Rev. Biol. Trop., 45(3): 1257-1261, 1997

BRIEF ARTICLE

Distribution of tilapia, *Oreochromis mossambicus* (Perciformes: Cichlidae), and water body characteristics in Quintana Roo, Mexico

Juan Jacobo Schmitter-Soto[1] and Clara I. Caro[2]
[1] El Colegio de la Frontera Sur (ECOSUR), A.P. 424, MX-77000 Chetumal, Q.R., Mexico, fax (983) 20447; jschmit@xaway.ciqro.conacyt.mx.
[2] Instituto Amazónico de Investigaciones Científicas Sinchi, A.P. 0334174, Bogotá, Colombia, fax (571) 4177418; sasinchi@col1.telecom.com.co.

(Recibido 10-IX-1996 Corregido 5-II-1997 Aceptado 15-IV-1997)

Abstract: Based on field collection in freshwater bodies (1992 to 1996) in the Mexican State of Quintana Roo, Yucatan Peninsula, as well as on official reports from the former Mexican Ministry of Fisheries, this work documents the distribution of tilapia in the state, and its relative abundance as a function of water body area. Introductions of tilapia in Quintana Roo began in 1974; these were mainly extensive cultures (direct releases) until 1982, when floating cages began to be used. The fish were collected with throw, seine, and hand nets, plastic bags or hook and line, as the local conditions allowed; each fishing gear provided a separate abundance estimate for a given site. Water body area was calculated from maps (1:50 000) by clipping the lake area in homogeneously thick paper and weighing it to the nearest 0.1 mg. Temperature, conductivity and dissolved oxygen, as well as the number of native fish species, were recorded, but these variables showed no relationship to tilapia abundance or distribution; however, tilapia was not found in the wild at water conductivities above 5500 mmho/cm. Escape from floating cages, perhaps caused by crocodiles or water level elevations, was found in 50% of the intensive culture sites visited. Moreover, tilapia (*Oreochromis mossambicus* and hybrids, probably with *O. niloticus*) was captured in four sites where it had not been officially introduced; two of these may be natural invasions from nearby lakes during wetter cycles, the others (lakes Cobá and Makanxoc) probably are unofficial introductions. Tilapia was not frequent throughout Quintana Roo (4.2% of 237 water bodies visited), but it was dominant (>20% of the total number of individuals) in most localities where it appeared, including lake Chichancanab, habitat of an endemic *Cyprinodon* species flock. The correlation between the logarithm of water body area and tilapia relative abundance was significantly negative, possibly meaning that smaller sites were more vulnerable to tilapia proliferation.

Key words: Cichlidae, *Oreochromis mossambicus*, introduced species, environmental impact, Quintana Roo, Yucatan Peninsula, Mexico.

The introduction of exotic fishes frequently has an impact on the native fish populations. The harm caused by alochthonous species is well documented in Mexico and elsewhere (Contreras-Balderas and Escalante-Cavazos 1984, Williams *et al.* 1989, McKaye *et al.* 1995). The tilapia or African mojarra is the alochthonous fish most widely used and dispersed in tropical areas (Welçomme 1988). This note presents the official and unofficial distribution of tilapia in natural environments of Quintana Roo (Caribbean versant of Yucatan Peninsula, Mexico), with data on the relationship of its relative abundance to lake area.

According to the official information (Anonymous 1981, 1987, 1991), tilapia has been cultivated in at least 12 natural water bodies (Fig. 1, Table 1); not included in that count are imprecise localities (*e.g.*,

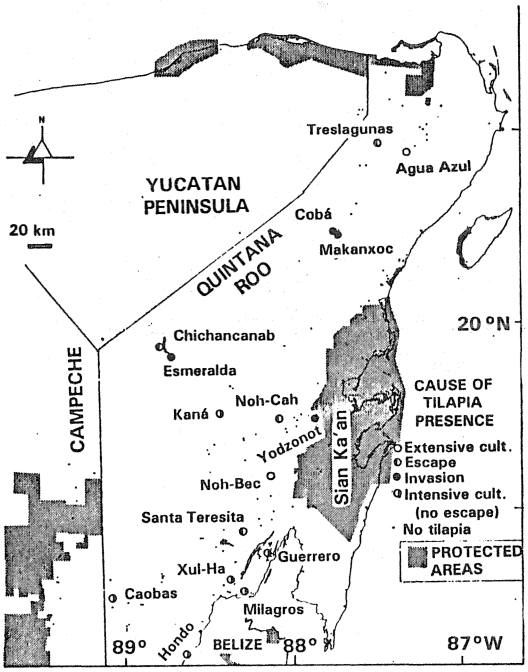

Fig. 1. Distribution and origin of tilapia (*Oreochromis mossambicus* and hybrids) in Quintana Roo until 1996; also shown are all visited localities (Schmitter-Soto 1997), as well as the protected areas in the region. "Invasion" includes also unofficial introductions; "Intensive culture (no escape)" includes unspecified type of culture. See table 1.

"Municipality of O.P. Blanco"), which are likely to include multiple sites. Direct release took place between 1974 and 1984; from 1982 it has been more usual to keep the tilapia in floating cages. Until 1985 there were no data on the species utilized; the official reports mentioned only "*Oreochromis* spp.". *Oreochromis niloticus* (Linnaeus, 1758) was raised in 1988 in the Hondo River; from then till 1991 the officially introduced tilapia has been *Oreochromis mossambicus* (Peters, 1852). Initial stock sizes ranged from 9000 to 32 500 individuals per site. The culture started in the northern third of the state; it spread later to the center and south, and now it is restricted to the southern zone. Production of tilapia in Quintana Roo was only 9.5 tons in 1990, less than 0.1% of the total tilapia catch for Mexico.

The official data were compared to the tilapia records obtained during the ichthyological sampling of 237 lakes, streams, marshes and cenotes (sinkholes) all over the state, from 1992 to 1996 (Schmitter-Soto 1997). The area of each water body (only the permanent basin, excluding the adjacent seasonal inundation zone) was taken from hydrological maps (Anonymous 1984-1985, scale 1:50 000), weighing (SARTORIUS BASIC, mod. 160P, ±0.1 mg) the area cut in uniformly thick paper: a square representing 1 km^2 weighed 37.7 mg.

The fish were collected with throw nets (diameter 3 m, 1 cm between adjacent knots), seine nets (area 15x2 m; 1 cm between adjacent knots), hand nets (area 40x30 cm; 1 mm mesh), plastic bags (while snorkeling) or mosquito hook and line, as the local conditions allowed. Abundance relative to the total number of fishes was calculated separately for each fishing gear: for a given site there were thus one or more different abundance estimates, according to the number of methods used. All specimens were deposited at the fish collection of ECOSUR (ECO-CH 923, 926, 1036, 1290, 1463, 1482, 1541, 1542, 1591, 1641, 1666, 2187, 2194, 2223, 2230, 2264, 2515).

In six out of the 12 official culture sites tilapia (*O. mossambicus* and hybrids, probably with *O. niloticus*) was actually captured or observed (Table 1). Two out of the six localities had experienced extensive culture, but presence of wild tilapia in the other four must be due to destruction of the floating cages by diverse natural agents, such as crocodiles or water level elevations. Thus, there was escape into the environment in 50% of eight intensive culture sites visited (Table 1).

Moreover, the sampling found tilapia in other four localities, where it had not been officially introduced: lakes Cobá, Makanxoc and Esmeralda, and cenote Yodzonot, the latter located in the limit of a protected area, Sian Ka'an Biosphere Reserve (Table 1, Fig. 1). It may be that in wetter cycles lake Esmeralda communicates with Chichancanab, and that the waters of lake Noh-Cah reach cenote Yodzonot, so these invasions may have been natural. On the contrary, lakes Cobá and Makanxoc belong in an endorheic basin with no connection to the

TABLE 1

*Distribution, abundance, and origin of tilapia (*Oreochromis mossambicus *and hybrids) in Quintana Roo.*

Locality (fishing gear)	Year(s) introduced	Origin of tilapia[a]	Estimated lake area (km^2)	Tilapia relative abundance (%)	Native fish fauna[b]
Lake Agua Azul	1974,1988	E,I			
Lake Noh-Cah	1982,1988	I*			
Lake Noh-Bec	1984	E,I	2.16		1,4,6,8,10,11
(hand net)				14.3	
Hondo River	1988	?			
Lake Milagros	1988	I			
Lake Caobas	1988	I			
Lake Kaná	1988	I			
Lake Chichancanab	1988	I*	5.01		1,2,3
(hand net)				20.9	
(throw net)				17.2	
(seine net)				11.2	
(plastic bag)				10.3	
Lake Treslagunas	1988	I*	0.10		?
(hook and line)				100 ?	
L. Sta. Teresita	1988	I*			
Lake Guerrero	1988	?			
Lake Xul-Ha	1990	I			
Lake Esmeralda	-	inv	1.30		2,3
(seine net)				33.3	
Cenote Yodzonot	-	inv	0.01		5,7,9,11
(hook and line)				100 ?	
Lake Cobá	?	intr	0.35		4,9
(throw net)				89.5	
(hand net)				45.8	
Lake Makanxoc	?	intr	0.29		4,9
(throw net)				4.3	

[a] Origin of tilapia: E, extensive culture; I, intensive culture (cages); I*, intensive culture with escape; inv, presumed invasion; intr, presumed unofficial introduction.

[b] Native species: 1, *Astyanax aeneus*; 2, five endemic *Cyprinodon*; 3, *Gambusia sexradiata*; 4, *G. yucatana*; 5, *Poecilia mexicana*; 6, *P. orri*; 7, *Cichlasoma friedrichsthali*; 8, *C. synspilum*; 9, *C. urophthalmus*; 10, *Petenia splendida*; 11, *Thorichthys meeki*.

Estimated lake area, relative abundance of tilapia (calculated separately for each fishing gear), and native fish fauna are given only for sites where tilapia was caught in the wild; other data come from official reports (Anonymous 1981, 1987, 1991); imprecise or artificial localities were omitted. In Noh-Cah and Santa Teresita, tilapia was only observed; in Noh-Bec and Yodzonot, tilapia was not caught with gear other than the one stated.

official introduction sites; the presence of tilapia here is probably due to unofficial liberations.

Although tilapia is not very frequent in Quintana Roo (ten out of 237 localities, 4.2%), its relative abundance reached values higher than 20% in five out of the eight places where it was captured (Table 1). If biomass were used instead of number of individuals, dominance would be even more notorious, especially in lake Chichancanab, where the native *Cyprinodon* -endemic to the lake- and *Gambusia sexradiata* have much smaller adult sizes.

Tilapia was captured between 24 and 33°C (temperature), 1400-5500 mmho/cm (conductivity) and 2.8-7.8 mg/l (dissolved oxygen). There was no significant relationship between these variables and tilapia abundance; however, tilapia was not found in the wild in localities such as lake Guerrero, where conductivity rises above 5500 mmho/cm. There was also no relationship between number of native species and tilapia abundance (Table 1).

Excluding the imprecise datum of cenote Yodzonot (100% tilapia abundance estimated with hook and line, zero with other methods), a negative correlation was detected (F=8.45, 9 d.f., $p<0.05$, $r^2=51.4\%$) between estimated relative abundance of tilapia and the logarithm of the area of the water bodies where it occurred (Fig. 2). (In fact, the use of hook and line was expected to underestimate tilapia abundance, because its detritivory makes it very difficult to bait; if the datum of cenote Yodzonot were included in the regression, F would rise to 15.27, with $p<0.01$ and $r^2=62.91\%$. The biases of the other four catch methods may be estimated from the results in Chichancanab: Table 1.) This means that smaller water bodies are possibly more vulnerable to tilapia proliferation.

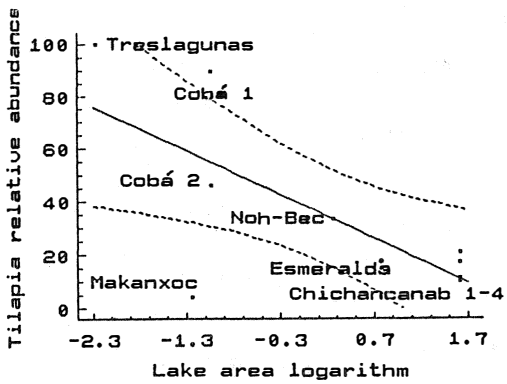

Fig. 2. Estimated relative abundance of tilapia as a function of the logarithm of the area of the water bodies where it occurred. Dashed lines represent the 95% confidence limits. Numbers beside lake names refer to fishing gear (from top to bottom, the four data points of Chichancanab): 1, throw net; 2, hand net; 3, plastic bag; 4, seine net. See table 1.

Lake Makanxoc falls below the 95% confidence band (Fig. 2). It may be speculated that it did not receive a direct unofficial tilapia introduction, but a recent invasion from nearby lake Cobá (Fig. 1).

The karstic origin of water bodies in the Peninsula of Yucatan induces low productivity and high alkalinity and hardness. Olvera (1997) stressed, on the introduction of alochthonous species in Quintana Roo, "the null capacity of cenotes to be utilized for pisciculture, because of their limited extension and the small size of their eufotic zone". The presence of endangered species (the *Cyprinodon* flock of Chichancanab) or alternative protein sources (*Petenia splendida* at Noh-Bec, among others) should also be considered before further introductions, intentional or not, are committed.

ACKNOWLEDGEMENTS

S.I. Salazar-Vallejo, M. Sánchez-Crespo, R. Campos-Verduzco, A. de Jesús-Navarrete and anonymous referees revised previous versions of the manuscript. Funding was provided by CONACYT through grants 1829-N9211 (to JJSS) and 3376-N9309 (to CIC). The former Mexican Ministry of Fisheries issued fishing permits No. 1004 and 2682.

REFERENCES

Anonymous. 1981. Diagnóstico pesquero de Quintana Roo. Dir. Gral. Plan. Informát. Estadíst., Mexico City. 30 p.

Anonymous. 1984-1985. Cartas de aguas su-perficiales: Dziuché; Cobá; Ignacio Zaragoza; Laguna Kaná. Escala 1:50 000. Inst. Nac. Estadíst., Geogr. Informát., Mexico City.

Anonymous. 1987. Acuacultura intensiva rural 1988. Deleg. Fed. Pesca Quintana Roo, Chetumal, Mexico. 41 p.

Anonymous. 1991. Evaluación Anual del Departamento de Acuicultura. Deleg. Fed. Pesca Quintana Roo, Chetumal, Mexico. 15 p.

Contreras-Balderas, S. & M.A. Escalante-Ca-vazos. 1984. Distribution and known impacts of exotic fishes in Mexico, p. 102-130. In W.R. Courtenay Jr. & J.R. Stauffer Jr. (eds.). Distribution, Biology, and Management of Exotic Fishes. Johns Hopkins Univ., Baltimore.

McKaye, K.R., J.D. Ryan, J.R. Stauffer Jr., L.J. López Pérez, G.I. Vega & E.P. van den Berghe. 1995. African Tilapia in Lake Nicaragua: Ecosystem in transition. BioScience 45:406-411.

Olvera, M. 1997. La Piscicultura en Quintana Roo. Una alternativa para su desarrollo, p. 99-106. In C.I. Caro (ed.). Memorias del I Seminario de Acuicultura para el Estado de Quintana Roo. Centr. Invest. Quintana Roo, Chetumal, Mexico. (In press.)

Schmitter-Soto, J.J. 1997. *Catálogo de los peces continentales de Quintana Roo. Guías Científicas ECOSUR. ECOSUR, San Cristóbal de Las Casas, Mexico. (Inpress.)*

Welcomme, R.L. 1988. International introductions of inland aquatic species. FAO Fish. Tech. Pap. 294:1-318.

Williams, J.E., J.E. Johnson, D.A. Hendrickson, S. Contreras-Balderas, J.D. Williams, M. Navarro-Mendoza, D.E. McAllister & D.E. Deacon. 1989. Fishes of North America endangered, threatened or of special concern: 1989. Fisheries 14:2-20.