introduction is unconfirmed, but they may have escaped from the zoo aquarium as did Mozambique tilapia.

Gastropods

Family Ampullariidae (Pilidae): Apple Snails

- Giant ramshorn snails (*Marisa cornuarietis*) were not listed in Burch's (1989) recent review of North American freshwater gastropods as present in Texas; however, they have been present in the San Marcos River, Hays County, and Comal River, Comal County, for several years. Introductions may have arisen from pet trade specimens (sold as *M. rotula*) or university research sources. This snail was still present at both locations in 1991. Note that Burch (1989) and Turgeon et al. (1988) differ on family affinities.

Family Thiaridae: Melanias

- Red-rimmed melania (*Melanoides tuberculatus*) were listed as present in Texas by Murray (1964) and Dundee (1974), and were collected by TPWD personnel in the San Marcos River in 1991. Murray (1976) also reported their presence in Las Moras Creek, Bracketville, Kinney County. Introduction could have come from the pet trade.
- Quilted melania (*Thiara granifera*) were listed as present in Texas by Murray (1964), and were collected by TPWD personnel in the San Marcos River in 1991. Introduction could have come from the pet trade. Note that Turgeon et al. (1988) and Burch (1989) differ on the generic identification.

Family Physidae: Physas or Pond Snails

- Marbled aplexa (*Stenophysa marmorata*) were listed as present in Texas by Te (1978); present status is undetermined. Source of introduction is unknown, but they could have come from the pet trade.
- Tawny aplexa (*S. maugeriae*) were listed as present in Texas by Te (1978); present status is undetermined. Source of introduction is unknown, but they could have come from the pet trade.

Pelecypods

Family Corbiculidae: Asiatic Clams

- Asiatic clam (Corbicula sp. or spp.) were first reported in Washington in 1938, spread south through California and east along the Gulf states, up the Ohio and Tennessee River Valleys, and ultimately to the east coast of Virginia by 1972 (Diaz 1974). Their entry into various river systems in Texas is largely undocumented, but they are now widely distributed and were observed present in numerous waters by TPWD biologists in 1990. Corbicula in U. S. waters have been identified as C. manilensis and C. fluminea, with the additional suggestion that more than one species may actually be involved. Although Turgeon et al. (1988) recognized only C. fluminea, specific identification of Texas specimens might be best reserved until taxonomic confusion is resolved.

Crustaceans

Family Penaeidae: Penaeid Shrimps

- Mexican White Shrimp (Penaues vannamei) were collected by a commercial shrimp trawler in 1989 off Brownsville, Cameron County, and reportedly represented a sizable portion of his catch; however, following extremely cold winter temperatures in December 1989 and January 1990, no additional specimens have been reported (T.L. King; TPWD, pers. comm.). Several shrimp culture facilities in Texas maintain this species and it is likely these specimens represented individuals released from such facilities.

Aquatic Plants

Family Parkeriaceae: Water Sprite Ferns

- Water sprite (Ceratopteris thalictroides) were listed by Correll and Correll (1972) as introduced at San Marcos (also found in New Braunfels by TPWD in 1990), by Hatch et al. (1990) as introduced and by Reed (1988b) as native. The species is widespread in the Northern Hemisphere and it may be questionable whether it occurred naturally in Texas. Two other water sprites, C. pteridoides and C. deltoidea may have also been introduced but taxonomy and field identification records are confusing.

Family Potamogetonaceae: Pondweeds

- Curled or curlyleaf pondweed (Potamogeton crispus), which are native to Europe, have been introduced in Texas (Reed 1988b).

Family Posidoniaceae: Posidonias

- Oceanic posidonia (Posidonia oceania) were listed by Reed (1988b) and Correll and Johnson (1970) as an introduced aquatic

plant in Texas; however, Hatch et al. (1990) failed to list them.

Family Butomaceae: Flowering-Rushes

- Water-poppy (Hydrocleys nymphoides) are native to Brazil and were introduced in Texas (Reed 1988b).

Family Hydrocharitaceae: Frog-bits

- Egeria or Brazilian elodea (Egeria densa) was listed by Reed (1988a, 1988b) as native in Texas; however, Correll and Correll (1972) and many other sources consider it native to South America.
- Hydrilla or African elodea (Hydrilla verticillata) are native from East Africa north into eastern Europe (Rataj 1979). Hatch et al. (1990) listed this species as native to Texas, but Correll and Correll (1972), Reed (1988a, 1988b) and most other authorities consider it to have been introduced here.
- Ottelia (Ottelia alismoides) were listed by Hatch et al. (1990) as introduced in Texas.

Family Gramineae: Grasses

Correll and Correll (1972), Reed (1988a, 1988b), Hatch et al. (1990) and others listed numerous introduced genera and species in this family. Lists by Reed (1988a, 1988b) placed grasses in their own grouping and did not consider them aquatic plants. None the less, several species which may be closely associated with aquatic conditions, and related species in the genus, are listed here.

- Common reed (Phragmites sp[p].) are sometimes listed as P. communis or P. australis, and also as introduced in Texas or cosmopolitan. Both Reed (1988b) and Hatch et al. (1990) listed P. australis as native in Texas.
- Water bentgrass (Agrostis semiverticillata) are listed as introduced in Texas by Reed (1988b), but are native to the Old World (Correll and Correll 1972).
- Torpedo grass (Panicum ripens) which were listed by Reed (1988b) as introduced in Texas are native to Australia. Hatch et al. (1990) listed over 30 species found in the genus in Texas, of which six additional less-aquatic species were introduced (P. antidotale, P. coloratum, P. maximum, P. miliaceum, P. pilcomayense and P. purpurescens).

Family Cyperaceae: Sedges

- Variable flatsedge (Cyperus difformis) were reported by Correll and Correll (1972) as introduced in Texas and native to Asia, but listed by Hatch et al. (1990) as native to Texas.
- Alternate-leaf flatsedge or umbrella sedge (C. alternifolius) were listed by Reed (1988b) as introduced in Texas, and are native to the Old World.
- Purple flatsedge or nut grass (C. rotundus) were listed by Reed (1988b) as introduced in Texas, and are native to Eurasia.

Family Araceae: Arums

- Sweet flag (*Acorus calamus*) are native to Europe, and have been introduced in Texas (Reed 1988b).
- Water lettuce (*Pistia stratiotes*), which are restricted by TPWD as an exotic plant in Texas, were listed as native by Reed (1988a, 1988b) and Hatch et al. (1990) as native to the state. The species is also known from the fossil record from the Upper Cretaceous of Wyoming and North Carolina (Stoddard 1989); however, other botanists have questioned whether water lettuce is native to North America or a more recent reintroduction (Stoddard 1989). Based on U.S. Fish and Wildlife Service and Texas A&M University publications, and on the fossil record, water lettuce might best be considered native to Texas. Water lettuce have been collected in the San Marcos River, Comal County, by TPWD Inland Fisheries Research biologists, and have achieved noxious levels in Dunlap Reservoir, Guadalupe County, where treatment with herbicide was required (N.J. Johnson; TPWD, pers. comm.).
- Colocasia (*Colocasia esculenta*) were reported as introduced in Texas by Hatch et al. (1990).
- Elephant-ear (*Xanthosma sagittifolium*) were reported as introduced in Texas by Hatch et al. (1990).

Family Lemnaceae: Duckweeds

- Giant duckweeds (*Spirodela polyrhiza* and *S. oligorhiza*) may have been introduced in Texas from more southern waters, or may have been native; however, Lachner et al. (1972) indicated *S. oligorhiza* from Australia and Asia originally entered California in 1930. Both are listed as native in Texas by Hatch et al. (1990), but Reed (1988a, 1988b) reported *S. polyrhiza* was introduced here.

Family Pontederiaceae: Pickerel Weeds

- Floating or common water-hyacinth (*Eichhornia crassipes*) are native to South America; Reed (1988b) reported this species as native in Texas, but other references do not agree.
- Rooted or saw-petal water-hyacinth (*E. azurea*) are native to South America. Hatch et al. (1990) indicated previous reports of this species in Texas were incorrect (e.g., Correll and Correll 1972; Reed 1988a, 1988b). Further, specimens of *E. crassipes* observed by TPWD staff growing under abnormal conditions occasionally root in mud after water recedes and produce poorly inflated petioles which resemble those of *E. azurea*, suggesting the potential for misidentification.

Family Iridaceae: Irises

- Yellow-flag (*Iris pseudacorus*) were native to Eurasia and Africa, and have been introduced in Texas (Reed 1988b). Additionally, shortstem iris (*I. brevicaulis*) were listed by Hatch et al. (1990) as introduced, but may be unlikely to occur in aquatic situations.

Family Salicaceae: Willows

- Crack willow (Salix fragilis) are native to Europe. Vines (1976) did not list them as present in Texas, but Hatch et al. (1990) listed them as introduced here.
- Babylon weeping willow (S. babylonica) are native to China, and have been widely planted in Texas (Vines 1976).
- White poplar (Populus alba) and black poplar (P. nigra) have been introduced in Texas (Hatch et al. 1990), but typically occur in more upland situations.

Family Polygonaceae: Knotweeds

- Queen's wreath (Antigonon leptopus) were listed by Hatch et al. (1990) as introduced in Texas.
- Sheep sorrel (Rumex acetosella) were listed by Hatch et al. (1990) as introduced in Texas.
- Yellow dock (R. crispus) were listed by Reed (1988b) as introduced in Texas, and are native to Eurasia.
- Clustered dock (R. conglomeratus) were listed by Reed (1988b) as introduced in Texas, and are native to Europe.
- Narrow-leaf dock (R. stenophyllus) are native to Eurasia. They were listed by Correll and Correll (1972) and Reed (1988a, 1988b) as introduced in Texas, but not by Hatch et al. (1990).
- Bitterdock (R. obtusifolius) were listed as native to Europe by Correll and Correll (1972) and as introduced in Texas by Reed (1988a, 1988b), but considered native to Texas by Hatch et al. (1990).
- Fiddle dock (R. pulcher) were listed by Reed (1988b) as introduced in Texas, and are native to the Mediterranean.
- Black bindweed or dullseed cornbind (Polygonum convolvulus) were listed by Reed (1988b) as introduced in Texas, and are native to Europe.
- Silver-sheath knotweed or Persian wiregrass (P. argyrocoleon) were listed by Reed (1988b) as introduced in Texas, and are native to the Middle East.
- Prostrate knotweed or wiregrass (P. aviculare) were listed as native to Europe (Correll and Correll 1972) and as introduced in Texas by Reed (1988a, 1988b), but considered native in Texas by Hatch et al. (1990).
- Willow-weed or willow smartweed (P. lapathifolium) were listed as native to Europe by Correll and Correll (1972) but as native in Texas by Reed (1988a, 1988b) and Hatch et al. (1990).
- Princess- or Prince's-feather (P. orientale) were reported as native to Europe and used as cultivated plants (Correll and Correll 1972), and listed as introduced in Texas by Reed (1988b), but not listed by Hatch et al. (1990) as either native or introduced.
- Lady's thumb (P. persicaria) were listed by Reed (1988b) as introduced in Texas, and are native to Europe.

Family Amaranthaceae: Amaranths

- Alligatorweed (Alternanthera philoxeroides) were listed as

Family Euphorbiaceae: Spurges

- Marsh caperonia (Caperonia palustris) were reportedly introduced into Texas about 1920 (Correll and Correll 1972); they were also listed as introduced in Texas by Reed (1988b), but as native by Hatch et al. (1990).

Family Callitrichaceae: Water Starwarts

- Larger water starwart (Callitriche heterophylla) were listed by Reed (1988b) as introduced in Texas, but by Hatch et al. (1990) as native.

Family Tamaricaceae: Tamarisks

- African tamarisk (Tamarix africana) were listed by Reed (1988b) as introduced in Texas, and are native to Europe and the Mediterranean.
- Athel tamarisk (T. aphylla) were listed by Reed (1988b) as introduced in Texas, and are native to Africa and the Middle East.
- Tamarisk (T. articulata) were listed as a reported but unconfirmed exotic introduction in Texas by Hatch et al. (1990).
- Chinese tamarisk (T. chinensis) were listed by Reed (1988b) as introduced in Texas, and are native to Asia.
- French tamarisk (T. gallica) were listed by Reed (1988b) as introduced in Texas, and are native to Europe.
- Small-flower tamarisk (T. parviflora) were listed by Reed (1988b) as introduced in Texas, and are native to the Mediterranean.
- Salt cedar (T. ramoissima) were listed by Reed (1988b) as introduced in Texas, and are native to Europe.

Family Onagraceae: Evening Primroses

- Ludwigia (Ludwigia spp.) including several exotic species are sold in the pet trade and therefore could be present in Texas; however, confirmed introductions here are lacking.

Family Haloragaceae: Watermilfoils

- Parrotfeather or Brazilian watermilfoil (Myriophyllum braziliense or M. aquaticum) were listed by Reed (1988b) as introduced in Texas, and are native to South America.
- Eurasian watermilfoil (M. spicatum) are native to Eurasia (Correll and Correll 1972). Both Reed (1988a, 1988b) and Hatch et al. (1990) listed M. spicatum as native to Texas based on considering American watermilfoil "exalbescens" as a subspecies (M. s. exalbescens). However, recent discussions with a number of botanists throughout the United States indicated all presently agree M. spicatum and M. exalbescens are both considered valid species, but M. exalbescens is probably not present in Texas. Therefore M. spicatum is listed here as an introduced and established exotic plant.

Family Gentianaceae: Gentians

- Yellow floating-heart (Nymphoides peltata) were listed by Hatch et al. (1990) as introduced in Texas, and are native to Europe.

introduced in Texas by Correll and Correll (1972) and Reed (1988b), and are native to South America. Two other less-aquatic species, pungent amaranth (A. pungens) and A. tenella were also listed by Hatch et al. (1990) as introduced in Texas.

Family Lythraceae: Loosestrifes

- Purple loosestrife (Lythrum salicaria) were listed as introduced in Texas by Reed (1988b), and are native to Europe. Although often recognized as a flower-garden species, news reports indicate purple loosestrife has dominated marshes along the Great Lakes in recent years; however, the species appears not to have been reported as problematic in Texas.

Family Nymphaeaceae: Water-lilies

A number of exotic genera, species and hybrids (Nymphaea, Nuphar, Nelumbo) are cultivated, occasionally under semi-natural conditions. Although none are formally listed as established in Texas at this time, escape from culture may be possible in the future.

Family Ranunculaceae: Crowfoots

- Creeping buttercup (Ranunculus repens), a cultivated species, were listed by Correll and Correll (1972) and Reed (1988a, 1988b) as introduced in Texas, but by Hatch et al. (1990) as native in Texas.
- Crowfoot (R. acris) are native to the Old World. They were listed by Correll and Correll (1972) as introduced in Texas, but not by Reed (1988b) or Hatch et al. (1990).
- Smallflower buttercup (R. parviflorus) were listed by Reed (1988b) as introduced in Texas, and are native to the Old World.
- Hairy buttercup (R. sardous) were listed by Reed (1988b) as introduced in Texas, and are native to the Old World.
- Spiny-fruit, spring or roughseed buttercup (R. muricatus) were listed by Reed (1988b) as introduced in Texas, and are native to the Old World.
- Buttercup (R. marginatus) were listed by Hatch et al. (1990) as introduced in Texas.
- Buttercup (R. platensis) were listed by Hatch et al. (1990) as introduced in Texas.

Family Cruciferae: Mustards

- Water-cress (Rorippa nasturtium-aquaticum) are native to Europe. They were listed by Correll and Correll (1972) and Hatch et al. (1990) and by the synonym Nasturtium officinale by Reed (1988b) as introduced in Texas.

Family Leguminosae: Legumes

- Water neptune or floating neptunia (Neptunia plena) were reported as collected in Texas, but as "not persistent" (Correll and Correll 1972) and "not established" (Hatch et al. 1990); they are native to South America and the West Indies. This species was also listed by Reed (1988b) as native to Texas.

Numerous domestic strains and hybrids are cultured in semi-wild conditions, but confirmation of established populations is lacking.

Family Hydrophyllaceae: Waterleafs

- False baby-blue-eyes (Ellisia nyctelea) were listed as reportedly introduced in Texas from surrounding states by Correll and Correll (1972), but were considered native by Reed (1988b) and Hatch et al. (1990).

Family Labiatae: Mints

Mints and their relatives rarely grow in aquatic environments but are included here because many are found in moist areas adjacent to water.

- Beefsteak plant (Perilla frutescens) were listed by Correll and Correll (1972) as introduced in Texas, and are native to India.
- Applemint or roundleaf mint (Mentha rotundifolia) were listed by Correll and Correll (1972) as introduced in Texas, and are native to Europe.
- Spearmint (M. spicata) were listed by Correll and Correll (1972) as introduced in Texas, and are native to Europe.
- Peppermint (M. piperita) were listed by Correll and Correll (1972) as introduced in Texas, and are native to Europe.
- Catnip (Nepeta cataria) were listed by Correll and Correll (1972) as introduced in Texas, and are native to the Old World.

Family Scrophulariaceae: Figworts

- Asian marshweed (Limnophila sessiliflora) are native to Asia; Lachner et al. (1970) reported this and L. indica present in Texas, but Reed (1988b) and Hatch et al. (1990) listed only L. sessiliflora.
- Brook-pimpernel or water speedwell (Veronica anagallis-aquatica) were listed as introduced in Texas by Correll and Correll (1972) and Hatch et al. (1990), and are native to Eurasia; they were listed as native here by Reed (1988b).

SUMMARY

Among 41 species of fish not native to Texas, 68% (28) were initially imported and released by either federal or state fish and wildlife agencies, though often with other introductions from other sources at later dates. Three species (7%), blue tilapia, bighead carp and rudd, were originally introduced from fish farm/bait fish sources; six species (15%) almost certainly originated from home aquaria; and five species (12%) apparently arose from public aquarium and zoo origins. Common carp, walleye, smallmouth bass, blue tilapia and yellow perch are well established. Goldfish are commonly found in many waters but typically not in exceptionally large populations. Blueback herring are present at two locations, rainbow trout are established at a single site and northern pike and muskellunge may occur in small numbers at several locations. Suckermouth catfish, green swordtail, Mozambique tilapia and redbelly tilapia collectively occur at a single site,

although an additional location has recently been reported for suckermouth catfish. Rock bass apparently occur in limited numbers in several areas. Orangethroat corvina are still present in two reservoirs (its hybrid with spotted seatrout is also found in one of these). Striped bass are widely distributed, although most striped bass populations are maintained through stocking. Grass carp from a stocking near Houston are still taken in field collections, as are specimens from illegal stockings and TPWD research studies which occur at several locations; additionally, hybrid grass carp have also been stocked for TPWD research studies at a number of sites. A small number of Nile perch could still exist in a single reservoir. Rudd from bait bucket releases and pacus and oscars from aquarium releases appear sporadically, but have never been recorded in large numbers. American shad, other salmonids, ide, tench, pike killifish, guppy, Mexican silverside, white perch and peacock cichlids are apparently no longer present in Texas waters. The status of shoal bass is undetermined and the status of Mexican molly is unknown; however, local anglers have indicated the shoal bass population was destroyed during flooding of the stocking site.

At least five gastropods and one pelecypod have been introduced into Texas waters. Sources of origin are poorly documented, but the snails could have originated in the pet trade as direct imports or inadvertently on aquarium plants. The spread of Asiatic clam across Texas is well recognized but largely undocumented.

The collection of Mexican white shrimp by a commercial shrimper probably resulted from an inadvertent release from shrimp culture facilities nearby where several exotic penaeid shrimps are produced. Extreme cold shortly after the collection may have eliminated them from Texas waters. However, aquacultural production of non-native penaeids in Texas may be a potential source for additional escapes or releases in the future.

The number of introduced aquatic and semiaquatic plants in Texas is difficult to define. Not only are numerous species involved and taxonomy sometimes confused, but sources of origin are often unknown. Typically, introduced organisms are those that have been released into natural setting directly or indirectly by man; however, many plants exist in semi-cultivated or semi-domestic conditions which makes determination of status as "introduced", or not, highly qualitative. Further, natural range extensions, as in situations where animals distribute seeds, are generally not considered introductions; how a particular plant came to be present in an area is often undocumented and unknown. None the less, nearly 70 non-native plant species from wetland and aquatic environments were likely introduced into Texas.

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