U.S. Fish & Wildlife Service

Mozambique Tilapia (*Oreochromis mossambicus*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, April 2011
Revised, August 2014, July 2015, February 2018, March 2018
Web Version, 4/9/2018

Photo: Greg Hume. Licensed under Creative Commons BY-SA 3.0. Available: https://commons.wikimedia.org/wiki/File:Oreochromis_mossambicus.JPG.

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2018):

"Africa: Lower Zambezi, Lower Shiré and coastal plains from Zambezi delta to Algoa Bay. Occurs southwards to the Brak River in the eastern Cape and in the Transvaal in the Limpopo system [de Moor and Bruton 1988]."

Froese and Pauly (2018) list *Oreochromis mossambicus* as native to Botswana, Lesotho, Malawi, Mozambique, South Africa, Swaziland, and Zimbabwe.

From Russell et al. (2012):

"The natural distribution of *O. mossambicus* in Africa is somewhat confused because of its wide translocation but is generally thought to be restricted to eastward-flowing streams extending from the lower Zambezi River and its delta and the lower Shire River southwards to Algoa Bay and the Bushmans River (Jubb 1974; Pullin and Lowe-McConnell 1980; Shelton and Popma 2006; Trewavas 1983). Populations also exist in the Hunyani and Shangani Rivers and the middle Zambezi River drainage but whether these are native or introduced is unclear (Jubb 1974; Shelton and Popma 2006)."

CABI (2018) lists *Oreochromis mossambicus* as native in Botswana, Lesotho, Malawi, Mozambique, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.
CABI (2018) also lists *O. mossambicus* as native in East Timor, Jordan, Kenya but these locations are thought to be errors since they are outside the native range indicated by all other sources (Cambray and Swartz 2007; Russel et al. 2012; Froese and Pauly 2018; GSID 2018).

Status in the United States

From Nico and Neilson (2018):

"Established or locally established in seven states including Arizona, California, Colorado, Florida, Hawaii, Idaho, and Texas. Formerly considered locally established but no longer extant in Georgia, Montana, and North Carolina. Reported from Alabama, Illinois, and New York."

"This species was stocked annually by the Alabama Department of Conservation and Auburn University in lakes and farm ponds in Alabama during the late 1950s and 1960s (Rogers 1961; Smith-Vaniz 1968), but such stockings reportedly have not been carried out for some time now (Wieland et al. 1982). Boschung (1992) reported Mozambique tilapia from Pickwick Lake in the northwestern part of the state. However, Mettee et al. (1996) did not mention the species as still occurring in Alabama. The species was introduced into several agricultural drains and mitigation ponds in Arizona near Yuma, Yuma County, and has been considered established in the state since the early 1960s (Hoover and St. Amant 1970; Hoover 1971; Minckley 1973; Courtenay et al. 1986). The species also occurs and is established in the Colorado River drainage, mainly the Gila River, from Phoenix to just north of Yuma (Minckley 1973; Lee et al. 1980 et seq.; Courtenay and McCann 1981; Barrett 1983; Grabowski et al. 1984; Courtenay et al. 1986). Populations established at Warm Springs on the San Carlos River, in Gila and Graham counties, and in the Salt River in Tempe, Maricopa County, reportedly were destroyed by floods (Minckley 1973). Populations are established in Bill Williams National Wildlife Refuge and in springs in The Nature Conservancy's Ramsey Canyon Preserve in the Huachuca Mountains (USFWS 1997, 2005). The first record of this species in California was that of a population found in a small pond and its tributary near the Hot Mineral Spa on the east side of the Salton Sea near Niland, Imperial County, on 3 January 1964; more than 5,000 tilapia in the pond were killed with rotenone in an eradication attempt (St. Amant 1966). The species is now broadly established in the southern part of the state and has been in the Santa Ana, San Gabriel, and Los Angeles rivers since 1974 (St. Amant 1966; Hoover and St. Amant 1970; Moyle 1976; Knaggs 1977; Lee et al. 1980 et seq.; Shapovalov et al. 1981; Courtenay et al. 1984, 1991; Grabowski et al. 1984; Courtenay and Robins 1989; Swift et al. 1993). Two specimens were taken from Lake

Success in the San Joaquin Valley, Tulare County, in 1989 (Heyne et al. 1991). This species is also established in Riverside and Imperial Counties (Shapovalov et al. 1981). The species was found to be locally established in high-altitude, warmwater ponds in Colorado in the Upper Rio Grande River system in Conejos County, in 1977. These fish had escaped from a local farm where they were being cultured for food in warm artesian waters at a 7,500-ft elevation (Zuckerman and Behnke 1986). They are established in the San Luis Valley, Alamosa County (Courtenay et al. 1986). The Mozambique tilapia was first introduced into and became established in Florida in Dade County during the 1960s (Courtenay and Stauffer 1990). It is now established or has been reported in five counties including Brevard, Dade, Indian River, Palm Beach, Lee and possibly Hillsborough (Ogilvie 1969; Courtenay et al. 1974, 1984, 1986, 1991; Hogg 1976a, 1976b; Courtenay and Hensley 1979; Courtenay and McCann 1981; Dial and Wainright 1983; Loftus and Kushlan 1987; Charlotte Harbor NEP 2004). Reports of this species from Six-Mile Creek, Hillsborough County (Courtenay et al. 1974), were probably based on misidentifications of *O. aureus* (Courtenay and Hensley 1979). It has also been collected in Everglades National Park (Tilmant 1999). Specimens have been reported the Everglades drainage (Hogg 1976[b][).] Individuals of this species were released into a pond in Georgia near Athens, but failed to survive (Dahlberg and Scott 1971b). It was indicated that this tilapia may be established in golf course ponds on Sea Island and St. Simons Island, Glynn County (Courtenay and Hensley 1979; Courtenay et al. 1986); however, *O. mossambicus* was not collected on St. Simons Island during 1980 sampling efforts and as of 1992 the Georgia Department of Natural Resources had concluded that this species was no longer present in state open waters (Gennings, personal communication). This species is established and has large populations in many streams, estuaries, low wetlands, and reservoirs or ponds of Hawaii; it is found on all the major islands including Oahu, Kauai, Maui, Hawaii, and Molokai (Brock 1960; Maciolek 1984; Randall 1987; Devick 1991a, 1991b; Bishop Museum 2000; Coles 1999). It is established in Pu'uhonua o Honaunau National Historical Park (Courtenay 1989; B. Farm, personal communication; Tilmant 1999). A reproducing population was found in Idaho in Barney Hot Springs and at the upper end of Barney Creek in Custer County, Little Lost River Valley, in September 1985 (Courtenay et al. 1987). The species was listed by Idaho Fish and Game (1990) as being introduced into and confined to geothermal waters of the Snake River below Shoshone Falls. A red hybrid of this species, possibly a cross between *O. mossambicus* and *O. urolepis*, was found in thermally heated sections of the Bruneau River near Bruneau Hot Springs, Owyhee County, after it had escaped from a local aquaculture facility (Courtenay et al. 1987; Courtenay and Stauffer 1990). This species was introduced into ponds in Illinois, probably during the early 1960s, but there was no evidence of overwintering (Smith 1965). Specimens were reported inArrowhead [sic] Pond, Allerton Park of the University of Illinois near Monticello and were taken indoors over the winter (Courtenay et al. 1986). Four specimens were taken from a high-altitude, thermal spring fed pond of the Pend Orielle drainage in Montana in Bearmouth, Granite County, during 1962-1963 surveys (Brown and Fox 1966), but the pond habitat was later destroyed during highway construction (Brown 1971; Courtenay et al. 1986). In North Carolina, the species was introduced into and temporarily established in the Julian Reservoir (formerly Skyland Lake) in French Broad-Tennessee drainage, south of Asheville, Buncombe County, in 1965 (Courtenay and Hensley 1979), but that population reportedly did not survive beyond the early 1970s (Courtenay et al. 1986). There are unconfirmed reports that this species was introduced into Hyco Reservoir, Roanoke River drainage, in Person and Caswell counties (Menhinick 1991, but see Crutchfield 1995). In New York, a single adult fish was seined by state personnel from Hall's Pond in Hall's

Pond Park, West Hempstead, Nassau County, in the summer of 1976 (Briggs, personal communication). Probably in reference to the same collection, the species was reported as having been collected in the state by Lee et al. (1980 et seq.). This species has been found in Texas in the headwaters of the San Antonio River within the San Antonio Zoo, in Bexar County, since the late 1950s; the first specimen-based record was of a juvenile fish trapped in the San Marcos River in San Marcos, Hays County, in 1959 (Brown 1961). Populations of this species have been identified from several areas along the Balcones fault zone, including tributaries of the San Antonio River within and near the San Antonio Zoo; at the Spring Lake headwaters and in the vicinity of the state fish hatchery of the San Marcos River; and in Canyon Reservoir on the Guadalupe River (Brown 1961; Hubbs et al. 1978, 1991; Muoneke 1988; Howells 1991, 1992a, 1992b).

Oreochromis mossambicus has been introduced to Puerto Rico to control algae (Erdsman 1984). It has been reported from mangrove lagoons, creeks, and bays on both eastern and western portions of the island (Burger et al. 1992), and from other non-specific locations (Lee et al. 1983). […]"

From Russell et al. (2012):

"Canonico et al. (2005) reported that a *O. mossambicus* X *O. urolepis hornorum* hybrid, a popular aquaculture species in the Americas, is established in the wild with a large self-sustaining population in the Salton Sea (Costa-Pierce and Riedel 2000). *Oreochromis mossambicus* and *O. u. hornorum* hybrids are also reported to be established in other parts of the United States (Costa-Pierce 2003)."

From Froese and Pauly (2018):

"Introduced into freshwater ponds [in the U.S. Virgin Islands] [Ogden et al. 1975]."

"Introduced and is quite abundant in the swampy areas of Aunu'u Island [American Samoa] [Wass 1984]. Also [Welcomme 1988]."

"Well established in all the major islands of Hawaii. […] Also [Frimodt 1995; Mundy 2005]."

GISD (2018) lists *Oreochromis mossambicus* as alien and established in American Samoa, Guam, Northern Mariana Islands (Pagan and Saipan islands), Puerto Rico, Hawaii, California, and Arizona,

From GISD (2018):

"Mozambique tilapia (*Oreochromis mossambicus*) aquaculture is restricted to southern California below the Tehacapi Mountains in San Bernadino, Los Angeles, Orange, Riverside, San Diego and Imperial counties [Costa-Pierce 2003]."

Means of Introductions in the United States

From Nico and Neilson (2018):

"Similar to *O. aureus*, this species has been introduced for a wide variety of reasons. Most introductions have been the result of intentional stockings for aquatic plant control by state and federal agencies and private companies, but introductions have also come about from stockings for potential use of the species as an insect control agent (e.g., to control mosquitoes and chironomids), as a sport fish, as a bait fish, and as a food or commercial fish, and through aquarium releases; the species also has been introduced through releases or escapes from fish farms, hatcheries, and zoos (Shapovalov et al. 1981; Dial and Wainright 1983; Courtenay et al. 1984, 1986; Grabowski et al. 1984; Courtenay and Stauffer 1990). This species was brought to Hawaii from Singapore in a small shipment of fish in 1951 (Brock 1960; Maciolek 1984; Randall 1987). The Mozambique tilapia was introduced with the expectation that it would be useful for aquatic plant control in irrigation systems, as a food fish, as a sport fish, and as live bait for tuna fishing (Brock 1960); results were only partially successful (Randall 1987). In California, introductions resulted from escapes or releases from fish farms and from intentional stocking by the state (Shapovalov et al. 1981). The Mozambique tilapia's initial introduction into Dade County, Florida, is believed to have been the result of escapes or releases from aquarium fish farms that cultured the species in the 1960s (Courtenay and Stauffer 1990). In some areas of Florida, this species may have been introduced by local anglers to create a commercial fishery (Dial and Wainright 1983), or intentionally stocked by aquarists (Courtenay and Stauffer 1990). In New York, introduction was probably due to aquarium release (Briggs, personal communication). In Texas, this species was introduced as a result of escapes from the San Antonio Zoo in 1956 and also from state and federal hatcheries during the late 1950s and early 1960s (Brown 1961; Courtenay and McCann 1981). Sources and reasons for many of the introductions have been reviewed by Courtenay and McCann (1981), Wieland et al. (1982), and Courtenay and Stauffer (1990)."

From GISD (2018):

"Mozambique tilapia (*Oreochromis mossambicus*) were introduced to Puerto Rico to control algae."

Remarks

From Nico and Neilson (2018):

"Some records of this species apparently are based on incorrect identifications. For instance, recent electrophoretic evidence indicated that populations in the San Marcos River and in Canyon Reservoir were *O. mossambicus* x *O. aureus* hybrids (Howells 1991, 1992b). With the aid of W. Smith-Vaniz, we examined preserved juveniles catalogued as *O. mossambicus* from the San Marcos River (TCWC 2073.01) and determined them to be *O. aureus* based on their caudal fin patterns and scale and gill raker counts. Some California records of this species may actually be those of *O. urolepis* (= *O. hornorum*) or of hybrids between *O. mossambicus* and *O. urolepis* (Swift et al. 1993). […] *Oreochromis mossambicus* has largely replaced redbelly tilapia *Tilapia zillii* in the Salton Sea and possibly other areas in southern California (Swift et al. 1993)."

"Electrofishing was an effective way to remove adults from a population during a project in Australia, but the removal was met with questionable success because the number of juveniles greatly increased as the adult numbers decreased (Thuesen et al. 2011).

Bowen (1980) suggested that different detrital nonprotein amino acid concentrations may help to explain variable establishment success and growth of *O. mossambicus*."

From Cambray and Swartz (2007):

"Threatened by hybridization with the rapidly spreading *Oreochromis niloticus*. […] Hybridization is already occurring throughout the northern part of the species' range, with most of the evidence coming from the Limpopo River system. […] The species is therefore assessed as Near Threatened."

From Russell et al. (2012):

"Since tilapiine species have diverged from a relatively recent marine ancestor (Laurent and Jean-François 1995), some representatives of the group can hybridise and produce viable progeny. For example, hybridisation of *O. mossambicus* with *O. aureus* has been undertaken for aquaculture to improve cold tolerance (Cnaani et al. 2000), while crosses with genetically improved *O. niloticus* showed average positive heterosis for biomass gain (Kamal and Mair 2005). Hybridisation of *O. mossambicus* with *O. hornorum* can also lead to the production of all male progeny which are better suited for intensive aquaculture (Lovshin 1982). Many *O. mossambicus* populations established outside of their natural range are not of a 'pure' strain, but are rather hybrids."

From GISD (2018):

"Outside of Asia exotic tilapia fishes were not imported directly from Africa, but arrived as transits from third or fourth party sources. Founder populations may be morphologically and meristically distinct in Africa but are still reproductively compatible due to their recent divergence (Costa-Pierce, 2003)."

"The hybrids that are commercially cultured are tetrahybrids derived from *O mossambicus* × *O. urolepis hornorum* × *O. niloticus* × *O. aureus* [Jory et al. 1999]."

From Froese and Pauly (2018):

"[…] breeds with *O. andersonii* [Jackson 1961; Okeyo 2003]."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Eschmeyer et al. (2018):

"*mossambicus, Chromis* (Tilapia) Peters [W. (C. H.)] 1852:681 [Monatsberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin 1852; […]] Zambezi River, Mozambique [East Africa]. Syntypes: BMNH [ex Peters] 1861.5.2.58-59 (2), FMNH 54267 [ex CM 2898] (2) Mosambique; ZMB 2805-06 (2, 1), 16035 (3), 31564 (15). Type catalog: Ibarra & Stewart 1987:24 […]. •Valid as *Tilapia mossambica* (Peters 1852) -- (Lee et al. 1980:774 […], Uyeno & Fujii in Masuda et al. 1984:190 […], Wang 1984:105 […], Yu & Zhou in Kuang et al. 1986:256 […], Ye in Pan et al. 1991:415 […]). •Valid as *Sarotherodon mossambicus* (Peters 1852) -- (Pethiyagoda 1991:236 […], Indra 1991:242 […]). •Valid as *Oreochromis mossambicus* (Peters 1852) -- (Ortega & Vari 1986:20 […], Heemstra 1986:670 […], Kawanabe & Mizuno 1989:534 […], Allen & Coates 1990:89 […], Page & Burr 1991:334 […], Trewavas & Teugels 1991:325 […], Talwar & Jhingran 1991:887 […], Rema Devi 1992:359 […], Allen et al. 1992:301 […], Indra 1993:189 […], Kottelat et al. 1993:123 […], Rema Devi & Ilango 1993:250 […], Skelton 1993:325 […], Indra 1994:423 […], Zhu 1995:171, 205 […], Arthington & Cadwallader in McDowall 1996:179 […], Arun et al. 1996:103 […], Rainboth 1996:192 […], Rema Devi et al. 1996:142 […], Coad 1996:86 […], Zacharias et al. 1996:41 […], Cheng & Zhou 1997:310 […], Martin-Smith & Tan 1998:592 […], Manimekalan 1998:441 […], Marquet et al. 1999:43 […], Fricke 1999:362 […], Rema Devi & Raghunathan 1999[a]:158 […], Rema Devi & Raghunathan 1999[b]:173 […], Rema Devi et al. 1999:163 […], Fuller et al. 1999:439 […], Bijukumar & Sushama 2000:186 […] as *mossambica*, Lim in Randall & Lim 2000:625 […], Nakabo 2000:916 […], Laboute & Grandperrin 2000:73 […], Matsuura et al. 2000:215 […], Rafique 2000:327 […], Raju Thomas et al. 2000:444 […] as *mossambica*, Allen et al. 2000:159 […] as mossambica, Arunachalam et al. 2001:129 […] as mossambica, Sakai et al. 2001:102 […], Carpenter 2001:3336 […], Hutchins 2001:37 […], Wang et al. 2001:240 […], Skelton 2001:325 […], Allen et al. 2002:370 […], Keith et al. 2002:118 […], Nakabo 2002:916 […], Raju Thomas et al. 2002:51 […] as *mosambica*, Moyle 2002:417 […], Lim et al. 2002:86 […], Carpenter 2003:1693 […], Mirza 2003:24 […], Yadav 2003:24 […] as *mossambica*, Seegers et al. 2003:44 […], Tan & Lim 2004:110 […], Nelson et al. 2004:153 […], Larson & Pidgeon 2004:197 […], Bogutskaya & Naseka 2004:209 […], Grinang & Lim 2004:292 […], Mundy 2005:421 […], Allen et al. 2006:1437 […], Shestha 2008:220 […], Allen et al. 2008:196 […], Fricke et al. 2009:77 […], Scharpf 2009:9 […], Minckley & Marsh 2009:266 […], Matamoros et al. 2009:21 […], McCosker & Rosenblatt 2010:193 […], Page & Burr 2011:612 […], Marshall 2011:244 […], Page et al. 2013:156 […], Gurung et al. 2013:4885 […] as *mossambica*, Barriga S. 2012:118 […], Kottelat 2013:374 […], Yoshida et al. 2013:171 […], Smith-Vaniz & Jelks 2014:59 […], Fricke et al. 2014:111 […], Jiménez-Prado et al. 2015:337 […], Çiçek et al. 2015:152 […], Félix et al. 2016:D [4] […], Miesen et al. 2016:91 […], Zhang et al. 2016:213 […]). Current status: Valid as *Oreochromis mossambicus* (Peters 1852). Cichlidae: Pseudocrenilabrinae."

From ITIS (2018):

“Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Acanthopterygii
Order Perciformes
Suborder Labroidei
Family Cichlidae
Genus *Oreochromis*
Species *Oreochromis mossambicus* (Peters, 1852)”

Size, Weight, and Age Range

From Froese and Pauly (2018):

“Maturity: L_m 15.4, range 6 - 28 cm
Max length : 39.0 cm SL male/unsexed; [Wohlfarth and Hulata 1983]; common length : 35.0 cm TL male/unsexed; [Frimodt 1995]; max. published weight: 1.1 kg [IGFA 2001]; max. reported age: 11 years [Noakes and Balon 1982]”

From Nico and Neilson (2018):

“Size: 40 cm SL (Skelton 1993).”

From Masterson (2007):

“The maximum size of the *Oreochromis mossambicus* tends to vary based on its geographical location. Collections from within the native range indicate a maximum size of around 430 mm, while animals in the Gulf of Mexico measured a maximum of 360mm (Bruton and Allanson 1974, Lee et al, 1980).”

From Tachihara and Obara (2003):

“The maximum age of males was observed as 8.5years and females 14 years [on Okinawa Island, Japan]. […] The maximum ages in different populations of *O. mossambicus* varied with locality. The normal maximum age of the Genka population in both sexes (ca. 8 years) is reduced compared to that of the native South African population (11 years). It is similar to those of other introduced populations in tropical regions such as Egypt (7 years) and Lake Kariba (8 years) [Noakes and Balon 1982] and longer than populations in Australia (3 years) [Arthington and Milton 1986] and in temperate regions such as Hong Kong (4 years) [Noakes and Balon 1982].”

From Lintermans et al. (2007):

“The Mozambique mouthbrooder is a moderate-sized fish that attains a maximum total length of approximately 500 mm and 3 kg (Skelton 2001), but it is often much smaller and is known to form populations of stunted individuals with early sexual maturity (3 months, 50 mm TL).”

Environment

From Froese and Pauly (2018):

“Freshwater; brackish; benthopelagic; amphidromous [Riede 2004]; depth range 1 - 12 m [Bruton and Boltt 1975]. […]; 17°C - 35°C [assumed to be recommended aquarium temperature range] [Philippart and Ruwet 1982]; […]”

From Russell et al. (2012):

“Having evolved from a marine ancestor, *O. mossambicus* are considered to be one of the most saline tolerant of all the tilapiine species, tolerating salinities between 0 and 120‰ (Costa-Pierce and Riedel 2000; Myers 1938; Philippart and Ruwet 1982; Trewavas 1983; Whitfield and Blaber 1979).”

“*Oreochromis mossambicus* tolerates wide fluctuations in salinity, however, the species does not readily exploit open estuarine and near-shore marine areas.”

“In an experimental study, Stauffer (1986) found the preferred [water] temperatures of *O. mossambicus* acclimated to freshwater was 32.2°C which was significantly lower than the final preferred temperatures of fish acclimated at either 15 or 30‰ salinity. In freshwater, *O. mossambicus* experienced osmoregulatory collapse at 15°C (Smit et al. 1981) and lapsed into a secondary chill coma at 11°C (Allanson et al. 1971). *Oreochromis mossambicus* resident in areas of higher salinity appear to be able to tolerate lower temperatures. […] In laboratory studies, Allanson et al. (1971) found that *O. mossambicus* exposed to 11°C in 5‰ seawater did not lapse into a secondary chill coma nor did they display any drops in serum ionic concentrations.”

“*Oreochromis mossambicus* are tolerant of very low dissolved oxygen levels (e.g. <1 mg L^{-1}), at least for short periods, and they can apparently supplement their oxygen requirements by ‘‘gulping’’ air at the water surface (Maruyama 1958).”

“*Oreochromis mossambicus* show considerable tolerance to both high and low pH, with Murthy et al. (1981) reporting an upper lethal alkaline limit of pH 10.3 and a lower lethal acidic limit of pH 3.7. Sampath et al. (1991) reported that *O. mossambicus* could withstand ammonia concentrations of 3 mg L^{-1} without any significant adverse impact on food uptake or growth. The 96 h LC_{50} for ammonia was 32 mg L^{-1} and at concentrations below 14 mg L^{-1} they found 100% survival (Sampath et al. 1991).”

From Masterson (2007):

"Mozambique tilapia was found to have a lower lethal limit of 9.5°C under laboratory conditions (Shafland and Pestrak 1982). Trewevas (1983) similarly reported that *Oreochromis mossambicus* does not tolerate temperatures below 10°C. This temperature limits its distributional range, although some studies suggest the species may exploit thermal refuges similar to other cichlids such as the blue tilapia, *O. aureus*, to move somewhat further north (Hubbs et al. 1978)."

From Lintermans et al. (2007):

"The species survives in [water] temperatures between 8-42 °C, is active above 16 °C and breeds at temperatures of 20-24 °C (Mackenzie et al. 2001, Skelton 2001)."

Climate/Range

From Froese and Pauly (2018):

"Tropical; […]; 13°S - 35°S, 180°W - 180°E"

Distribution Outside the United States

Native

From Froese and Pauly (2018):

"Africa: Lower Zambezi, Lower Shiré and coastal plains from Zambezi delta to Algoa Bay. Occurs southwards to the Brak River in the eastern Cape and in the Transvaal in the Limpopo system [de Moor and Bruton 1988]."

Froese and Pauly (2018) list *Oreochromis mossambicus* as native to Botswana, Lesotho, Malawi, Mozambique, South Africa, Swaziland, and Zimbabwe.

From Russell et al. (2012):

"The natural distribution of *O. mossambicus* in Africa is somewhat confused because of its wide translocation but is generally thought to be restricted to eastward-flowing streams extending from the lower Zambezi River and its delta and the lower Shire River southwards to Algoa Bay and the Bushmans River (Jubb 1974; Pullin and Lowe-McConnell 1980; Shelton and Popma 2006; Trewavas 1983). Populations also exist in the Hunyani and Shangani Rivers and the middle Zambezi River drainage but whether these are native or introduced is unclear (Jubb 1974; Shelton and Popma 2006)."

CABI (2018) lists *Oreochromis mossambicus* as native in Botswana, Lesotho, Malawi, Mozambique, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.
CABI (2018) also lists *O. mossambicus* as native in East Timor, Jordan, Kenya but these locations are thought to be errors since they are outside the native range indicated by all other sources (Cambray and Swartz 2007; Russel et al. 2012; Froese and Pauly 2018; GSID 2018).

Introduced

Froese and Pauly (2018) list *Oreochromis mossambicus* as introduced to Algeria, Angola, Benin, Congo, Democratic Republic of Congo, Egypt, Kenya, Madagascar, Namibia, Réunion, Seychelles, Tanzania, Tunisia, Uganda, Andaman Island, Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Japan, Jordan, Laos, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Singapore, Sri Lanka, Taiwan, Thailand, Timor-Leste, Turkey, Vietnam, Yemen, Russia, Antigua Barbuda, Bahamas, Barbados, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Mexico, Netherland Antilles, Nicaragua, Panama, St. Lucia, Trinidad Tobago, Australia, Caroline Island, Cook Islands, Fiji, French Polynesia, Kiribati, Micronesia, Nauru, New Caledonia, Niue, Papua New Guinea, Samoa, Solomon Islands, Tahiti, Tonga, Vanuatu, Wallis Futuna, Bolivia, Brazil, Colombia, Guyana, Peru, Suriname, and Venezuela.

Froese and Pauly (2018) list *Oreochromis mossambicus* as introduced but not established in Cote d'Ivoire, Israel, South Korea, France, Malta, Argentina, and Ecuador.

From Froese and Pauly (2018):

"Introduction to north Egypt considered a complete failure [Philippart and Ruwet 1982]."

"Known from the lower course of the Ramisi River [Kenya] [Seeger et al. 2003]. Also reported from the lower Athi [Thys van den Audenaerde 1988] and the Tana River [Whitehead 1959], although this is probably at least part *O. spilurus spilurus* [Trewavas 1966]."

"Introduced to Lake Alaotra [Madagascar] in 1960 [Lever 1996] or 1961 [Lévêque 1997], and Lake Itasy in 1961-1962 [Lever 1996; Lévêque 1997], but seems to have disappeared in the latter [Lévêque 1997]. […] Recorded from the lower Mangoro river and Nosivolo tributary, Marolambo region [Reinthal and Stiassny 1997], and the Manantenina River [Stiassny and Harrison 2000]. Widespread throughout the island [Stiassny and Harrison 2000]. Also [Goldstein 1973; Philippart and Ruwet 1982; Welcomme 1988; Stiassny and Raminosoa 1994; Lévêque 1997]."

"Introduced to Lake Otjikoto, near Tsumeb [Namibia], where its population is still increasing [Agenbag 1998]. Known from Lower Orange, Interior [Hay et al. 1999] and Fish River [Hay 1991]. Present in all major state dams: Hardap, Naute, Omatako, Otjivero, Swakoppoort and Von Bach [Hay et al. 1999; Okeyo 2003], and the Cuvelai system (Omuramba Omatako and Owamboland); also collected from Goreangab Reservoir (Windhoek) [Okeyo 2003]. […] First introduced into Namibia from the Cape in 1947 for angling/sport [Schrader 1985; Okeyo 2003]. Distribution in Namibian ephemeral rivers sporadic and depends on good rains [Okeyo 2003]. Also [Trewavas 1983; Skelton 1993; Okeyo 2000, 2005]."

"Successfully introduced to Mwadingusha, Koni and Nzilo [Tanzania]."

"Widely cultured in ponds and rice paddies [in Bangladesh] [Haroon 1998]. Due to overcrowding of stunted tilapia in ponds, few reach marketable size and hence culture was discontinued [Jalal and Rouf 1997]. […] Also [Welcomme 1981, 1988; Philippart and Ruwet 1982].”

“Known from the Mekong basin [Cambodia] [FAO 1996]. Also [FAO 1993, 1997[a]].”

“Established in brackish and marine coastal waters and in the rivers of the central and southern provinces [China] [Philippart and Ruwet 1982]. Recorded from the Yili river [sic] [Walker and Yang 1999]. Also [Bardach et al. 1972; FAO 1983; Welcomme 1988].”

“Well established in Plover Cove Reservoir [Hong Kong] [Hodgkiss and Man 1977; Man and Hodgkiss 1981; Lowe-McConnell 1982; Philippart and Ruwet 1982].”

“Introduced in Periyar Lake [India] [Lal 2000]. Known from Muttukadu lagoon [Azad et al. 2004]. Recorded from the Chalakudy river, part of the Western Ghats, Kerala [Raghavan et al. 2008], Tambraparani river system, Kalakkad Mundanthurai Tiger Reserve, Cauveri and Chinnar river systems, Chimmony and Peechi-Vazhani WLS, Nilgiri Biosphere Reserve, Bangalore adn [sic] Kolar districts, Karnataka [Radhakrishnan et al. 2012]. Also [Welcomme 1988; Bhat 2000; Shaji et al. 2000; Baby et al. 2011].”

“Found in virtually every body of water [in Indonesia], including ditches and stagnant pits where few other fish of value can be grown [Bardach et al. 1972]. Also [Fish 1955; Philippart and Ruwet 1982; Trewavas 1983; Welcomme 1988; FAO 1993, 1997[a]; Frimodt 1995; Costa-Pierce 2003].”

“Found in hot springs, from Hokkaido to Kyushu and Okinawa [Japan] [Masuda et al. 1984]. Also Philippart and Ruwet 1982; Japan Ministry of Environment 2005].”

“Recorded from the lower Segama [Malaysia] [Martin-Smith and Tan 1998]. […] Also [Bardach et al. 1972; Philippart and Ruwet 1982; Trewavas 1983; FAO 1993, 1997[a]; Lamboj 2004].”

“Introduced in 1985 to ponds in Janakpur [Nepal] but have not been introduced elsewhere to prevent competition with indigenous species [Shrestha 1994]. Also [Shrestha 1999].”

“Occurs in North West Frontier Province, Punjab, Sindh and Balochistan [Pakistan] (introduced for fish culture in saline waters) [Mizra 2003]. Also [Welcomme 1988; Talwar and Jhingran 1991].”

“Established in all brackish water farms, rivers, swamps and rice fields throughout the country [Philippines]. Introduced in a reservoir in Ambuklao, Mountain Province in 1956, in 1986-1989, they constituted the bulk (66%) of fish production [Guererro 1998]. Introduced to Lake Mainit [Pauly et al. 1990; Mercene 1997; Labajo and Nuñeza 2003], Lake Buluan [Yap et al. 1983], Lake Buhi [Kottelat and Whitten 1996], Lake Lanao [Mercene 1997; Ismail et al. 2014] and Lake Naujan [Mercene 1997; Mamaril 2001]. Also reported from Ormoc Bay [U.P. Visayas Foundation 1993] and San Miguel Bay [Cinco et al. 1994]. […] Cultured in Laguna de Bay [Vallejo 1985; Palma et al. 2005]; in reservoirs (Ambuklao, Angat, Caliraya, and Binga) [Balite

1993]. Also [88, Bardach et al. 1972; Coche 1982; Philippart and Ruwet 1982; Guerrero and Tayamen 1988; Welcomme 1988]."

"Well-established populations throughout the country [Singapore] [Tan and Tan 2003]. […] Also [Trewavas 1983; Welcomme 1988; Lever 1996; Tang 2004; Ng and Tan 2010; NSS Vertebrate Study Group 2014]."

"Widespread throughout the country [Sri Lanka] up to an elevation of about 1,000m. Occurs also in lagoons, where it has been found to breed in occasion. […] Recorded from a large number of reservoirs [De Silva and Chandrasoma 1980; Pet and Piet 1993; Nathaniel and Silva 1996; Wijeyaratne and Perera 2001; Amarasinghe 2002; Weliange and Amarasinghe 2003a, b]. Also [Philippart and Ruwet 1982; De Silva et al. 1984; De Silva 1985, 1988; Maitipe and De Silva 1985; Welcomme 1988; Talwar and Jhingran 1991; Shaji et al. 2000]."

"Collected from the Tsengwen estuary [Taiwan] [Kuo and Shao 1999] and from mangrove creeks in southwestern Taiwan (Pu-Tai, Pei-Men, and Syh-Tsao) [Kuo et al. 1999]. Also known from the Penghu Islands [Chen 2004]. […] First successful larviculture in Taiwan occurred in 1946 [Liao et al. 2001]. Also [Bardach et al. 1972; Philippart and Ruwet 1982; Trewavas 1983; Shen 1993]."

"Introduced [to Turkey] in the 1970s for research in aquaculture. Introduced into southern Anatolia [Çiçek et al. 2015]. Found in Koycegiz Lake [Innal and Erk'akan 2006]."

"Present in Da River [Vietnam] [Bui et al. 2009; Nguyen et al. 2011] Also [Philippart and Ruwet 1982]."

"Known from Wadi Hajr [Yemen] [Attaala and Rubaia 2005]."

"Known from Western and Southern Australia, Victoria, New South Wales and Queensland [Native Fish Australia 2003]. Feral populations recorded from reservoirs in Brisbane area (Qld) [Appleyard and Mather 2000; Allen et al. 2002] and from freshwater and tidal creeks around Townsville [Appleyard and Mather 2000; Allen et al. 2002] and Cairns (Qld) [Allen et al. 2002], in the latter possibly an interspecific cross with *O. niloticus* [Appleyard and Mather 2000]. Established on the Atherton Tablelands (Qld) in the Barron (including Lake Tinaroo) and North Johnstone rivers and Western Australia in the Gascoyne-Lyons river system [Allen et al. 2002]. Also [Trewavas 1983; Welcomme 1988; Blühdorn and Arthington 1990b; Fulton and Hall 2014]."

"Well established in freshwater habitats on Yap [Nelson and Eldredge 1991]."

"Well established in freshwater habitats [in the Cook Islands] [Nelson and Eldredge 1991]."

"Well established in freshwater habitats [in Fiji] [Nelson and Eldredge 1991]. Feral populations known from the rivers Rewa, Navua, Sigatoka and Ba [Macaranas et al. 1997]. Known from Viti Levu and Vanua Levu [Andrews 1985]. Also [Lewis and Pring 1986; Welcomme 1988; Seeto and Baldwin 2010]."

“Found in rivers of Tubuaï, Mangareva, Moorea and Tahiti [Marquet 1993]. Also [Hureau 1991; Bacchet et al. 2006].”

“Known from the lagoons of Tarawa [Nelson and Eldredge 1991] and Gilbert and Ellice Islands [Trewavas 1983]. Established in the Fanning Atoll [Trewavas 1983]. Also [Eldredge 2000].”

“Well established in freshwater habitats [in Nauru] [Nelson and Eldredge 1991].”

“Well established in freshwater habitats [Nelson and Eldredge 1991]. Also [Welcomme 1988; Thollot 1996; Marquet et al. 1997; Firmat and Alibert 2011]. Introduced in New Caledonia in 1955 [Marquet et al. 2003].”

“Well established in freshwater habitats [in Papua New Guinea] [Nelson and Eldredge 1991]. Occurs throughout Madang Province [Parenti and Allen 1991]. Known from the Laloki River system [Berra et al. 1975]. Abundant in the lower Ramu and middle and lower Sepik rivers. […] Also [Trewavas 1983; Welcomme 1988; Hitchcock 2002].”

“Well established in freshwater habitats [in Samoa] [Nelson and Eldredge 1991]. Recorded from Sato'alepai and Fagamalo in Savaii Island. […] Small-scale aquaculture is established from introduced fingerlings which came from the Sigatoka Agricultural Station in Fiji [Nelson and Eldredge 1991]. [Welcomme 1988].”

“Well established in freshwater habitats; impressive harvests taken from Lake Tenaggano on the island of Rennell [Solomon Islands] [Nelson and Eldredge 1991].”

“Found in rivers [in Tahiti]. Also [Welcomme 1988; Marquet et al. 1997].”

“Well established in freshwater habitats; important fisheries in Lake Vaihali (Niuafo'ou Island) and the islands of Vava'u and Nomuka [Nelson and Eldredge 1991].”

“Known from Funafuti, Namumanga and Niutao [Eldredge 2000].”

“Known from Efate Island and Tanna Island [Eldredge 2000].”

“Well established in freshwater habitats on Wallis Island [Nelson and Eldredge 1991] (also [Keith and Marquet 2011]).”

“Reportedly used for aquaculture [in Suriname] [Chakalall 1993]. Known from brackish lagoons in the Bigi Pan area [Mol et al. 2000].”

“Known from the Manzanares River and its estuary [Venezuela] [Ruiz et al. 2005].”

“Introduced to open waters at Ain Skhouna [Algeria], […]. Total sites of introduction 2 and total number of introduction events 2 [Kara 2011].”

“Reportedly introduced [to Israel] in 1975 from South Africa […]. Reportedly introduced from Thailand in 1966 [Welcomme 1988]. No specimens have been reported from the local natural environment [Golani and Mires 2000].”

“Established in aquaculture [in South Korea] through unassisted reproduction. Has not established in the wild [Welcomme 1988]. Collected but not known to have established [Jang et al. 2002]. Also [FAO 1997a].”

“Introduction considered a complete failure [in Malta] [Philippart and Ruwet 1982].”

“Cultivated in several fish farms and reported in 2000 in the in-take channel of the Krasnodar electric power station [Russia]. Recorded in Kuban River [Vasil’eva 2003]. Also [Ivoilov 1992].”

“Found in the Paradise Island, New Providence [Bahamas]. Abundant in a brackish pond on the Paradise Island Golf Course [Barton and Wilmhoff 1996].”

“Established in fishponds and small streams in Huila Province [Costa Rica] [Lever 1996]. Also [Bardach et al. 1972].”

“Probably established in nature [in El Salvador] [Philippart and Ruwet 1982]. Also [Bowman 1975].”

“Established in natural waters [in Grenada] [Philippart and Ruwet 1982].”

“Widespread, cultivated in ponds and established in natural waters [Guatemala] [Welcomme 1981].”

“Established in natural waters [in Haiti] [Pullin and Lowe-McConnell 1982].”

“Known from Tegucigalpa and Lago de Yojoa [Honduras] [Welcomme 1981].”

“Unpopular, relegated to rivers and smaller ponds [in Jamaica] [Aiken et al. 2002]. Also [Philippart and Ruwet 1982; Trewavas 1983].”

“Introduced and established in the Lerma River basin [Mexico] [Lyons et al. 1998]. Also know from Laguna Chichancanab (Yucatan peninsula), where it was introduced in the 1980's [Fuselier 2001]. Also [Philippart and Ruwet 1982].”

“One of the most frequently encountered species in natural or semi-natural freshwater habitats in Curaçao; abundant in water basins built around the natural spring of Fontein in Aruba; reported from brackish water bays in Curaçao and Aruba [Debrot 2003]. […]”

“Escaped into Lake Managua [Nicaragua] […]. Introduced to Lake Moyua [Riedel 1965; Philippart and Ruwet 1982; Lowe-McConnell 1982]. Also [Lever 1996].”

"Established in a few impoundments [in Panama] [Welcomme 1981]."

"Established in natural waters [in St. Lucia] [Pullin and Lowe-McConnell 1982]."

"Occurs in lakes and ponds, but occasionally found in rivers such as below Hollis Reservoir and in brackish waters such as the Caroni Swamp and Fullerton Swamp [Trinidad and Tobago]. […]"

GISD (2018) lists *Oreochromis mossambicus* as alien and established in Algeria, Antigua and Barbuda, Australia, Bahamas, Bangladesh, Barbados, Benin, Bolivia, Brazil, Colombia, Congo, Cook Islands, Costa Rica, Cuba, Dominican Republic, Egypt, El Salvador, Fiji, Viti Levu Island, French Polynesia, Guadeloupe, Guatemala, Guyana, Honduras, Hong Kong, India, Indonesia, Israel, Jamaica, Japan, Gilbert Island, Kiribati, Madagascar, Malaysia, Maldives, Martinique, Mexico, Micronesia, Namibia, Nauru, New Caledonia, Nicaragua, Niue, Pakistan, Panama, Papua New Guinea, Philippines, Saint Lucia, Samoa, Saudi Arabia, Seychelles, Singapore, Solomon Islands (Malaita and Santa Ana islands), South Africa, Sri Lanka, Taiwan, Thailand, Tonga (Tongatapu Island), Tuvalu, Uganda, Vanuatu (Efate and Tana islands), Venezuela, Vietnam, and Wallis and Futuna.
GISD (2018) lists *O. mossambicus* as alien and not established in the wild in Argentina, Ecuador, Malta, Russian Federation (Kuban River), and Suriname.
GISD (2018) lists *O. mossambicus* as alien and probably not established in the wild in China, Czech Republic, Nepal, Tunisia, and the United Kingdom.
GISD (2018) lists *O. mossambicus* as alien but unknown if established in the wild in Burundi, Cambodia, Dominica, Grenada, Haiti, Kenya, South Korea, Palau, Peru, and Trinidad and Tobago.
GISD (2018) lists *O. mossambicus* as alien but only present in containment facilities in Reunion.

From GISD (2018):

"In Victoria [Australia] tilapia are only found in Hazelwood Pondage, which is a waterway heated by the effluent cooling water from a power station [Wager and Jackson 1993]."

"Mozambique tilapia (*Oreochromis mossambicus*) were introduced [to Jordan] for aquaculture and weed control purposes, now established in the wild through continuous restocking [FAO 2004]."

"Mozambique tilapia (*Oreochromis mossambicus*) are reported near the intake channel of Krasnodar electric power station and are cultivated in several fish farms [in the Russian Federation] [Vasileva 2003]."

CABI (2018) lists *Oreochromis mossambicus* as present and introduced in Bangladesh, Cambodia, China (Fujian, Guangdong, Guangxi, Hainan, Hong Kong, Macau, and Shandong), India, Indonesia, Israel, Japan, Republic of Korea, Kuwait, Laos, Lebanon, Malaysia (including Peninsular Malaysia), Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Singapore, Sri Lanka, Syria, Taiwan, Thailand, Turkey, United Arab Emirates, Vietnam, Yemen, Algeria, Angola, Benin, Cameroon, Cape Verde, Congo, Democratic Republic of the Congo, Côte d'Ivoire, Egypt, Eritrea, Ethiopia, Madagascar, Namibia, Nigeria, Réunion, Rwanda, Seychelles,

Canary Islands, Sudan, Tunisia, Uganda, Canada (Alberta, British Columbia, Manitoba, Ontario), Mexico, Antigua and Barbuda, Bahamas, Barbados, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Martinique, Netherlands Antilles, Nicaragua, Panama, Saint Lucia, Trinidad and Tobago, Argentina, Bolivia, Brazil, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela, Belgium, France, Germany, Hungary, Italy, Malta, Netherlands, Russian Federation, Spain, UK, Australia, Caroline Islands, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Micronesia, Nauru, New Caledonia, Niue, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna Islands.
CABI (2018) lists *O. mossambicus* as present but does not give an indication of its native or introduced status in Mayotte and Senegal.

From Russell et al. (2012):

"[…] One of the first places they became established was in the Indonesian province of West Java where they acquired the common name 'Java' tilapia (Blaxter 2000). […]. Invasive populations of *O. mossambicus* are now widely distributed on five continents and recent records suggest that they have been successfully introduced into 94 countries, territories or regions throughout the world (Fishbase 2010). Philippart and Ruwet (1982) noted that this species was found in 13 countries in south east Asia and in 11 countries in North and South America. *Oreochromis mossambicus* are now also widespread in the South Pacific after being introduced into eight locations in Micronesia, 13 locations in Polynesia and 10 locations in Melanesia (Nelson and Eldredge 1991). They have also been introduced outside their native range in Africa including to Madagascar where they are now widespread (Canonico et al. 2005; Reinthal and Stiassny 1991). Invasive populations have also become established in Papua New Guinea (Glucksman et al. 1976) and in Australia (Bluhdorn and Arthington 1989, 1990a, b; McKay 1978)."

From Tachihara and Obara (2003):

"Fortunately, in mainland Japan, the distribution of *O. mossambicus* is restricted around hot springs in temperate areas as a result of low temperatures in the winter season [Imai 1980]. In the case of Okinawa Island, *O. mossambicus* can be found in 110 rivers (41.2% of the main water bodies investigated) [Tachihara et al. 2002] as a result of relatively higher water temperatures in winter."

Means of Introduction Outside the United States

From CABI (2018):

"The Mozambique tilapia was the first tilapia to be widely distributed as a farmed fish."

"Dispersal of the Mozambique tilapia accelerated in the 1940s and 1950s with Japanese occupiers and later post-war reconstruction efforts spreading the fish to several countries in Asia. Sixty individuals were sent from Singapore to Hawaii in 1951. Progeny of these fish were later sent to public aquariums in California and New York, who later shared further progeny with universities and resource agencies in Alabama, Arizona and California. […]"

From GISD (2018):

"The mouthbrooding habit of this species allows it to nurture and carry its young long distances to invade habitats far from the original site of introduction (Costa-Pierce, 2003)."

"Mozambique tilapia (*Oreochromis mossambicus*) were introduced to Fiji to culture for pig feed."

From Froese and Pauly (2018):

"Translocated and introduced for aquaculture, sport fishing, stocking man-made lakes and biological control of nuisance plants and animals [de Moor and Bruton 1988]."

"Introduced [to Madagascar] in 1956 by the Forestry Service for rizipisciculture [Stiassny and Harrison 2000]."

Short Description

From Froese and Pauly (2018):

"Dorsal spines (total): 15 - 18; Dorsal soft rays (total): 10-13; Anal spines: 3; Anal soft rays: 7 - 12; Vertebrae: 28 - 31. Diagnosis: snout long; forehead with relatively large scales, starting with 2 scales between the eyes followed by 9 scales up to the dorsal fin [Pfeffer 1893, 1894]. Adult males develop a pointed, duckbill-like snout [Lamboj 2004] due to enlarged jaws, often causing the upper profile to become concave [Bell-Cross 1976; Trewavas 1983; Bell-Cross and Minshull 1988; Skelton 1993; Lamboj 2004], but upper profile convex in smaller specimens [Boulenger 1899; Weber 1897]. Pharyngeal teeth very fine, the dentigerous area with narrow lobes, the blade in adults longer than dentigerous area; 28-31 vertebrae; 3 anal spines; 14-20 lower gill-rakers; genital papilla of males simple or with a shallow distal notch; caudal fin not densely scaled; female and non-breeding male silvery with 2-5 mid-lateral blotches and some of a more dorsal series; breeding male black with white lower parts of head and red margins to dorsal and caudal fins [Trewavas 1983]."

"Coloration: basic melanin pattern of 2 horizontal and 6-7 vertical bars never fully realized; more commonly, at least in preserved specimens, females and sexually inactive males have no bands, but may have the intersection points of the facultative bands represented by 3-4 upper and 2-5 mid-lateral blotches, or some or all of these may be present [Trewavas 1983]. Basic body coloration silvery grey [Trewavas 1983; Lamboj 2004] to greenish grey, sometimes a more bluish colored head [Lamboj 2004]. Belly greyish [Gilchrist and Thompson 1917; Copley 1952; Bruton et al. 1982]. Spiny part of dorsal fin light with dark mottling [Pfeffer 1893]. Soft dorsal and anal, and caudal and pelvic fins blackish [Pfeffer 1893, 1894; Boulenger 1915; Gilchrist and Thompson 1917]. Pectoral fins colorless [Pfeffer 1893, 1894]. Indistinct, dark opercular spot present [Steindachner 1864; Pfeffer 1893, 1894; Boulenger 1899, 1915; Pellegrin 1904; Gilchrist and Thompson 1917]. Vertical fins uniform [Gilchrist and Thompson 1917], blackish with more or less distinct whitish spots [Günther 1862] or with large or small, fused or non-fused, dark spots on a pale background [Weber 1897; Gilchrist and Thompson 1917], given a darker aspect to these fins [Weber 1897]. 3 black blotches present in juveniles but possibly obscured in adults due to the dark body coloration of breeding males or old adults [Bell-Cross 1976; Bell-Cross and Minshull 1988].

Female and non-breeding male: dirty yellowish-olive [Pienaar 1978] or silvery-gray, with 2-5 mid-lateral blotches and some of a more dorsal series [Trewavas 1983; Lamboj 2004]. Sometimes a series of more or less distinct spots along the side of the body above and below the upper lateral line [Gilchrist and Thompson 1917].

Breeding male: uniform dark olive-brown [Gilchrist and Thompson 1917; Copley 1952], deep blue-black [Trewavas 1983] or black, with white lower parts of head [Gilchrist and Thompson 1917; Copley 1952; Trewavas 1983; Skelton 1993], including throat, lower lips, lower parts of cheeks and opercles, but with a dark blue to black base to the throat [Crass 1964; Lamboj 2004], and red margins to dorsal and caudal fins [Crass 1964; Bell-Cross 1976; Pienaar 1978; Trewavas 1983; Bell-Cross and Minshull 1988; Skelton 1993; Lamboj 2004]. Dorsal fin with light coloured spots on membrane between spinous and soft rays [Bell-Cross 1976; Bell-Cross and Minshull 1988]. Caudal fin olive-green with light coloured spots on anterior section [Bell-Cross 1976; Bell-Cross and Minshull 1988], but may sometimes appear totally red [Lamboj 2004]. Tip of dorsal and extremity of caudal lobes yellowish [Gilchrist and Thompson 1917; Copley 1952]. Anal fin dark gray [Lamboj 2004] or olive-green [Bell-Cross 1976; Bell-Cross and Minshull 1988], sometimes with a thin red/orange margin [Crass 1964; Bell-Cross 1976; Pienaar 1978; Bell-Cross and Minshull 1988; Lamboj 2004]. Unpaired fins normally exhibit greenish to silvery iridescent dots [Lamboj 2004]. Pectoral fin rays red [Trewavas 1983]. Pectoral and pelvic fins olive-yellow [Bell-Cross 1976].

Juveniles: body silvery [Arrignon 1962; Welcomme 1964; Bell-Cross 1976; Bruton et al. 1982; Trewavas 1983; Bell-Cross and Minshull 1988; de Moor and Bruton 1988; Skelton 1993] or olive-brown, light on belly [Gilchrist and Thompson 1917]. Scales with dark outer edge [Gilchrist and Thompson 1917]. Usually 5-8 or more indistinct dark cross bars on body [Weber 1897; Gilchrist and Thompson 1917; Welcomme 1964; Trewavas 1983; Skelton 1993; Stiassny and Harrison 2000], often in addition to the 2 series of blackish spots [Gilchrist and Thompson 1917], but with no horizontal stripes [Trewavas 1983]. Dark opercular spot [Weber 1897; Gilchrist and Thompson 1917], on posterior dorsal edge of operculum [Welcomme 1964]. Black spot at base of anterior rays of soft dorsal [Günther 1862; Gilchrist and Thompson 1917] and 1-2 whitish spots enclosed by dark streaks [Gilchrist and Thompson 1917]. Oblique streaks [Weber 1897] or translucent round spots [Welcomme 1964] on soft dorsal. Anal dark at base with a light outer half [Gilchrist and Thompson 1917], with oblique streaks [Weber 1897]. Caudal dark at base, light in centre, a black outer ridge [Gilchrist and Thompson 1917], with 2-3 bars across the fin [Weber 1897]. Tilapia-spot present [Crass 1964; Bruton et al. 1982; Trewavas 1983; de Moor and Bruton 1988], conspicuous in younger fish persisting albeit faintly to 8cm [Welcomme 1964]. Fins flesh coloured [Bell-Cross 1976; Bell-Cross and Minshull 1988], all except soft dorsal immaculate [Welcomme 1964]."

From Masterson (2007):

“The blue tilapia, *Oreochromis aureus*, and the blackchin tilapia *Sarotherodon melanotheron* also occur as exotic species in Florida. They sre [sic] superficially quite similar to *Oreochromis mossambicus*, but species-specific markings (e.g., the black chin of *S. melanotheron* which *O. aureus* lacks) as well as differing spine/ray counts are sufficient to differentiate the species from one another.”

Biology

From Froese and Pauly (2018):

“Adults thrive in standing waters [Crass 1964; Skelton 1993]. Inhabit reservoirs, rivers, creeks, drains, swamps and tidal creeks; commonly over mud bottoms, often in well-vegetated areas [Allen et al. 2002]. Also found in warm weedy pools of sluggish streams, canals, and ponds [Page and Burr 1991]. Most common in blind estuaries and coastal lakes [Blaber 1997], but usually absent from permanently open estuaries and open sea [de Moor and Bruton 1988] and from fast-flowing waters [Crass 1964; Skelton 1993]. Normally not found at high altitudes [de Moor and Bruton 1988]. Able to survive extreme reduction of temporary water bodies [Trewavas 1983; Lévêque 1997]. […] Grow and reproduce in fresh-, brackish and seawater [Bardach et al. 1972; Balarin 1979; Bruton et al. 1982; Chervinski 1982; Trewavas 1983; Wohlfarth and Hulata 1983; Suresh and Lin 1992; Lévêque 1997]. Can be reared under hyper-saline conditions [Robins et al. 1991; Allen et al. 2002; Lamboj 2004]. […] Mainly diurnal. May form schools [Philippart and Ruwet 1982; Robins et al. 1991; Allen et al. 2002]. Omnivorous [Bell-Cross 1976; Wohlfarth and Hulata 1983], feed mainly on algae and phytoplankton [Crass 1964; Bardach et al. 1972; Bell-Cross 1976; Pienaar 1978; Bell-Cross and Minshull 1988; Robins et al. 1991; Skelton 1993; Allen et al. 2002; Lamboj 2004] but also take some zooplankton, small insects and their larvae [Bell-Cross 1976; Bell-Cross and Minshull 1988; Robins et al. 1991; Skelton 1993; Allen et al. 2002; Lamboj 2004], shrimps [Bell-Cross 1976; Bell-Cross and Minshull 1988], earthworms [Crass 1964] and aquatic macrophytes [de Moor and Bruton 1988]. Juveniles carnivorous/omnivorous, adults tend to be herbivorous or detritus feeders [Trewavas 1983; Otto-Infante 1985; de Moor and Bruton 1988]. Large individuals have been reported to prey on small fishes [Crass 1964; Pienaar 1978; Trewavas 1983; de Moor and Bruton 1988], and occasionally cannibalise their own young [Trewavas 1983; de Moor and Bruton 1988]. Exhibit considerable plasticity in their feeding habits [Maitipe and De Silva 1985; de Moor and Bruton 1988] as well as in their reproductive biology [Maitipe and De Silva 1985]. Polygamous [Bell-Cross 1976; Bell-Cross and Minshull 1988], maternal mouthbrooder [Bell-Cross 1976; Bruton et al. 1982; Trewavas 1982; Bell-Cross and Minshull 1988]. Reach sexual maturity at 15 centimeter length [Allen et al. 2002], but stunted fish may breed at 6-7 centimeters and at an age of just over 2 months [Lamboj 2004]. Fecundity high [Gupta and Acosta 2004]. […] Somewhat aggressive toward other species [Bardach et al. 1972]. […] Eurytopic; a most successful and vagile invader [de Moor and Bruton 1988].”

“Spawns at the edge of the littoral terrace of lakes [Lowe-McConnell 1982; Trewavas 1982, 1983; de Moor and Bruton 1988], in sandy or muddy bottoms [Oliveira et al. 2005]. Displays a lek mating system; territorial males establish breeding territories where they dig spawning pits, assume a dark coloration, defend a breeding territory and actively court females; sneaking males intrude into nests during a spawning episode, exhibiting quivering behavior which is usually an indicator of sperm release; sneaking is predominantly performed by subordinate males, which may adopt pseudo-female behavior [Oliveira et al. 2005]. Only territorial males produce sounds, during all phases of courtship but especially during the late stages, including spawning [Amorim et al. 2003]. Territorial male excavates and defends a basin-shaped pit in the center of his territory, where female deposits 100-1700(1800) eggs [Allen et al. 2002; Lamboj 2004]. Eggs and milt are sucked up by the female [Trewavas 1983; Allen et al. 2002]. Fertilization is reported to sometimes occur in the mouth of the female [Pethiyagoda 1991]. Females incubate eggs alone [Crass 1964; Lamboj 2004]. It is possible, albeit rare, that males take up some eggs after spawning [Bruton and Boltt 1975; Trewavas 1983; Arthington and Milton 1986; Lamboj 2004], but they almost always eat them soon after [Lamboj 2004]. Females school together while mouthbrooding [Holden and Bruton 1994], they cease to feed and subsist on food reserves stored in their body [Trewavas 1982]. Females may spawn a full clutch with just one male, or may spawn with several different males in a series [Lamboj 2004]. Water is circulated over the eggs by chewing movements of the jaws [Crass 1964; Pienaar 1978]. Fry hatch in the female's mouth after 3-5 days [Crass 1964; Pienaar 1978; Trewavas 1983; Allen et al. 2002; Lamboj 2004], depending on the temperature [Lamboj 2004]. The young are released from the mouth in 10-14 days, but remain near the female and enter the mouth if threatened until about 3 weeks old [Trewavas 1983; Allen et al. 2002; Lamboj 2004]. Fry and juveniles shoal in shallow water [Bruton and Boltt 1975; de Moor and Bruton 1988; Skelton 1993] where they feed during the day, and retreat to deep water at night [Lowe-McConnell 1982; de Moor and Bruton 1988]. Females raise multiple broods during a season [Bruton and Boltt 1975; Skelton 1993]."

From Russell et al. (2012):

"In Africa, Gaigher (1973) and de Pienaar (1968) demonstrated that *O. mossambicus* preferred quiet open pools in both perennial and annual streams and avoided rapids and other areas of swiftly flowing water. This is supported by the experimental evidence of Whitfield and Blaber (1979) who found that *O. mossambicus* avoid flows exceeding 370 m h^{-1}. The aversion of *O. mossambicus* for higher water velocities may in part, be due to their nest building activities which require calm, sandy areas (Jubb 1967). The growth of aquatic macrophytes and inundation of marginal terrestrial vegetation during elevated flows can provide additional shelter for *O. mossambicus* juveniles (Ward 1976). In African lakes where predatory tigerfish, *Hydrocynus vittatus* were present, young *O. mossambicus* utilised the vegetated littoral zones until they reached maturity and were too large to be consumed (Donnelly 1969). Donnelly (1969) noted that juvenile *O. mossambicus* showed a preference for shallow waters of up to 30 cm deep on gently sloping shorelines."

"[…] In Sri Lankan reservoirs, de Silva and Sirisena (1988) noted that nests of similar sizes were usually clustered together. Males actively advertise their dominant status through urinary odorants which act as a 'dominance' pheromone to modulate aggression in rivals, thereby contributing to social stability within the lek (Barata et al. 2008; Frade et al. 2002; Miranda et al. 2005). A male uses the nest to attract a female in spawning condition to deposit eggs prior to external fertilisation (Fryer and Iles 1972). […] Females defend their brood aggressively against predators and conspecifics. Agonistic behaviour peaks when fry are mobile and capable of exogenous feeding, thus ensuring that fry may forage more safely without being consumed by other larger fish (Oliveira and Almada 1998a; Oliveira and Canario 2000)."

"Females usually choose males that build larger leks, display conspicuous dark black-purple colouration, produce higher levels of hormones and pheromones and have a higher gonadosomatic index (Oliveira and Almada 1996). Turner (1986) suggested that one of the costs of reproductive and territorial activity was reduced growth and that this will eventually lead to a loss of status. Oliveira and Almada (1998b) discussed evidence which showed that male territoriality was associated with an energetic cost that eventually forces males to leave their territories. Further, males can morphologically resemble females or immature fish (Oliveira and Canario 2000), allowing them to 'sneak' into nests during spawning episodes and fertilise the eggs of a spawning female (Oliveira and Almada 1998b). […] Oliveira and Almada (1998b) observed that even territorial males intruded into the territories of their neighbours when spawning was occurring to engage in 'sneaking' attempts. The presence of both 'sneakers' and 'floaters' that wander around a spawning area trying to occupy recently vacated territories was likely to result in the frequent disruption of spawning acts. […]"

"In South Africa, James and Bruton (1992) estimated that *O. mossambicus* in ponds can spawn up to five broods per female during a 133 day period. Riedel (1965) observed that spawning takes place every 2 months or at even shorter intervals under favourable conditions. In Sri Lanka, De Silva and Chandrasoma (1980) found that *O. mossambicus* in a man-made lake spawned throughout the year with four possible peak periods. In contrast, the breeding season for *O. mossambicus* in the Brisbane area of south-eastern Queensland only spans 6–7 months of the year, when water temperatures exceed 23°C (Arthington and Milton 1986). In the Townsville area of north-eastern Queensland, Webb (1994) found that *O. mossambicus* spawned for 9–10 months. Further north in the Cairns region, populations of *O. mossambicus* can, depending on local conditions, spawn for much, or all of the year (Russell et al. 2010, in press)."

From GISD (2018):

"Thought to be ideal pond fish, they readily produce stunted stocks when overcrowded, as has been observed on Pagan in the Northern Mariana Islands (Eldredge, 2000)."

From Lintermans et al. (2007):

"Growth of populations and individuals is often rapid. For example, from 6-8 fish released into an ornamental pond in Cairns 18 months prior to rotenone treatment, 12.5 ton of fish were removed!"

Human Uses

From Froese and Pauly (2018):

"Used extensively in biological, physiological and behavioural research [Skelton 1993]."

"Highly preferred food fish [in Laos] [Saphakdy and Rodger 2005]."

“Reared in fish culture with satisfactory results up to altitudes of 2400m [in Ecuador] [Philippart and Ruwet 1982].”

“By 1998 production had surpassed 2000 mt and made up more than 20% of total aquacultural production [in Venezuela].”

From GISD (2018):

“Mozambique tilapia (*Oreochromis mossambicus*) is a declared noxious pest in Queensland. It is illegal to possess, rear, sell or buy tilapia. It is also an offence to release tilapia into Queensland waterways or to use them as bait, live or dead. Penalties up to $AUS 150 000 apply.”

From Canonico et al. (2005):

“The most important tilapias in aquaculture are species in the mouthbrooding genus *Oreochromis* (*O. niloticus*, *O. mossambicus*, and *O. aureus*) and certain hybrids, which account for 99.5% of global tilapia production (FAO, 1997[b]).”

Diseases

No records of OIE reportable diseases were found for *Oreochromis mossambicus*.

From Froese and Pauly (2018):

“Fish louse Infestation 1, Parasitic infestations (protozoa, worms, etc.)
White spot Disease, Parasitic infestations (protozoa, worms, etc.)
Ichthyobodo Infection, Parasitic infestations (protozoa, worms, etc.)
Dactylogyrus Gill Flukes Disease, Parasitic infestations (protozoa, worms, etc.)
Trichodinosis, Parasitic infestations (protozoa, worms, etc.)
False Fungal Infection (*Epistylis* sp.), Parasitic infestations (protozoa, worms, etc.)
Transversotrema Infestation, Parasitic infestations (protozoa, worms, etc.)
Trichodinella Infection 1, Parasitic infestations (protozoa, worms, etc.)
Trichodina Infection 1, Parasitic infestations (protozoa, worms, etc.)
Trichodina Infection 5, Parasitic infestations (protozoa, worms, etc.)
Orientocreadium Disease, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation, Parasitic infestations (protozoa, worms, etc.)
Ichthyophthirius Disease, Parasitic infestations (protozoa, worms, etc.)
Fish Louse Infestation 3, Parasitic infestations (protozoa, worms, etc.)
Fish louse Infestation 1, Parasitic infestations (protozoa, worms, etc.)
HTRLO Disease, Parasitic infestations (protozoa, worms, etc.)
Lernaea Infestation, Parasitic infestations (protozoa, worms, etc.)
Cryptobia Infestation, Parasitic infestations (protozoa, worms, etc.)
Amyloodinium Infestation, Parasitic infestations (protozoa, worms, etc.)
Ambiphyra Infestation 2, Parasitic infestations (protozoa, worms, etc.)
Turbidity of the Skin (Freshwater fish), Parasitic infestations (protozoa, worms, etc.)
Euclinostomum Infestation 2, Parasitic infestations (protozoa, worms, etc.)
Fish Tuberculosis 2, Parasitic infestations (protozoa, worms, etc.)

Dolops Infestation, Parasitic infestations (protozoa, worms, etc.)
Edwardsiellosis, Bacterial diseases
Epitheliocystis, Bacterial diseases
Saccocoelioides Infection, Parasitic infestations (protozoa, worms, etc.)
Goezia Disease 2, Parasitic infestations (protozoa, worms, etc.)
Gnathostoma Disease (larvae), Parasitic infestations (protozoa, worms, etc.)
Diplostomum Infection, Parasitic infestations (protozoa, worms, etc.)
Goezia Disease 2, Parasitic infestations (protozoa, worms, etc.)
Rhabdochona Infestation 6, Parasitic infestations (protozoa, worms, etc.)
Rhabdochona Infestation 6, Parasitic infestations (protozoa, worms, etc.)
Contracaecum Disease (larvae), Parasitic infestations (protozoa, worms, etc.)
Gnathostoma Infestation 2, Parasitic infestations (protozoa, worms, etc.)
Gnathostoma Disease (larvae), Parasitic infestations (protozoa, worms, etc.)
Spinning Tilapia Syndrome, Viral diseases
Cichlidogyrus Infestation 4, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation 4, Parasitic infestations (protozoa, worms, etc.)
Pentastoma Infection 2, Parasitic infestations (protozoa, worms, etc.)
Velvet Disease 2 (*Piscinoodinium* sp.), Parasitic infestations (protozoa, worms, etc.)"

From Russell et al. (2012):

"[…] *Trichodina heterodentata*, which is known to use *O. mossambicus* as a host (Dove and O'Donoghue 2005)."

"Webb (2003) recorded 11 parasites on *O. mossambicus* in north Queensland waters, including the non-indigenous cestode *Bothriocephalus acheilognathi* and the non-indigenous monogenean *Cichlidogyrus tilapiae*."

Poelen et al. (2014) lists *Aeromonas veronii* and *Gyrodactylus ulinganisus* as parasites of *Oreochromis mossambicus*.

Threat to Humans
From Froese and Pauly (2018):

"Potential pest"

3 Impacts of Introductions
From Russell et al. (2012):

"[…] *Oreochromis mossambicus* was directly or indirectly responsible for the disappearance of native species in Venezuela (Pérez et al. 2006a). In Central America, *O. mossambicus* and other tilapia species have been implicated in the decline of native cichlid populations in Lake Nicaragua, probably as a result of competitive displacement (McKaye et al. 1995) and their presence has been related to damage to indigenous fauna in Florida and Columbia (Philippart and

Ruwet 1982). The introduction of *O. mossambicus* into Laguna Chichancanab in Mexico negatively impacted on a species flock of endemic pupfish (*Cyprinodon* spp.) (Fuselier 2001) by competitively excluding them from optimal habitats, resulting in declines in the abundance in four out of the five flock members. These results were supported by both field and laboratory experiments that suggested agonistic behaviour of *O. mossambicus* towards pupfish had caused major microhabitat shifts. Fuselier (2001) also cautioned that the introduction of *O. mossambicus* may have disrupted the evolutionary mechanisms that led to the sympatric speciation of the pupfish flocks. This potentially could result in the breakdown of reproductive barriers between the recently diverged species, resulting in introgression and loss of rare phenotypes. On the Pacific island of Nauru, milkfish (*Chanos chanos*) aquaculture collapsed following the introduction of *O. mossambicus* to the island's mangrove lined lagoons and ponds to provide a food source and to control mosquitoes (Fortes 2005). Similar observations were made where *O. mossambicus* were introduced into milkfish ponds in the Philippines thereby resulting in predation and competition for food (Philippart and Ruwet 1982). In Fiji, stream networks with populations of *Oreochromis* spp. (*O. mossambicus* and/or *O. niloticus*) that were affected by loss of forest cover had, on average, 11 fewer species of native fish than did intact systems (Jenkins et al. 2009)."

"More recently Morgan et al. (2004) observed that since their introduction, *O. mossambicus* have spread rapidly throughout the Gascoyne River in Western Australia and are now the largest and most abundant fish in the system. *Oreochromis mossambicus* were observed during this study to be aggressive towards native fish when guarding their nests which, in places, covered up to 80% of the shallow, sandy river channels. Further, these authors suggested that because of this aggressive behaviour and reduced available habitat to endemic fishes through nest building, *O. mossambicus* must be impacting significantly on native fish populations especially during the dry season when the river contracts to isolated, small pools. They did not, however, quantify these impacts.

In a laboratory study investigating the impact of *O. mossambicus* on the spawning success of the native eastern rainbow-fish (*Melanotaenia splendida splendida*), the presence of breeding groups of *O. mossambicus* resulted in a decrease in both egg production and proportion of eggs fertilised by 70 and 30%, respectively (Doupé et al. 2009b). These authors observed no agonistic interactions and suggested that the results were possibly a combination of behavioural and chemical factors. Interestingly, when in the presence of a single *O. mossambicus* male, there was no negative impact on the spawning success of eastern rainbow-fish, with egg production actually increasing."

"Doupé et al. (2010) reported that herbivory from *O. mossambicus* significantly reduced macrophyte biomass of three native Australian species (*Hydrilla verticillata*, *Ceratophyllum demersum* and *Vallisneria nana*) in controlled microcosm experiments. However, within Australia, the impact of *O. mossambicus* on macrophytes at a community scale has not been assessed. […] In an aquarium experiment Wager and Rowe-Rowe (1972) found that out of 15 aquatic plants tested, *Spirogyra* sp. was the only one eaten by *O. mossambicus*. As a result they suggested that *O. mossambicus* was not as harmful to freshwater habitat as other tilapia species (e.g. *Tilapia rendalli*)."

“There are no confirmed cases in the literature of *O. mossambicus* being responsible for outbreaks of new diseases or parasite infestations in Australian native fishes. However, a recent study of Trichodinids of freshwater fish in Australia revealed new records of the exotic species *Trichodina heterodentata,* which is known to use *O. mossambicus* as a host (Dove and O’Donoghue 2005). Some specimens of *T. heterodentata* were collected more than a 1,000 km away and on the other side of the Great Dividing Range from the nearest wild *O. mossambicus* population, suggesting the parasite may be endemic or was introduced via another source (Dove and O’Donoghue 2005). Trichodinids can result in mass mortality of fish, particularly when the fish are stressed or in high densities (Barker et al. 2002). Webb (2003) recorded 11 parasites on *O. mossambicus* in north Queensland waters, including the non-indigenous cestode *Bothriocephalus acheilognathi* and the non-indigenous monogenean *Cichlidogyrus tilapiae*.”

From GISD (2018):

“Juveniles [of *Oreochromis mossambicus*] have been documented to feed on other fish (de Moor et al. 1986).”

“In Hawai‘i, this species is suspected to be a threat to native species such as striped mullet (*Mugil cephalus*) (Randall 1987; Devick 1991). Tilapia also have been considered a major factor in the decline of the desert pupfish (*Cyprinodon macularius*) in the Salton Sea area (Courtenay and Robins, 1989; Swift et al. 1993).”

“Mozambique tilapia (*Oreochromis mossambicus*) compete with the threatened native Bahama pupfish (*Cyprinodon laciniatus*) resulting in declining abundance of these fish (Barton, 1999).”

“Mozambique tilapia (*Oreochromis mossambicus*) in the Amaravathy [India] have resulted in chages [sic] in the fish assemblage.”

“Mozambique tilapia (*Oreochromis mossambicus*) compete with the vulnerable silverside fish charal de la caldera (see *Chirostoma bartoni* in IUCN Red List of Threatened Species) that is endemic to La Alberca crater-lake [Alcocer et al. 2000].”

“Mozambique tilapia (*Oreochromis mossambicus*) compete with the native *Cyprinodon* species for habitat, resulting in declining abundance of these fish [Fuselier 2001].”

“Stocking of Mozambique tilapia (*Oreochromis mossambicus*) in ponds has resulted in a net decrease in fisheries production, due to competition with other fish species [Contreras-MacBeath et al. 1998].”

“Mozambique tilapia (*Oreochromis mossambicus*) have caused the collapse of milkfish aquaculture [in Nauru] [Adams et al. 2000].”

“The introduction of two tilapia species (*Oreochromis mossambicus* and *Sarotherodon occidentalis*) in 1955, followed by that of the largemouth bass (*Micropterus salmoides*) in 1960, has led to a decrease in numbers of galaxias (*Galaxias neocaledonicus*). These introduced species preyed on the different stages of *G. neocaledonicus* (Keith 2002).”

From Froese and Pauly (2018):

"Enhanced food security and rural development [in Myanmar] [Thame 2003]."

"Has competed aggressively for food with *Mugil cephalus* leading to its decrease in population [Randall 1987]."

"Poses a serious threat of genetic pollution in Kunene and Okavango rivers: breeds with *O. andersonii* [Jackson 1961; Okeyo 2003]."

"Compete with small indigenous fish and gradually occupy their habitats [in Bangladesh] [Barua et al. 2001; Islam et al. 2003]."

"Considered invasive [in Malaysia], their numbers growing rapidly and often displacing native species particularly in rivers and lakes [Chong et al. 2010]."

"Competes with *Chanos chanos* for food in brackish water farms [in the Philippines] [Juliano et al. 1989]. Caused the near extinction of the local endemic fish *Mistichthys luzonensis* in Lake Buhi [Kottelat and Whitten 1996]."

From Nico and Neilson (2018):

"In Hawaii, this species is suspected as a threat to native species such as striped mullet *Mugil cephalus* (Randall 1987; Devick 1991b). […]"

From Canonico et al. (2005):

"In Lake Alaotra [Madagascar], the progressive introductions of different species of carp first, followed by several species of tilapias in 1954 (*T. rendalli*), 1958 (*O. macrochir*), and 1961 (*O. niloticus* and *O. mossambicus*) have also induced a drastic decline of native [fi]sh (Leveque, 1997)."

"By 1990, three species of introduced tilapias (*O. aureus*, *O. mossambicus,* and *O. niloticus*) were being caught throughout the coastal region, including in Lake Nicaragua's outlet on the San Juan River, the southern islands of Solentiname, and the northern shore (including isletas). In comparison with standing crop levels in the lake before tilapia introduction, and in locations where tilapias had not yet migrated, there was approximately 80% reduction of native cichlids and a 50% reduction in total cichlid biomass (including tilapias) wherever introduced tilapias were found in Lake Nicaragua (McKaye et al., 1995, 1998b)."

"In Lake Chichincanab, introduced *O. mossambicus* competed strongly for habitat with an endemic cyprinodontid, threatening extinction (Fuselier, 2001), and was the dominant species (Schmitter-Soto and Caro, 1997)."

From Pallewatta et al. (2003:95):

"Thus, this IAS [*Oreochromis mossambicus*, reported under the name *Sarotherodon mossambicus*] has replaced some of the native inhabitant fish such as *Labeo porcellus* and *L. dussumieri* [in Sri Lanka] (Bambaradeniya et al., 2001)."

From Lintermans et al. (2007):

"The species [*Oreochromis mossambicus*] has been reported elsewhere to kill aquatic macrophytes while feeding on periphyton, and they may eliminate submerged and emergent macrophytes by grazing or by uprooting plants (Lahser 1967). There is little data available on competition for food between Mozambique mouthbrooder and Australian native fish species, however the diet of juvenile *O. mossambicus* in the Chapman River (WA) and mature fish in the Gascoyne River was dominated by detritus, while some aquatic insects are also taken (Maddern 2003; Morgan et al. 2004)."

4 Global Distribution

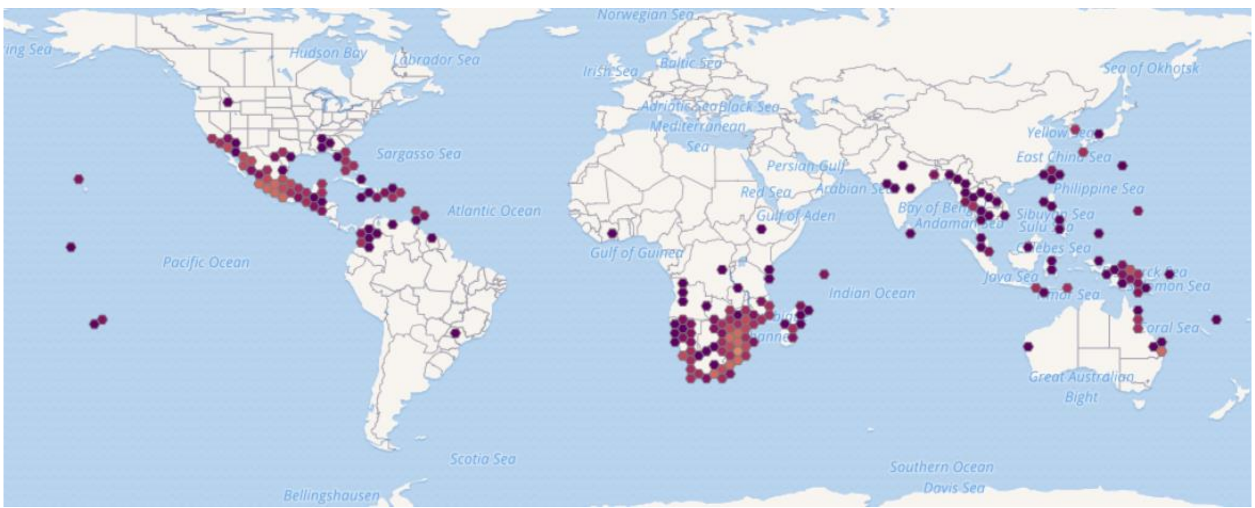

Figure 1. Known global distribution of *Oreochromis mossambicus*. Map from GBIF Secretariat (2018).

The location in Idaho is from a population established in hot springs (GBIF Secretariat 2018; Nico and Neilson 2018), the influence of the geothermal waters on the establishment and persistence of the population cannot be controlled for in the climate matching program (Sanders et al. 2014) so this point was not used as a source point for the climate match.

Figure 2. Known global distribution of *Oreochromis mossambicus*. Map from VertNet (2018).

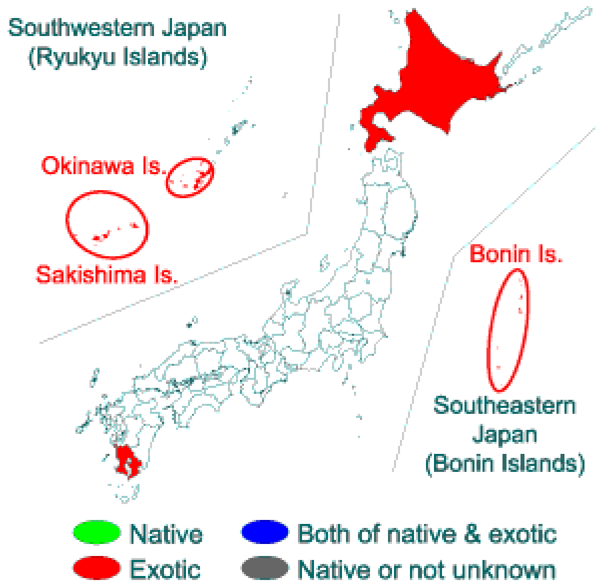

Figure 3. Known distribution of *Oreochromis mossambicus* in Japan. Map from NIES (2018).

The main islands of Japan were not used as source points for the climate match as *Oreochromis mossambicus* only persists overwinter in thermal refuges (Tachihara and Obara 2003).

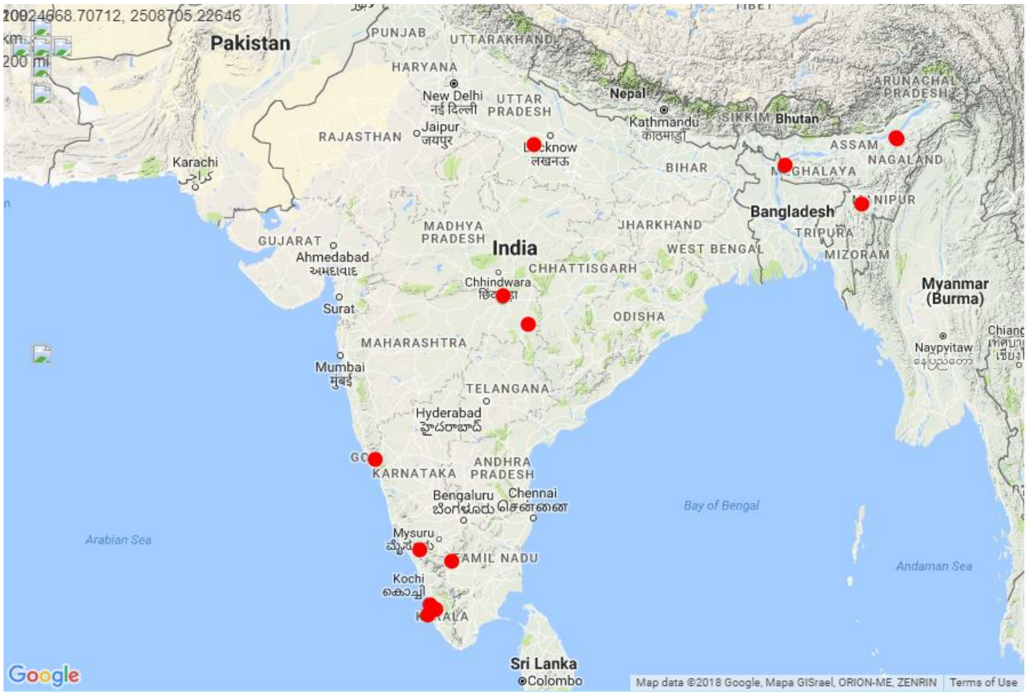

Figure 4. Known distribution of *Oreochromis mossambicus* in India. Map adapted from India Biodiversity Portal (No date).

5 Distribution Within the United States

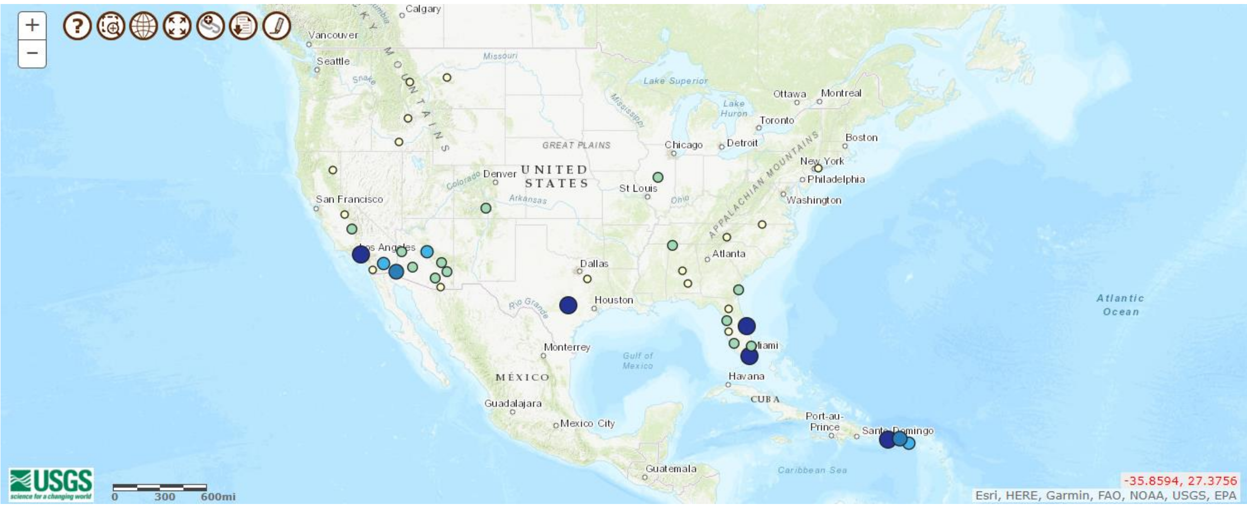

Figure 5. Known distribution of *Oreochromis mossambicus* in the contiguous United States and Caribbean U.S. territories. Map from Nico and Neilson (2018).

The location in New York is from an introduction that did not result in an established population (Nico and Neilson 2018) and was not used as a source point in the climate match. The locations in Idaho and western Montana are from populations established in geothermal waters and hot springs (Nico and Neilson 2018), the influence of the geothermal waters on the establishment and persistence of the population cannot be controlled for in the climate matching program (Sanders et al. 2014) so these points were not used as source points for the climate match. The location in the middle of Montana is the result of a record with no specific location (Nico and Neilson 2018) and was not used as a source point for the climate match. The northernmost point in California is the result of a biocontrol stocking that did not result in an established population (Nico and Neilson 2018); this location was not used as a source point for the climate match. The records from Illinois are either non-specific location records or from a research population that was moved indoors in the winter (Nico and Neilson 2018). The research population does not reflect the ability of the species to establish wild populations under the full climate conditions at that location and was not used as a source point for the climate match. The locations in Alabama, Georgia, and North Carolina are all from failed introductions (Nico and Neilson 2018) and were nost used as source points for the climate match. The location in northeast Texas is also the result of a failed introduction (Nico and Neilson 2018) and was not used as a source point for the climate match.
The locations in Colorado were used as source points for the climate match as the records indicated that they were established without mention of a thermal refuge (Nico and Neilson 2018).

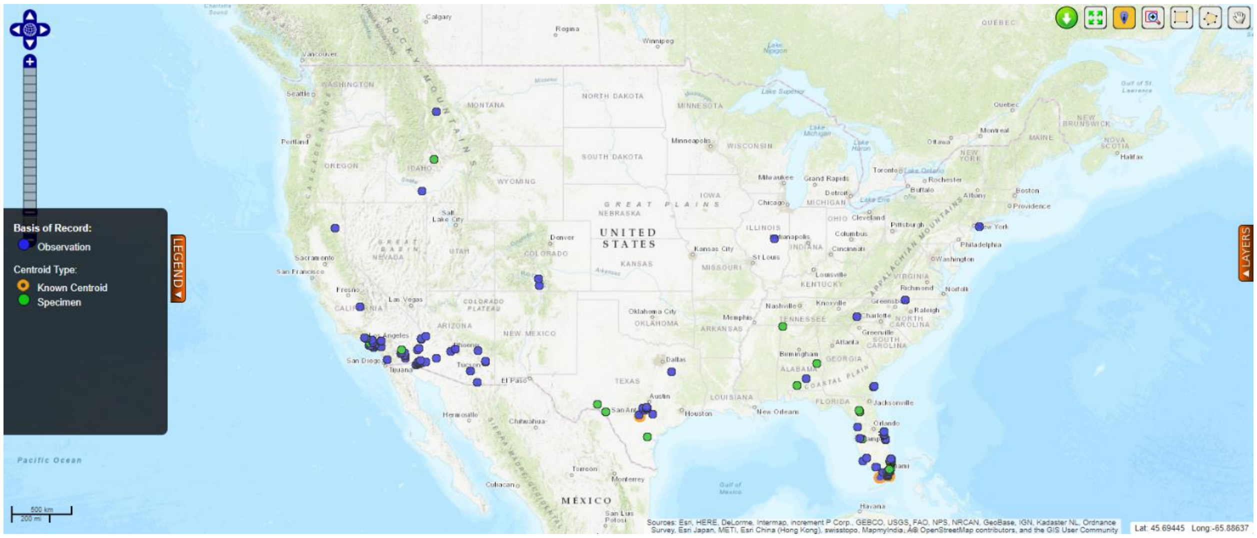

Figure 6. Known distribution of *Oreochromis mossambicus* in the contiguous United States. Map from BISON (2018).

Figure 7. Known distribution of *Oreochromis mossambicus* in Hawaii. Map from Nico and Neilson (2018).

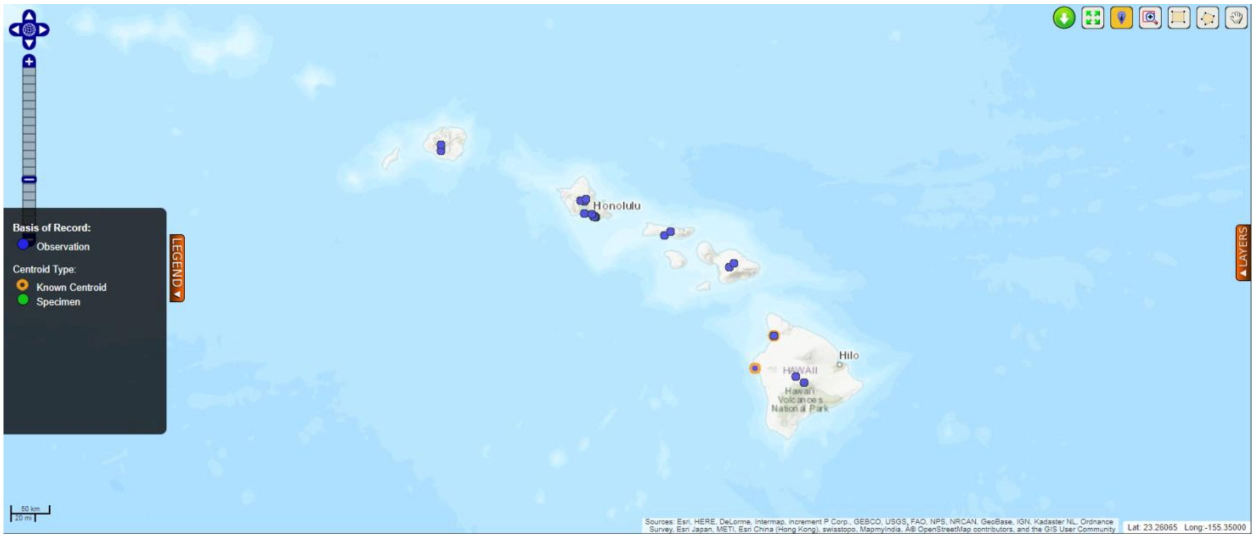

Figure 8. Known distribution of *Oreochromis mossambicus* in Hawaii. Map from BISON (2018).

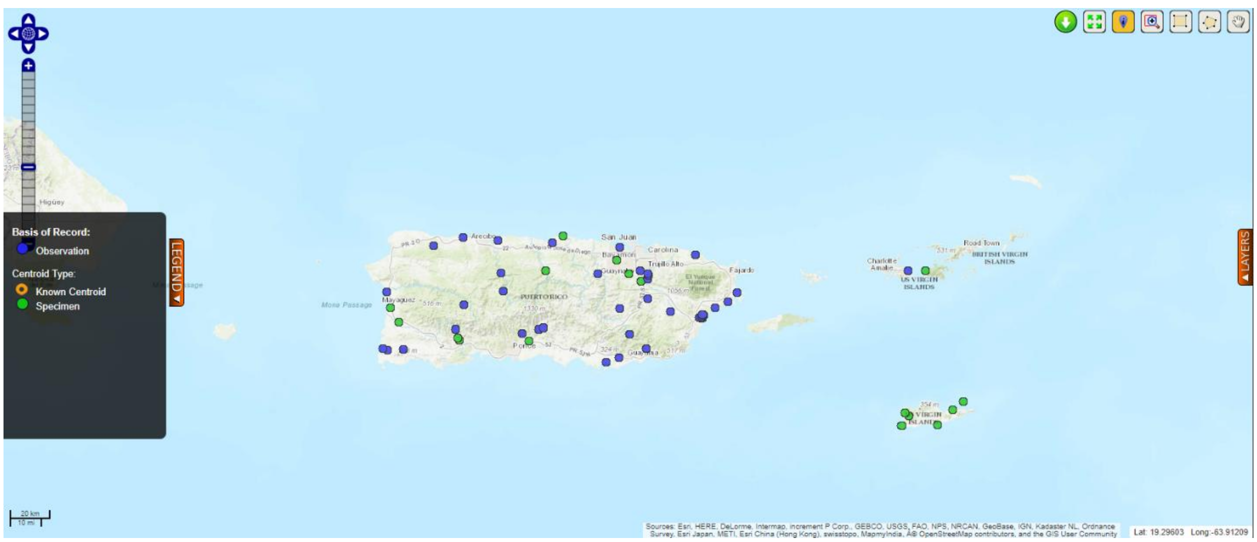

Figure 9. Known distribution of *Oreochromis mossambicus* in Puerto Rico and the U.S Virgin Islands. Map from BISON (2018).

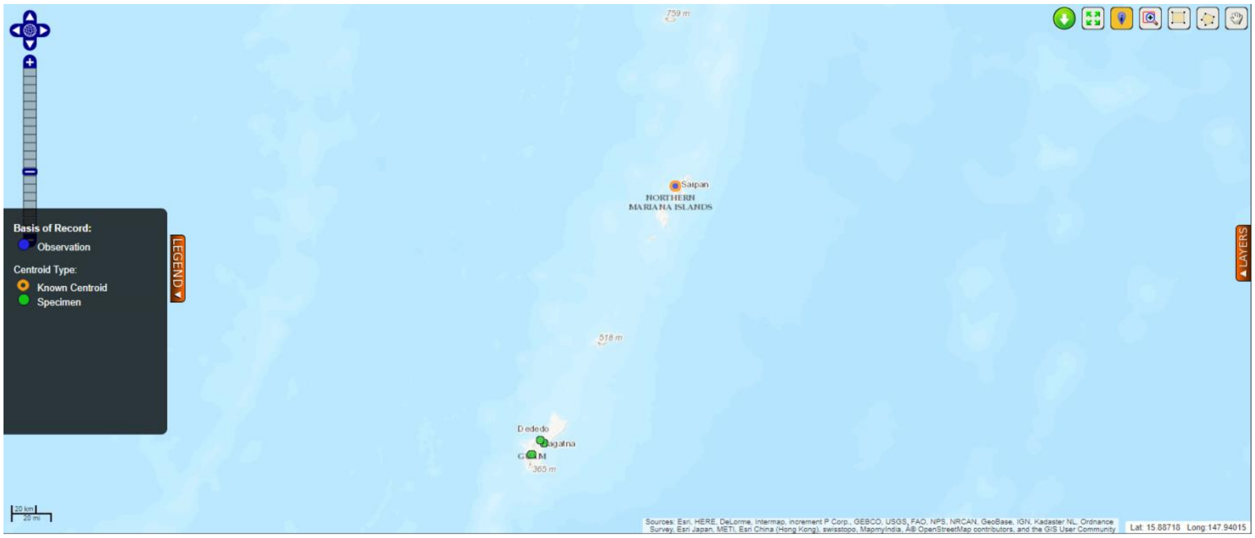

Figure 10. Known distribution of *Oreochromis mossambicus* in Guam and the Northern Mariana Islands. Map from BISON (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Oreochromis mossambicus* was high in Florida and the southern Atlantic Coast, along the border with Mexico extending north into most of Texas and the southwest, most of California, and a strip from Colorado to North Dakota. The climate match was low in the Pacific Northwest, and in the east from New England down through the Appalachian Mountains and small areas of Louisiana, Mississippi, and Alabama. Everywhere else had a medium match. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous U.S. was 0.486, high. The following states had individually high climate scores: Arizona, California, Colorado, Florida, Georgia, Idaho, Michigan, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Oklahoma, South Carolina, South Dakota, Texas, Utah, Washington, West Virginia, Wisconsin, and Wyoming.

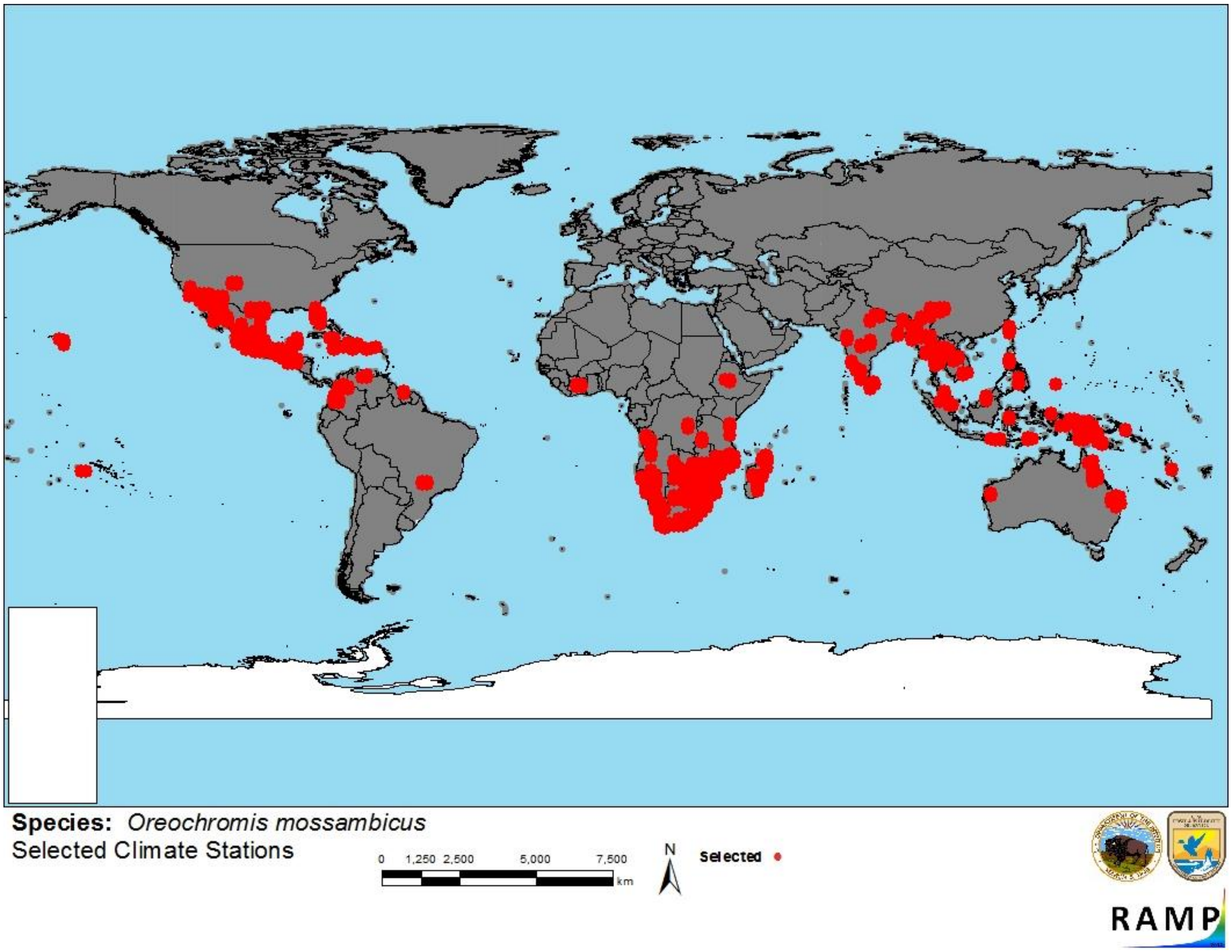

Figure 11. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Oreochromis mossambicus* climate matching. Source locations from Tachihara and Obara (2003), BISON (2018), GBIF Secretariat (2018), Nico and Neilson (2018), NIES (2018), VertNet (2018), and India Biodiversity Portal (no date).

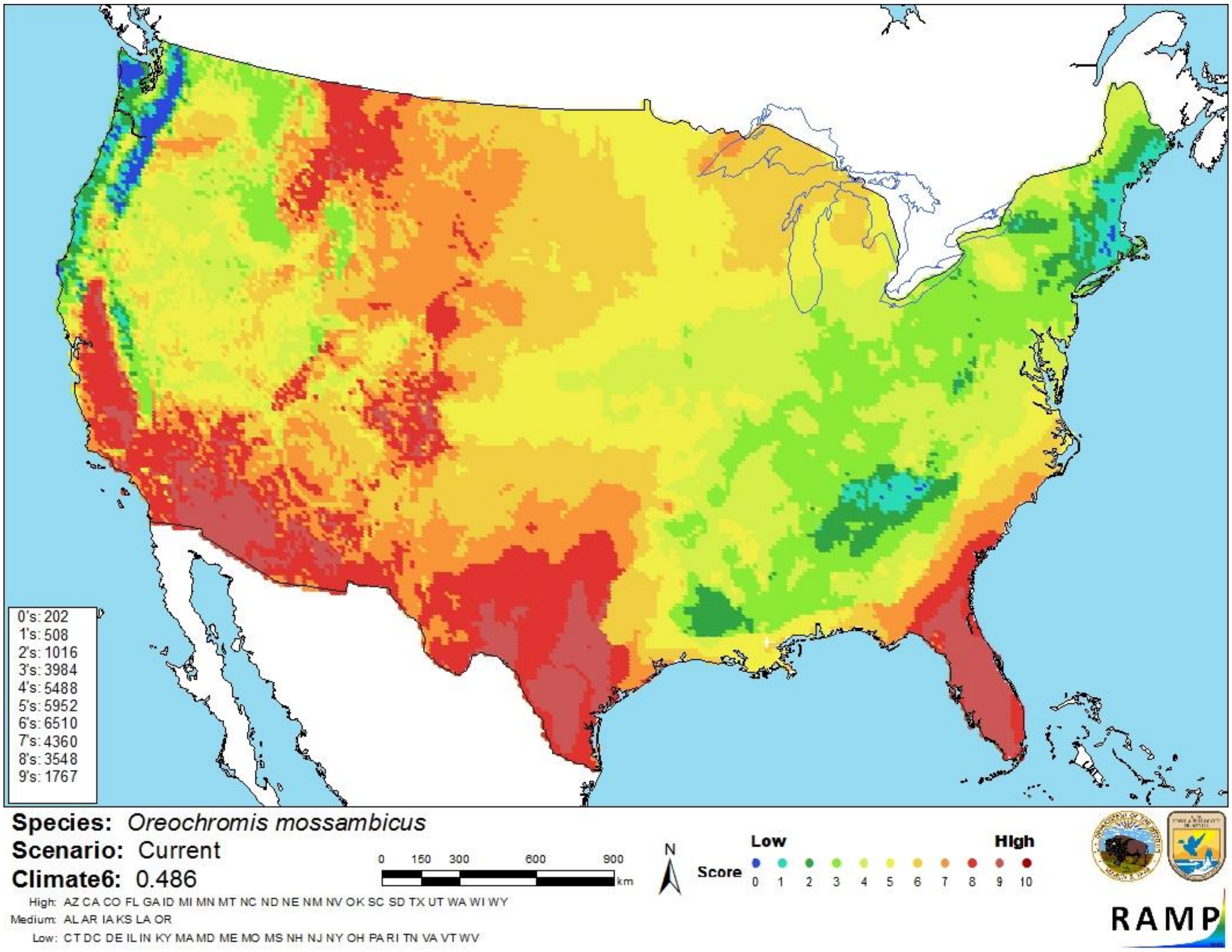

Figure 12. Map of RAMP (Sanders et al. 2014) climate matches for *Oreochromis mossambicus* in the contiguous United States based on source locations reported by Tachihara and Obara (2003), BISON (2018), GBIF Secretariat (2018), Nico and Neilson (2018), NIES (2018), VertNet (2018), and India Biodiversity Portal (no date). 0 = Lowest match, 10 = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

The certainty of assessment for *Oreochromis mossambicus* is high. Information on the biology, distribution, and impacts of this species is readily available. Negative impacts from introductions of this species are adequately documented in the scientific literature. No further information is needed to evaluate the negative impacts the species is having where introduced.

8 Risk Assessment

Summary of Risk to the Contiguous United States

The history of invasiveness for *Oreochromis mossambicus* is high. *O. mossambicus* has a truly circumglobal distribution currently owing to its high value to humans for commercial and recreational fishing, aquaculture, the aquarium trade, mosquito and macrophyte control, and biological research. Where *O. mossambicus* has been introduced outside its native range in southeastern Africa, numerous impacts have been documented on native fish and macrophytes including potential extirpation of native species. In addition to impacts of herbivory, competition, and predation, *O. mossambicus* is susceptible to numerous parasitic, bacterial, and viral diseases that could be transmitted to native fish populations. Climate match to the contiguous U.S. is high. There are already established populations in some states. The species has established in thermal springs, even in colder climates, such as Idaho and Japan. The certainty of assessment is high. Overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information** This species is very popular in the worldwide aquaculture industry and easily hybridizes with other species of *Oreochromis*. Known to establish in thermal springs around the world.
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

BISON. 2018. Biodiversity Information Serving Our Nation (BISON). U.S. Geological Survey. Available: https://bison.usgs.gov. (February 2018).

CABI. 2018. *Oreochromis mossambicus* (Mozambique tilapia) [original text by K. Fitzsimmons]. *In* Invasive Species Compendium. CAB International, Wallingford, UK. Available: https://www.cabi.org/isc/datasheet/72085. (February 2018).

Cambray, J., and E. Swartz. 2007. *Oreochromis mossambicus*. The IUCN Red List of Threatened Species, version 2015.2. Available: http://www.iucnredlist.org/details/63338/0. (July 2015).

Canonico, G. C., A. Arthington, J. K. McCrary, and M. L. Thieme. 2005. The effects of introduced tilapias on native biodiversity. Aquatic Conservation: Marine and Freshwater Ecosystems 15:463–183.

Eschmeyer, W. N., R. Fricke, and R. van der Laan, editors. 2018. Catalog of fishes: genera, species, references. Available: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. (February 2018).

Froese, R., and D. Pauly, editors. 2018. *Oreochromis mossambicus* (Peters, 1852). FishBase. Available: http://www.fishbase.org/summary/Oreochromis-mossambicus.html. (February 2018).

GBIF Secretariat. 2018. GBIF backbone taxonomy: *Oreochromis mossambicus* (Peters, 1852). Global Biodiversity Information Facility, Copenhagen. Available: https://www.gbif.org/species/2372396. (February 2018).

GISD (Global Invasive Species Database). 2018. Species profile: *Oreochromis mossambicus* (fish). Invasive Species Specialist Group, Gland, Switzerland. Available: http://www.iucngisd.org/gisd/speciesname/Oreochromis+mossambicus. (February 2018).

India Biodiversity Portal. No date. *Oreochromis mossambicus* (Peters, 1852). India Biodiversity Portal, species page. Available: http://indiabiodiversity.org/species/show/232949. (February 2018).

ITIS (Integrated Taxonomic Information System). 2018. *Oreochromis mossambicus* (Peters, 1852). Integrated Taxonomic Information System, Reston, Virginia. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170015. (February 2018).

Lintermans, M., T. Raadik, D. Morgan, and P. Jackson. 2007. Overview of the ecology and impact of three alien fish species: redfin perch, Mozambique mouthbrooder (tilapia) and oriental weatherloach. Pages 22–32 *in* D. Ansell, and P. Jackson, editors. Emerging issues in alien fish management in the Murray-Darling Basin: statement, recommendations and supporting papers. Proceedings of a workshop held in Brisbane QLD, 30-31 May 2006. Murray-Darling Basin Commission, Canberra, Australia.

Masterson, J. 2007. Indian River Lagoon species inventory: *Oreochromis mossambicus* Peters, 1852. Smithsonian Marine Station, Fort Pierce, Florida. Available: http://www.sms.si.edu/irlspec/Oreochromis_mossambicus.htm. (February 2018).

Nico, L., and M. Neilson. 2018. *Oreochromis mossambicus* (Peters, 1852). U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=466. (February 2018).

NIES (National Institute for Environmental Studies). 2018. *Oreochromis mossambicus*. *In* Invasive species of Japan. National Research and Development Agency, National Institute for Environmental Studies, Tsukuba, Japan. Available: http://www.nies.go.jp/biodiversity/invasive/DB/detail/50350e.html. (February 2018).

Pallewatta, N., J. K. Reaser, and A. T. Gutierrez, editors. 2003. Invasive alien species in South-Southeast Asia: national reports and directory of resources. Global Invasive Species Programme, Cape Town, South Africa.

Poelen, J. H., J. D. Simons, and C. J. Mungall. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. Ecological Informatics 24:148–159.

Russell, D. J., P. A. Thuesen, and F. E. Thomson. 2012. A review of the biology, ecology, distribution and control of Mozambique tilapia, *Oreochromis mossambicus* (Peters 1852) (Pisces: Cichlidae) with particular emphasis on invasive Australian populations. Reviews in Fish Biology and Fisheries 22:533–554.

Sanders, S., C. Castiglione, and M. Hoff. 2014. Risk assessment mapping program: RAMP. U.S. Fish and Wildlife Service.

Tachihara, K., and E. Obara. 2003. Age and growth of the Mozambique tilapia, *Oreochromis mossambicus* introduced into the Genka River on Okinawa Island. Suisanzoshoku 51(3):307–313.

VertNet. 2018. VertNet. Available: http://portal.vertnet.org/search?q=Oreochromis+mossambicus. (February 2018).

10 References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Adams, T., J. Bell, and P. Labrosse. 2000. Current status of aquaculture in the Pacific Islands. Pages 295–305 *in* Aquaculture in the third millennium. R. P. Subasinghe, P. Bueno, M. J. Phillips, C. Hough, C. E. McGladdery, and J. R. Arthur, editors. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand.

Agenbag, S. 1998. Lake Otjikoto: history and mystery. Windhoek, Namibia.

Aiken, K. A., D. Morris, F. C. Hanley, and R. Manning. 2002. Aquaculture in Jamaica. WorldFish Center, Naga Q.2 25(3-4):10–15.

Alcocer, J., E. Escobar, and A. Lugo. 2000. Water use (and abuse) and its effects on the crater-lakes of Valle de Santiago, Mexico. Lakes & Reservoirs: Research and Management 5:145–149.

Allanson, B. R., A. Bok, and N. I. Wyk. 1971. The influence of exposure to low temperature on *Tilapia mossambica* Peters (Cichlidae). Journal of Fish Biology 3(2):181–185.

Allen, G. R., C. J. Allen, and D. F. Hoese. 2006. Latidae. Cichlidae. Pages 966–968, 1435–1438 *in* D. F. Hoese, D. J. Bray, J. R. Paxton, and G. R. Allen. Zoological catalogue of Australia, volume 35. Fishes. Parts 1-3. CSIRO, Collingwood, Australia.

Allen, G. R., and D. Coates. 1990. An ichthyological survey of the Sepik River, Papua New Guinea. Records of the Western Australian Museum Supplement 34:31–116.

Allen, G. R., K. G. Hortle, and S. J. Renyaan. 2000. Freshwater fishes of the Timika region, New Guinea. PT Freeport Indonesian, Timika Environmental Laboratory, Timika, Indonesia.

Allen, G. R., S. H. Midgley, and M. Allen. 2002. Field guide to the freshwater fishes of Australia. Western Australian Museum, Perth, Western Australia.

Allen, G. R., L. R. Parenti, and D. Coates. 1992. Fishes of the Ramu River, Papua New Guinea. Ichthyological Exploration of Freshwaters 3(4):289–304.

Allen, G. R., A. W. Storey, and M. Yarrao. 2008. Freshwater fishes of the Fly River Papua New Guinea.

Amarasinghe, U. S. 2002. The fishery and population dynamics of *Oreochromis mossambicus* and *Oreochromis niloticus* (Osteichthyes, Cichlidae) in a shallow irrigation reservoir in Sri Lanka. Asian Fisheries Science 15(1):7–20.

Amorim, M. C. P., P. J. Fonseca, and V. C. Almada. 2003. Sound production during courtship and spawning of *Oreochromis mossambicus*: male-female and male-male interactions. Journal of Fish Biology 62(3):658–672.

Andrews, S. 1985. Aquatic species introduced to Fiji. Domodomo 3(2):67–82.

Appleyard, S. A., and P. B. Mather. 2000. Investigation into the mode of inheritance of allozyme and random amplified polymorphic DNA markers in tilapia *Oreochromis mossambicus* (Peters). Aquaculture Research 31:435–445.

Arrignon, J. 1962. *Tilapia mossambica* Peters, *Tilapia macrochir* Blgr., *Tilapia zillii* Gervais. Trois nouveaux venus dans les eaux douces algériennes. Ann. Centr. Rech. Exper. Forest. Alger 2:33–63.

Arthington, A. H., and D. A. Milton. 1986. Reproductive biology, growth and age composition of the introduced *Oreochromis mossambicus* (Cichlidae) in two reservoirs, Brisbane, Australia. Environmental Biology of Fishes 16:257–266.

Arun, L. K., C. P. Shaji, and P. S. Easa. 1996. Record of new fishes from Periyar Tiger Reserve. Journal of the Bombay Natural History Society 93(1):103–104.

Arunachalam, M., A. Sankaranarayanan, J. A. Johnson, C. Vijayakumar, A. Manimekalan, et al. 2001. Fishes of Ramanadhi River in Kalakkad Mundanthurai Tiger Reserve, Tamil Nadu, India. Journal of the Bombay Natural History Society 98(1):128–129.

Attaala, A. M., and B. S. Rubaia. 2005. First record of the eel *Anguilla bengalensis* from Arabia with notes on freshwater fishes from Hadhramout, Yemen. Zool. Middle East 34:35–44.

Azad, I. S., A. R. Thirunavukkarasu, M. Kailasam, and J. J. S. Rajan. 2004. Virulence and histopathology of *Vibrio anguillarumlike* (VAL) bacterium isolated from hatchery produced juveniles of *Lates calcarifer* (Bloch). Asian Fisheries Science 17(1&2):101–110.

Baby, F., J. Tharian, S. Philip, A. Ali, and R. Raghavan. 2011. Checklist of the fishes of the Achankovil forests, Kerala, India with notes on the range extension of an endemic cyprinid *Puntius chalakkudiensis*. Journal of Threatened Taxa 3(7):1936–1941.

Bacchet, P., T. Zysman, and Y. Lefèvre. 2006. Guide des poissons de Tahiti et ses îles. Tahiti (Polynésie Francaise): Éditions Au Vent des Îles.

Balarin, J. D. 1979. Tilapia. A guide to their biology and culture in Africa. University of Stirling, Stirling, Scotland.

Balite, L. R. 1993. Status of fish production and management of fisheries in the reservoirs of NPC Hydroelectric Power Plants (HEPs). Pages 21–52 *in* R. C. Sevilleja, E. V. Manalili, and R. D. Guerrero III, editors. Reservoir fisheries management in the Philippines. PCAMRD Book Series 17.

Bambaradeniya, C. N. B., S. P. Ekanayake, and J. Gunawardena. 2001. Preliminary observations on the status of alien invasive biota in natural ecosystems of Sri Lanka. Pages 67–76 *in* P. Balakrishna, editor. Report of the Workshop on Alien Invasive Species. Global Biodiversity Forum, South and Southeast Asia Session, October 1999, Colombo, Sri Lanka.

Barata, E. N., J. M. Fine, P. C. Hubbard, O. G. Almeida, P. Frade, P. W. Sorensen, and A. V. M. Canario. 2008. A sterol-like odorant in the urine of Mozambique tilapia males likely signals social dominance to females. Journal of Chemical Ecology 34(4):438–449.

Bardach, J. E., J. H. Ryther, and W. O. McLarney. 1972. Aquaculture: the farming and husbandry of freshwater and marine organisms. Wiley-Interscience, New York.

Barker, D. E., D. K. Cone, and M. D. B. Burt. 2002. *Trichodina murmanica* (Ciliophora) and *Gyrodactylus pleuronecti* (Monogenea) parasitising hatchery-reared winter flounder, *Pseudopleuronectes americanus* (Walbaum): effects on host growth and assessment of parasite interaction. Journal of Fish Disease 25:81–89.

Barrett, P. J. 1983. Systematics of fishes of the genus *Tilapia* (Perciformes: Cichlidae) in the lower Colorado River basin. Master's thesis. Arizona State University, Tempe.

Barriga S., R. 2012. Lista de peces de agua dulce e intermareales del Ecuador. Revista Politécnica 30(3):83–119.

Barton, M. 1999. Threatened fishes of the world: *Cyprinodon laciniatus* Hubbs & Miller, 1942 (Cyprinodontidae). Environmental Biology of Fishes 55:422.

Barton, M., and C. Wilmhoff. 1996. Inland fishes of the Bahamas - new distribution records for exotic and native species from New Providence Island. Bahamas Journal of Science 3(2):7–11.

Barua, S. P., M. M. H. Khan, and A. H. M. Ali Reza. 2001. The status of alien invasive species in Bangladesh and their impact on the ecosystems. Pages 1–7 *in* P. Balakrishna, editor. Report of Workshop on Alien Invasive species, GBF-SSEA. Colombo. IUCN Regional Biodiversity Programme, Asia, Colombo, Sri Lanka.

Bell-Cross, G. 1976. The fishes of Rhodesia. National Museums and Monuments of Rhodesia, Salisbury.

Bell-Cross, G., and J. L. Minshull. 1988. The fishes of Zimbabwe. National Museums and Monuments of Zimbabwe, Harare.

Berra, T. M., R. Moore, and L. F. Reynolds. 1975. The freshwater fishes of the Laloki river system of New Guinea. Copeia 1975(2):316–326.

Bhat, A. 2000. Fish germplasm inventory of Sharavati, Aghanashini, Bedti and Kali rivers, Uttara Kannada. Pages 148–151 *in* A. G. Ponniah, and A. Gopalakrishnan, editors. Endemic fish diversity of Western Ghats. NBFGR-NATP Publication. National Bureau of Fish Genetic Resources, Lucknow, India.

Bijukumar, A., and S. Sushama. 2000. Ichthyofauna of Ponnani estuary, Kerala. Journal of the Marine Biological Association of India 42(1–2):182–189.

Bishop Museum. 2000. Pearl Harbor Legacy Project. Available: http://www.bishop.hawaii.org/bishop/invert/phlegacy.html.

Blaber, S. J. M. 1997. Fish and fisheries of tropical estuaries. Fish and Fisheries Series 22, Chapman and Hall, London.

Blaxter, J. H. S. 2000. The enhancement of marine fish stocks. Advances in Marine Biology 38:1–54.

Bluhdorn, D. R., and A. H. Arthington. 1989. Tilapia in Australia and around the world. Snippets 1:25–29.

Bluhdorn, D. R., and A. H. Arthington. 1990a. The incidence of stunting in Australian populations of the introduced cichlid *Oreochromis mossambicus* (Peters). Second Asian Fisheries Forum, Tokyo, Japan, 17–22 April 1989.

Bluhdorn, D. R., and A. H. Arthington. 1990b. Somatic characteristics of an Australian population of *Oreochromis mossambicus* (Pisces: Cichlidae). Environmental Biology of Fishes 29(4):277–291.

Bogutskaya, N. G., and A. M. Naseka. 2004. Catalogue of agnathans and fishes of fresh and brackish waters of Russia with comments on nomenclature and taxonomy. Russian Academy of Sciences, Moscow. (In Russian.)

Boschung, H. T. 1992. Catalog of freshwater and marine fishes of Alabama. Bulletin of the Alabama Museum of Natural History 14:1–266.

Boulenger, G. A. 1899. A revision of the African and Syrian fishes of the family Cichlidae. Part II. Proceedings of the Zoological Society of London 1899:98–143.

Boulenger, G. A. 1915. Catalogue of the fresh-water fishes of Africa in the British Museum (Natural History). Volume III. Printed by order of the Trustees, London.

Bowen, S. H. 1980. Detrital nonprotein amino acids are the key to rapid growth of Tilapia in Lake Valencia, Venezuela. Science 207(4436):1216–1218.

Bowman, D. 1975. Comparacion entre *Tilapia aurea* y *Tilapia mossambica* en estanques de El Salvador. FAO Fisheries Reports 159(1):78–90.

Brock. 1960. [Source material did not give full citation for this reference.]

Brown, W. H. 1961. First record of the African mouthbreeder *Tilapia mossambica* Peters in Texas. Texas Journal of Science 13:352–354.

Brown, C. J. D. 1971. Fishes of Montana. Montana State University, Bozeman.

Brown, C. J. D., and A. C. Fox. 1966. Mosquito fish (*Gambusia affinis*) in a Montana pond. Copeia 1966(3):614–616.

Bruton, M. N., and B. R. Allanson. 1974. The growth of *Tilapia mossambica* Peters (Pisces: Cichlidae) in Lake Sibaya, South Africa. Journal of Fish Biology 6:701–715.

Bruton, M. N., and R. E. Boltt. 1975. Aspects of the biology of *Tilapia mossambica* Peters (Pisces: Cichlidae) in a natural freshwater lake (Lake Sibaya, South Africa). Journal of Fish Biology 7:423–445.

Bruton, M. N., P. B. N. Jackson, and P. H. Skelton. 1982. Pocket guide to the freshwater fishes of southern Africa. Centaur Publishers, Cape Town, South Africa.

Bui, T. A., N. T. L. Anh, N. Q. Thai, and N. H. Son. 2009. Assessment for domestic fisheries in Son La. Technical report, Ministry of Agriculture and Rural Development.

Burger J., K. Cooper, D. J. Gochfeld, J. E. Saliva, C. Safina, D. Lipsky, and M. Cochfeld. 1992. Dominance of *Tilapia mossambica*, an introduced fish species, in three Puerto Rican estuaries. Estuaries 15:239–245.

Carpenter, K. E. 2001. Family Cichlidae. *In* K. E. Carpenter, and V. H. Niem. Species identification guide for fishery purposes. The living marine resources of the western central Pacific. Bony fishes part 3 (Menidae to Pomacentridae). FAO, Rome.

Carpenter, K. E. 2003. Lobotidae. Sparidae. Kyphosidae. Cichlidae. Uranoscopidae. Pages 1505, 1554–1577, 1684–1687, 1690–1693, 1746–1747 *in* K. E. Carpenter, editor. The living marine resources of the Western Central Atlantic, volume 3. Bony fishes part 2 (Opistognathidae to Molidae). FAO species identification guide for fishery purposes and American Society of Ichthyologist and Herpetologists Special Publication 5, FAO, Rome.

Chakalall, B., complier. 1993. Species cultured in insular Caribbean countries, Belize, French Guiana, Guyana and Suriname. Caribbean Technical Co-operation Network in Artisanal Fisheries an Aquaculture. FAO Regional Office for Latin America and the Caribbean, RLAC/93/28-PES-24, Santiago, Chile.

Charlotte Harbor NEP. 2004. [Source material did not give full citation for this reference.]

Chen, C.-H. 2004. Checklist of the fishes of Penghu. FRI Special Publication 4.

Cheng, Q.-T., and C.-W. Zhou, editors. 1997. The fishes of Shandong Province.

Chervinski, J. 1982. Environmental physiology of tilapias. ICLARM Conference Proceedings 7:119–128.

Chong, V. C., P. K. Y. Lee, and C. M. Lau. 2010. Diversity, extinction risk and conservation of Malaysian fishes. Journal of Fish Biology 76(9):2009–2066.

Çiçek, E., S. S. Birecikligil, and R. Fricke. 2015. Freshwater fishes of Turkey: a revised and updated annotated checklist. Biharean Biologist 9(2):141–157.

Cinco, E. A., J. C. Diaz, Q. P. Sia III, and G. T. Silvestre. 1994. A checklist of fishes caught in San Miguel Bay, Philippines. *In* G. Silvestre, C. Luna, and J. Padilla, editors. Multidisciplinary assessment of the fisheries in San Miguel Bay, Philippines (1992-1993). International Center for Living Aquatic Resources Management, ICLARM Technical Report 47, Makati, Philippines.

Cnaani, A., G. A. E. Gall, and G. Hulata. 2000. Cold tolerance of tilapia species and hybrids. Aquaculture International 8(4):289–298.

Coad, B. W. 1996. Exotic and transplanted fishes in southwest Asia. Publicaciones Especiales Instituto Español de Oceanografía, Madrid 21:81–106.

Coche, A. G. 1982. Cage culture of tilapias. Pages 205–246 *in* R. S. V. Pullin, and R. H. Lowe-McConnell, editors. The biology and culture of tilapias. ICLARM Conference Proceedings 7.

Coles, S. L., R. C. DeFelice, and L. G. Eldredge. 1999. Nonindigenous marine species introductions in the harbors of the south and west shores of Oahu, Hawaii. Available: http://hbs.bishopmuseum.org/pdf/southshore.pdf.

Contreras-MacBeath, T., H. M. Mojica, and R. C. Wilson. 1998. Negative impact on the aquatic ecosystems of the state of Morelos, Mexico from introduced aquarium and other commercial fish. Aquarium Sciences and Conservation 2:67–78.

Copley, H. 1952. The game fishes of Africa. H.F. & G. Witherby, London.

Costa-Pierce, B. A. 2003. Rapid evolution of an established feral tilapia (*Oreochromis* spp.): the need to incorporate invasion science into regulatory structures. Biological Invasions 5:71–84.

Costa-Pierce, B. A., and R. Riedel. 2000. Fisheries ecology of the tilapias in subtropical lakes of the United States. *In* B. A. Costa-Pierce, and J. E. Rakocy, editors. Tilapia aquaculture in the Americas, volume 2.World Aquaculture Society, Baton Rouge, Louisiana.

Courtenay, W. R., Jr. 1989. Exotic fishes in the National Park System. Pages 237–252 *in* L. K. Thomas, editor. Proceedings of the 1986 conference on science in the national parks, volume 5. Management of exotic species in natural communities. U.S. National Park Service and George Wright Society, Washington, D.C.

Courtenay, W. R., Jr., and D. A. Hensley. 1979. Survey of introduced non-native fishes. Phase I report. Introduced exotic fishes in North America: status 1979. National Fishery Research Laboratory, U.S. Fish and Wildlife Service, Gainesville, Florida.

Courtenay, W. R., Jr., D. A. Hensley, J. N. Taylor, and J. A. McCann. 1984. Distribution of exotic fishes in the continental United States. Pages 41–77 *in* W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. Distribution, biology and management of exotic fishes. Johns Hopkins University Press, Baltimore, Maryland.

Courtenay, W. R., Jr., D. A. Hensley, J. N. Taylor, and J. A. McCann. 1986. Distribution of exotic fishes in North America. Pages 675–698 *in* C. H. Hocutt, and E. O. Wiley, editors. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York.

Courtenay, W. R., Jr., D. P. Jennings, and J. D. Williams. 1991. Appendix 2: exotic fishes. Pages 97–107 *in* C. R. Robins, R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott, editors. Common and scientific names of fishes from the United States and Canada, 5th edition. American Fisheries Society, Special Publication 20, Bethesda, Maryland.

Courtenay, W. R., Jr., and J. A. McCann. 1981. Status and impact of exotic fish presently established in U.S. open waters. National Fishery Research Laboratory, Report, U.S. Fish and Wildlife Service, Gainesville, Florida.

Courtenay, W. R., Jr., and C. R. Robins. 1989. Fish introductions: good management, mismanagment, or no management? CRC Critical Reviews in Aquatic Sciences 1(1):159–172.

Courtenay, W. R., Jr., C. R. Robins, R. M. Bailey, and J. E. Deacon. 1987. Records of exotic fishes from Idaho and Wyoming. Great Basin Naturalist 47(4):523–546.

Courtenay, W. R., Jr., H. F. Sahlman, W. W. Miley II, and D. J. Herrema. 1974. Exotic fishes in fresh and brackish waters of Florida. Biological Conservation 6(4):292–302.

Courtenay, W. R., Jr., and J. R. Stauffer, Jr. 1990. The introduced fish problem and the aquarium fish industry. Journal of the World Aquaculture Society 21(3):145–159.

Crass, R. S. 1964. Freshwater fishes of Natal. Shuter & Shooter, Pietermaritzburg, South Africa.

Crutchfield. 1995. [Source material did not give full citation for this reference.]

Dahlberg and Scott. 1971b. [Source material did not give full citation for this reference.]

de Moor, I. J., and M. N. Bruton. 1988. Atlas of alien and translocated indigenous aquatic animals in southern Africa. Foundation for Research Development and Council for Scientific and Industrial Research, South African National Scientific Programmes Report 144, Pretoria, South Africa.

de Moor, F. C., R. C. Wilkinson, and H. M. Herbst. 1986. Food and feeding habits of *Oreochromis mossambicus* (Peters) in hypertrophic Hartbeespoort Dam, South Africa. South African Journal of Zoology 21:170–176.

de Pienaar, U. V. 1968. The freshwater fishes of the Kruger National Park. Koedoe 11:1–82.

De Silva, S. S. 1985. Body condition and nutritional ecology of *Oreochromis mossambicus* (Pisces: Cichlidae) populations of man-made lakes in Sri Lanka. Journal of Fish Biology 27:621–633.

De Silva, S. S. 1988. Reservoirs of Sri Lanka and their fisheries. FAO, Fisheries Technical Paper 298.

De Silva, S. S., and J. Chandrasoma. 1980. Reproductive biology of *Sarotherodon mossambicus*, an introduced species, in an ancient man-made lake in Sri-Lanka. Environmental Biology of Fishes 5(3):253–259.

De Silva, S. S., M. K. Perera, and P. Maitipe. 1984. The composition, nutritional status and digestibility of the diets of *Sarotherodon mossambicus* from nine man-made lakes in Sri Lanka. Environmental Biology of Fishes 11(3):205–219.

De Silva, S. S., and H. K. G. Sirisena. 1988. Observations on the nesting habits of *Oreochromis mossambicus* (Peters) (Pisces: Cichlidae) in Sri Lankan reservoirs. Journal of Fish Biology 33(5):689–696.

Debrot, A. O. 2003. A review of the freshwater fishes of Curaçao, with comments on those of Aruba and Bonaire. Caribbean Journal of Science 39(1):100–108.

Devick, W. S. 1991a. Disturbances and fluctuations in the Wahiawa Reservoir ecosystem. Division of Aquatic Resources, Project F-14-R-15, Job 4, Study I, Hawaii Department of Land and Natural Resources.

Devick, W. S. 1991b. Patterns of introductions of aquatic organisms to Hawaiian freshwater habitats. Pages 189–213 *in* New directions in research, management and conservation of Hawaiian freshwater stream ecosystems. Proceedings of the 1990 symposium on freshwater stream biology and fisheries management, Division of Aquatic Resources, Hawaii Department of Land and Natural Resources.

Dial, R. S., and S. C. Wainright. 1983. New distributional records for non-native fishes in Florida. Florida Scientist 46(1):8–15.

Donnelly, B. G. 1969. A preliminary survey of Tilapia nurseries on Lake Kariba during 1967/68. Hydrobiologia 34:195–206.

Doupé, R. G., M. J. Knott, J. Schaffer, D. W. Burrows, and A. J. Lymbery. 2010. Experimental herbivory of native Australian macrophytes by the introduced Mozambique tilapia *Oreochromis mossambicus*. Australian Ecology 35(1):24–30.

Doupé, R. G., J. Schaffer, M. J. Knott, and D. W. Burrows. 2009b. How might an exotic fish disrupt spawning success in a sympatric native species? Marine and Freshwater Research 60(5):379–383.

Dove, A. D. M., and P. J. O’Donoghue. 2005. Trichodinids (Ciliophora: Trichodinidae) from native and exotic Australian freshwater fishes. Acta Protozool 44:51–60.

Eldredge, L. G. 2000. Non-indigenous freshwater fishes, amphibians, and crustaceans of the Pacific and Hawaiian islands. Pages 173–190 *in* Invasive species in the Pacific: a technical review and draft regional strategy. South Pacific Regional Environment Programme, Samoa.

Erdsman, D. S. 1984. Exotic fishes in Puerto Rico. Pages 162–176 *in* W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. Distribution, biology and management of exotic fishes. Johns Hopkins University Press, Baltimore, Maryland.

FAO. 1983. Freshwater aquaculture development in China. Report of the FAO/UNDP study tour organized for French-speaking African countries, 22 April-20 May 1980. FAO Fisheries Technical Paper 215.

FAO. 1993. Aquaculture production (1985-1991). Fishery Information, Data and Statistics Service, FAO Fisheries Circular 815, revision 5.

FAO. 1996. Aquaculture production statistics 1985-1994. FAO Fisheries Circular 815.

FAO. 1997a. FAO database on introduced aquatic species. FAO Database on Introduced Aquatic Species, FAO, Rome.

FAO. 1997b. Review of the state of world aquaculture. Inland Water Resources and Aquaculture Service, Fishery Resources Division, FAO Fisheries Circular 886, revision 1. FAO, Rome.

FAO (Food and Agriculture Organisation of the United Nations). 2004. Database on Introductions of Aquatic Species. Food and Agriculture Organization of the United Nations. Available: http://www.fao.org/fishery/introsp/search. (February 2005).

Félix, P. M., P. Chainho, R. F. Lima, J. L. Costa, A. J. Almeida, I. Domingos, and A. C. Brito. 2016. Mangrove fish of São Tomé Island (Gulf of Guinea): new occurrences and habitat usage. Marine and Freshwater Research A-H[1-8]. [Published online.]

Fish, G. R. 1955. The food of tilapia in east Africa. Uganda J. 19:85–89.

Fishbase. 2010. *Oreochromis mossambicus* (Peters, 1852). Fishbase. Available: http://fishbase.org/Summary/speciesSummary.php?ID=3&genusname=Oreochromis&speciesname=mossambicus&lang=English. (July 2010).

Firmat, C., and P. Alibert. 2011. One more alien freshwater fish species in New Caledonia: the three-spot gourami *Trichogaster trichopterus* (Teleostei: Osphronemidae). Belgian Journal of Zoology 141(2):90–92.

Fortes, R. D. 2005. Review of techniques and practices in controlling tilapia populations and identification of methods that may have practical applications in Nauru including a national tilapia plan. Secretariat of the Pacific Community, Noumea, New Caledonia.

Frade, P., P. C. Hubbard, E. N. Barata, and A. V. M. Canario. 2002. Olfactory sensitivity of the Mozambique tilapia to conspecific odours. Journal of Fish Biology 61(5):1239–1254.

Fricke, R. 1999. Fishes of the Mascarene Islands (Réunion, Mauritius, Rodriguez). An annotated checklist with descriptions of new species. Koeltz Scientific Books, Koenigstein, Germany.

Fricke, R., G. R. Allen, S. Andréfouët, W.-J. Chen, M. A. Hamel, P. Laboute, R. Mana, H. H. Tan, and D. Uyeno. 2014. Checklist of the marine and estuarine fishes of Madang District, Papua New Guinea, western Pacific Ocean, with 820 new records. Zootaxa 3832(1):1–247.

Fricke, R., T. Mulochau, P. Durville, P. Chabanet, E. Tessier, and Y. Letourneur. 2009. Annotated checklist of the fish species (Pisces) of La Réunion, including a Red List of threatened and declining species. Stuttgarter Beiträge zur Naturkunde A, Neue Serie 2:1–168.

Frimodt, C. 1995. Multilingual illustrated guide to the world's commercial warmwater fish. Fishing News Books, Osney Mead, Oxford, UK.

Fryer, G., and T. D. Iles. 1972. The cichlid fishes of the Great Lakes of Africa—their biology and evolution. Oliver and Boyd, Edinburgh, Scotland.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, Maryland.

Fulton, W., and K. Hall. 2014. Forum proceedings: tilapia in Australia-state of knowledge. PestSmart Toolkit publication, Invasive Animals Cooperative Research Centre, Canberra, Australia.

Fuselier, L. 2001. Impacts of *Oreochromis mossambicus* (Perciformes: Cichlidae) upon habitat segregation among cyprinodontids (Cyprinodontiformes) of a species flock in Mexico. Revista de Biologia Tropical 49:647–656.

Gaigher, I. G. 1973. The habitat preferences of fishes from the Limpopo River system. Transvaal Mozambique Koedoe 16:103–116.

Gilchrist, J. D. F., and W. W. Thompson. 1917. The freshwater fishes of South Africa (continued). Annals of the South African Museum 11(6):465–579.

Glucksman, J., G. West, and T. M. Berra. 1976. The introduced fishes of Papua New Guinea with special reference to *Tilapia mossambica*. Biological Conservation 9(1):37–44.

Golani, D., and D. Mires. 2000. Introduction of fishes to the freshwater system of Israel. Israel Journal of Aquaculture, Bamidgeh 52(2):47–60.

Goldstein, R. J. 1973. Cichlids of the world. T.H.F. Publications, New Jersey.

Grabowski, S. J., S. D. Hiebert, and D. M. Lieberman. 1984. Potential for introduction of three species of nonnative fishes into central Arizona via the Central Arizona Project? A literature review and analysis. REC-ERC-84-7. U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.

Grinang, J., and K. K. P. Lim. 2004. Fishes. Sarawak Bau Limestone Biodiversity. The Sarawak Museum Journal Special Issue 6:285–298.

Guererro, R. D. III. 1998. Impact of tilapia introductions on the endemic fishes in some Philippine lakes and reservoirs. Aquaculture Asia 3(1):16–17.

Guerrero, R. D. III, and M. M. Tayamen. 1988. The status of wild and cultured tilapia genetic resources in various countries. Pages 42–45 *in* R. S. V. Pullin, editor. Tilapia genetic resources for aquaculture. ICLARM Conference Proceedings 16, International Center for Living Aquatic Resources Management, Manila, Philippines.

Günther, A. 1862. Catalogue of the fishes in the British Museum. Catalogue of the Acanthopterygii, Pharyngognathi, and Anacanthini in the collection of the British Museum. British Museum of Natural History 4.

Gupta, M. V., and B. O. Acosta. 2004. A review of global tilapia farming practices. Aquaculture Asia 9(1):7-12,16.

Gurung, D. B., S. Dorji, U. Tshering, and J. T. Wangyal. 2013. An annotated checklist of fishes from Bhutan. Journal of Threatened Taxa 5(14):4880–4886.

Haroon, A. K. Y. 1998. Diet and feeding ecology of two sizes of *Barbodes gonionotus* (=*Puntius gonionotus*) and *Oreochromis* sp. in ricefields in Bangladesh. Naga, ICLARM Q., 21(3):13–19.

Hay, C. J. 1991. The distribution of fish in the Fish River, Namibia. Madoqua 17(2):211–215.

Hay, C. J., B. J. van Zyl, F. H. van der Bank, J. T. Ferreira, and G. J. Steyn. 1999. The distribution of freshwater fish in Namibia. Cimbebasia 15:41–63.

Heemstra, P. C. 1986 [Numerous family accounts]. *In* M. M. Smith, and P. C. Heemstra, editors. Smiths' sea fishes. Macmillan South Africa, Johannesburg.

Heyne, T., B. Tribbey, M. Brooks, and J. Smith. 1991. First record of Mozambique tilapia in the San Joaquin Valley, California. California Fish and Game 77(1):53–54.

Hitchcock, G. 2002. Fish fauna of the Bensbach River, southwest Papua New Guinea. Memoirs of the Queensland Museum 48(1):119–122.

Hodgkiss, I. J., and H. S. H. Man. 1977. Age composition, growth and body condition of the introduced *Sarotherodon mossambicus* (Cichlidae) in Plover Cove Reservoir, Hong Kong. Environmental Biology of Fishes 2(1):35–44.

Hogg, R. G. 1976a. Ecology of fishes of the family Cichlidae introduced into the fresh waters of Dade County, Florida. Doctoral dissertation. University of Miami, Coral Gables, Florida.

Hogg, R. G. 1976b. Established exotic cichlid fishes in Dade County, Florida. Florida Scientist 39(2):97–103.

Holden, K. K., and M. N. Bruton. 1994. The early ontogeny of the southern mouthbrooder, *Pseudocrenilabrus philander* (Pisces, Cichlidae). Environmental Biology of Fishes 41(1/4):311–329.

Hoover, F. G. 1971. Status report on *Tilapia mossambica* (Peters) in southern California. California Department of Fish and Game, Inland Fisheries Administrative Report 716.

Hoover, F. G., and J. A. St. Amant. 1970. Establishment of *Tilapia mossambica* (Peters) in Bard Valley, Imperial County, California. California Fish and Game 56(1):70–71.

Howells, R. G. 1991. Electrophoretic identification of feral and domestic tilapia in Texas. Texas Parks and Wildlife Department, Management Data Series 62, Austin, Texas.

Howells, R. G. 1992a. Annotated list of introduced non-native fishes, mollusks, crustaceans and aquatic plants in Texas waters. Texas Parks and Wildlife Department, Management Data Series 78, Austin, Texas.

Howells, R. G. 1992b. Guide to identification of harmful and potentially harmful fishes, shellfishes and aquatic plants prohibited in Texas. Texas Parks and Wildlife Department Special Publication, Austin, Texas.

Hubbs, C., R. J. Edwards, and G. P. Garrett. 1991. An annotated checklist of freshwater fishes of Texas, with key to identification of species. Texas Journal of Science, Supplement 43(4):1–56.

Hubbs, C., T. Lucier, G. P. Garrett, R. J. Edwards, S. M. Dean, E. Marsh, and D. Belk. 1978. Survival and abundance of introduced fishes near San Antonio, Texas. Texas Journal of Science 30(4):369–376.

Hureau, J.-C. 1991. La base de données GICIM: Gestion informatisée des collections ichthyologiques du Muséum. Pages 225–227 *in* Atlas Préliminaire des Poissons d'Eau Douce de France. Conseil Supérieur de la Pêche, Ministère de l'Environnement, CEMAGREF et Muséum national d'Histoire naturelle, Paris.

Hutchins, J. B. 2001 Checklist of the fishes of Western Australia. Records of the Western Australian Museum Supplement 63:9–50.

Ibarra, M., and D. J. Stewart. 1987. Catalogue of type specimens of recent fishes in Field Museum of Natural History. Fieldiana Zoology (New Series) 35:1–112.

Idaho Fish and Game. 1990. Fisheries Management Plan 1991-1995. Appendix I. A list of Idaho fishes and their distribution by drainage. Idaho Fish and Game.

IGFA (International Game Fish Association). 2001. Database of IGFA angling records until 2001. IGFA, Fort Lauderdale, Florida.

Imai, S. 1980. Tilapia. Pages 124–132 *in* T. Kawai, H. Kawanabe, and N. Mizuno, editors. Freshwater animals in Japan. Tokai University Press, Tokyo. (In Japanese.)

Indra, T. J. 1991. Report on the ichthyo fauna of Anna and Madurai districts, Tamil Nadu. Records of the Zoological Survey of India 89(1–4):233–243.

Indra, T. J. 1993. Report on the ichthyofauna of Kanyakumari District, Tamil Nadu. Records of the Zoological Survey of India 92(1–4):177–192.

Indra, T. J. 1994. On a collection of fishes from Tanjavur and Trichy districts, Tamilnadu. Records of the Zoological Survey of India 94(2–4):403–433.

Innal, D., and F. Erk'akan. 2006. Effects of exotic and translocated fish species in the inland waters of Turkey. Reviews in Fish Biology and Fisheries 16:39–50.

Islam, M. M., A. S. M. R. Amin, and S. K. Sarker. 2003. Bangladesh. Pages 7–20 *in* N. Pallewatta, J. K. Reaser, and A. T. Gutierrez, editors. Invasive alien species in South-Southeast Asia: national reports and directory of resources. Global Invasive Species Programme, Cape Town, South Africa.

Ismail, G. B., D. B. Sampson, and D. L. G. Noakes. 2014. The status of Lake Lanao endemic cyprinids (*Puntius* species) and their conservation. Environmental Biology of Fishes 97:425–434.

Ivoilov, A. A. 1992. Research on the tilapias in the republics of the former Soviet Union. Asian Fisheries Science 5(3):375–382.

Jackson, P. B. N. 1961. The fishes of Northern Rhodesia. A check list of indigenous species. The Government Printer, Lusaka, Zambia.

Jalal, K. C. A., and A. J. M. A. Rouf. 1997. Tilapia - as an exotic fish impacts on aquatic environment in Bangladesh. Fish. J. Garing 6(2):1–7.

James, N. P. E., and M. N. Bruton. 1992. Alternative life-history traits associated with reproduction in *Oreochromis mossambicus* (Pisces: Cichlidae) in small water bodies of the Eastern Cape, South Africa. Environmental Biology of Fishes 34(4):379–392.

Jang, M.-H., J.-G. Kim, S.-B. Park, K.-S. Jeong, G.-I. Cho, and G.-J. Joo. 2002. The current status of the distribution of introduced fish in large river systems of South Korea. International Review of Hydrobiology 87(2-3):319–328.

Japan Ministry of Environment. 2005. List of alien species recognized to be established in Japan or found in the Japanese wild. Website. (February 2005).

Jenkins, A. P., S. D. Jupiter, I. Quaqua, and J. Atherton. 2009. The importance of ecosystem-based management for conserving aquatic migratory pathways on tropical high islands: a case study from Fuji. Aquatic Conservation Marine and Freshwater Ecosystems 20(2):224–238.

Jiménez-Prado, P., W. Aguirre, E. Laaz-Moncayo, R. Navarrete-Amaya, F. Nugra-Salazar, E. Rebolledo-Monsalve, E. Zárate-Hugo, A. Torres-Noboa, and J. Valdiviezo-Rivera. 2015. Guía de peces para aguas continentales en la vertiente occidental del Ecuador. Pontificia Universidad Católica del Ecuador Sede Esmeraldas; Universidad del Azuay y Museo Ecuatoriano de Ciencias Naturales del Instituto Nacional de Biodiversidad, Esmeraldas, Ecuador.

Jory, D., T. Cabrera, B. Polanco, R. Sanchez, J. Millan, J. Rosas, C. Alceste, E. Garcia, M. Useche, and R. Agudo. 1999. Aquaculture in Venezuela: perspectives. Aquaculture Magazine 25(5).

Jubb, R. A. 1967. Freshwater fishes of southern Africa. A. A. Balkema, Cape Town, South Africa.

Jubb, R. A. 1974. The distribution of *Tilapia mossambicus* Peters, 1852, and *Tilapia mortimeri* Trewavas, 1966, in Rhodesian waters. Arnoldia Zimbabwe 6:1–14.

Juliano, R. O., R. D. Guerrero III, and I. Ronquillo. 1989. The introduction of exotic aquatic species in the Philippines. Pages 83–90 *in* S. S. De Silva, editor. Exotic aquatic organisms in Asia. Proceedings of the Workshop on Introduction of Exotic Aquatic Organisms in Asia. Asian Fisheries Society, Special Publication 3, Manila, Philippines.

Kamal, A. H. M. M., and G. C. Mair. 2005. Salinity tolerance in superior genotypes of tilapia, *Oreochromis niloticus*, *Oreochromis mossambicus* and their hybrids. Aquaculture 247(1–4):189–201.

Kara, H. M. 2011. Freshwater fish diversity in Algeria with emphasis on alien species. European Journal of Wildlife Research DOI 10.1007/s10344-011-0570-6.

Kawanabe, H., and N. Mizuno. 1989. Freshwater fishes of Japan. Yama-Kei Publishers, Tokyo. (In Japanese.)

Keith, P. 2002. Freshwater fish and decapod crustacean populations on Reunion island, with an assessment of species introductions. Bulletin Français de la Pêche et de la Pisciculture 364:97–107.

Keith, P., and G. Marquet. 2011. Poissons et crustacés d'eau douce de Wallis et Futuna. Société Française d'Ichtyologie, Paris.

Keith, P., E. Vigneux, and G. Marquet. 2002. Atlas des poissons et des crustacés d'eau douce de Polynésie française.

Knaggs, E. H. 1977. Status of the genus *Tilapia* in California's estuarine and marine waters. Cal-Nevada Wildlife Transactions 1977:60–67.

Kottelat, M. 2013. The fishes of the inland waters of Southeast Asia: a catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. Raffles Bulletin of Zoology Supplement 27:1–663.

Kottelat, M., and T. Whitten. 1996. Freshwater biodiversity in Asia, with special reference to fish. World Bank Technical Paper 343.

Kottelat, M., A. J. Whitten, S. N. Kartikasari, and S. Wirjoatmodjo. 1993. Freshwater fishes of Western Indonesia and Sulawesi. Periplus Editions, Hong Kong.

Kuang, Y.-D., and et al. 1986. The freshwater and estuaries fishes of Hainan Island.

Kuo, S.-R., H.-J. Lin, and K.-T. Shao. 1999. Fish assemblages in the mangrove creeks of northern and southern Taiwan. Estuaries 22(4):1004–1015.

Kuo, S.-R., and K.-T. Shao. 1999. Species composition of fish in the coastal zones of the Tsengwen estuary, with descriptions of five new records from Taiwan. Zoological Studies 38(4):391–404.

Labajo, Y. I., and O. M. Nuñeza. 2003. Ichthyofauna of Lake Maiinit, Mindanao. 3rd Annual Scientific Convention of the Philippines for the study of Nature, Iloilo, Philippines.

Laboute, P., and R. Grandperrin. 2000. Poissons de Nouvelle-Calédonie. Éditions Catherine Ledru, Nouméa, New Caledonia.

Lahser, C. W. 1967. *Tilapia mossambica* as a fish for aquatic weed control. Progressive Fish Culturalist 29:48–50.

Lal, M. S. 2000. Conservation of fish fauna of Periyar lake, Thekkady, Kerala. Page 160 *in* A. G. Ponniah, and A. Gopalakrishnan, editors. Endemic Fish Diversity of Western Ghats. NBFGR-NATP Publication. National Bureau of Fish Genetic Resources, Lucknow, India.

Lamboj, A. 2004. The cichlid fishes of western Africa. Birgit Schmettkamp Verlag, Bornheim, Germany.

Larson, H. K., and B. Pidgeon. 2004. New records of freshwater fishes from East Timor. The Beagle, Records of the Museums and Art Galleries of the Northern Territory 20:195–198.

Laurent, P., and A. Jean-François. 1995. Phylogenetic relationships between 21 species of three tilapiine genera *Tilapia*, *Sarotherodon* and *Oreochromis* using allozyme data. Journal of Fish Biology 47(1):26–38.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980 et seq. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh.

Lee et al. 1983. [Source material did not give full citation for this reference.]

Lévêque, C. L. 1997. Biodiversity dynamics and conservation: the freshwater fish of tropical Africa. ORSTOM. Cambridge University Press, Cambridge, UK.

Lever, C. 1996. Naturalized fishes of the world. Academic Press, California.

Lewis, A. D., and C. K. Pring. 1986. Freshwater and brackishwater fish and fisheries of Fiji. Pages 38–59 *in* T. Petr, editor. Reports and papers presented at the Indo-Pacific Fishery Commission Expert Consultation on inland fisheries of the larger Indo-Pacific islands. Bangkok, Thailand. FAO Fisheries Report 371(Supplement).

Liao, C.-I., H.-M. Su, and E. Y. Chang. 2001. Techniques in finfish larviculture in Taiwan. Aquaculture 200(2001):1–31.

Lim, P., F. J. Meunier, P. Keith, and P. Y. Noël. 2002. Atlas des poissons et des crustacés d'eau douce de la Martinique. Muséum National d'Historie Naturelle, Paris.

Loftus, W. F., and J. A. Kushlan. 1987. Freshwater fishes of southern Florida. Bulletin of the Florida State Museum of Biological Science 31(4):255.

Lovshin, L. L. 1982. Tilapia hybridization. Pages 279–308 *in* R. S. V. Pullin, and R. H. Lowe-McConnell, editors. The biology and culture of tilapias, ICLARM conference proceedings, volume 7. International Center for Living Aquatic Resources Management, Manila, Philippines.

Lowe-McConnell, R. H. 1982. Tilapias in fish communities. ICLARM Conference Proceedings 7:83–113.

Lyons, J., G. González-Hernandéz, E. Soto-Galera, and M. Guzmán-Arroyo. 1998. Decline of freshwater fishes and fisheries in selected drainages of west-central Mexico. Fisheries 23(4):10–18.

Macaranas, J. M., P. B. Mather, S. N. Lal, T. Vereivalu, M. Lagibalavu, and M. F. Capra. 1997. Genotype and environment: a comparative evaluation of four tilapia stocks in Fiji. Aquaculture 150(1/2):11–24.

Maciolek, J. A. 1984. Exotic fishes in Hawaii and other islands of Oceania. Pages 131–161 *in* W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Maryland.

MacKenzie, R., P. Jackson, and E. Cotterell. 2001. Control of exotic pest fish, an operational strategy for Queensland freshwaters 2000-2005. Department of Primary Industries, Information Series Ql 01005, Queensland.

Maddern, M. 2003. The distribution, biology and ecological impacts of three introduced freshwater teleosts in Western Australia. Honours thesis. Murdoch University, Western Australia.

Maitipe, P., and S. S. De Silva. 1985. Switches between zoophagy, phytophagy and detritivory of *Sarotherodon mossambicus* (Peters) populations in twelve man-made Sri Lankan lakes. Journal of Fish Biology 26:49–61.

Mamaril, A. C. 2001. Translocation of the clupeid *Sardinella tawilis* to another lake in the Philippines: a proposal and ecological considerations. Pages 137–147 *in* C. B. Santiago, M. L. Cuvin-Aralar, and Z. U. Basiao, editors. Conservation and ecological management of Philippine lakes in relation to fisheries and aquaculture. Southeast Asian Fisheries Development Center, Aquaculture Department, Iloilo, Philippines; Philippine Council for Aquatic and Marine Research and Development, Los Baños, Laguna, Philippines; and Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines.

Man, S. H., and I. J. Hodgkiss. 1981. Hong Kong freshwater fishes. Urban Council, Wishing Printing, Hong Kong.

Manimekalan, A. 1998. The fishes of Mudumalai Wildlife Sanctuary, Tamil Nadu, south India. Journal of the Bombay Natural History Society 95(3):431–443.

Marquet, G. 1993. Etude biogeographique de la faune d'eau douce de Polynesie Francaise. Biogeographica 69(4):157–170.

Marquet, G., P. Keith, and E. Vigneux. 2003. Atlas des poissons et des crustacés d'eau douce de Nouvelle-Calédonie. Muséum national d'Histoire naturelle, Patrimoines Naturels 58, Paris.

Marquet, G., N. Mary, and R. Watson. 1999. Comments on the freshwater fishfauna of French Polynesia. Pages 41–44 *in* B. Séret, and J.-Y. Sire, editors. Proceedings of the 5th Indo-Pacific Fish Conference, 1997, Noumea, New Caldeonia.

Marquet, G., B. Séret, and R. Lecomte-Finiger. 1997. Inventaires comparés des poissons des eaux intérieures de trois îles océaniques tropicales de l'Indo-Pacifique (la Réunion, la Nouvelle-Calédonie et Tahiti). Cybium 21(1)supplement:27–34.

Martin-Smith, K. M., and H. H. Tan. 1998. Diversity of freshwater fishes from eastern Sabah: annotated checklist for Danum Valley and a consideration of inter- and intra-catchment variability. Raffles Bulletin of Zoology 46(2):573–604.

Marshall, B. 2011. The fishes of Zimbabwe and their biology. Smithiana Monographs 3.

Maruyama, T. 1958. An observation on *Tilapia mossambica* in ponds referring to the diurnal movement with temperature change. Bulletin of the Freshwater Fisheries Research Laboratory, Tokyo 26:11–19.

Masuda, H., K. Amaoka, C. Araga, T. Uyeno, and T. Yoshino. 1984. The fishes of the Japanese Archipelago. Tokai University Press, Tokyo.

Matamoros, W. A., J. F. Schaefer, and B. R. Kreiser. 2009. Annotated checklist of the freshwater fishes of continental and insular Honduras. Zootaxa 2307:1–38.

Matsuura, K., A. Doi, and G. Shinohara. 2000. Distribution of freshwater fishes in Japan. Supplement to catalog of the freshwater fish collection in the National Science Museum, Tokyo. National Science Museum, Tokyo.

McCosker, J. E., and R. H. Rosenblatt. 2010. The fishes of the Galápagos Archipelago: an update. Proceedings of the California Academy of Sciences (Series 4) 61(supplement II)(11):167–195.

McDowall, R. M. 1996. Freshwater fishes of south-eastern Australia.

McKay, R. J. 1978. The exotic freshwater fishes of Queensland. Report to Australian National Parks and Wildlife Canberra, Australia.

McKaye, K. R., J. D. Ryan, J. R. Stauffer, L. J. Lopez, G. I. Vega, E. P. van den Berghe, and J. K. McCrary. 1998b. *Tilapia africana* en el Lago de Nicaragua: ecosistema in transicion. Encuentro 46:46–53.

McKaye, K. R., J. D. Ryan, J. R. Stauffer, J. L. Lorenzo, G. I. Vega, and E. P. van den Berghe. 1995. African tilapia in Lake Nicaragua: ecosystem in transition. Bioscience 45:406–411.

Menhinick, E. F. 1991. The freshwater fishes of North Carolina. North Carolina Wildlife Resources Commission.

Mercene, E. C. 1997. Freshwater fishes of the Philippines. Pages 81–105 *in* R. Guerrero III, A. Calpe, and L. Darvin, editors. Aquatic biology research and development in the Philippines. PCAMRD Book Series 20.

Mettee et al. 1996. [Source material did not give full citation for this reference.]

Miesen, F. W., F. Droppelmann, S. Hüllen, R. K. Hadiaty, and F. Herder. 2016. An annotated checklist of the inland fishes of Sulawesi. Bonn zoological Bulletin 64(2):77–106.

Minckley, W. L. 1973. Fishes of Arizona. Arizona Fish and Game Department. Sims Printing, Phoenix, Arizona.

Minckley, W. L., and P. C. Marsh. 2009. Inland fishes of the Greater Southwest. Chronicle of a vanishing biota. The University of Arizona Press.

Miranda, A., O. G. Almeida, P. C. Hubbard, E. N. Barata, and A. V. M. Canario. 2005. Olfactory discrimination of female reproductive status by male tilapia (*Oreochromis mossambicus*). Journal of Experimental Biology 208(11):2037–2043.

Mirza, M. R. 2003. Checklist of freshwater fishes of Pakistan. Pakistan Journal of Zoology Supplemental Series (3):1–30.

Mol, J. H., D. Resida, J. S. Ramlal, and C. R. Becker. 2000. Effects of El Niño-related drought on freshwater and brackish-water fishes in Suriname, South America. Environmental Biology of Fishes 59(4):429–440.

Morgan, D. L., H. S. Gill, M. G. Maddern, and S. J. Beatty. 2004. Distribution and impacts of introduced freshwater fishes in Western Australia. New Zealand Journal of Marine and Freshwater Research 38:511–523.

Moyle, P. B. 1976. Inland fishes of California. University of California Press, Berkeley.

Moyle, P. B. 2002. Inland fishes of California. -- revised and expanded.

Mundy, B. C. 2005. Checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletins in Zoology 6:1–703.

Muoneke, M. I. 1988. Tilapia in Texas waters. Texas Parks and Wildlife Department, Inland Fisheries Data Series 9, Austin.

Murthy, V. K., P. Reddanna, and S. Govindappa. 1981. Hepatic carbohydrate metabolism in *Tilapia mossambica* (Peters) acclimated to low environmental pH. Canadian Journal of Zoology 59:400–404.

Myers, G. S. 1938. Fresh-water fishes and West Indian zoogeography. Annual report of the board of regents of the Smithsonian Institution 92:339–364.

Nakabo, T., editor. 2000. Fishes of Japan with pictorial keys to the species, 2nd edition. Tokai University Press, Tokyo. (In Japanese.)

Nakabo, T., editor. 2002. Fishes of Japan with pictorial keys to the species, English edition. Tokai University Press, Tokyo.

Nathaniel, S., and E. I. L. Silva. 1996. Food and nest site availability: an indicator of the colonization of a highland reservoir in Sri Lanka by three species of cichlids. Sri Lanka Journal of Aquatic Science 1:81–90.

Native Fish Australia. 2003. A taxonomic summary of Australian freshwater fish. Available: http://www.nativefish.asn.au/taxonomy.html. (September 2003).

Nelson, J. S., E. J. Crossman, H. Espinosa Pérez, L. T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico, 6th edition. American Fisheries Society, Special Publication 29, Bethesda, Maryland.

Nelson, S. G., and L. G. Eldredge. 1991. Distribution and status of introduced cichlid fishes of the genera *Oreochromis* and *Tilapia* in the islands of the South Pacific and Micronesia. Asian Fisheries Science 41:11–22.

Ng, T. H., and H. H. Tan. 2010. The introduction, origin and life-history attributes of the non-native cichlid *Etroplus suratensis* in the coastal waters of Singapore. Journal of Fish Biology 76:2238–2260.

Nguyen, T. D. P., T. H. T. Nguyen, V. T. Do, T. T. Nguyen, and H. D. Nguyen. 2011. Freshwater ecosystem services and biodiversity values of Phu Yen District, Son La, Viet Nam. Pages 313–363 *in* Report on highland aquatic ecosystem services and biodiversity values, including livelihoods, trade, policy and conservation oriented inputs to two global online databases. Highland Aquatic Resources Conservation and Sustainable Development Project. European Community's Seventh Framework Programme, Project 213015, Research Institute for Aquaculture, Viet Nam.

Noakes, D. G. L., and E. K. Balon. 1982. Life histories of tilapias: an evolutionary perspective. ICLARM Conference Proceedings 7:61–82.

NSS Vertebrate Study Group. 2014. A checklist of the freshwater fishes, amphibians, reptiles and mammals of Singapore. National Parks, Singapore Government.

Ogden, J. C., J. A. Yntema, and I. Clavijo. 1975. An annotated list of the fishes of St. Croix, U.S. Virgin Islands. Special Publication 3.

Ogilvie, V. E. 1969. Illustrated checklist of fishes collected from the L-15 Canal (Lake Worth Drainage District) in Palm Beach County, Florida (collection date November 8, 1969). Florida Game and Fresh Water Fish Commission.

Okeyo, D. O. 2000. Inland fisheries development in Namibia: evaluating alternative paths for sustainable development. Pages 109–131 *in* B. Fuller, and I. Prommer, editors. Population-development-environment in Namibia, interim report IR-00-031, IIASA, Laxenburg, Austria.

Okeyo, D. O. 2003. On the biodiversity and the distribution of freshwater fish of Namibia: an annotated update. Pages 156–194 *in* M. L. D. Palomares, B. Samb, T. Diouf, J. M. Vakily, and D. Pauly, editors. Fish biodiversity: local studies as basis for global inferences. ACP-EU Fish. Res. Rep. 14.

Okeyo, D. O. 2005. Fishes of Namibia. Unpublished compilation of D. O. Okeyo.

Oliveira, R. F., and V. C. Almada. 1996. Dominance hierarchies and social structure in captive groups of the Mozambique tilapia *Oreochromis mossambicus* (Teleostei Cichlidae). Ethology, Ecology, and Evolution 8:39–55.

Oliveira, R. F., and V. C. Almada. 1998a. Maternal aggression during the mouthbrooding cycle in the cichlid fish, *Oreochromis mossambicus*. Aggressive Behavior 24:187–196.

Oliveira, R. F., and V. C. Almada. 1998b. Mating tactics and male–male courtship in the lek-breeding cichlid *Oreochromis mossambicus*. Journal of Fish Biology 52(6):1115–1129.

Oliveira, R. F., and A. V. M. Canario. 2000. Hormones and social behaviour of cichlid fishes: a case study in the Mozambique tilapia. Journal of Aquaculture and Aquatic Science 9:187–207.

Oliveira, R. F., A. F. H. Ros, and D. M. Gonçalves. 2005. Intra-sexual variation in male reproduction in teleost fish: a comparative approach. Hormones and Behavior 48(4):430–439.

Ortega, H., and R. P. Vari. 1986. Annotated checklist of the freshwater fishes of Peru. Smithsonian Contributions to Zoology 437.

Otto-Infante, C. 1985. Bio-ecological aspects of tilapia *Sarotherodon mossambicus* (Peters) 1852 (Teleostei, Perciformes, Cichlidae) of Lake Valencia, Venezuela. Acta Cientifica Venezolana 36:68–76.

Page, L. M., and B. M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. The Peterson Field Guide Series, volume 42. Houghton Mifflin, Boston.

Page, L. M., and B. M. Burr. 2011. Peterson Field Guide to freshwater fishes of North America North of Mexico, 2nd edition. Freshwater fishes of North America.

Page, L. M., H. Espinosa-Pérez, L. D. Findley, C. R. Gilbert, R. N. Lea, N. E. Mandrak, R. L. Mayden, and J. S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico, 7th edition. American Fisheries Society, Special Publication 34, Bethesda, Maryland.

Palma, A. L., E. C. Mercene, and M. R. Goss. 2005. Fish. Pages 115–132 *in* R. D. Lasco, and M. V. O. Espaldon, editors. Ecosystems and people: the Philippine millennium ecosystem assessment (MA) sub-global assessment. Environmental Forestry Programme, College of Forestry and Natural Resources, University of the Philippines, Los Baños.

Pan, J.-H., L. Zhong, C.-Y. Zheng, H.-L. Wu, and J.-H. Liu, editors. 1991. The freshwater fishes of Guangdong Province. Guangdong Science and Technology Press.

Parenti, L. R., and G. R. Allen. 1991. Fishes of the Gogol River and other coastal habitats, Madang Province, Papua New Guinea. Ichthyological Explorations of Freshwater 1(4):307–320.

Pauly, D., M. Small, R. Vore, and M. L. D. Palomares. 1990. Fisheries yields and morphoedaphic index of Lake Mainit, Philippines. Pages 835–838 *in* R. Hirano, and I. Hanyu, editors. The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.

Pellegrin, J. 1904. Contribution à l'étude anatomique, biologique et taxinomique des poissons de la famille des cichlidés. Mémoires de la Société Zoologique de France 16:41–399.

Pérez, J. E., C. Alfonsi, M. Nirchio, and J. Barrios. 2006a. The inbreeding paradox in invasive species. Interciencia 31(7):544–546.

Pet, J. S., and G. J. Piet. 1993. The consequences of habitat occupation and habitat overlap of the introduced tilapia *Oreochromis mossambicus* and indigenous fish species for fishery management in a Sri Lankan reservoir. Journal of Fish Biology 43(Supplement A):193–208.

Peters, W. 1852 Diagnosen von neuen Flussfischen aus Mossambique. Monatsberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin 1852:275–276, 681–685.

Pethiyagoda, R. 1991. Freshwater fishes of Sri Lanka. The Wildlife Heritage Trust of Sri Lanka, Colombo.

Pfeffer, G. J. 1893. Ostafrikanische Fische gesammelt von Herrn Dr. F. Stuhlmann im Jahre 1888 und 1889. Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten 10(2):131–177.

Pfeffer, G. J. 1894. Fische. *In* K. Möbius. Deutsch Ost-Afrika 3(18). Hamburg and Berlin.

Philippart, J. C., and J. C. Ruwet. 1982. Ecology and distribution of tilapias. Pages 15–60 *in* R. S. V. Pullin, and R. H. Lowe-McConnell, editors. The biology and culture of tilapias. International Center for Living Aquatic Resource Management, Manila.

Pienaar, U. de V. 1978. The freshwater fishes of the Kruger National Park. National Parks Board of South Africa, Pretoria, South Africa.

Pullin, R. S. V., and R. H. Lowe-McConnell. 1980. The biology and culture of tilapias. Pages 25–58, 74–80 *in* International conference on the biology and culture of tilapias, Bellagio, Italy. International Center for Living Aquatic Resource Management.

Pullin, R. S. V., and R. H. Lowe-McConnell, editors. 1982. The biology and culture of tilapias. International Conference on the Biology and Culture of Tilapias, Bellagio, Italy, 2-5 September 1980. ICLARM Conference Proceedings 7.

Radhakrishnan, K. V., B. M. Kurup, B. R. Murphy, and S.-G. Xie. 2012. Status of alien fish species in the Western Ghats (India) as revealed from 2000-2004 surveys and literature analyses. Journal of Applied Ichthyology 28:778–784.

Rafique, M. 2000. Fish diversity and distribution in Indus River and its drainage system. Pakistan Journal of Zoology 32(4):321–332.

Raghavan, R., G. Prasad, P. H. Anvar Ali, and B. Pereira. 2008. Exotic fish species in a global biodiversity hotspot: observations from River Chalakudy, part of Western Ghats, Kerala, India. Biological Invasions 10:37–40.

Rainboth, W. J. 1996. FAO species identification field guide for fishery purposes. Fishes of the Cambodian Mekong. FAO, Rome.

Raju Thomas, K., C. R. Biju, C. R. Ajithkumar, and M. J. George. 2000. Fish fauna of Idukki and Neyyar wildlife sanctuaries southern Kerala, India. Journal of the Bombay Natural History Society 97(3):443–446.

Raju Thomas, K., M. J. George, and C. R. Biju. 2002. Freshwater fishes of southern Kerala with notes on the distribution of endemic and endangered species. Journal of the Bombay Natural History Society 99(1):47–53.

Randall, J. E. 1987. Introductions of marine fishes to the Hawaiian Islands. Bulletin of Marine Science 41(2):490–502.

Randall, J. E., and K. K. P. Lim. 2000. A checklist of the fishes of the South China Sea. Raffles Bulletin of Zoology Supplement 8:569–667.

Reinthal, P. N., and M. L. J. Stiassny. 1991. The freshwater fishes of Madagascar: a study of an endangered fauna with recommendations for a conservation strategy. Conservation Biology 5(2):231–242.

Reinthal, P. N., and M. L. J. Stiassny. 1997. Revision of the Madagascan genus *Ptychochromoides* (Teleostei: Cichlidae), with description of a new species. Ichthyological Exploration of Freshwaters 7(4):353–368.

Rema Devi, K. 1992. On a small collection of fish from Javadi Hills, North Arcot District, Tamil Nadu. Records of the Zoological Survey of India 91(3–4):353–360.

Rema Devi, K., and K. Ilango. 1993. On a collection of fish from Pudukkottai, District Tamil Nadu. Records of the Zoological Survey of India 93(1–2):241–251.

Rema Devi, K., T. J. Indra, and K. G. Emiliyamma. 1996. On the fish collections from Kerala, deposited in Southern Regional Station, Zoological Survey of India by NRM Stockholm. Records of the Zoological Survey of India 95(3–4):129–146.

Rema Devi, K., T. J. Indra, M. B. Raghunathan, and M. Mary Bai. 1999. On a collection of fish fauna from Chennai, Chengleput and Thiruvallur districts of Tamil Nadu. Records of the Zoological Survey of India 97(4):151–166.

Rema Devi, K., and M. B. Raghunathan. 1999a. The ichthyofauna of Dharmapuri district, Tamil Nadu. Records of the Zoological Survey of India 97(1):145–162.

Rema Devi, K., and M. B. Raghunathan. 1999b. Report on the ichthyofauna of north Arcot district, Tamil Nadu. Records of the Zoological Survey of India 97(1):163–177.

Riede, K. 2004. Global register of migratory species - from global to regional scales. Final Report of the R&D-Projekt 808 05 081. Federal Agency for Nature Conservation, Bonn.

Riedel, D. 1965. Some remarks on the fecundity of tilapia (*T. mossambica* Peters) and its introduction into middle Central America (Nicaragua) together with a first contribution towards the limnology of Nicaragua. Hydrobiologia 25:357–388.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1991. World fishes important to North Americans, exclusive of species from the continental waters of the United States and Canada. American Fisheries Society, Special Publication 21, Bethesda, Maryland.

Rogers, W. A. 1961. Second progress report on stocking and harvesting of tilapia and channel catfish in Alabama's state-owned and managed public fishing lakes. Federal Aid Project F-10. Alabama Department of Conservation.

Ruiz, L. J., S. Salazar, J. Pérez, and C. Alfonso. 2005. Diversidad íctica del sistema hidrográfico río Manzanares, estado sucre, Venezuela. Boletin del Centro de Investigaciones Biológicas 39(2):91–107.

Russell, D. J., P. A. Thuesen, and F. E. Thomson. 2010. Development of management strategies for control of feral tilapia populations in Australia. Queensland Department of Employment, Economic Development and Innovation, Brisbane.

Russell, D. J., P. A. Thuesen, and F. E. Thomson. In press. Reproductive strategies of two invasive tilapia species *Oreochromis mossambicus* (Peters 1852) and *Tilapia mariae* (Boulenger 1899) in northern Australia. Journal of Fish Biology.

Sakai, H., M. Sato, and M. Nakamura. 2001. Annotated checklist of fishes collected from the rivers in the Ryukyu Archipelago. Bulletin of the National Science Museum (Tokyo) Series A 27(2):81–139.

Sampath, K., V. Sivakumar, M. Sakthivel, and R. James. 1991. Lethal and sublethal effects of ammonia on survival and food utilization in *Oreochromis mossambicus* (Pisces: Cichlidae). Journal of Aquacultures in the Tropics 6(2):223–230.

Saphakdy, B., and K. Rodger. 2005. Alien aquatic species in Lao People's Democratic Republic. *In* D. M. Bartley, R. C. Bhujel, S. Funge-Smith, P. G. Olin, and M. J. Phillips, editors. International mechanisms for the control and responsible use of alien species in aquatic ecosystems. Report of an Ad Hoc Expert Consultation. Xishuangbanna, People's Republic of China, 27-30 August 2003. FAO, Rome.

Scharpf, C. 2009. Annotated checklist of North American freshwater fishes, including subspecies and undescribed forms. Part V: Sciaenidae ... [through] Achiridae (plus supplemental material). American Currents 35(1):1–32.

Schmitter-Soto, J. J., and C. I. Caro. 1997. Distribution of tilapia, *Oreochromis mossambicus* (Perciformes: Cichlidae), and water body characteristics in Quintana Roo, Mexico. Revista de Biologia Tropical 45:1257–1261.

Schrader, H. J. 1985. Invasive alien species in south west Africa/Namibia. *In* C. J. Brown, I. A. W. Macdonald, and S. E. Brown, editors. Invasive alien organisms in south west Africa/Namibia. South African National Scientific Programmes Report 119, Pretoria, South Africa.

Seegers, L., L. D. G. De Vos, and D. O. Okeyo. 2003. Annotated checklist of the freshwater fishes of Kenya (excluding the lacustrine haplochromines from Lake Victoria). Journal of East African Natural History 92:11–47.

Seeto, J., and W. J. Baldwin. 2010. A checklist of the fishes of Fiji and a bibliography of Fijian fish. Division of Marine Studies Technical Report 1/2010. The University of the South Pacific, Suva, Fiji.

Shafland, P. L., and J. M. Pestrak. 1982. Lower lethal temperatures for fourteen non-native fishes in Florida. Environmental Biology of Fishes 7:139–156.

Shaji, C. P., P. S. Easa, and A. Gopalakrishnan. 2000. Freshwater fish diversity of Western Ghats. Pages 33–35 *in* A. G. Ponniah, and A. Gopalakrishnan, editors. Endemic fish diversity of Western Ghats. NBFGR-NATP Publication. National Bureau of Fish Genetic Resources, Lucknow, U.P., India.

Shapovalov, L., A. J. Cordone, and W. A. Dill. 1981. A list of freshwater and anadromous fishes of California. California Fish and Game 67(1):4–38.

Shelton, W. L., and T. J. Popma. 2006. Chapter 1. Biology. *In* C. Lim, and C. D. Webster, editors. Tilapia: biology, culture, and nutrition. Haworth Press, New York.

Shen, S. C., editor. 1993. Fishes of Taiwan. Department of Zoology, National Taiwan University, Taipei.

Shrestha, T. K. 2008. Ichthyology of Nepal. A study of fishes of the Himalayan waters. Himalayan Ecosphere, Kathmandu, Nepal.

Shrestha, J. 1994. Fishes, fishing implements and methods of Nepal. Smt. M.D. Gupta, Lalitpur Colony, Lashkar (Gwalior), India.

Shrestha, J. 1999. Coldwater fish and fisheries in Nepal. FAO Fisheries Technical Paper 385:13–40.

Skelton, P. H. 1993. A complete guide to the freshwater fishes of southern Africa. Southern Book Publishers, Halfway House, South Africa.

Skelton, P. H. 2001. A complete guide to the freshwater fishes of southern Africa. Struik Publishers, Halfway House, South Africa.

Smit, G. L., J. Hattingh, and J. T. Ferreira. 1981. The physiological responses of blood during thermal adaptation in three freshwater fish species. Journal of Fish Biology 19:147–160.

Smith, P. W. 1965. A preliminary annotated list of the lampreys and fishes of Illinois. Biological Notes 54. Illinois Natural History Survey, Urbana.

Smith-Vaniz, W. F. 1968. Freshwater fishes of Alabama. Auburn University Agricultural Experiment Station, Auburn.

Smith-Vaniz, W., and H. L. Jelks. 2014. Marine and inland fishes of St. Croix, U. S. Virgin Islands: an annotated checklist. Zootaxa 3803(1):1–120.

St. Amant, J. A. 1966. Addition of *Tilapia mossambica* Peters to the California fauna. California Fish and Game 52:54–55.

Stauffer, J. R. J. 1986. Effects of salinity on preferred and lethal temperatures of the Mozambique tilapia, *Oreochromis mossambicus* (Peters). Water Resource Bulletin 22:205–208.

Steindachner, F. 1864. Ichthyologische Mittheilungen (VII). Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, Band 14:223–232.

Stiassny, M. L. J., and I. J. Harrison. 2000. Notes on a small collection of fishes from the Parc National de Marojejy, northeastern Madagascar, with a description of a new species of the endemic genus *Bedotia* (Atherinomorpha: Bedotiidae). Fieldiana Zoology 97:143–156.

Stiassny, M. L. J., and N. Raminosoa. 1994. The fishes of the inland waters of Madagascar. Pages 133–148 *in* G. G. Teugels, J.-F. Guégan, and J.-J. Albaret, editors. Biological diversity of African fresh- and brackish water fishes. Geographical overviews presented at the PARADI Symposium, Senegal, 15–20 November 1993. Annales du Musés Royal del l'Afrique Centrale, Science Zoologique.

Suresh, A. V., and C. K. Lin. 1992. Tilapia culture in saline waters: a review. Aquaculture 106:201–226.

Swift, C. C., T. R. Haglund, M. Ruiz, and R. N. Fisher. 1993. The status and distribution of the freshwater fishes of southern California. Bulletin of the Southern California Academy of Science 92(3):101–167.

Tachihara, K., K. Tokunaga, and Y. Chimura. 2002. Alien fishes in Okinawa Island. Pages 248–249 *in* Ecological Society of Japan, editor. Handbook of alien species in Japan. Chijin-shokan, Tokyo. (In Japanese.)

Talwar, P. K., and A. G. Jhingran. 1991. Inland fishes of India and adjacent countries. Oxford & IBH Publishing, New Delhi, Bombay, Calcutta, India.

Tan, H. H., and K. K. P. Lim. 2004. Inland fishes from the Anambas and Natuna Islands, South China Sea, with description of a new species of *Betta* (Teleostei: Osphronemidae). Raffles Bulletin of Zoology Supplement 11:107–115.

Tan, B. C., and K.-S. Tan. 2003. Singapore. Pages 85–90 *in* N. Pallewatta, J. K. Reaser, and A. T. Gutierrez, editors. Invasive alien species in South-Southeast Asia: national reports and directory of resources. Global Invasive Species Programme, Cape Town, South Africa.

Tang, B. Y. 2004. Fishes introduced to Singapore. Personal communication

Thame, M. 2003. Aquatic Alien Species of Myanmar. Available: http://www.aquaticaliens.org/documents/PenangWorkshoppublications/Session%203/3.6%20Myanmar%20(Minn%20Thame%20and%20Myat%20Myat%20Htwe%20combined).pdf

Thollot, P. 1996. Les poissons de mangrove du lagon sud-ouest de Nouvelle-Calédonie. ORSTOM Éditions, Paris.

Thuesen, P. A., D. J. Russell, F. E. Thomson, M. G. Pearce, T. D. Vallance, and A. E. Hogan. 2011. An evaluation of electrofishing as a control measure for an invasive tilapia (*Oreochromis mossambicus*) population in northern Australia. Marine and Freshwater Research 62:110–118.

Thys van den Audenaerde, D. F. E. 1988. Natural distribution of tilapias and its consequences for the possible protection of genetic resources. ICLARM Conference Proceedings 16:1–11.

Tilmant, J. T. 1999. Management of nonindigenous aquatic fish in the U.S. National Park System. National Park Service.

Trewavas, E., 1966. A preliminary review of fishes of the genus Tilapia in the eastward-flowing rivers of Africa, with proposals of two new specific names. Rev. Zool. Bot. Afr. 74(3–4):394–424.

Trewavas, E. 1982. Tilapias: taxonomy and speciation. ICLARM Conference Proceedings 7:3-13.

Trewavas, E. 1983. Tilapiine fishes of the genera *Sarotherodon*, *Oreochromis* and *Danakilia*. Cornell University Press, Ithaca, New York.

Trewavas, E., and G. G. Teugels. 1991. *Danakilia*. *Oreochromis*. *Sarotherodon*. Pages 75, 307–346, 425–437 *in* J. Daget, J.-P. Gosse, G. G. Teugels, and D. F. E. Thys van den Audenaerde. Check-list of the freshwater fishes of Africa. CLOFFA. ISBN Bruxelles, MRAC Tervuren, ORSTOM Paris.

Turner, G. F. 1986. Territory dynamics and cost of reproduction in a captive population of the colonial nesting mouthbrooder Oreochromis mossambicus (Peters). Journal of Fish Biology 29(5):573–587.

U.P. Visayas Foundation. 1993. Resource and ecological assessment of Ormoc Bay, volume 5. The fisheries of Ormoc Bay. Institute of Marine Fisheries and Oceanology Bureau of Fisheries and Aquatic Resources. IMFO Technical Report 15.

USFWS. 1997. [Source material did not give full citation for this reference.]

USFWS. 2005. [Source material did not give full citation for this reference.]

Vallejo, A. N. 1985. Fishes of Laguna de Bay. Nat. Appl. Sci. Bull. 37(4):285–346.

Vasil'eva, E. D. 2003. Main alterations in ichthyofauna of the largest rivers of the northern coast of the Black Sea in the last 50 years: a review. Folia Zoologica 52(4):337–358.

Wager, V. A., and D. T. Rowe–Rowe. 1972. The effects of *Tilapia rendalli* and *T. mossambica* on aquatic macrophytes and fauna in five ponds. South African Journal of Science 68:257–260.

Wager, R., and P. Jackson. 1993. The action plan for Australian freshwater fishes. Department of the Environment and Heritage. Available: http://www.environment.gov.au/biodiversity/threatened/publications/action/fish/index.html. (March 2008).

Walker, K. F., and H. Z. Yang. 1999. Fish and fisheries in western China. FAO Fisheries Technical Paper 385:237–278.

Wang, H.-Y. 1984. Fishes of Beijing.

Wang, S.-A., Z.-M. Wang, G.-L. Li, Y.-P. Cao, et al. 2001. The fauna of Hebei, China. Pisces. Hebei Science and Technology Publishing House. (In Chinese.)

Ward, C. J. 1976. Aspects of the ecology and distribution of submerged macrophytes and shoreline vegetation of Lake St Lucia. *In* A. E. F. Heydorn, editor. St. Lucia scientific advisory council workshop meeting, Natal Parks, Fish and Game Preservation Board Publication 10, Pietermaritzburg, Natal.

Wass, R. C. 1984. An annotated checklist of the fishes of Samoa. Special Scientific Report Fisheries 781. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Webb, A. C. 1994. Ecological aspects of the Mozambique mouthbrooder, *Oreochromis mossambicus*, and other introduced cichlids in northern Queensland. Master's thesis. James Cook University, Townsville, Australia.

Webb, A. C. 2003. The ecology of invasions of non-indigenous freshwater fish in north Queensland. Doctoral dissertation. James Cook University, Townsville, Queensland.

Weber, M. 1897. Beiträge zur Kenntnis der Fauna von Süd-Afrika. I. Zur Kenntnis der Süsswasser-Fauna von Süd-Afrika. Zoologische Jahrbücher: Abteilung für Systematik, Ökologie und Geographie der Tiere 10(2):135–200.

Welcomme, R. L. 1964. Diagnoses and key to the juveniles of *Tilapia* (Pisces, Cichlidae) in Lake Victoria. East African Agricultural and Forestry Journal 30(2):129–136.

Welcomme, R. L. 1981. Register of international transfers of inland fish species. FAO Fisheries Technical Paper 213.

Welcomme, R. L. 1988. International introductions of inland aquatic species. FAO Fisheries Technical Paper 294.

Weliange, W. S., and U. S. Amarasinghe. 2003a. Accounting for diel feeding periodicity in quantifying food resource partitioning in fish assemblages in three reservoirs of Sri Lanka. Asian Fisheries Science 16(3&4):203–213.

Weliange, W. S., and U. S. Amarasinghe. 2003b. Seasonality in dietary shifts in size-structured freshwater fish assemblages in three reservoirs of Sri Lanka. Environmental Biology of Fishes 68:269–282.

Whitehead, P. J. P. 1959. Notes on a collection of fishes from the Tana River below Garissa, Kenya. Journal of the East African Natural History Society 23(4):167–171.

Whitfield, A. K., and S. J. M. Blaber. 1979. The distribution of the freshwater cichlid *Sarotherodon mossambicus* in estuarine systems. Environmental Biology of Fishes 4:77–81.

Wieland, W., W. L. Shelton, and J. S. Ramsey. 1982. Biological synopsis of the Mozambique tilapia (*Tilapia mossambica*). Final Report. National Fisheries Research Laboratory, U.S. Fish and Wildlife Service, Gainesville, Florida.

Wijeyaratne, M. J. S., and W. M. D. S. K. Perera. 2001. Trophic interrelationships among exotic and indigenous fish co-occurring in some reservoirs in Sri Lanka. Asian Fisheries Science 14(3):333–342.

Wohlfarth, G. W., and G. Hulata. 1983. Applied genetics of tilapias. ICLARM Studies and Reviews 6, 2nd edition.

Yadav, B. E. 2003. Ichthyofauna of northern part of Western Ghats. Records of the Zoological Survey of India 215:1–39.

Yap, W., E. A. Baluyot, and J. F. Pavico. 1983. Limnological features of Lake Buluan: preliminary findings and observations. Fisheries Research Journal of the Philippines 8(1):18–25.

Yoshida, T., H. Motomura, P. Musikasinthorn, and K. Matsuura. 2013. Fishes of northern Gulf of Thailand. National Museum of Nature and Science.

Zacharias, V. J., A. K. Bhardwaj, and P. C. Jacob. 1996. Fish fauna of Periyar Tiger Reserve. Journal of the Bombay Natural History Society 93(1):39–43.

Zhang, C.-G., Y.-H. Zhao, et al. 2016. Species diversity and distribution of inland fishes in China. Science Press, Beijing, China. (In Chinese with some sections in English.)

Zhu, S.-Q. 1995. Synopsis of freshwater fishes of China. Jiangsu Science and Technology Publishing House, Nanjing, China. (In Chinese, English summary.)

Zuckerman, L. D., and R. J. Behnke. 1986. Introduced fishes in the San Luis Valley, Colorado. Pages 435–452 *in* R. H. Stroud, editor. Fish culture in fisheries management. Proceedings of a symposium on the role of fish culture in fisheries management at Lake Ozark, Missouri, March 31-April 3, 1985. American Fisheries Society, Bethesda, Maryland.