

Parade of Protozoan Ciliates in Lake Lanao, Lanao Del Sur before the Marawi Siege*

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ABSTRACT

Protozoan ciliates are one-celled animal-like organisms characterized by the presence of hair-like structures called cilia. They have been utilized as bio-indicators of organic pollution to monitor the health of an aquatic ecosystem. At present, there are scant studies on ciliates in Lake Lanao, Lanao del Sur, the second largest lake in the Philippines and one of the ancient lakes in the world. Hence this study was conducted to make an inventory of ciliated protozoans and their distribution in the lake at the littoral and pelagic zones of Marawi City, Ramin, Binidayan, Balindong, Taraka, Masiu, Marantao, and Buadipuso from January 2016 to February 2017, before the Marawi Siege. A total of 45 morphologically distinct ciliate species were accounted for which were found distributed across 40 genera namely; *Aspidisca*, *Blepharisma*, *Campanella*, *Chilodonella*, *Climacostomum*, *Coleps*, *Colpoda*, *Colpidium*, *Cothurnia*, *Cyclidium*, *Didinium*, *Dileptus*, *Euplotes*, *Frontonia*, *Glaucoma*, *Halteria*, *Hastatella*, *Holophrya*, *Holosticha*, *Litonotus*, *Loxodes*, *Metacineta*, *Onychodromus*, *Opercularia*, *Opisthonecta*, *Oxytricha*, *Paramecium*, *Podophrya*, *Spathidium*, *Spirostomum*, *Stentor*, *Strombidium*, *Stylonychia*, *Tetrahymena*, *Tokophrya*, *Trachelius*, *Trichodina*, *Urocentrum*, and *Vorticella*. The species of *Paramecium*, *Tetrahymena* and *Vorticella* had the widest distribution among the ciliates observed since they were consistently observed in all sites. Morphological features of these genera are described and the photomicrographs of representative ciliates are likewise presented. The molecular identification of the ciliates and post-siege inventory of the same are underway.

Keywords: Protozoans, Ciliates, Lake Lanao

I. INTRODUCTION

Lake Lanao in Lanao del Sur, ARMM region, is the Philippines' second largest lake and one of the world's ancient lakes. It is the habitat for countless freshwater floral and faunal organisms. Reportedly the lake is deteriorating due to increased human population and activities. This change surely impacts the Meranaw tribe thriving around the lake whose culture is intricately intertwined with the lake for food and water source, livelihood, religious practices, transport and sports.

Ciliated protozoans are microscopic unicellular organisms characterized by the presence of hair-like structures called cilia. Ciliates have been utilized as bio-indicators of organic pollution in freshwater ecosystems such as lakes [1]. There has been scant documentation regarding the identification of ciliated protozoans in Lake Lanao. The work of Lewis [2] on Lake Lanao mentioned ciliates as a group under protozoans but he did not segregate and identify a ciliate genus or species. The study, therefore, primarily aimed to generate a preliminary inventory of ciliated protozoans in Lake Lanao. It also intended to identify the ciliates morphologically up to the genus level and to determine their distribution in the eight sampling sites. This project could be pioneering and the baseline data on ciliate identification could be fed into the taxonomic system. Compilations of photomicrographs and video clips on ciliates are very useful information for teachers, students and future researchers residing around the lake. The identified ciliates can be tapped as low-cost alternative indicators in the monitoring of the water quality of Lake Lanao.

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II. METHODS AND MATERIALS

Sampling of Ciliates

Samplings of ciliates were conducted in the littoral and pelagic water zones of the eight municipalities in Lanao del Sur bordering Lake Lanao, namely: Marawi City, Ditsaan-Ramain, Binidayan, Balindong, Taraka, Masiu, Marantao, and Buadipuso (Figure 1) [3]. In the littoral and pelagic zones of each municipality, three sampling stations were established at 100-m intervals, with each station serving as replicate. In the littoral zone, ciliates were collected along the lake shore from scrapings of floating detritus, stones or plants and from integrated surface and subsurface water (up to 1m) and horizontal and vertical tow samplings using conical plankton net (53- μm mesh) (Figure 2). In the pelagic zone where the lake bottom is no longer lit by the sun, the ciliates were collected at 100-m interval moving towards the lake center perpendicular from the lakeshore. Collected water samples were concentrated to 10mL by a 10- μm mesh sieve for fixation. For live culture of ciliates, a separate 500mL water sample was collected through horizontal towing, transferred to sterile bottle and immediately brought to laboratory for hay infusion culture (15g sterile hay per 500mL water sample). The collected water samples (10ml) were added with 1mL 5% Formalin to a final concentration of 0.45% and added with one drop of acidified Logul's solution (LS). Logul's solution was prepared by dissolving 6g potassium iodide in 40mL distilled water; 4g iodine crystals were dissolved in the solution then added with distilled water up to 100ml; for acidified LS, 20mL glacial acetic acid was added and stored in amber glass.

Microscopic Observation and Identification

Microscopic observation of the ciliates from the samples was performed in the ciliate research laboratory of the Mindanao State University Biology Department in Marawi City. Alpha-Ken vision compound light microscope and stereomicroscope were used in observing live and preserved ciliates. For live samples, hanging drop technique was employed to minimize the movement of ciliates. Some ciliates were trapped by putting a few fibers of cotton on the specimen before covering it with a coverslip. Ciliates were identified primarily by the presence of hair-like structures called cilia, the presence of contractile vacuoles, two kinds of nuclei, the macronucleus and the micronucleus, by size (average size 20-200 μm), and the shape of the body [4,5]. Photos and videos were also taken during microscopic observations.

III. RESULTS AND DISCUSSION

Forty five (45) ciliate species were identified from eight sampling sites and were classified into 40 genera namely; *Aspidisca*, *Blepharisma*, *Campanella*, *Chilodonella*, *Climacostomum*, *Coleps*, *Colpoda*, *Colpidium*, *Cothurnia*, *Cyclidium*, *Didinium*, *Dileptus*, *Euplotes*, *Frontonia*, *Glaucoma*, *Halteria*, *Hastatella*, *Holophrya*, *Holosticha*, *Litonotus*, *Loxodes*, *Metacinetia*, *Onychodromus*, *Opercularia*, *Opisthionecta*, *Oxytricha*, *Paramecium*, *Podophrya*, *Spathidium*, *Spirostomum*, *Stentor*, *Strombidium*, *Stylonychia*, *Tetrahymena*, *Tokophrya*, *Trachelius*, *Trichodina*, *Urocentrum*, and *Vorticella*. The photomicrographs of the ciliates are presented in Figures 3A-C.

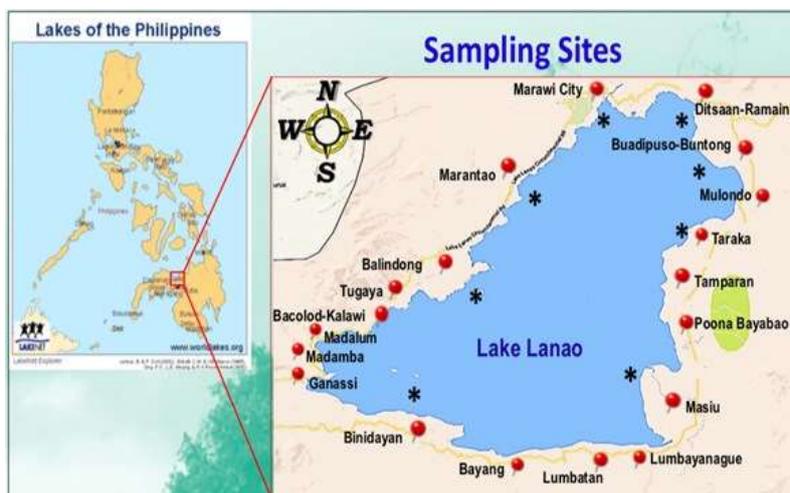


Figure 1. Map of the Philippines showing Location of Lake Lanao, Marawi City and the bordering municipalities (red pins) of the Lake (Google Map, 2016; [3]). The black asterisks indicate the sampling sites.



Figure 2. Ciliate collection using the conical plankton net.

Morphological Descriptions of the 40 Ciliate Genera

The identification of the collected ciliates primarily followed the key guides by Jahn et al., (1979) [4], Curds, 1982 [5], and Curds et al. 1983 [6] which group the ciliates into three, namely: Oligohymenophora, Polyhymenophora and Kinetofragminophora. Other identification keys were also used such as Foissner & Berger (1996) [7].

A. The Oligohymenophorans

The identified ciliates under genera

Campanella, Colpidium, Cothurnia, Cyclidium, Frontonia, Glaucoma, Hastatella, Opercularia, and Opisthonecta, Paramecium, Tetrahymena, Trichodina, Urocentrum, and Vorticella are Oligohymenophorans (Figure 3A). Typically this group have ventral groove containing the mouth (cytostome) and series of orderly arranged cilia (membranelles) or row of fused cilia (undulating membranes). The membranelles curve counter clockwise along the rim of the mouth (adoral zone) which usually referred to as the adoral zone of membranelles (AZM) and into the cytopharynx or buccal cavity (=peristome). Most have uniform body ciliation. Some species have stalks which may separate from the ciliate after

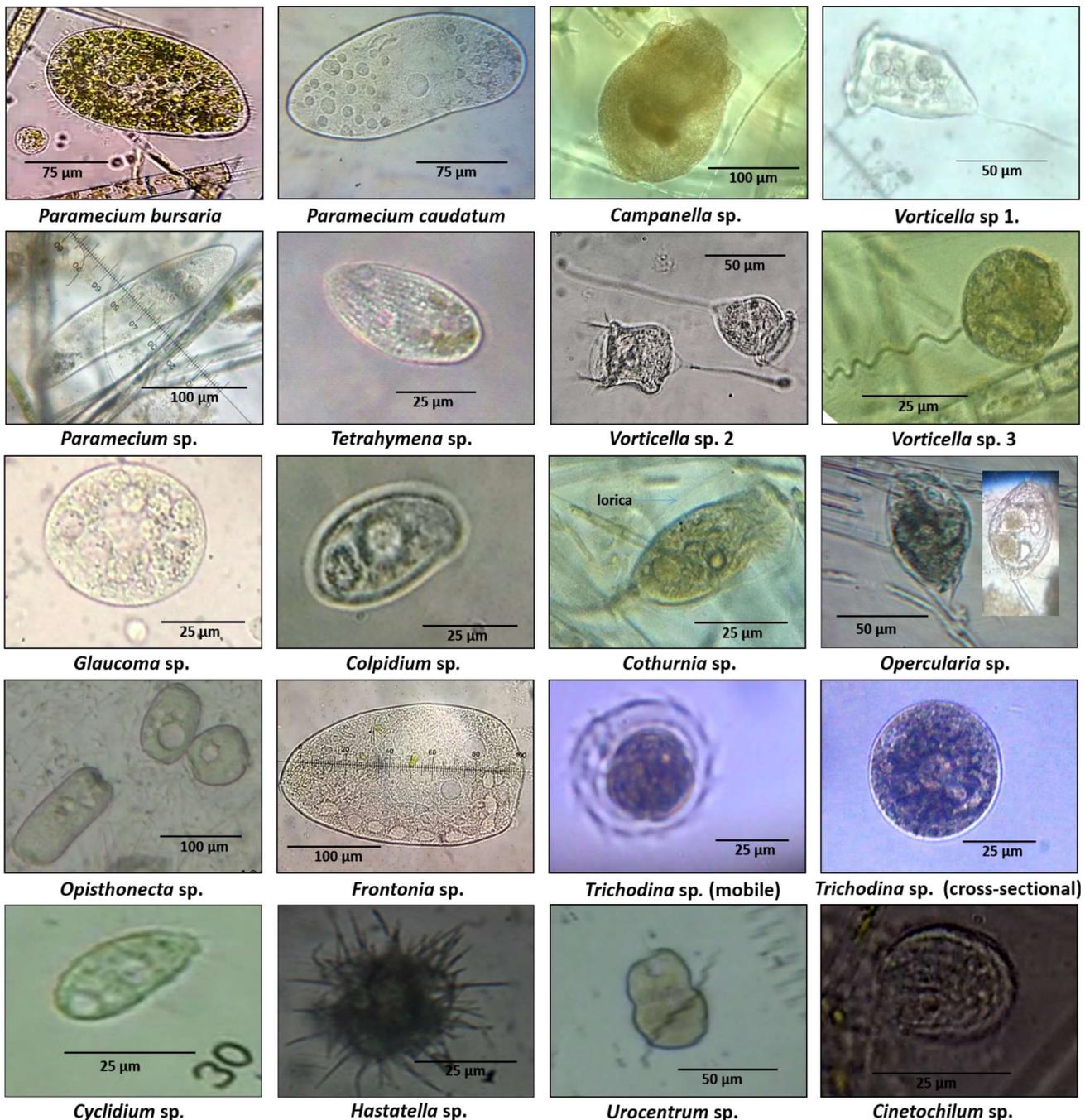


Figure 3A. The Oligohymenophorans

growing a posterior ring of membranelles used for swimming, becoming a motile telotroch (free swimming stage). Others have no stalks, but may have a posterior adhesive disc or may be in loricas.

Genus *Campanella*. They are bell-shaped ciliates that resemble *Vorticella*. They are attached to a non-contractile stalk but they can be free-swimming. It has 4-6 turns of AZM that spiral on peristomal disc. They are bigger than *Vorticella* that measure up to 250 μm . Posterior ring of cilia present only in free-swimming cell [6].

Genus *Colpidium*. Its body shape is elongated, reniform or sometimes ovoid with a length of 50-120 μm . It has uniform ciliation except for a group of longer cilia at the posterior pole. The preoral suture is slightly displaced towards the ventral side with the suture curved to right. Its small triangular buccal cavity is situated near the right side of the body at about one-quarter of the body length from the anterior pole. The buccal ciliation is tetrahymenal. There is 1 undulating membrane on the right side and 3 adoral membranelles on the left. It has 1 spherical macronucleus and 1 micronucleus in the central part of the body. It has 1 contractile vacuole located near the right margin [4,6].

Genus *Cothurnia*. Members of this genus are loricated, and stalked. The lorica is narrow and elongated, cylindrical and rounded posteriorly (up to 65 μm long, 30 μm wide). In the posterior end, the lorica is connected through an endostyle with the cellular body. The opposite end of the lorica contained the apical aperture, which is elliptical when viewed from above, generally wider than the width in the middle zone. The macronucleus is ovoid and located in the anterior half of the body. The micronucleus is spherical and situated near the macronucleus [6,7].

Genus *Cyclidium*. This genus is characterized by having an ovoid body with flattened anterior cap; long peristome, with large, undulating membrane, intended for feeding. These ciliates have long cilia in rows and 1 long caudal cilium. It moves by "jumping" and seldom swims [4].

Genus *Frontonia*. They are closely similar to *Paramecium* spp. They are elongate to oval and large triangular in shape, dorso-

ventrally flattened, and rounded at both ends but usually wider anteriorly. They have flexible body. There is undulating membrane on the right aperture and three membranelles on the left running closely together along the margin of the aperture. The body ciliation is uniform with both pre-oral and post-oral sutures. Many trichocysts present. Contractile vacuole may sometimes be served by radiating canals [6,7].

Genus *Glaucoma*. *Glaucoma* ciliates resemble the *Tetrahymena* species but tend to be anteriorly rounded, rather than pointed or bent. It has undulating membrane under the rim of the oral cavity and two membranelles in the cavity. Body length is 40-80 μm ; body ellipsoid, ventrally flattened, uniformly ciliated; mouth groove oblique to the longitudinal axis of the cell, buccal cavity with 1 large undulating membrane and 3 adoral membranelles; and contractile vacuole posteriorly located [4,8].

Genus *Hastatella*. It has inverted bell-shaped body with peristomial disc held forward when swimming. Cilia on peristome wind anticlockwise around the apical region. Aboral end without stalk, suckers etc. but with distinctly visible spines in the body (40-60 μm). Body is covered with 2 to 4 rings of long conical ectoplasmic processes [6].

Genus *Opercularia*. They are sessile, stalked ciliates that are 45-65 μm long with a stalk of about 50-100 μm long. It can form small colonies consisting of 3-6 individuals. The body is elongated with peristomal area small and not constricted from the body. The buccal area has a distinct oblique disk which is set off from the border by a deep incision with obvious undulating membrane. The macronucleus is horseshoe-like. The stalk are noncontractile and with dichotomous branching [4].

Genus *Opisthnecta*. This genus is characterized by a barrel-shaped body, rear end rounded with posterior ring of cilia and the anterior end with membranelles. The macronucleus is C-shaped. It has no stalked stages and is free-swimming [4]. The peristome has 2 membranelles winding counter clockwise to the cytostome and is directed forwards as it swims, aided by a permanent aboral ring cilia. The macronucleus is C-shaped [6].

Genus *Paramecium*. They are easily recognizable because of its slipper-like shape

thus it is often called slipper animalcules and ranges from 100-350 μm in length. They have prominent oral groove and their uniformly cilia surrounding their body and trichocysts just under their entire surface. There are membranelles near the mouth, oral groove surrounding or bordering the oral zone and no cirri in the body. There are several groups of Paramecia, namely *multinucleatum*-group with a diameter of 250-350 μm , the *caudatum*-group which is 180-300 μm ; other groups range from 100-180 μm , this includes the *aurelia* and *bursaria* groups [4,8]. Three different species were observed in this study (Figure 3A).

Genus *Tetrahymena*. Members of this genus have ovoid to tear-drop shape, uniform body ciliation, undulating membrane on the right rim of the oral cavity and three membranelles in the cavity. The size of the mouth varies among these species. They are small ciliates about 25-90 μm in length. The spherical macronucleus located medially is usually accompanied by 1 micronucleus and 1 contractile vacuole near the posterior end [4,8].

Genus *Trichodina*. They are free-swimming, mobile peritrichs, with conspicuous oral ciliary wreaths and posterior girdle of cilia. The body axis is shortened. They are ectozoic (parasite) usually on hydra, fish and tadpoles. These ciliates appear disc-shaped or hemispherical. It is the aboral surface of the trichodinids that attaches to the skin of the host or other substrate which is supported by a ring of interlocking cytoskeletal denticles [6,7].

Genus *Urocentrum*. It has a length of about 40-70 μm . Its body is cylindrical and ventrally slightly flattened and constricted at the middle. There are two broad girdles of cilia and one eccentric posterior tuft within a zone of short cilia in the constricted area [5]. The macronucleus is horseshoe-shaped and posteriorly positioned. It has a single micronucleus and the contractile vacuole is located at the end terminal part. Additionally, it has eight collecting canals [8].

Genus *Vorticella*. *Vorticella* sp. is sessile and has inverted bell-shaped body. The stalk has contractile fibril called myoneme that enable the stalk to contract, shortens and coils. The body size is usually between 20-150 μm and 35-100 μm in width, with a stalk of about 250-350 μm . The buccal cavity or the vestibulum is very large and

equipped with an outer undulating membrane. Its pellicle is faintly annulated. It has a micronucleus and a macronucleus that is very long and worm-like. It has one contractile vacuole near the buccal cavity. Moreover, the stalk is invaginated into the basal portion of the body [4,7]. Three distinct *Vorticella* species were observed which differed in size.

B. The Polyhymenophorans

The ciliates classified under these genera, namely, *Aspidisca*, *Blepharisma*, *Climacostomum*, *Euplotes*, *Halteria*, *Holosthica*, *Onychodromus*, *Oxytricha*, *Spirostomum*, *Stentor*, *Strombidium*, and *Stylonychia* are polyhymenophorans (Figure 3B). These ciliates have AZM that wind clockwise around the mouth and into the cytopharynx. They may or may not be dorsoventrally flattened, with or without cirri (fused cilia), with ventral cirri, may or may not have a uniform body ciliation.

Genus *Aspidisca*. Members of this genus are usually ovate, small, rigid, coated, with a convex dorsal and a plain ventral surface. The AZM is reduced or rudimentary. The left side is nearly straight, right sharply convex while the right border having a thickened margin. Marginal and caudal cirri are absent; large transverse cirri, 5 located posteriorly and 7 anteriorly. The macronucleus is C-, horseshoe-shaped with 1 or 2 micronuclei. The contractile is vacuole posterior to the transverse cirri [6,9].

Genus *Blepharisma*. This genus is characterized by having a spindle-shaped body with the anterior end pointed and slightly curved tip. The posterior end is bluntly rounded and contains a contractile. The body is usually colored pale pink to bright red. The body is non-contractile, but may be variable in size and shape, even within one culture. Aberrant forms such as dwarfs, rounded spheres as well as carnivore giants, are common in some species and indicate poor nutritional conditions. Ciliary rows lie in ridges and are variable in number depending upon the size of the organisms [4,5]. Two distinct species were observed.

Genus *Climacostomum*. Their body outline is oval-shaped with anterior slightly pointed in some species. It has flattened body and uniform ciliation. The peristomial area is entirely ciliated and a conspicuous AZM on the left edge spirals down to the cytostome. The

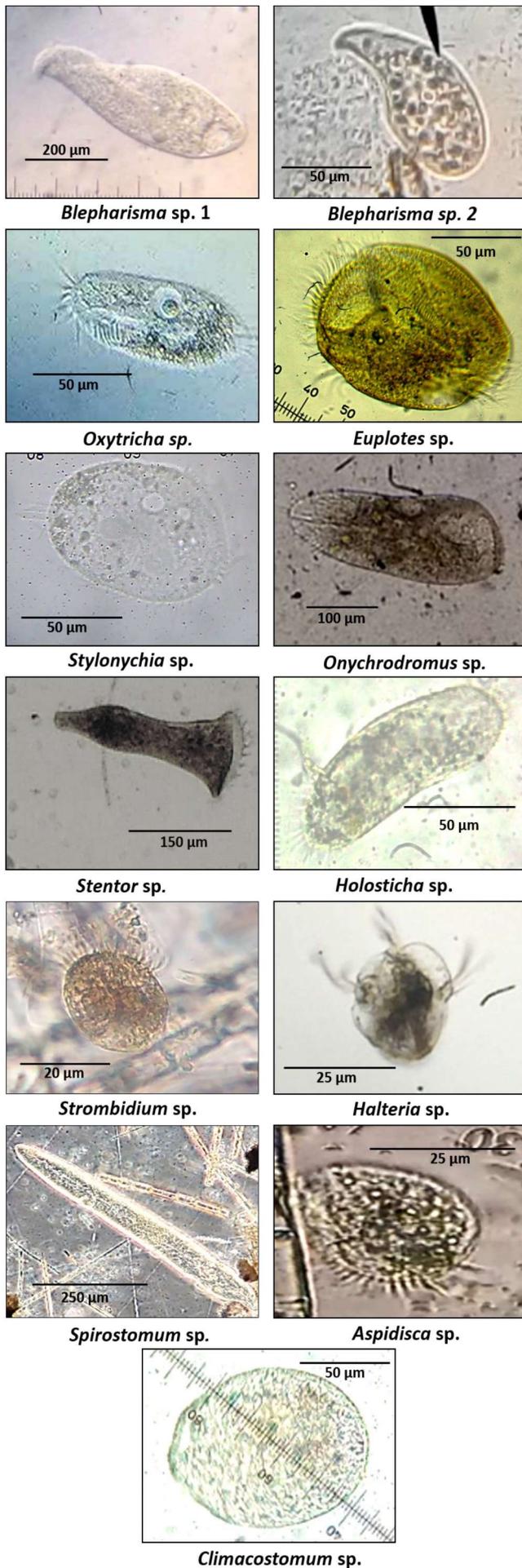


Figure 3B. The Polyhymenophorans

right edge without a membranelle. The contractile vacuole is terminal and served by 2 longitudinal canals. Macronucleus may be spherical or ribbon-like [6].

Genus *Euplotes*. The members of this group have oval inflexible body; flat ventral, convex dorsum; have nine fronto-ventrals, five anals, four separated caudals, and no marginal. The body is clear, and has distinct cirri ranging from 80 μm to 165 μm in length [4]. They large AZM usually extending at least two-thirds the body length, broadly triangular and often supported anteriorly by a cytoplasmic collar. Large fronto-ventral and transverse cirri present. Large (right) caudal cirri (usually 2-3) present. Macronucleus C-, M- or horseshoe-shaped, with single adjacent micronucleus [6].

Genus *Halteria*. This ciliate's body is oval with thick somatic cirri encircling equatorially at dorso-ventral area. Its terminal pole is broadly rounded with spherical macronucleus and contractile vacuole located centrally. The somatic cilia are reduced to about a dozen rows, each with 5 or 6 long, bristle-like cirri. It jumps and rotates as it moves abruptly. Its size ranges from 10-15 μm [6].

Genus *Holosticha*. These ciliates are elongated, cigar-shaped body, with 2 rows of marginal cirri (fused cilia) and a midventral series of 2 zigzag rows of cirri extending into the frontal region. They have 3 to 4 prominent frontal cirri and occasionally a few isolated ones elsewhere. Transverse cirri are present. AZM are relatively small, less than third of body length. Macronucleus is usually in two parts but sometimes numerous [6].

Genus *Onychodromus*. It resembles *Stylonychia* but it is bigger and its body is rigid, rectangularly oval, dorso-ventrally flattened body bearing a large AZM extending to the equator. There are two rows of marginal cirri joining posteriorly; transverse cirri present but caudal cirri are absent. Most of the front-ventral cirri arranged in 3 parallel rows with 3 large anterior frontal cirri. Contractile vacuole is found equatorial and macronucleus in four parts each with an adjacent micronucleus [6].

Genus *Oxytricha*. The members of this genus are very similar to *Stylonychia* but their ends are more rounded than broader. This ciliate has a flexible, ellipsoid body, flat ventrally, and

convex dorsally. It has the following cirri: 8 frontals, 5 ventrals, 5 anals, and short caudals. The marginal cirri continue around rear end (not so for some other species). It has two macronuclei [4].

Genus Spirostomum. Their body is very elongated (150 µm up to 4 mm), cylindrical and brownish in color. It is very large and easily distinguishable by the unaided eye. It has uniform ciliation in longitudinal rows with the peristome constituting two-thirds of the body length and closely lined with short membranelles. The long macronucleus appears like a string of beads. It has many micronuclei and a single large contractile vacuole terminally, with 1 long canal close to the dorsal side [8].

Genus Stentor. *Stentor* spp. are large ciliates known to be trumpet-shaped and reach lengths of 2 mm with the narrower end attached to a substratum. The body is highly contractile. The peristome is conspicuous with AZM spiralling clockwise into the cystostome. They could be detached and free-swimming shaped as oval or pyriform. They are uniformly ciliated. Their cilia which sweep in food also aid in swimming [6].

Genus Strombidium. *Strombidium* ciliates are ovoid, elongate to pyriform. They have a circle of conspicuous apical membranelles surrounding the oral area. Somatic cilia absent are absent. Internally there is a series of oblique trichites with a skeletal function. They swim fast in a helical pattern or jerks [6].

Genus Stylonychia. This ciliate group has an inflexible ovoid body, dorso-ventrally flattened, and its length ranges between 100 to 300 µm. Its venter is flat and its dorsum is convex. It has strong fused cilia or cirri on the ventral side: eight frontals, five ventrals, five anals, marginal, three caudals. They use their cirri to walk or run across a surface and to propel itself in the water [4,6].

Genus Cinetochilum. These are small ciliates, 15-45 microns long, discoid, flattened dorso-ventrally. The body shape is oval to ellipsoid, flattened, with ciliation present only on the ventral surface and with 3 or 4 caudal cilia. The buccal cavity in the right posterior part of the cell has membranes situated on both edges with the right part forming a pocket. It has one spherical macronucleus and one micronucleus in the central

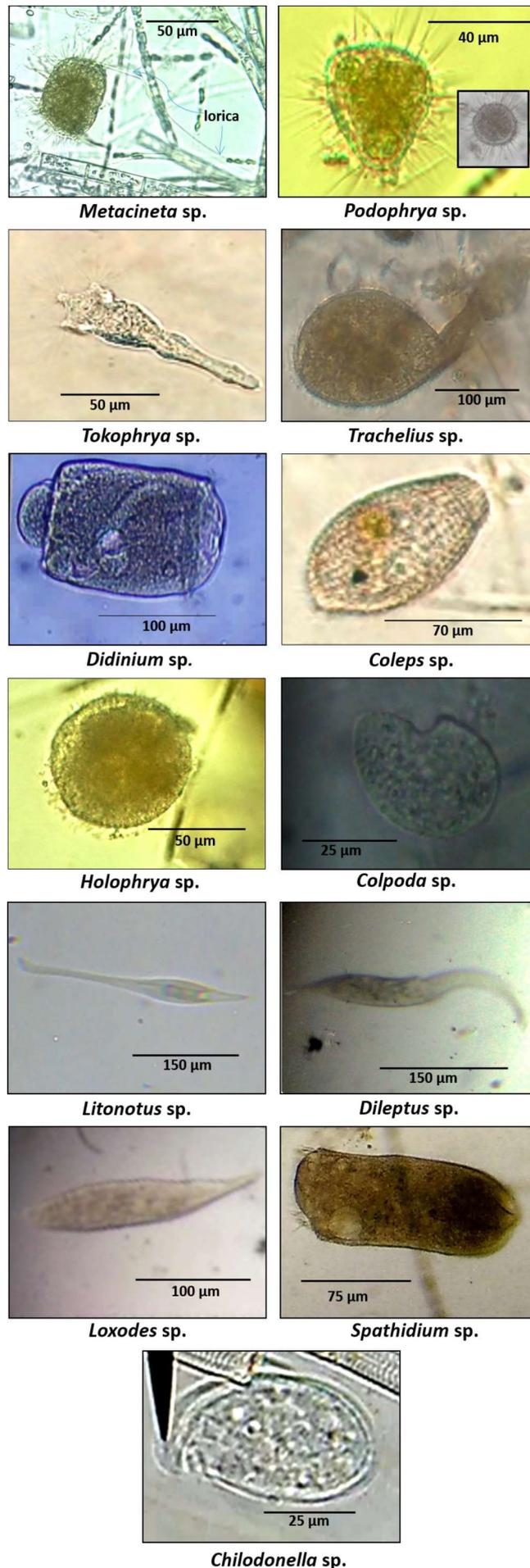


Figure 3C. The Kinetofragminophorans

part of the cell [8].

C. The Kinetofragminophorans

The ciliates classified under genera *Chilodonella*, *Coleps*, *Colpoda*, *Didinium*, *Dileptus*, *Holophrya*, *Litonotus*, *Loxodes*, *Metacineteta*, *Podophrya*, *Spathidium*, *Tokophrya* and *Trachelius* are Kinetofragminophorans (Figure 3C). In some species, adult ciliates do not bear cilia but present only on young developing larval stage. The adults can be free-swimming, sessile and suctorians with sucking (and sometimes piercing) tentacles. The body may or may not have a supporting stalk. Other species, the mouth is ventral side or at the anterior end and at or near the surface supported by a group of rodlets (trichites), more or less fused as a cyrtos ("pharyngeal basket"). Moreover, there are species which have a vestibule (cell indentation), with distinct ciliature, leading to the mouth.

Genus *Chilodonella*. Their body length ranges from 75-300 μm . The body is dorsoventrally flattened with the ventral surface flat with about 20 ciliary rows. The anterior part of the dorsal surface is flattened with only 1 transverse row of cilia and the posterior part convex and lacking cilia. The mouth opening is round with about 12 cytopharyngeal trichites forming a tube. The macronucleus is oval with a characteristic concentric structure. It has 1 small micronucleus and about 6-8 contractile vacuoles [5].

Genus *Coleps*. This ciliate group has barrel-shaped body covered regularly with arranged prominent ectoplasmic plates composed of calcium carbonate, with tooth-like projections from the plates. Each end of the cell is rounded or slightly flattened but never pointed. Somatic ciliature is uniform in regular longitudinal kineties along the striations in the plates. Its macronucleus is ovoid and contractile vacuole is located posteriorly [5]. It has with 8 posterior spines, 12 circular and about 24 longitudinal rows of plates [4]. They can swim rapidly in a revolving manner.

Genus *Colpoda*. Its length ranges from 40 to 120 μm with uniform ciliation. It is broadly kidney-shaped. The buccal cavity has a deep oral funnel starting at a groove near the left side of the body; ciliated but without membranes or membranelles; and leads to a diagonal groove on the dorsal surface. It has 1 spherical

macronucleus, 1 micronucleus and a single terminal contractile vacuole. In the presence of a good food supply, the body is packed with food inclusions and appears very dark [8].

Genus *Didinium*. *Didinium* ciliates are barrel-shaped with short cone-shaped snout protruding from flattened anterior region, posterior broadly rounded with body length from 80 to 200 μm . Oral aperture not permanent, forms only when ingesting prey which is typically *Paramecium*; then the feeding oral aperture becomes highly expandable. Body ciliation is reduced to 2 narrow bands of cilia anteriorly and posteriorly which encircle the body transversely. The rest of the body is devoid of cilia. Macronucleus is sausage to horse-shoe shape while contractile vacuole at the posterior [4,5].

Genus *Dileptus*. This genus group is highly elongated ranging from 100 μm to 1,600 μm long, rounded in cross-section, with long highly mobile, contractile prehensile anterior neck region. Ventral surface of neck is lined with trichocysts. Some species have a pointed tail region, others are rounded posteriorly. Oral aperture is supported by a cytopharyngeal basket of trichites (not always easily visible). Ciliation is complete, in form of longitudinal kineties. Contractile vacuoles are usually numerous in rows along dorsal surface often with large terminal vacuole. Macronucleus is highly variable from species to species [5].

Genus *Holophrya*. The body shape is ovoid to spherical with uniform somatic ciliation all over body except that in some species there may be a caudal tuft of longer cilia. There is a circular apical oral aperture which leads to a cytopharynx which is usually supported by a basket of trichites. The oral aperture is a simple invagination and is flush with the apical surface, there is no apical collar-like process. Trichocysts often present all over body below the pellicle. Macronucleus is ovoid and contractile vacuole terminal [5].

Genus *Litonotus*. They are elongated with flattened and somewhat sigmoid being broad in middle and tapering to the poles. Length is ranging from 40-200 μm . The mouth is slit-like, about one-third of the central side, clearly visible only when the ciliate is feeding. Cilia are present only on the right side. It has 2 spherical macronuclei, between which a

micronucleus is located and single contractile vacuole close to the posterior end. Movement is slow gliding, very flexible, amongst detritus [8].

Genus *Loxodes*. The body is elongated (125 μm – 700 μm) easily recognized by the presence of its indented, subterminal mouth. The anterior part is pointed and strongly bent ventrally to form a concavity in which a slit-like oral aperture is situated. At the base of the slit lies a primitive pharyngeal basket of trichites. Many trichocysts present which give a brownish tint to the body. Several Muller's vesicles (vesicles containing spherical bodies may be balancing organelles). It has a single contractile vacuole in posterior region and macronucleus in 1, 2 or more vesicular parts [4,5].

Genus *Metacineta*. They are stalked ciliate with lorica that is attached to the substrate (stones, plants, artificial substrates, e.g., glass slides). Its body is about 35-100 μm in diameter with tentacles up to 150 μm . The lorica is up to 800 μm . In its mature stage it lacks cilia but has suckorial tentacles to ingest food since it has no cytostome. It has 1 spherical macronucleus and a single contractile vacuole [4].

Genus *Podophrya*. The members of this genus are small spherical to ovoid ciliates suckorians with rigid stalk and tentacles. They catch their prey by means of their tentacles. The tentacles of the *Podophrya* normally remain motionless and extended. When a suitable ciliate collides with the *Podophrya*, the tentacles which the latter ciliate happens to touch at the tip adheres to it [4].

Genus *Spathidium*. The body shape spatula-like, elongated, rounded in cross-section, posterior end bluntly pointed or rounded. Anterior region of body characteristically terminates obliquely but variable between transverse to longitudinal to the major body axis. There is always a ciliated apical ridge which is lined by trichocysts. The oral aperture is a slit lying along the length of the ridge. Ciliation is uniform on both lateral surfaces in longitudinal parallel rows. Macronucleus is often elongated, ribbon-like or moniliform. It has single contractile vacuole [5].

Genus *Trachelius*. This genus has a length of 200-400 μm and has more or less spheroidal body with a distinct short proboscis.

Its right side is flattened and often somewhat concave. The left side is strongly convex. Its body ciliation is uniform with rows of slightly longer cilia on the ventral face of the proboscis. The circular cytostome is located at the base of the proboscis. Its cytopharynx exhibits long trichites and it has numerous contractile vacuoles. The macronucleus is sausage-shaped. It has a single micronucleus with the endoplasm vacuolated, brown granules often concentrated in the posterior region [4].

Genus *Tokophrya*. They are sessile, stalked ciliates that are several times longer than the body. A *birth pore* is at the upper surface. The cavity below it houses a small ciliate being constricted from the parent's body, containing a lobe of the macronucleus and one or more micronucleus. The young *Tokophrya* has several median bands of cilia and caudal tuft of cilia – but without tentacles. The swimming larva soon attaches by means of its caudal cilia, grows tentacles, loses all cilia, and secretes a stalk when it matured [4].

Ciliate Distribution across Sampling Sites

Table 1 shows the 40 ciliate genera identified and their distribution across the eight sampling sites. Among the ciliate genera listed, *Paramecium*, *Tetrahymena*, and *Vorticella* were consistently observed in all sites.

Although protozoan ciliates usually have cosmopolitan distribution [10] and the species in these 3 genera mentioned are commonly reported and observed in freshwater bodies, their wider distribution during sampling could probably be attributed to conditions that favorably support their life habit and diet. For instance, these ciliates are all bacterial feeders [4, 8], and factors such as the increase of detritus in the lake could support bacterial growth which in turn serves as food for the ciliates. Moreover, *Tetrahymena sp.* and *Paramecium spp.* are planktonic free-swimming ciliates, while *Vorticella spp.* could be free-swimming or attached to floating debris [7], thus they can easily be distributed around the lake by the water currents. Moreover, among the sites sampled, the pelagic zone of Taraka had the highest number of ciliate genera observed. Taraka is an agricultural zone with paddy areas near the lake tributary (Taraka River) with turbid run-off waters. The currents from the river most likely propel ciliates, thus bringing more of them to the deeper pelagic area. Turbid water could also indicate higher organic load thus providing ample food source for

Table 1. The presence (√) and distribution of ciliates in the littoral (L) and pelagic (P) water zones of the eight sampling sites in Lake Lanao. *Vorticella*, *Paramecia* and *Tetrahymena* spp. were consistently found in all sites.

No.	Ciliate Genera	Marawi		Ramin		Taraka		Binidayan		Balindong		Masiu		Buadiposo		Marantao	
		L	P	L	P	L	P	L	P	L	P	L	P	L	P	L	P
1	<i>Aspidisca</i>													√	√		
2	<i>Blepharisma</i>			√		√	√			√		√					
3	<i>Campanella</i>		√				√										
4	<i>Cinetochilum</i>							√	√								
5	<i>Chilodonella</i>					√	√				√						
6	<i>Climacostomum</i>			√													
7	<i>Coleps</i>	√	√	√	√	√	√	√	√	√	√	√					
8	<i>Colpoda</i>					√										√	√
9	<i>Colpidium</i>					√											
10	<i>Cothurnia</i>	√	√	√	√	√	√	√	√	√	√					√	√
11	<i>Cyclidium</i>		√		√	√			√	√		√		√	√		
12	<i>Didinium</i>	√	√	√	√	√	√	√	√	√	√						
13	<i>Dileptus</i>												√				
14	<i>Euplotes</i>	√		√		√	√	√		√	√	√		√	√	√	√
15	<i>Frontonia</i>								√								
16	<i>Glaucoma</i>	√	√			√	√	√		√	√	√	√		√		√
17	<i>Halteria</i>				√	√	√									√	
18	<i>Hastatella</i>	√					√										
19	<i>Holosticha</i>			√												√	√
20	<i>Holophyra</i>									√	√						
21	<i>Litonotus</i>	√		√	√		√	√	√								
22	<i>Loxodes</i>	√												√		√	
23	<i>Metacineta</i>	√	√		√	√	√	√		√						√	
24	<i>Onychodromus</i>									√	√						
25	<i>Opercularia</i>			√		√	√				√			√	√		√
26	<i>Opisthonecta</i>		√			√	√			√	√			√	√		
27	<i>Oxytricha</i>			√		√	√	√	√			√	√	√		√	√
28	<i>Paramecium</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
29	<i>Podophrya</i>	√	√			√	√				√	√		√	√	√	√
30	<i>Spathidium</i>								√								
31	<i>Spirostomum</i>									√							
32	<i>Stentor</i>	√	√			√	√		√	√	√			√			
33	<i>Strombidium</i>	√	√	√		√	√			√	√						
34	<i>Stylonychia</i>			√						√	√	√		√	√		
35	<i>Tetrahymena</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
36	<i>Tokophrya</i>			√				√	√	√	√						
37	<i>Trachelius</i>	√					√	√									
38	<i>Trichodina</i>			√		√	√										
39	<i>Urocentrum</i>			√			√			√				√	√		
40	<i>Vorticella</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

various ciliates.

IV. CONCLUSION

Initial surveys of ciliated protozoans were conducted in the littoral and pelagic water zones around Lake Lanao bordered by the seven municipalities and one city of Lanao del Sur in ARMM prior to the Marawi siege. Using microscopes, protozoan ciliates were observed in all stations and were identified primarily based

on the presence of cilia and their distinct morphological features such as their nucleus, size and shape. The ciliates found were classified into 40 different genera. Each genus was described. *Tetrahymena*, *Vorticella* and *Paramecium* were widely distributed among the ciliates observed, reflective of their cosmopolitan distribution and diet, that is, bacterial feeders. The molecular identification of the ciliates and post-siege inventory of the same

are ongoing.

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