Translocation of the Clupeid *Sardinella tawilis* to Another Lake in the Philippines: A Proposal and Ecological Considerations

Augustus C. Mamaril

Institute of Biology, College of Science
University of the Philippines
Diliman, 1101 Quezon City

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Abstract

The dwindling commercial catch of *Sardinella tawilis* (Clupeidae), locally known as 'tawilis', reported in recent years by local fisher folk in Lake Taal, Batangas, Philippines, could be a result of the interaction of factors such as over fishing, destructive fish-capture techniques, changes in water quality, and others. Like the rest of the handful of endemic freshwater fish species in the Philippines, *S. tawilis* is threatened with depletion of its stocks, if not with extinction in the near future. A conservation strategy that could be considered is the translocation of 'tawilis' to another lake in the Philippines, whose ecological features closely resemble those of Lake Taal and where 'tawilis' would receive socio-economic and cultural acceptability. Cases of clupeid introductions – natural and man-made, successes and failures – are presented from published literature. Special attention is given to the case of a well-planned trans-country (Thailand-to-Indonesia) attempt to introduce a clupeid fish. The broader questions of biodiversity, endemicity, conservation, and fish community structure in Lake Taal (and elsewhere) must be underpinned by sound basic taxonomy and ecology.

Introduction

An endemic lacustrine fish, believed to have arisen in a caldera lake formed during historically recent eruptions of one of the world's most active volcanoes and which has survived for two centuries in the shadow of this volcano, is feared to be on the verge of extinction. Its impending extinction may be partly traced to the human-mediated arrival of a commercial fish species. Its conservation may partly depend on translocating this fish to another "ideal" lake within its national geographic range where it might adapt and become established.

For an archipelagic country such as the Philippines, which has extensive and deep marine waters but has only a few large natural lakes, the presence of a freshwater clupeid, *Sardinella tawilis*, in Lake Taal in southern Luzon, seems an oddity. Although described as "of minor local interest" in fisheries (Whitehead 1985), 'tawilis', as it is commonly known, presents ecological and possibly evolutionary implications in biodiversity and lacustrine community structure. 'Tawilis' could be either a close relative or descendant of a species of *Sardinella* that inhabited what used to be a marine bay. Based on old Spanish maps, Hargrove (1991) speculated that this bay opened via a wide channel into Balayan Bay of the South China Sea. The violent erup᾿on of Taal Volcano located in the middle of the bay in 1754 might have reduced this channel to what is presently the narrow Pansipit River and in the process trapped founder stocks of biota of marine origin. These land-locked forms, which included a *Sardinella*, adapted to the changing hydrobiological conditions of the erstwhile marine habitat. Virtually cut off from the South China Sea, the bay subsequently evolved into Lake Taal, the third largest freshwater lake in the country. The Pansipit River remains the sole migratory route of diadromous species of vertebrates (fish, reptiles) but at times it is obstructed by fish corrals in its lakeward opening and by sand and other materials that render the opening into Balayan Bay shallow and narrow.

'Tawilis' was described as a new species and identified as *Harengula tawilis* by Herre (1927), along with three other new species : the blenny *Petroscirtes ferox*, the goby *Rhinogobius flavoventris*, and the pipefish *Bombonia luzonica*. Wongratana (1980, 1983) re-described 'tawilis' and transferred it to the genus *Sardinella* and listed 'tawilis' as one of 18 species of *Sardinella* in the Indo-Pacific region; Whitehead (1985) listed it as one of 21 species of *Sardinella* world-wide and considered 'tawilis' as the only freshwater *Sardinella*. Herre (1927) observed that 'tawilis' was never caught in the fish corrals along Pansipit River. Villadolid (1931, 1937) and Magistrado and Mercene (undated) had similar observations and considered 'tawilis' a permanent resident of Lake Taal. Thus, 'tawilis' appears to be effectively isolated from its probable marine ancestor which roamed (or still does) the South China Sea.

Aside from *S. tawilis*, Conlu (1986) reported seven other species of *Sardinella* occurring in the Philippines. Comparing a suite of morphological characters, Wongratana (1980) concluded that 'tawilis' is closest to *Sardinella fijiense*, which curiously does not occur in Philippine waters (Whitehead 1985). Further, considering that the isolation of the founder stock of 'tawilis' in Lake Taal began only in the 1750s, speciation would have to be unusually rapid in an evolutionary time scale. Thus, the status as distinct species and affinities of 'tawilis' may have to be resolved using genetic and molecular techniques.

Is *Sardinella tawilis* Disappearing from Lake Taal?

Whereas the more complex questions of biodiversity, trophic relationships, and population interactions in the Taal ecosystem remain to be addressed, fisheries researchers and Taal fisher folk unanimously agree that the numbers and sizes of 'tawilis' are dwindling. Unfortunately, data on 'tawilis' catches and biology are very inadequate and fragmentary (UPLBFI 1996). For example, an annual catch of 7,000 t was cited by UPLBFI (1996), which cited PCTT (1993) statistics, which in turn cited Bureau of Fisheries and Aquatic Resources data!

A summary of reports on 'tawilis' catch (Table 1) gathered from various sources may provide some clues on the "decline" of the 'tawilis' fishery.

Table 1. Summary of the catch (in tons) of 'tawilis' in Lake Taal in various years

Year	Catch (mt per year)	Sources of data/Remarks
1962	???	'tawilis' disappeared (Conlu 1986, p. 40)
1969	???	'tawilis' re-appeared (Conlu 1986, p. 40)
1970		start of decline in volume of catch and size (Aypa et al. 1991)
1972	15	District Fishery Office of Batangas City (cited in Castillo *et al.* 1974, typewritten terminal report, p. 5)
1973	97*	District Fishery Office of Batangas City (cited in Castillo *et al.* 1974, typewritten terminal report, p. 5)
1974	104*	District Fishery Office of Batangas City (cited in Castillo *et al.* 1974, typewritten terminal report, p. 5)
1978	900	BFAR, cited in Baluyut (1983, p. 35)
1979	407	BFAR, cited in Baluyut (1983, p. 35)
1980	326	BFAR, cited in Baluyut (1983, p. 35)
1984	≅29,000	Bureau of Fisheries, cited by Hargrove (1991, p. 112); Bleher (1996, p. 34)
1988	8798	Office of the Provincial Planning and Development Coordinator, cited by PCTT (1994b, v. 4, p. 34)
Undated	207	Bureau of Fisheries, cited by Hargrove (1991, p. 112)
1992	6858	Various government agencies, fisher folk interviewed, cited in PCTT (1994b, p. 34) and UPLBFI (1996, p. 146)
1995	<60	Bleher (1996, p. 34)

*The data were 107.9 tons in 1973 and 213.6 tons in 1974 in PCTT (1994b, v. 4, p. 34) which cited Castillo *et al.* (1974)

The dwindling catch of 'tawilis' has been attributed to various factors such as use of non-selective fishing gear, overfishing, and possibly, changes in water quality arising from the proliferation of loosely regulated tilapia cages (Castillo *et al.* 1974; Aypa *et al.* 1991; UPLBFI 1996). Biological factors such as food availability (plankton community) and food preference, piscivory, competition, loss of breeding areas, life-history (including reproductive biology) and population genetics, are being looked into only recently (e.g., Mamaril 1986; Zafaralla 1989; Aypa *et al.* 1991; Zafaralla *et al.* 1992; Zafaralla 1995; Mamaril 1997; Flores 1997).

The current efforts to help sustainably develop 'tawilis' fisheries need to be complemented with bold programs of action or conservation strategies. On-going efforts include (i) designating a fish sanctuary (ii) declaring a limited open 'tawilis' fishing season (during which motorized push nets are allowed) (iii) restricting the mesh size of gill nets (iv) monitoring 'tawilis' catch at landing sites. These efforts may prove inadequate especially if the perceived decline of 'tawilis' is biological, and not anthropogenic in nature.

Saving 'Tawilis' by its Translocation to Another Lake: The Possibilities

A bold and necessarily complex proposal to conserve and develop 'tawilis' fishery is the translocation of 'tawilis' to another lake in the Philippines. This other lake must approximate the hydrological and limnological conditions of Lake Taal. The translocation of 'tawilis' may begin with the consideration of the suitability of a predominantly zooplanktivore such as 'tawilis' as a "candidate" for translocation.

What makes *Sardinella tawilis* appropriate for translocation from Taal to another lake in the Philippines? *S. tawilis* is one of more than 300 species of the suborder Clupeoidei (of the order Clupeiformes), or the clupeoid fishes. Clupeoids include four families: Clupeidae (herrings, sardines, sardinellas and sprats), Engraulidae (anchovies) and the lesser known Chirocentridae (wolf-herrings) and Pritigasteridae. Heavily exploited, they are of prime importance to global fisheries as a result of two main features of their biology: (i) clupeoids feed close to the start of food chains and thus benefit directly from nutrient-enriched waters that experience seasonally or continuously occurring plankton blooms and (ii) majority are schooling and thus easily caught by nets (Whitehead 1985).

Although typically marine, clupeids have successfully established populations in tropical lakes and new reservoirs, where environmental conditions are relatively unstable, either by migration via riverine routes or by deliberate human introductions. These fish have certain biological characteristics that favor their invasion of new habitats: (i) offshore spawning which spares the eggs and juveniles from the uncertainties of fluctuating water levels; (ii) high fecundity and short life cycle which enhance reproductive success; and (iii) wide range of food preference. Among planktivorous fish, clupeids are considered so far the best choice for stocking in lakes and reservoirs that do not have native pelagic fish (Petr and Kapetsky 1983).

Lever (1996) lists down only three species of freshwater Clupeidae as having been involved in transnational introductions: the threadfin shad *Dorosoma petenense* and the Tanganyika sardines *Limnothrissa miodon* and *Stolothrissa tanganicae*. Present in the temperate waters of eastern North America, the threadfin shad was introduced to Puerto Rico and the Hawaiian islands of Kauai and Oahu, in both instances as food item for predatory species, the largemouth bass *Micropterus salmoides* and tuna, respectively. Constituting a valuable commercial fishery in Lake Tanganyika in eastern Africa, the sardine-like *L. miodon* and *S. tanganicae* were initially introduced in Lake Kivu; populations of *L. miodon* were later established in four other lakes (Lake Kariba, Lake Cahora Bassa, Lake Volta, and Lake Kainji).

Clupeid Introduction in Southeast Asia: A Case Study

A feasibility study to introduce a species of a planktivorous clupeid, *Clupeichthys aesarnensis*, from Thailand to Indonesia underwent a critical evaluation and review in the early 1990s (Costa-Pierce and Soemarwoto 1990). A species native to nearly all river systems in northeastern Thailand, *C. aesarnensis*, or the Thai river sprat, had successfully become established as part of the fishery of Ubolratana Reservoir in that region. It was originally identified as *Corica goniognathus* (Petr and Kapetsky 1983) until it was reclassified as a distinct genus in Wongratana (1980, 1983) and Whitehead (1985). The taxonomy of these clupeids had to be clarified because *C. goniognathus* was long known to be already present in Indonesia. The recipient reservoir, the Saguling reservoir in West Java, lacked a native planktivore, which was envisioned to support a pelagic fishery for the displaced residents.

The results of the feasibility study showed that *C. aesarnensis* would have a good chance to found a productive fishery in Saguling Reservoir (Costa-Pierce and Soemarwoto 1990). The limnological features of Ubolratana and Saguling, especially the zooplankton and phytoplankton communities, were essentially similar. The diet of the Thai river sprat with >50 mm average length consists of 60% zooplankton, 20% phytoplankton, and 15% insects.

Other potential impacts of fish importation (i.e., pathological risks, ecological risks, etc.) were likewise taken into account. Over 500 of *C. aesarnensis* from Thailand reached the quarantine facility in West Java situated an hour ride away from Saguling reservoir. Lack of funds and technical capabilities needed to stock a sufficiently large founder stock of *C. aesarnensis* from a quarantine facility led to alarming mortality a week into captivity in the concrete raceways. Only about 20 fish in poor condition were introduced but failed to establish in the reservoir. More details about the study are contained in an upcoming World Bank technical report (Costa-Pierce, pers. comm.).

Where Can 'Tawilis' Go?

Of the major lakes in the Philippines to which 'tawilis' may be translocated, the most "ideal" seems to be Lake Lanao in northern Mindanao. A feasibility study similar to that of the planned introduction of *C. aesarnensis* from Thailand to Indonesia must be made. It would be highly involved but would have the advantage of having information available on both the donor lake (Taal) and recipient lake (Lanao). Davies *et al.* (1990) provide synoptic data on these lakes. An overview of the relevant literature (i.e., hydrology/ecology and fisheries) follows.

In Southeast Asia, which has a low density of natural lakes - for a region with a relatively high rainfall, Lake Lanao stands out as one of only four large natural lakes (in terms of area and volume) and arguably the best known limnologically (Fernando 1984). It was one of the lakes investigated in the region during the Wallacea expedition by Woltereck (1941) who reported on some chemical measurements and the biota, including plankton. The ecology of Lake Lanao was studied by Frey (1969) and Lewis (1973, 1974, 1975, 1976, 1977a, 1977b, 1977c, 1978a, 1978b, 1978c, 1978d, 1978e, 1979, 1980). Mamaril and Fernando (1978), Lai *et al.* (1979) and Mamaril (1986) reported on the zooplankton in the lake and areas around the lake. Herre (1924, 1926) initiated studies of Lanao fishes, especially cyprinids, which subsequently took on considerable importance in evolutionary biology (reviewed in Greenwood 1984 and Kornfield and Carpenter 1984). Bleher (1994) provided a literally colorful account of the lake and its fish fauna. An updated list of fish species in Lanao is given in Mercene (1997). Various aspects of Lanao fisheries (e.g., feeding habits of the surviving cyprinid species, fishing techniques, percentages of fish caught and sold in the local market, etc.) are presented in Sanguila *et al.* (1975), Escudero *et al.* (1980), and Escudero (1995). Baluyut (1983) provides a summary of Lanao fisheries.

The fish and fisheries of Lake Taal are likewise well-known (Herre 1925, 1927a, 1927b, Herre 1958, Herre and Montalban 1927, De Beaufort 1932, Roxas 1934, Villadolid 1931, 1932, 1937, Castillo *et al.* 1974, Vallejo and Habito 1987, Mercene 1997). Bleher (1996) provided an update on and fascinating color pictorial of the fish fauna. Castillo *et al.* (1974), Habito and Mendoza (1987 cited in Zafaralla *et al.* 1989), and Flores (1997) provide information on feeding of *Sardinella tawilis* on zooplankton. Some aspects of the reproductive biology of 'tawilis' were investigated by Aypa *et al.* (1991). Hydrological conditions were measured by Castillo and Gonzales (1976) and LWUA (1978). The Philippine Institute of Volcanology and Seismology (Phivolcs) regularly monitors some physico-chemical parameters around the lake (unpublished). Woltereck (1941) described the lake and its biota, including the fishes, as part of the Wallacea expedition on Philippine lakes. Limnological conditions are reported in Aquino and Nielsen (1983), Darvain *et al.* (1984), Montemayor (1984-1985), Zafaralla (1990, 1992, 1995), Zafaralla and Orozco (1989), Zafaralla *et al.* (1989, 1992), Mamaril (1993), Acedera (1993), Santos (1993), UPLB Foundation Inc. (1996) and Alcañices et al. (1997). Data on zooplankton are available in Mamaril (1986, unpublished data), Zafaralla *et al.* (1989, 1992) and UPLBFI (1996). Summaries of environmental conditions and fisheries management in Taal are provided in several recent works (PCTT 1993, 1994a, 1994b, UPLB Foundation Inc. 1996) in response to the proliferation of tilapia cage culture and development of the Tagaytay-Taal area. Hargrove (1991) provided a well-written non-technical account of Lake Taal's conditions and its possible origin.

A brief comparison of Lake Taal and Lake Lanao emphasizing the zooplankton and zooplanktivory was made by Mamaril (1997). The two lakes can be further compared using available information relevant to the proposed translocation of 'tawilis' to Lake Lanao (Tables 2 & 3).

The two lakes are indeed comparable in most of their features vis-a-vis a possible fish translocation. Both lakes have limnetic zones that are underexploited and characterized by a relatively diverse plankton community. The most notable absentee in the Lanao plankton are *Brachionus* spp., limnetic species which are favored rotifer prey items of 'tawilis'. Lake Lanao has no considerable chemical gradients arising from point sources and thus lacks the temporal and spatial variations in chemical parameters, such as water hardness and SiO_2, that Lake Taal experiences.

Table 2. Selected physico-chemical features of Lakes Taal and Lanao

Features	Lake Taal	Lake Lanao
Mode of origin	Volcanic (caldera formation)	Volcano-tectonic (damming of a river by lava flow)
Years of existence	200 yr +	Since Tertiary?
Surface area (km^2)	263	357
Maximum depth (m)	198	112
Mean depth (m)	60.1	60.3
Volume (km^3)	NA*	21.5
Replacement time (yr)	NA*	6.5
Outlet	Pansipit River	Agus River (variable)
Circulation	Jan-Feb	Jan-Feb Nonseasonal remixing of epilimnion
Thickness of epilimnion (m)	5-50	40-60
Light penetration (m)	z_{SD} = 0.7-1.8[a]; 1-8[b]; 3.8-6.5[c]	z_{eu} = 12
Water temperature range °C	34[b]-25.6[d]	30-24
Conductivity ($\mu S\ cm^{-1}$)	1000[c]-2000[b]	105
Nutrients		NO_3-N, 1 $\mu g/l$ PO_4 > 10 $\mu g/l$

*NA means information not available at the time
[a] Aquino and Nielsen (1983)
[b] Zafaralla (1990)
[c] Davies *et al.* (1990)
[d] Castillo and Gonzales (1976)

Table 3. Selected biological features of Lakes Taal and Lanao

Features	Lake Taal	Lake Lanao
Primary production	2.5, 2.7 g $C/m^2/d$ [a] 0.2-6.5 g $C/m^3/d$ [b]	1.7 g $C/m^2/d$ net
Trophic status	Oligotrophy	Oligotrophy
Limnetic zooplankton	*Brachionus* spp., *Keratella* *Diaphanosoma* spp. *Moina, Bosmina* *Calanoid copepod*	*Keratella* *Diaphanosoma* spp. *Moina, Bosmina* *Tropodiaptomus* spp.
True pelagic planktivore	*Sardinella tawilis* (Clupeidae), endemic, obligate	Instars of *Chaoborus* sp.(Diptera, Chaoboridae); possibly *Puntius sirang* (Cyprinidae), endemic, facultative
Possible ancestor of Dominant planktivore	Marine, pelagic species *of Sardinella,* planktivore	Riverine species, *Puntius binotatus,* Omnivore
Piscivores	*Caranx* spp. ('maliputo')	*Glossogobius giurus* *Hypseleotris agilis* *Micropterus salmoides*
Fish community	With migratory species; only 'tawilis' endemic	ca. 20 spp. of endemic cyprinids, mostly extinct; non-migratory
Problems of fisheries	Overfishing, destructive fishing techniques, loss of breeding places, cage culture, deterioration in water quality?	Overfishing, predators, destructive fishing techniques, catch of gravid females, lowered lake water level due to hydroelectric power generation

[a] Aquino and Nielsen (1983)
[b] Zafaralla (1990)

Introduction, Naturalization, Translocation: What are They Really?

Strictly speaking, the transfer of 'tawilis' to Lake Lanao is *not* an introduction. *Introduction* is "the deliberate or accidental release of a species into a country in which it is not known to have occurred within historic times." *Translocation* is "the deliberate or accidental movement by man of a species from an area where it is established, as either native or alien, to another area within the same national geographic range" (Lever 1996). In the Philippines, there have been several fish introductions, some of which have ill-consequences to local fish fauna (Juliano *et al.* 1989). Some species have become *naturalized* fishes, i. e., species introduced to a country where they are not indigenous but in which they may flourish under the same conditions as those that are native. Populations of a naturalized fish must be self-maintaining and self-perpetuating unsupported by and independent of man and free-living in the wild. *Intra*national transfers, or translocations, do not conform with the accepted definitions of 'Introduced' and 'Naturalized' which refer only to *inter*national transfers. This dichotomy may be of doubtful ecological validity on the assumption that the movement of species between different drainages and river basins within the same country may be of considerably greater ecological significance that those between neighboring countries (Lever 1996). Table 4 lists species of fish that have been introduced in the Philippines and those that have become naturalized; species introduced to Lake Lanao are indicated.

Why 'Tawilis' May Be the One

What makes 'tawilis' "ideal" for transfer to Lanao? Some of the reasons are: (i) 'tawilis' is an indigenous species, not exotic; (ii) it is likely to be an obligate zooplanktivore, unlikely to consume other fish but could potentially occasionally shift to *Chaoborus* instars, which would become simultaneously its competitor (for Cladocera) and prey; (iii) it is truly a pelagic species which, like its Tanganyika relatives (*Limnothrissa miodon* and *Stolothrissa tanganicae*), could then exploit the pelagic zone, particularly populations of the Lanao congeneric calanoid copepods; (iv) it is less likely to become a competitor of a Lanao planktivore, if there is any; and (v) it breeds all-year round and may take advantage of the year-long productivity of oligotrophic Lanao, which does not experience the low water transparency and high volume-specific standing crop syndrome of eutrophic lakes.

The transfer to Lake Lanao of a non-piscivorous species such as *Sardinella tawilis* would avoid the well-documented cases of alterations in the fish community wrought by an introduced piscivore through direct predation upon one or more native fish species. Still, even if the translocated species is not piscivorous, predator-prey dynamics in the recipient lake may be disrupted through indirect predation effects if the newcomer and one (or more) native species share a common predator (Adams 1996). The fish community structure may also be disrupted if the exotic species occupies the same ecological niche (feeding, breeding, etc.) of one or more resident species.

'Tawilis' stands out among clupeids that have become naturalized in tropical freshwaters such as lakes and reservoirs as perhaps the only species without a riverine history. Freshwater clupeids descended from marine ancestors and slowly made it to inland waters via river systems; some have remained riverine species although they have colonized lacustrine habitats (e.g., the Thai river sprat *Clupeichthys aesarnensis* in Southeast Asia). It seems 'tawilis' has always been a pelagic fish, one that might have had only a fleeting riverine existence.

Why Lake Lanao?

Lake Lanao is an "ideal" recipient lake for several reasons, among which are in a "trophic cascade" sequence: (i) Lanao supports a suitable limnetic plankton community, including the two species of *Tropodiaptomus*, large-bodied prey items; (ii) it has no known obligate planktivore which could turn out to be a competitor of 'tawilis'; (iii) it seems to lack a dominant predator on 'tawilis', especially a carnivore in the league of the notorious Nile perch (Barel et al. 1985; Payne 1987; Acere 1988) and, worse, the African catfish *Clarias gariepinus*.

Table 4. Fishes which have been introduced in the Philippines, those that have become naturalized (*), and those that have been introduced to Lake Lanao (‡). Data from Villaluz 1966 (as cited by Baluyut 1983), Juliano *et al.* (1989), Lever (1996), and Mercene (1997)

Species	Common name	Remarks
Cyprinidae		
*Barbus (= Puntius) javanicus/ gonionotus**	tawes	
*Carassius carassius**	Crucian carp	
*Catla catla**	catla	
*Cyprinus carpio**‡	common carp	
*Labeo rohita**	rohu	
Cobitidae		
*Misgurnus anguillicaudatus**	Japanese loach/Oriental weatherfish	
Clariidae		
*Clarias batrachus**‡	walking catfish	Lanao has *C. macrocephalus* (Escudero 1995); preyed on Lanao cyprinids (Payne 1987);
*Clarias gariepinus**	African catfish	
Poeciliidae		
*Gambusia affinis**	mosquitofish	mosquito control; piscivorous?
*Poecilia (= Mollienesia) latipinna**	sailfin molly	mosquito control
Poecilia reticulata		mosquito control
Centrarchidae		
*Lepomis cyanellus**	green sunfish	
*Lepomis macrochirus**	bluegill	
*Micropterus salmoides**‡	largemouth bass	preyed on Lanao cyprinids (Payne 1987);
Micropterus salmoides floridanus		
Cichlidae		
*Oreochromis aureus**	blue tilapia	
*Oreochromis mossambicus**‡	Mozambique tilapia	
*Oreochromis niloticus**‡	Nile tilapia	
Gobiidae		
*Glossogobius giurus**‡	goby	preyed on Lanao cyprinids
Osphronemidae		
*Osphronemus gouramy**	giant gourami	
*Trichogaster leeri**	pearl gourami	
*Trichogaster pectoralis**‡	snakeskin gourami	endangered in Lanao
*Trichogaster trichopterus**	three-spot gourami	
Anabantidae		
Anabas testudineus‡	climbing perch	endangered in Lanao
*Helostoma temmincki**		kissing gourami
Ictaluridae		
Ictalurus catus		
Ictalurus punctatus	channel catfish	
Cyprinodontidae		
Fundulus heteroclitus		mosquito control
Eleotridae		
Hypseleotris agilis‡		predator in Lanao, littoral (Escudero 1995)
Anguillidae		
Anguilla mauritiana‡	eel	
Chanidae		
Chanos chanos‡	milkfish	
Ophicephalidae		
Ophicephalus striatus‡	snakehead	
Pangasiidae		
Pangasius sp.		
Characidae		
Serrasalmus sp.	piranha	

Obviously, there are other considerations, some still unknown, that need to be factored in the matrix of variables of fish translocation. In the case at hand, a major consideration is the impact of 'tawilis' on the Lanao zooplankton community. Can the Cladocera withstand having two planktivores, a vertebrate ('tawilis') and an invertebrate (*Chaoborus*)? In Tanganyika, Cladocera have virtually vanished and Rotifera are reduced most likely due to the two sardines; *Chaoborus* is absent. Still, Tanganyika has a remarkable trophic efficiency which results in the conversion of primary production to high fish yield (Burgis 1984; Coulter 1991). The diaptomid calanoid, *Tropodiaptomus simplex*, the primary grazer and prey of the sardines, is very much involved in trophic transfers. Additionally, there is a need to know more about the breeding biology of 'tawilis'. Are its eggs pelagic as most clupeid eggs are believed to be? Or do the eggs stay in the littoral (as in eelgrass beds reported by Castillo *et al.* 1974)? Does 'tawilis' harbor parasites that might infest Lanao fishes? A not-too minor consideration is the acceptability of *Sardinella tawilis* among Lanao or Maranao consumers. The observation by Escudero *et al.* (1980) that *Sardinella melanura* (locally known as 'tamban') was one of several marine species sold at the Marawi City market augurs well for 'tawilis'.

The Tasks to be Done

Further, there needs to be a more cautious and deliberate study on the implementation of fish translocation, such as catching and keeping the fish fry alive and healthy during transit (obligate planktivores are said to be extremely delicate and difficult to capture alive; as in Lazzaro 1987, p. 105; Castillo *et al.* 1974 on keeping 'tawilis' in plastic bags), transportation costs, effective quarantine, acclimatization in the recipient lake, monitoring mortality, etc.

Fernando and Holcík (1982, 1985) summed up the idea of fish introductions by stating that among the large number of tropical freshwater fishes, only Cichlidae and Clupeidae have been shown to be preadapted to colonize lacustrine habitats and to increase total fish yields considerably. Suitable cichlid/clupeid species may be introduced into natural lakes, albeit these should be of more recent origin. Exotic species have had disastrous, frequently unexpected, impact on native fishes of natural lakes. The biology of such fishes must be well-understood, as well as their role in the fish community and lake ecosystem. The limnological features of both donor and recipient basins should be thoroughly studied along with the responses of the native ichthyofauna that may be exposed to pathogens and parasites (even other fish species!) introduced in carrying out the fish transfer. Protocols for fish introduction/importation have been suggested and implemented (Courteny and Robins 1973 as cited in Fernando and Holcík 1982; a stringent ICES protocol from Kohler and Stanley 1984 as shown in Costa-Pierce and Soemarwoto 1990).

Risks and Rewards: Saving a Species and Having More to Eat

The proposed translocation of *Sardinella tawilis*, or any fish species for that matter, needs careful study, deliberate planning and patience. Considering the emotional nature of the subject of fish introductions (Fernando 1989), it has potentially tremendous social, economic, ecological, and even political costs. The protocol has to be worked out, preferably with international technical and financial assistance. The risks may be lower in a transnational movement of fish than those in trans-country and trans-continental introductions. If the translocation is successful, the rewards are far-reaching in significance to biodiversity and fisheries - (i) conservation of *S. tawilis* as an endemic species in the Philippines and its uniqueness as the only freshwater sardinella in the world and (ii) development of the pelagic fisheries of Lake Lanao, without sacrificing what still remains of the once-diverse cyprinid flock.

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