Spawning habitat of *Telmatherina sarasinorum* (Family: Telmatherinidae) in Lake Matano

[Habitat pemijahan ikan *Telmatherina sarasinorum* (Famili: Telmatherinidae) di Danau Matano]

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Abstract

A study on habitat of *Telmatherina sarasinorum* was conducted in Lake Matano. An underwater observation on the fish habitat was performed to allow description on habitat while investigating its reproductive behaviour. There were two types of spawning habitat on the fish observed. The first was shallow beach with flat contour and bottom covered by cobble and little sand in between which was located in littoral area with trees on the lake sides. The second was deeper water with steeper bottom which has hanging down roots and fallen down stems and twigs of any trees covered by alga. In the two habitats the fish prefers shading places provided by any trees existing on the lake sides as spawning sites. The fish was not observed spawn in places covered by dense cobbles and open waters exposed directly to sunlight. Such a habitat specialist becomes important factor needed to be taken into account in the attempts to conserve the fish and its habitat in Lake Matano. Maintaining the existence of spawning habitat through protecting the presence of terrestrial vegetation surrounding the lake is important key for conservation of the fish and its habitat.

Keywords: habitat preference, Lake Matano, spawning arena, spawning substrate, *Telmatherina sarasinorum*.

Abstrak

Penelitian tentang habitat *Telmatherina sarasinorum* dilakukan di Danau Matano. Pengamatan bawah air pada habitat ikan ini dilakukan untuk membuat gambaran mengenai habitat sambil meneliti tingkah laku reproduksinya. Ada dua tipe habitat pemijahan ikan yang diamati. Pertama adalah pantai dangkal dengan kontur datar dan dasar ditutupi oleh kerikil dan sedikit pasir diantaranya yang terletak di daerah litoral dengan pohon-pohon di pinggiran danau. Kedua adalah perairan dalam dengan dasar lebih curam yang mempunyai akar-akar menggantung serta batang dan ranting pohon tumbang yang diselimuti oleh alga. Pada kedua tipe habitat tersebut ikan menyukai tempat-tempat teduh yang mendapat bayang-bayang dari pohon yang ada di pinggiran danau sebagai tempat pemijahan. Ikan diamati tidak memijah di tempat-tempat yang ditutupi oleh kerikil yang padat dan perairan terbuka yang terpapar langsung oleh cahaya matahari. Habitat khusus demikian merupakan faktor penting yang perlu dipertimbangkan dalam usaha konservasi ikan dan habitatnya di Danau Matano. Pemeliharaan habitat pemijahan melalui perlindungan keberadaan vegetasi terestrial di sekeliling danau adalah kunci penting untuk konservasi ikan dan habitatnya.

Kata penting: arena pemijahan, Danau Matano, pemilihan habitat, substrat pemijahan, *Telmatherina sarasinorum*.

Introduction

Sulawesi Island has long been known as the hotspot in global biodiversity because of high endemism among its native faunas (Whitten *et al*., 2002), 76% of native fishes in Sulawesi are the endemics (Kottelat *et al*., 1993) and unique. Lake Matano is one of the world ancient lakes which are situated in the central south of Sulawesi Island, and it is in the uppermost end of Malili Lakes System. Lake Matano (Haffner *et al*., 2001) has a total area of 164 km^2, 590 m in depth, high water transparency (the Secchi disc still can be visualized from the distance of 23 m), steep sides along the lake with relatively narrow littoral area, and it is famous as an oligotrophic lake. The lake is at least inhabited by seven Telmatherinidae species (*T. abendanoni*, *T. antoniae*, *T. obscura*, *T. opudi*, *T. prognatha*, *T. sarasinorum*, and *T. wahjui*) (Kottelat, 1991) and 1 newly described species *T. albolabiosus* (Tantu & Nilawati, 2008), and one other species – *Telmatherina bonti* – (Tantu & Nilawati, 2007) re-

ported previously by Kottelat (1990) only found in Lake Towuti. Telmatherinidae is known for male polychromatism.

Many studies were previously conducted on the fishes of Telmatherinidae from Lakes Malili including aspects of diversity and evolution, adaptive radiation and population genetics, maintenance of male colour polymorphism, and comparing mating behaviour (Herder *et al*., 2006; Heath *et al*., 2006; Gray *et al*., 2006; Gray & McKinnon, 2006; Nilawati & Tantu, 2007; Tantu & Nilawati, 2007; Tantu & Nilawati, 2008). Among the above studies, however, there was no study specifically focused on spawning habitat. *T. sarasinorum* is known as a small endemic fish from Lake Matano being one of predominant species among the telmatherinids. The fish inhabits littoral area and has two differential spawning habitat types (phytophil and lithophil). The fish has a relatively limited distribution along the shallow lake sides and often found in southern lake side (Kottelat, 1991). In many fish species, spawning incorporates behavioural factors that ensure to appropriate conditions for the eggs and offspring after hatching. A common behavioural factor is the selection of an appropriate location through preference of particular spawning structures. The appropriateness of the selected location for egg and larval development affects mortality of the offspring, especially in species without parental care.

The appropriateness of a location, which ensures protection on the eggs and larval development and survival of the offsprings, becomes a major control in species with no parental care. The fish is one of fish species inhabits an oligotrophic lake known as substrate spawner and does not perform parental care.

The present paper reports on physical aspects of spawning habitat characteristics of the fish in Lake Matano. Observation on these aspects was conducted simultaneously with observation on reproductive behaviour in both habitat types (reproductive behaviour aspects *in preparation*). The aim of the present study was to determine habitat selection for oviposition site of the fish by identifying its preferred physical characteristics of spawning substrate in the field that determine factors supporting the existence of the fish reproductive strategy. The study of fish reproductive habitat is expected to help attempts of conservation of the endemic fish and its habitat in Lake Matano.

Materials and methods

Research was conducted in Lake Matano District of East Luwu, South Sulawesi (02° 25.00′ -02°34.00′ S and 121°12.00′ -121°29.00′ E). Field activities were performed in September 2008; December 2008; March 2009; and June 2009. Spawning locations were established based on underwater observations through snorkelling. These locations were considered from the presence of mating events characterized by pairing fish and they performed quivering. Females presented movements as laying eggs and males presented movements as releasing sperm. Observations were accomplished in 12 localities (Figure 1) and these underwater observations were conducted for three hour in each location. In each sampling locality observer performed slow swimming by snorkelling along 50 meter transect in the depth between 0.5 and 2 meter parallel to the shoreline. The observer identified particular localities of spawning arena of the fish. The spawning arena here is defined as a restricted area, almost looks like a stage, in which spawning activities were performed by the presence of male displays, pairings and courting of males and females of the fish. The spawning arenas were

then marked by the observer and percent of material coverage that compose spawning substrates was subsequently analyzed according to Wolman method (1954) (Table 1). The number of spawning arena within transect line was also recorded.

Table 1. Classification of substrate sizes

Material	Size range (mm)
Silt/clay	0-0.06
Fine sand	0.061-0.25
Medium sand	0.26-0.5
Coarse sand (pea gravel)	0.51-2
Gravel	2-64
Cobble (rubble)	65- 256
Boulder	257-4096
Bedrock	>4096

Source: Wolman (1954)

Results

Underwater observations showed that spawning habitat of the fish has the form of an arena in which the fish presented in the arena performed male-male displays, pairings and mating. There were two types of spawning arena. The first was spawning arena on bottom substrate, in which the arena composed of cobbles with sand traps in between. The second was spawning arena composed of hanging down roots and/or fallen down stems and twigs covered by alga and freshwater sponge.

Spawning arena was generally located near the shoreline, within water depth of 0.30-0.75 meter, with water transparency of 10-15 meter (distance of the observer vision relative towards a white plate with the dimension of 30 cm x 30 cm horizontal in water column). The spawning arena on bottom substrate is located in littoral with relatively flat bottom contour. Whereas spawning arena with hanging down roots and/or fallen down stems/twigs is located in deeper water with relatively steep bottom contour (Figure 2). These two types of arena were always observed be under shading and or near shading from vegetation and cobbles/boulders.

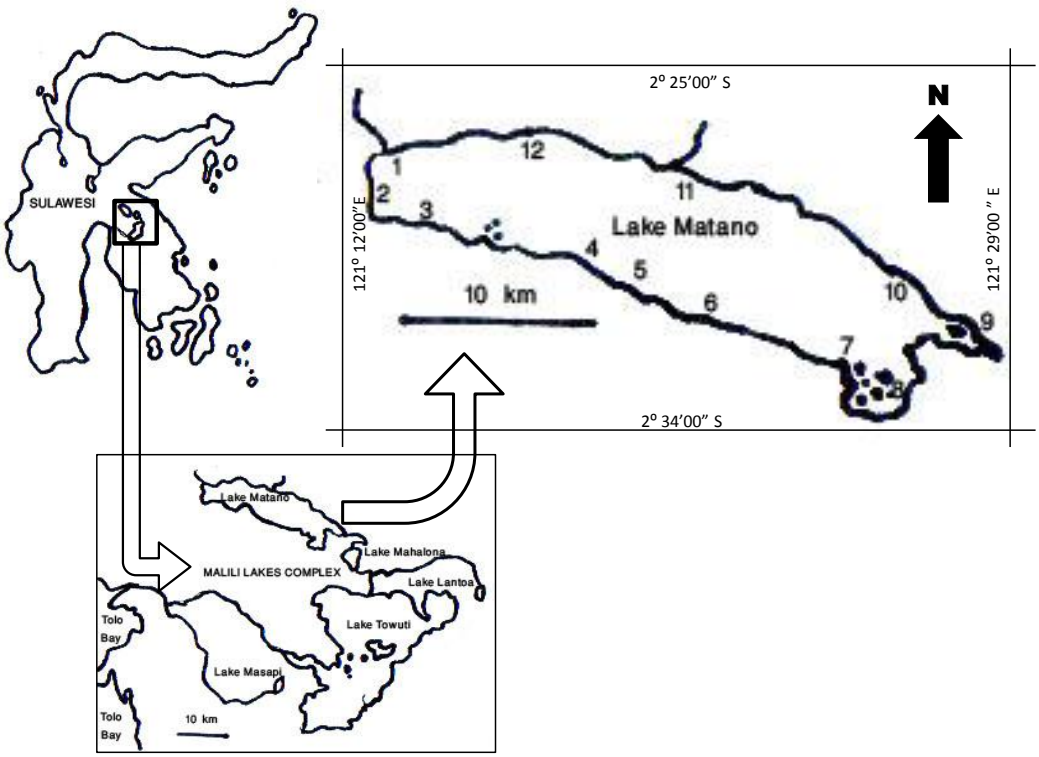

Figure 1. Sampling localities in Lake Matano
Note: 1-12 were the site numbers indicated in Table 2

The fish presented within spawning arena were sexually mature individuals. They performed their fitness in the form of male colour displays by unfurling brighter, stronger and colourful larger fins, following by pairing, fighting for females, and movement such as releasing eggs and sperm. Within bottom spawning arena the movements of reproductive behaviour were performed horizontally towards the bottom, while in other type of spawning arena reproductive behaviour were performed both in vertical and horizontal movements.

Males and females presented in spawning arena were not only pairing males and females but also single males and single females. The pairing fish in spawning arena were observed always be followed by other males disrupted the spawning events and seemed likely ready at any time for eating the freshly laid eggs on the substrates.

Pairing males and females were observed actively spawned onto the substrates under shading condition, which provided by the tree shaded the arena from the lake sides or large cobble or small boulder shaded the arena (description of reproductive behaviour is *in preparation*). When the water was waving and bottom substrates were mixed there was no mating activity observed, and the fish were observed moved to deeper and clearer water.

The present study also found that spawning activity rarely occurred on bottom substrate within open water without shading effect from terrestrial vegetations or large cobble and/or small boulder. Within a such open area the fish used most of their time for feeding by following the pairing congeneric, *T. antoniae* and foraging the freshly laying eggs. The study also noted that on the bottom substrate covered by cobbles and/or sand substrate it was rarely found the assemblages of the fish performing mating activity. Whereas on silt substrate mating activity of the fish was never found. The spawning arena observed has particular physical characteristics (Table 2).

Spatially, the highest number of spawning arena in transect was found in Island I and Island II with four spawning arenas (each with two roots habitat and two bottom habitat). In Kupu-kupu Beach, Salonsa Beach, and Old Camp each had three spawning arenas. Where Kupu-kupu Beach and Old Camp only had one habitat type, in Salonsa Beach we found two habitat types (two bottom habitats and one root habitat). In Matano Village, Salure River, and Tanah Merah River there was only one spawning arena each. There was no spawning arena in localities surrounding Petea River and Sokoio although underwater survey found several the fish individuals swimming around the transects (*unpublished data*).

Several spawning arenas during dry season dried as decreasing water level and they were inundated during rainy season as water level increased. However, currently, condition of Lake Matano has changed. Period of dryness and inundation changed from the original mode and not following the period of dry and rainy seasons. This seemed likely due to dam operation in the purpose of maintaining water level in Lake Matano. Dam operation caused those spawning arenas experiencing longer inundation period (Figure 3).

Discussion

Sexually mature individuals of the fish seemed to have spawning habitat preferences. They seemed identify spawning substrate type's potential for spawning arena. In relatively flat bottom of the beach individuals preferred bottom substrate composed of cobbles with sand traps in

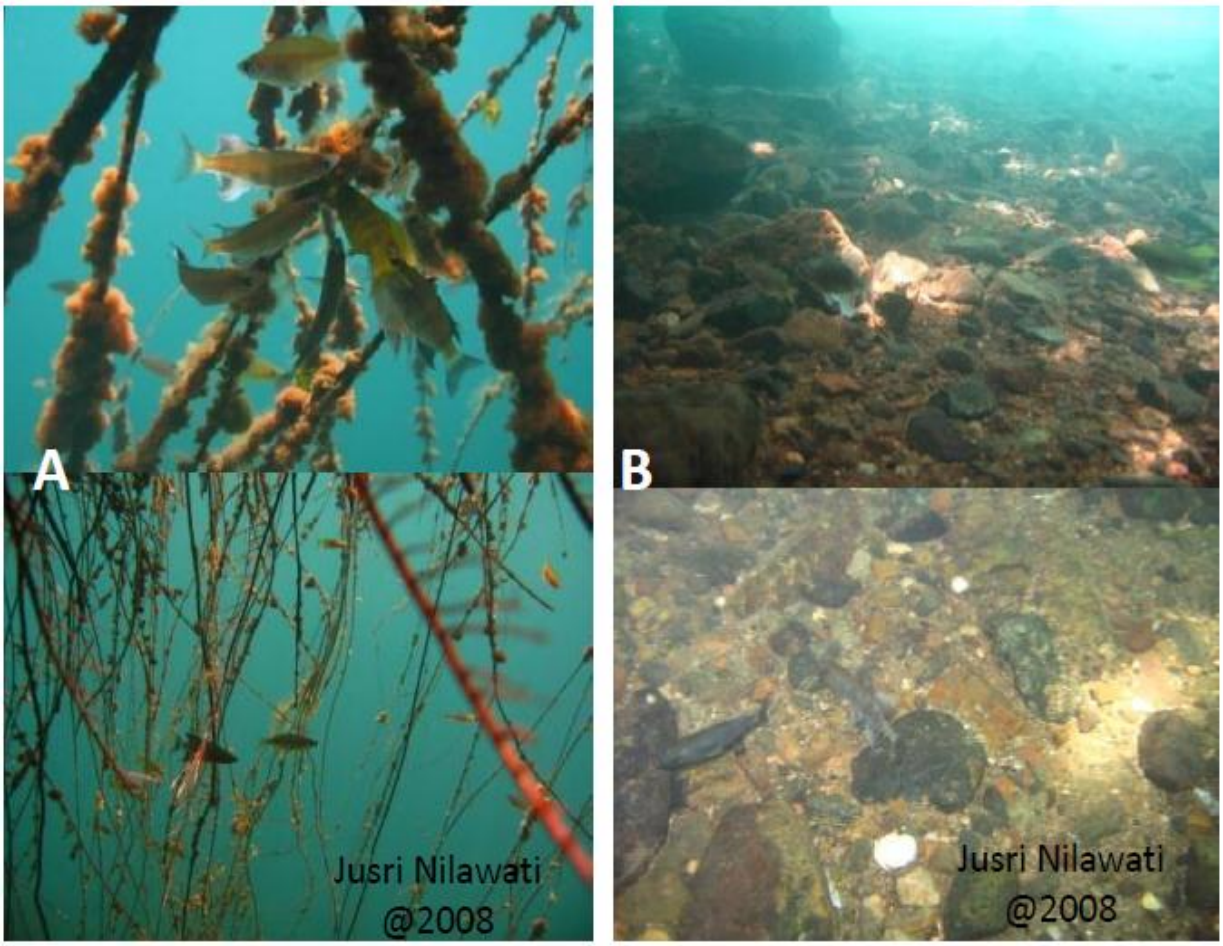

Figure 2. Picture of spawning arena on bottom substrate and roots
A. Hanging down roots and/or fallen down stems/twigs; B. Sand and cobble substrate

between or structures looked like sand pools among the cobbles. Mating events, characterized by movements as if egg release by females and sperm release by males, performed onto the sand surface. The fish is known as non parental care species. Females observed lay their eggs onto the sand in order to protect them from the dynamics of water movements that possibly drift the eggs or indeed caused egg mortality. In addition, the eggs laid onto the sand would oxygenationed which is needed for development. During our observations there was no pairing the fish found spawned in silt substrate. Beside possible reasons of vision, this might be one of the ways for the fish to ensure the survival of their offsprings. Reasons of protecting the offsprings were also show-ed in other species. Walleye preferred for gravel and cobble substrates with low flows in Upper Wabash River, Indiana (Weitzel & Pyron, 2005). The walleye tended to use habitat with in stream cover during low discharge conditions and to move up onto flooded banks with timber during high flow periods. Riparian vegetation seems to be beneficial for the species during flood events. Spine loach showed a strong preference on dense vegetation as spawning substrate, suggesting this factor to have great importance in reproductive biology (Bohlen, 2003).

Beach habitat with relatively flat bottom covered by sand cobbles and habitat with hang-

ing down roots and/or fallen down stems/twigs covered by alga and/or freshwater sponge were preferred as spawning arena. Oviposition was acted upon roots or stems covered by alga/freshwater sponge. In this spawning arena type it seemed likely that females hided the freshly laying eggs among algal or sponge, in purpose to protect them from predator. In addition, alga/sponge also provided the offsprings by the food availability after hatching. Such this way, although the fish did not perform parental care for the offsprings but such oviposition selection is the way of the fish to ensure survival of the offsprings. Behaviour of oviposition on the sand and among alga/sponge was intended to protect the offsprings from filial cannibalism often exhibited by conspecific males. Filial cannibalism by the males was described by Gray *et al*. (2006; 2007; 2008).

The present results coincide with the results of the other studies on different systems. For example, Bohlen (2003) studied spawning habitat of spined loach (*Cobitis taenia*), found that the fish performed oviposition selection among dense vegetation. The existence of vegetation along the lake edges, which has submerge rooting system and terrestrial vegetation which shaded the water surface from direct sunlight might play an important key towards the existence of spawning arena (personal observation). To the best of our knowledge, this is the first reveal on the role of shading effect in endemic fish spawning under natural conditions. This, however, need to test through advanced study. The shading might has correlations with survival of the eggs and the offsprings. The shading in the arena also might help in protecting the eggs from vision of predator.

There is also possibility that conditions in the arena with shading effect are preferred by the fish for spawning because of correlation with environment light condition. The role of environmental light has been described by among them Maan (2006) and Gray *et al*. (2008). Substrate colours will determine the background colour

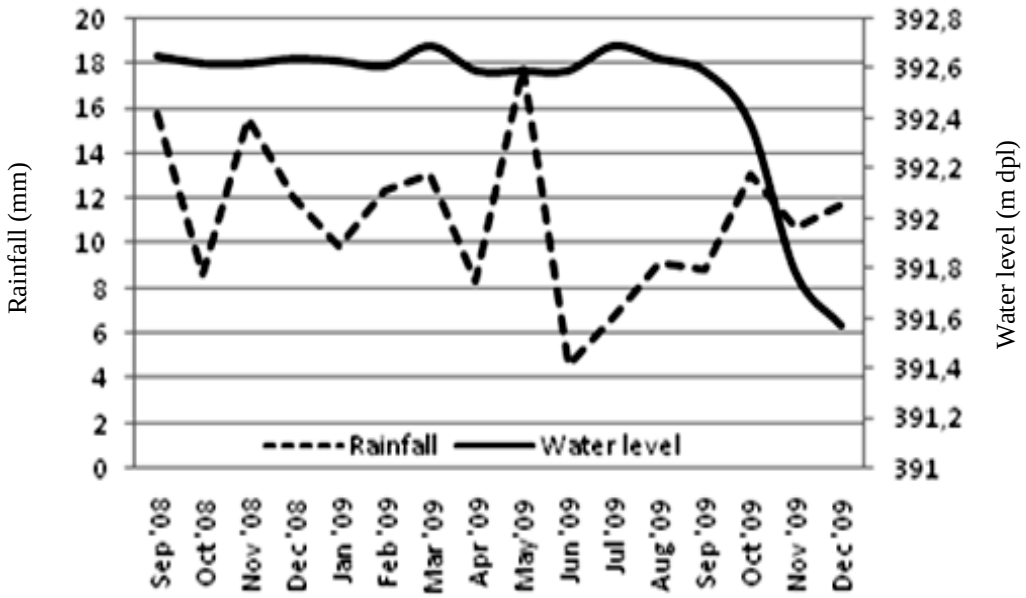

Figure 3. Water level and rainfall in Lake Matano

Table 2. Number of spawning arena, characteristics description in each sampling locality

No	Location	Spawning arena Habitat 1/ Habitat 2	Number of spawning arena (in Transect)	Area of spawning arena (m^2)	Distance from shoreline (m)	Water depth (m)	Pairing number	Bottom substrate characteristics and % of coverage					
								Silt/ Clay	Sand	Gravel	Cobble	Boulder	Bedrock
1	Lawa River	Habitat 1	2	6	4-8	0.30-0.60	2-5	-	30	20	50	-	-
2	Matano Village	Habitat 1	1	8	5-10	0.40-0.60	2-4	-	20	80	-	-	-
3	Paku	Habitat 1	2	8	5-10	0.40-0.60	3-6	-	20	30	50	-	-
4	Kupu-kupu Beach	Habitat 1	3	8	5-6	0.30-0.65	4-6	-	20	20	60	-	-
5	Salonsa Beach	Habitat 1	2	10	2-3	0.30-0.75	4-8	-	30	20	40	10	-
		Habitat 2	1	4	5-0	0.30-0.60	2-4	-	30	40	30	-	-
6	Old Camp	Habitat 1	3	6	3-5	0.40-0.60	3-5	-	30	55	15	-	-
7	Island I	Habitat 1	2	10	2-5	2.5-3.00	3-4	-	40	20	20	20	-
		Habitat 2	2	4	3-5	0.40-0.60	5-12	-		30	70		-
8	Island II	Habitat 1	2	5	4-5	0.40-0.60	3-4	-	30	60	10	-	-
		Habitat 2	2	6	2-4	2.00-2.50	5-10	10	20	40		30	-
9	Petea River	-	-	-	-	-	-	50	30	20	-	-	-
10	Salure River	Habitat 1	1	5	3-5	0.60-0.80	3-6	-	30	40	30	-	-
11	Tanah Merah River	Habitat 1	1	10	3-5	0.40-0.60	2-5	-	40	40	20	-	-
12	Sokoio	-	-	-	-	-	-	-	-	-	60	40	-

Notes: Habitat 1: Bottom substrate; Habitat 2: Hanging down roots and/or fallen down stems/twigs

against which an object is observed. Therefore, for example, a blue fish will look very conspicuous when viewed against a yellowish background. However, the ambient light spectrum, namely the light that will illuminate the fish and the substrates and everything under water, is determined by the water itself and the particles dissolved and suspended in it (Maan, *personal communication*). This was in agreement with field observation, and with results of Gray *et al*. (2008). Blue males the fish in spawning arena with sand cobble substrate were predominant over the other colour males. While in vegetated arena with hanging down roots and fallen down stems/twigs covered by alga and/or freshwater sponge, yellow males were dominant. In male orange throat darters (*Etheostoma spectabile*), under natural conditions, size and nuptial coloration do not have correlation with spawning success (Pyron, 1995). Females in this species also showed no preferences for bright versus dull males. Males and females did not differ significantly in size.

Maintaining diversity of habitat in Lake Matano is important for conservation of endemic fishes. The fish spawns in sand cobble habitat and vegetated area with hanging down roots and fallen down stems/twigs covered by alga and/or freshwater sponge, particularly localities with shading effect from terrestrial vegetations along the lake sides. Therefore, it is important to maintain the existence of shading by conserving terrestrial vegetation along the sides of Lake Matano. The fish preferred oviposition sites on sand pools among cobbles so that the presence of habitat with such substrate need to be defended. Landscape changes along sides of the lake might remove vegetations and sand cobble areas which cause habitat loss for the fish spawn in such specific sites. Many studies have been conducted on the relationships between fish composition and their habitat in the river including substrates. There were closed relationships between characteristics of substrate, water depth and composition of fishes in large river ecosystem (Mueller & Pyron, 2010) who studied fish assemblages and substrates in Middle Wabash River, USA. Depths and substrate composition determined fish assemblage composition in Wabash River. They found that the upstream sites which had shallow depth and coarse substrates (cobbles and gravel) had several fish species that are classified as intolerant. While the downstream sites which had habitats with increased turbidity and silt substrates, were dominated by tolerant, large-bodied generalist species. The downstream sites are characterized by greater depth and increased frequencies of fine substrates (i.e., sand and silt). In addition, when the hydrologic regime of the Wabash River is altered, it seemed likely that substrates will also degraded. Variation in substrates appears to directly control the distribution and abundance of many Wabash River fishes.

Rainfall surrounding Lake Matano presently does not influence the dynamics of water level. This condition might evolutionarily change reproductive periods of the endemic fishes in Lake Matano. This differs from the previous natural conditions (*unpublished data*) in which water level are correlated with temporal rainfall seasonally. During rain season water level increases and during dry season water level drops naturally.

Conclusion and suggestion

Telmatherina sarasinorum has preference on spawning habitat of an arena in sand cobble habitat and in vegetated habitat which have shading effect from the trees existed on the lake sides. Maintaining the existence of spawning habitat

through protecting the presence of terrestrial vegetation surrounding the lake is important key for conservation of the fish and its habitat. In spite of known as non parental care, however, selection on sand traps among the cobbles and alga/freshwater sponge covered hanging down roots and/or fallen down stems/twigs as oviposition site is a reproductive strategy of the fish to ensure the survival of its descendant.

Considering the role played by the terrestrial vegetation along the lake sides and sand traps among the cobbles it is suggested to maintain the landscape of terrestrial area surrounding the lake and to prevent unrestrained tree cuttings. Land clearing in the forest surrounding the lake may increase siltation into the lake that eventually may cover sand pools in which the fish performed reproductive activity. In addition, it is also suggested to protect bottom structure of sand cobble in littoral area which is preferred by the fish for oviposition site. Consideration is needed to be taken into account in dam operation by following the period of dry and rainy seasons to maintain natural water level dynamic condition.

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