Species Composition and Relative Dominance of Reservoir Phytoplankton in Sri Lanka: Indicators of Environmental Quality

www.cafetinnova.org

Indexed in
Directory of Open Access Journals (DOAJ) USA

ISSN 0976-1519, Volume 04, No. 04

International Journal of Biological Sciences and Engineering

December 2013, P.P. 92-102

Species Composition and Relative Dominance of Reservoir Phytoplankton in Sri Lanka: Indicators of Environmental Quality

E.I.L. SILVA[1], E. ROTT[2], I. THUMPELA[1], N. ATHUKORALA[1] AND E.N.S. SILVA[3]
[1]*Institute for Fundamental Studies, Hantana Road, Kandy, Sri Lanka,*
[2]*Institute of Botany, University of Innsbruck, Sternwartestrasse 15, A-6020 Innsbruck, Austria*
[3]*Aquatic Resources Technology Degree Programme, Uva Wellasa University, Passara Rd, Badulla, Sri Lanka*
Email: *eils.mecamp@gmail.com*

Abstract: Temporal patterns of the occurrence of phytoplankton in Sri Lankan reservoirs subjected to different hydrological regimes were diagnosed using the outcome of a long-term study conducted on species composition and their relative dominance in relation to environmental variables. Nearly 200 taxa belonging to nine taxonomic groups were identified and complied from 57 manmade inland water bodies located in both wet and dry zones of the country. Species list showed a wide variety in taxonomic composition. Species richness hardly exceeded 50 taxa for a particular reservoir ecosystem although the majority of them did not reach > 1% in most samples. Twenty one genera were found are common but, only 14 taxa showed time-specific numerical dominance.

Desmids (Family: Zygnematophyceae) represented the highest number of taxa in Sri Lankan reservoirs and some species were common in large numbers in least conductive oligo-mesotrophic waters. Species richness of green algae (Class: Chlorophyceae) and blue-green algae (Class: Cyanophyceae / Cyanobacteria) were more or less similar. Although several toxigenic genera of Cyanophytes were identified (e.g, *Anabaena, Aphanizomenon, Ceolosphaerium, Cylindrospermopsis, Lyngbya, Microcystis* and *Nodularia*) only *Microcystis aeruginosa* and *Cylindrospermopsis raciborskii*, formed into blooms in certain reservoirs including those are being used for drinking after conventional treatment. Of the diatoms (Class: Diatomophyceae), only the chain forming centric diatom, *Aulacoseira granulata* played an important role in the phytoplankton bio-volume and oscillated with *Pediastrum simplex* (Chlorophyceae) in meso-eutrophic waters subjected to rhythmic water level fluctuations. Other groups of planktonic algae (viz., Chrysophyceae, Cryptophyceae, Xanthophyceae, Dinophyceae and Euglenophyceae) were of minor importance for the species assemblage.

Apparently, relative abundance and species spectrum can be used to classify the water bodies into three distinct groups viz., oligo-mesotrophic (i.e., large and deep canyon-shaped, newly built hydropower reservoirs), meso-eutrophic (i.e, dry zone irrigation tanks subjected to high flushing rates) and eutrophic-hypereutrophic (i.e., terminal irrigation reservoirs experiencing long water retention and urban water bodies receiving urban waste). A majority of reservoirs showed a distinct seasonal variation in phytoplankton abundance influenced by monsoon driven rainfall pattern. Some exhibited non-rhythmic successional episodes in relation to site-specific hydrological regimes and specific chemical environments. Grazing seems to be less effective in regulation of phytoplankton biomass perhaps due to lack of zooplankton but a large quantum of plankton biomass is lost during water release from the shallow irrigation reservoirs. *C.* raciborskii attains the maximum growth in these water bodies during the dry season under low water level, creating a grave health risk since some of these reservoirs are being used for human consumption after conventional treatment.

Keywords: *phytoplankton, reservoirs, Environmental quality, human factors, Sri Lanka*.

1. Introduction:

Phytoplankton is a key component of the aquatic food web in oceanic and inland waters reflecting the trophic status of the water body. In shallow inland waters in the humid tropics, they play an additionally important role in the pelagic food web as a direct and important source of food for commonly found seston feeding fish [1]. Pico-phytoplankton (<2µm) is indispensable to sustain aquatic food webs in the ocean [2] and the pelagic zones of large inland lakes [3]. Phytoplankton taxa vary in distribution as they disperse through wind, oceanic currents, migratory birds etc. A majority of them are cosmopolitan. Phytoplankton communities in tropical lakes and reservoirs represent summer communities of temperate lakes with a large number of tropical taxa including pan-tropical and regional endemic elements [4]. Although there is a large diversity of standing water bodies in the tropical latitude resulting from climatic and geomorphologic heterogeneity, detailed phytoplankton investigations are rare on their spatial and temporal distribution, growth and survival, loss patterns, periodicity and changes in species composition in relation to environmental variables ([5], [6], [7], [8], Lewis, 1973,1978; [9], [10], [11], [12], [13], [14], [15]. A few studies have addressed phytoplankton composition and their temporal changes under eutrophic conditions ([16], [17], [18], [19], [20], [21]. The accepted phenomenon is that temporal variability of phytoplankton in the humid tropics is driven by seasonal rainfall and mixing, but diel patterns in shallow water bodies and long-term stable types with sudden shifts are poorly understood.

In small ponds and reservoirs in monsoon Asia, phytoplankton minimum is a characteristic feature during the wash-out and elevated turbidity in the wet months ([16], [17], [22], [23]. Lewis [24] suggested a progressive decline in phytoplankton diversity toward the tropics. Besides, extremely high diversity of phytoplankton has been shown for floodplain lakes in Papua New Guinea ([4]. Phytoplankton communities in large tropical lakes are dominated by non-motile species ([8], [25], [6]. Species sequences have been reported during the early development of man-made lakes ([26]; [27], [28]. However, dissimilarity in species composition and diversity of phytoplankton occurs in adjoining reservoirs in cascade systems during the same time period ([29].

Besides, the early taxonomic studies done by Holsinger ([30]-[31] and others ([32], [33], [34], [35], [36]-[37], [38], Abeywickrama, ([39], compiled already published workr a up to 1970s. Subsequently, the abundance and distribution of common planktonic algae have been reported by several workers ([40], [41], [42], [43], [44], [45], [46], while Durrschmidt and Cronberg. ([47], paid a special attention on Chrysophtes collected from Sri Lanka. Jayatissa et al. [48], addressed the distribution of toxigenic cyanobacteria in different types of freshwater bodies in Sri Lanka. There were instances that, some of the taxa described earlier have been revised today with technological advancements of microscopy.

Recently, attempts have also been made to understand the role of monsoon-bound seasonal hydrology on their abundance [45], [46], but long term changes, growth and survival and succession under monsoon-bound seasonal eco-hydrology are unknown to a greater extent. This compilation is based on information gathered on composition and relative abundance of common taxa of phytoplankton in manmade lakes in Sri Lanka over period of ten consecutive years (1998-2008). Together with related environmental variables. Outbreaks of several cyanobacteria blooms during this period were also taken into consideration. The primary objective of this paper is to highlight the current status of phytoplankton composition and abundance of Sri Lankan inland water bodies in relation to environmental variables and eco-hydrology resulting from both natural and anthropogenic events.

2. Materials and Methods:

The island of Sri Lanka (6º-10º N and 80º-82º E) is an extension of the Indian peninsula located on the Indo-Australian plate. Sri Lanka experiences two distinct monsoon driven rainy seasons; the southwest monsoon (May-Sep.) and the northeast monsoon (Dec.-Feb.). The northeast monsoon brings heavy rains, which is fairly widespread. Besides, the island is also influenced by atmospheric depressions that form in the Southwest Bay of Bengal and the Southeast Arabian Sea resulting in convectional rains. Nevertheless an orographic rainfall prevails in the central highlands. Sri Lanka has no natural lakes and all inland water bodies are essentially man-made, constructed primarily for irrigation during the past and hydropower generation at present. The entire landmass is drained by a radial drainage pattern. Perennial and seasonal rivers which drain the landmass empty into the Indian Ocean either via estuaries or they first discharge into coastal lagoons [49].

Phytoplankton samples were collected from most of the inland water bodies throughout the island including a few water bodies from LTTE controlled areas of the north and northeast since 1998 to 2008. Sampling was conducted in many reservoirs under low and high water levels using 10 µm net hauls integrated over the near surface layers and by a water sampler in some cases. In addition, time series samples were collected for two consecutive years (1998-2000) from three reservoirs; an elongated canyon shaped and deep hydropower reservoir (Victoria), located in the central uplands and moderately deep hydropower cum irrigation reservoir (Udawalawe) and an irrigation reservoir, Minnieriya) which are located at southern foothills of the mountains and close to the eastern lowland respectively (Fig. 1). Monthly samples were also collected from the reservoirs located in the Deduru Oya, Kala Oya, Malwathu Oya and Mi Oya basin basins during 2003-2004. Consequently, phytoplankton species have been examined from 57 standing water bodies located in eighteen river basins draining more or less entire land area of the island representing a wide geographical range of physical and climatic heterogeneity. All samples were immediately fixed with 2 % neutralized formalin for laboratory identification under a research microscope (Olympus BX 51, magnifications up to 400-times). Detail taxonomic analysis was carried out at the Institute of Botany, University of Innsbruck, Austria.

3. Results:

In the present compilation of planktonic algae of inland water bodies in Sri Lanka 200 taxa belonging to nine major taxonomic groups were identified (Table IA, IB,IC and ID). Of the total 200 taxa, the highest numbers of species were represented by Zygnemaphytes (34 %), followed by Chlorophytes (24 %), and Cyanophytes (22 %) Diatomophytes (8 %) (Table II). Other five groups (Chrysophytes, Cryptophytes, Dinophytes, Euglenophytes and Xanthophytes) that found were less than 5 % indicating of minor contribution to species richness. Although desmids represented by the highest number of taxa (68) belonging to 14 genera, the species belonging to both greens (48) and blue-greens (43) had the highest generic number of 24 each (Table II). The number of rare species, less than 5% in abundance was much higher (77%) compared to common, moderate and dominant species (Table III). There were only 26 common taxa (13%) whereas 11 (5.5%) and 4 (2 %) dominant and moderately abundant species respectively in the entire reservoir phytoplankton population. Although a few taxa of desmids were common, a majority of the species were either rare or found in small numbers (Table III). The highest number of desmids found were belonging to the genus *Staurastrum* (27 species) and genus *Cosmarium* and genus *Staurodesmus* were represented by 14 and 9 taxa respectively (Table IA). Except Closterium *aciculare*, none of the desmids were found numerically dominant in phytoplankton communities. Relatively high species richness of genus *Staurastrum* was found in extremely soft waters with low concentrations of calcium and magnesium ions. *Staurastrum* species were dominant in Samalawewa, an oligotrophic hydropower reservoir located in the Walwe river basin which had a low content of calcium ion. *Closterium aciculare*, was found as the numerically dominant species in Chandrikawewa in the same river basin. Nevertheless desmids were extremely low in numbers in eutrophic water bodies.

There were 48 species of planktonic green algae (Family: Chlorophyceae) belonging to 24 genera and the highest number of species was represented by the genus *Scenedesmus* (Table IB). Although some species of *Scenedesmus* were common and frequent, *Pediastrum simplex* was the only planktonic green algae became numerically dominant in wet zone reservoirs under eutrophic conditions. *P. simplex* was dominant in Kandy Lake, an eutrophic urban water body located in the hill country wet zone, prior to the Lake was collapsed by an outbreak of *Microcystis aeruginosa* bloom in May 1999. *Coelstrum astroideu*, other planktonic green algae in the Scenedesmaceae family was reported *in* large numbers in very few occasions in the wet zone reservoirs.

Patchy scums of *Botryococcus braunii*, a Chlorophyte were observed from Kurunegala city tank towards the end of February 2009. This is a colony forming Chlorophyte occurs in clusters and outer cell layers are covered by mucilage and oily substances resulting brownish red colour.

Cyanobacteria or blue-green algae (Family: Cyanophyceae) represented by 43 taxa belonging to 24 genera, with genus *Microcystis*, having the highest number species of seven and the other genera represented by less than four species (Table IC). *Microcystis aeruginosa* the most common taxa in the humid tropics with toxigenic strains reported numerically dominant in eutrophic waters with high N:P ratio. Several reservoirs including some urban lakes (Kandy Lake and Beira Lake), a high mountain hydropower reservoir (Kotmale) were collapsed by the outbreaks of *M. meruginosa* blooms. There were instances, that *Microcystis wesenbergii* which is also toxigenic cyanobacteria became co-dominant with *M. aeruginosa* in the phytoplankton assemblage whereas the other species of *Microcystis* were either moderate or relatively rare in their presence. *Cylindrospermopsis raciborskii*, a toxigenic, non-scum forming nitrogen fixer was found numerically dominant in many shallow dry zone reservoirs including very remote water bodies with undisturbed watersheds having low N:P ratio. *Oscillatoria raciborskii*, a filamentous cyanobacterium was reported blooming in Giant's tank in Mannar district under very low water level.

Diatoms (Family: Diatomophyceae), the fourth in the rank of phytoplankton abundance were represented by 17 taxa belonging to 13 genera (TABLE ID). Chain forming centric diatom, *Aulacoseira granulata* was the most common and numerically dominant species found in mesotrophic water bodies. Because of its larger size A. *granulata* made the largest bio-volume in the phytoplankton assemblage when it was numerically dominant. There were instances that unicellular centric diatoms (*Stephanodiscus neoastraea* and *Cyclotella pseudostelligera*) numerically dominating the dry zone reservoirs under high water level. Of the other diatoms only a species of genus *Synedra* was found as numerically dominant species in several reservoirs in the Kala Oya basin including Kalawewa at many instances under high water level. A new species of centric diatom described as Urosolenia *dentriculata* (a freshwater counterpart of the genus *Rhizosolenia*) by Rott et al. [50] was uncommon and infrequent in wet zone and dry zone reservoirs in the island.

Of the Euglenophytes (Family: Euglenophyceae), nine species belong four genera have been identified during this investigation and *Euglena* and *Phacus* species were always common in phytoplankton samples but in small numbers. Besides, there were five species of genus *Trachelomonas* but all of them were rare elements. Densities of these species were high in hyper-eutrophic waters. Dianoflagellates (Family: Dinophyceae) were represented by five taxa belonging to three genera and genus *Peridiniopsis* or genus *Peridinium* retained as the dominant species in waters rich in humic substances.The other three groups of plankctonic algae (Chrysophycea, Cryptophyceae and Xanthophyceae) were of minor importance to the species assemblage of phytoplanton in Sri Lankan inland waters bodies. However, two Xanthophytes, namely *Centritractus belenophorus and Isthmochloron lobulatum* were present in many samples in few numbers. There was only one species of Chysophytes (Genus: *Mallomonas*).

Table IA: *Diatomophyceae (Diatoms) Identified During the Study*

Group: Zygnemaphyceae (Desmids)	Remarks
Actinotaenium sp	r
Closterium aciculare West	c
Closterium acutum Lemm.	r
Closterium diane Ehrenberg	r
Closterium kuetzingii Bréb.	c
Cosmarium apertum (Skuja) Först.	r
Cosmarium binum Nordst.	r
Cosmarium bioculatum Bréb.	r
Cosmarium contractum West & West	r
Cosmarium depressum (Näg.) Lund.	c
Euastrum denticulatum (Kirchner) Gay.	r
Hyalotheca dissiliens Bréb.	r
Micrasterias foliacea Bail.	r
Micrasterias mahabuleshwarensis Hobs..	r
Mougeotia sp.	r
Onychnema laeve Nordst.	r
Penium spirostrialatum Bark.	r
Pleurotaenium ehrenbergi Menegh. - Starm	r
Pleurotaenium sp	r
Pleurotaenium trabecula Näg.	r
Spirotaenium condensata Bréb.	r
Staurastrum bifidum Ralfs	r
Staurastrum bigibbum Skuja	c
Staurastrum brachioprominens Börgesen	r
Staurastrum brevispina (Brebisson) Croasdale	r
Staurastrum cerastesLundell	.c
Staurastrum furcatum (Ehrbg.) Bréb.	r
Staurastrum gladiosum Turner	r
Staurastrum gracile Ralfs	c
Staurastrum laeve Ralfs	r
Staurastrum leptocladum Nordstedt	r
Staurastrum leptopus Krieg.	c
Staurastrum limneticum Schmidle	c
Staurastrum longipes (Nordst.) Teiling	r
Staurastrum margaritaceum (Ehrenberg)	r
Staurastrum muticum Brébisson	r
Staurastrum nodulosum Prescott	r
Staurastrum octoverrucosusScott et Grönblad	r
Staurastrum pingue Teiling	r
Staurastrum playfairi Scott et Prescott	r
Staurastrum protectum West & West	r
Staurastrum pseudosebaldi Wille	r
Staurastrum quadricornutum Roy & Bissett.	r
Staurastrum rotundatum Turn.	r
Staurastrum sebaldi Reinsch.	r
Staurastrum smithi (GM Smith) Teiling	r
Staurastrum tetracerum (Kützing) Ralfs	r
Staurastrum tohopekaligense Wolle	r
Staurodesmus aristiferus (Ralfs) Thomasson	r
Staurodesmus convergens (Ehrenberg) Teiling	r
Staurodesmus cuspidatus (Bréb. ex Ralfs) Teiling	r
Staurodesmus dickiei (Ralfs) Lillier	r
Staurodesmus omearii (Archer) Teiling	r
Staurodesmus patens (Nordst.) Croasdale	r
Staurodesmus phimus (Turn.) Thom.	r
Staurodesmus punctulatus	r
Staurodesmus spetsbergensis(Nordst.) Teiling	r
Xanthidium freemanii West et GS West	r

Xanthidium spinosum (Josh.) West & West	r
Staurodesmus spetsbergensis(Nordst.) Teiling	r

Table IB: *Chlorophyceae (Greeens) Identified Duringng the Study*

Group: Chlorophyceae (Greeens)	Remarks
Ankistrodesmus bernardi Komárek	c
Ankistrodesmus sp	r
Botryococcus braunii Kützing	r
Chlamydomonas sp.	r
Coelastrum astroideum De Notaris	d
Coelastrum indicum Turner	r
Coelastrum polychordum (Kors.) Hindak	r
Coelastrum pulchrum Schmidle	r
Coelastrum reticulatum (Dangeard) Senn	r
Coenococcus fotti Hindak	r
Crucigeniella saguei Komárek	r
Dimorphococcus lunatus A. Braun	r
Dictyosphaerium pulchellum Wood	r
Dictyosphaerium tetrachotomum Printz	r
Frabceia armarta Lemm.	r
Golenkinia radiata Chod.	r
Kirchneriella dianae (Bohlin) Comas	c
Kirchneriella sp	r
Koliella sp.	r
Lagerheimia citriformis (Snow) Coll.	r
Monoraphidium. caribeum Hindak	r
Monoraphidium contortum Komarkova-Legnerova	r
Monoraphidium irregularis Smith	r
Monoraphidium minutum Komarkova-Legnerova	r
Nephrocytium schilleri Comas	r
Oocystis marssoni Lemm.	c
Oocystis parva West & West	r
Pediastrum duplex Meyen	r
Pediastrum simplex Meyen	d
Pediastrum simplex var. biwaense Fucush.	r
Pediastrum tetras Ralfs	r
Quadricoccus verrucosus Fott	c
Scenedesmus brasiliensis Bohl.	r
Scenedesmus ellipticus Corda	r
Scenedesmus javanensis Chodat	r
Scenedesmus obtusus Meyen	r
Scenedesmus opoliensis Richter	r
Scenedesmus perforatus Lemm.	r
Scenedesmus polyglobus Hortob.	r
Scenedesmus spinosus Chodat	r
Scenedesmus tropicus Crow	r
Selenodictyum brasiliense Uherk. & Schmidt	r
Sorastrum americanum (Bohlin) Schmidle	r
Tetraedron incus (Teiling) Smith	r
Tetraedron minimum A. Braun	r
Tetraedron triangulare Kors.	r
Tetrastrum heteracanthum Chod.	r
Tetrastrum staurogeniaeforme Lemm.	r
Treubaria triappendiculata Bernard	r

Table IC: *Cyanophyceae (Cyanobacteria), Cryptophyceae and Chrysophycea Identified During the Study*

Group: Cyanophyceae (Cyanobacteria)	Remarks
Anabaena solitaria Klebahn	c
Anabaena sp	c
Anabaenopsis elenkini V. Miller.	r
Anabaenopsis sp	c
Aphanothece minutissima (W. West)	r
Aphanizomenon voltzi Lemm.	r
Aphanocapsa elachista West & West	r
Aphanocapsa delicatissima West & West	r
Aphanocapsa holsatica Lemm.	r
Chroococcus dispersus (Keissl.) Lemm.	m
Chroococcus limneticus Lemm.	m
Coelomoron microcystoides Komárek	r
Coelosphaerium kuetzingianum Näg.	c
Cyanodictyon imperfectum Cronberg et Weibull l	r
Cylindrospermopsis philippinensis (Taylor) Komárek	r
Cylindrospermopsis raciborskii (Woloszynska)	d
Dactylococcopsis smithii R. & F. Chodat	r
Gloeotrichia sp	r

Gomphosphaeria naegeliana Unger.	r
Gomphosphaeria pusilla (Goor) Komárek.	r
Lemmermaniella pallida Lemm.	r
Lyngbya circumreta West	r
Lyngbya limnetica Lemm.	r
Merismopedia elegans A. Braun ex Kützing	r
Merismopedia punctata Meyen	m
Merismopedia tenuissima Lemm.	r
Microcystis aeruginosa Kütz	d
Microcystis comperei Komárek.	r
Microcystis flos-aqua (Witt) Kirchner	c
Microcystis incerta Lemm.	c
Microcystis lamielliformes Holsinger	r
Microcystis protocystis Crow	r
Microcystis wesenbergii (Kom.) Kom.	m
Oscillatoria chlorina Kütz.	r
Oscillatoria raciborskii (Wol.) Seen	d
Oscillatoria sp	r
Panus soinosus Hickel	r
Planktolyngbya circumcreta West	c
Planktolyngbya limnetica Lemm.	c
Pseudoanabaena galeata Böcher	c
Rhabdogloea smithii R. & F. Chodat.	r
Group: Cryptophyceae	Remarks
Cryptomonas rostratiformis Skuja	r
Rhodomonas lacustris Pascher & Ruttner	r
Rhodomonas minuta Skuja	r
Group: Chrysophycea	Remarks
Mallomonas sp	1

***Table ID:** Diatomophyceae (Diatoms), Euglenophyceae, Xanthophyceae and Dinophyceae identified during the Study*

Group: Diatomophyceae (Diatoms)	**Remarks**
Aulacoseira granulata (Ehrenberg) Simonsen	d
Cyclotella comta (Ehrenb.) Kütz	r
Cyclotella meneghiniana Kutzing	r
Cyclotella pseudostelligera Hust.	c
Cymbella minutissima Kütz	r
Fragilaria acus Kütz	r
Gyrosigma sp	r
Navicula sp	r
Navicula sp	r
Pinnularia sp	r
Pinnularia sp	r
Rhizosolenia eriensis HL Smith	r
Stephanodiscus neoastrea Hakanson & Hicke	c
Surirella sp	r
Synedra sp	d
Tabellaria sp	r
Urosolenia dentriculata Rott, Kling & McGregor	r
Group: Euglenophyceae	**Remarks**
Euglena acus Ehrenberg	c
Euglena pisciformis Klebs	c
Lepocinclis ovum (Ehrenberg) Lemm.	r
Phacus sp	r
Trachelomonas armata (Ehrenberg) Stein	r
Trachelomonas hispida (Perty) Stein em. Defl.	r
Trachelomonas verrucosa Stokes	r
Trachelomonas volvocina Ehrenberg	r
Trachelomonas volvocinopsis Swirenko	r
Group: Xanthophyceae	**Remarks**
Centritractus belenophorus Lemm.	c
Goniochloris contorta (Bourrelly) Ettl,	r
Goniochloris sp	r
Isthmochloron gracile (Reinsch) Skuja	r
Isthmochloron lobulatum (Naegeli) Skuja	c
Pseudostaurastrum	r
Group: Dinophyceae	**Remarks**
Gymnodinium sp.	r
Peridiniopsis penardiforme (Lindeman) Bourrelly	c
Peridiniopsis sp	c
Peridinium gatunense Nygaard	c
Peridinium inconspicuum fa. Lemmermann	r

***Table II:** Phytoplanton Gropus, Genera and Species Numbers Ans Respective Percentage*

Group	**Genera**	**%**	**Species**	**%**
Chlorophyceae	24	27.3	48	24
Chrysophycea	1	1.1	1	0.5

Cryptophyceae	2	2.3	3	1.5
Cyanophyceae	24	27.3	43	21.5
Diatomophyceae	12	13.6	17	8.5
Dinophyceae	3	3.4	5	2.5
Euglenophyceae	4	4.5	9	4.5
Xanthophyceae	4	4.5	6	3.0
Zygnemaphyceae	14	15.9	68	34
Total	**88**	**100**	**200**	**100**

Table III: *phytoplanton gropus, common, dominant, moderate and rare species Iii discussion*

Group	Common	Dominant	Moderat	Rare
Chlorophyceae	4	2	0	42
Chrysophycea	0	0	0	1
Cryptophyceae	0	0	0	3
Cyanophyceae	9	3	4	27
Diatomophyceae	2	2	0	13
Dinophyceae	3	0	0	2
Euglenophyceae	2	0	0	7
Xanthophyceae	2	0	0	4
Zygnemaphyceae	8	0	0	60
Total	30	7	4	159
Percentage (%)	15	5.5	2	77

4. Discussion:

Being an equatorial island located in the warm humid tropics within Indo-Maysian North-Australian phycogeographical region, phytoplankton communities in inland water bodies of Sri Lanka represent summer communities of warm temperate lakes with a large number of tropical taxa including pantropical and regional endemic elements [4]. Although more than 4700 taxa have been recorded from the region, present study shows that there are about 200 taxa in Sri Lankan inland water bodies. With respect to reported geographical distribution, some species found in Sri Lanka are cosmopolitan, but none of them are endemic perhaps due to lack of old Tertiary natural lakes. A recent description of *Urosolenia denticulata*, a centric diatom of the freshwater counter part of a large genus *Rhizosolenia* [50] could be widespread in the Indo-Maysian North-Australian phycogeographical region. Likewise several species have been described originally from Sri Lankan freshwaters. *Microcystis protocystis* originally described from Sri Lanka by Crow [36]-[37] later cited several times in identification manuals [51], [52], but it has otherwise almost entirely disappeared from floristic and hydrobiological literature dealing with tropical phytoplankton. Recently, Komárek et al [53] described *Microcystis protocystis* from Brazilian freshwaters as a common bloom forming species probably pantropical and potentially toxicgenic. *Mallomonas ceylanica*, originally described from Sri Lanka [47] was detected in subtropical/tropical in South and East Asia [54]. However, taxonomic confusions still occur with very closely related taxa of the same genus (e.g. Genus *Staurastrum* of Zygnemaphytes, Genus *Microcystis* of Cyanophytes etc.,). *Aphanocapsa holsatica* found in Sri Lanka is very similar to Aphanocapsa *cumulus*, recently described from Africa [55].

Desmids require special unpolluted water conditions and many of the species of desmids thrive in the acid waters of marshes. Wet zone reservoirs in Sri Lanka become slightly acidic during the rainy season. Occurrence of *Closterium aciculare* in large number in Chandrikawewa may be attributed to soft water conditions after heavy rainfall. Chlorophytes the most diverse green algae with different life forms (terrestrial, brackish, marine, symbiotic) also dominate fresh water ecosystems as planktonic form in most instances. The abundance of individual taxa is determined environmental quality of the habitat. Although genus *Scenedesmus* and *Pediastrum siplex* were common in Sri Lankan reservoirs only *P. siplex* became dominant and co-existed with *Aulacoseira granulate* in moderately hard, alkaline, and nutrient-rich eutrophic water bodies. Both *P. simplex* and *A. granulata* are cosmopolitan species, very common in Sri Lankan reservoirs as elsewhere. *Botryococcus braunii* had been reported from Kurunegala tank once before but it was not in high densities. *B. braunii* is a cosmopolitan species which grows lavishly in ponds and lakes rich in inorganic phosphorous. Warusavithan and Yatigammana [56] have reported high densities of *B. braunii* in Kotmale reservoir at the outfall of Puna Oya.

Jayatiss et al. [48] showed that all M. *aeruginosa* populations found in Sri Lanka's water bodies were not toxygenic, only certain strains of the species produced toxins. Besides, its dominance in urban lakes and other water bodies including hydropower reservoirs in the wet zone, there were instances that *M. aeruginosa* formed into blooms without surface scums in a terminal reservoir (Kantalae reservoir) located in the dry zone. The most recent Mycrocystis bloom was reported in January 2013 from newly built Ulahitiy-Ratkinda twin reservoir in the Mahaweli basin. This is certainly the first such occurrence reported from these reservoirs. Therefore, it is imparative to study the causative factors for the numerical dominance of non-nitrogen fixing cyanobacteria (e.g., *M. aeruginosa*) in dry zone reservoirs under certain conditions rather than attributing it indistinctly to application of triple super phosphate to upland crops. Because the blooming of non-nitrogen fixing species requires water with high nitrogen concentrations. *M. aeruginosa* the most common cyanobacteria species in the humid tropic become numerically dominant only in eutrophic waters with high N:P ratio. There were also instances that *Microcystis wesenbergii* became co-dominant in the phytoplankton assemblage in wet zone urban water bodies. Other species of genus Microcystis were either sub dominant or rare in occurrence. In many instances, *Cylindrospermopsis raciborskii*, become numerically dominant in shallow dry zone reservoirs with low N: P ratio. A classic example for extremely high densities of *C. raciborskii* during August-September under low water level is Unnichchai tank located in the Batticaloa district in a very remote watershed dominated by scrub jungles. About hundred thousand of cattle and buffaloes graze on newly grown grasses in this reservoir bed during low water level.

Dinoflagellates can thrive in all aquatic environments; marine, brackish, and fresh water, including in snow or ice. They are also common in benthic environments and in sea ice. Freshwater form hardly formed into blooms unlike marine red tides. and The occurrence of genus *Peridiniopsis* or genus *Peridinium* in moderate numbers in some dry zone water with poor flushing rate may be attributed to high concentration of dissolved organic compounds composed of humic and fulvic acids. The occurrence of *Euglena* and *Phacus* species is also an indication of organic pollution and eutrophication. Their densities were higher in littoral and shallow benthic areas rather than pelagic water. Dürrschmidt and Cronberg [47] identified several species of Chrysophytes belonging family: Mallomonadaceae and Family: Paraphysomonadaceae nd also described *Mallomonas ceylanica* from Sri Lankan reservoirs. The other three Cryptophytes and Xanthophytes are of minor importance to the species richness of planktonic algae in Sri Lankan inland waters.

The species composition of phytoplankton communities and the relative abundance of dominant and sub-dominant species undergo continuous changes in a varying scale. Although the spatial and temporal distribution of phytoplankton are concurrent with environmental variables in different types of water bodies of diverse morphology and trophic status, progress in understanding and prediction has been very slow even in the case of temperate waters [57]. Certainly, still there are no widelyaccepted mechanisms to explain seasonal increase and declining of phytoplankton or the factors that adjust long-term floristic changes. However, in recent years, seasonal succession and changes in community composition in highly enriched (hypereutrophic) ponds and lakes in the tropics have been attributed to anthropogenic eutrophication. There is no sufficient circumstantial evidence to show that the environmental variables such as increasing temperature or stability, decreasing frequency of light fluctuations, and decreasing nutrient availability control phytoplankton growth periodicity in tropical waters. However, the dominance of desmids especially genus *Straurastrum* and genus *Kirchneriella* of green algae in low conductive waters with low concentration of Ca and Mg ions, the abundance of the chain forming centric diatom, *A. granulata* in silica rich waters and the relative abundance of non-nitrogen fixing and nitrogen fixing forms of cyanobacteria in nitrogen rich urban water and nitrogen poor remote tanks respectively are not uncommon in Sri Lanka.

Apparently, species richness in Sri Lankan reservoirs was relatively narrow compared to natural lakes located at similar latitudes {4], [46]. This may be ascribed to unavailability of truly lacustrine habitats. Of the 43 genera of cyanobacteria, a majority were found in three types of water bodies except in high mountain reservoirs. This has perhaps resulted from a low number of samples examined from highland reservoirs. Species richness of diatoms, green algae and desmids was low in both eutrophic urban water bodies and the small reservoirs located at highest elevation. Some of the diatoms found occasionally in fewer numbers could be either sessile or benthic forms, and may not be truly planktonic (e.g., *Cymbella*, *Gyrosigma*, *Navicula*, *Surirella*, *Tabellaria*).

The environmental variables in Sri Lankan stranding water bodies are strongly influenced by the seasonal changes of monsoon driven rainfall and orographic nature and sharp elevation in the highland. The highest rainfall occurs during the northeast monsoon (Nov-Jan) is widespread, whereas a dry spell occurs from June to September in the dry zone. However, the rainfall pattern in southeast Asia (and the total rainfall for a rainy season) is variable [58], consequently even within a short period of the investigation a considerable difference in phytoplankton could be found from year to year because of high water demand during dry periods. The temperature variation over time in the Sri Lankan reservoirs was not more than 5°C with a minimum in January. But diel range is significantly high and it increases with increasing altitude. This may have a pronounced influence on the diel variation of phytoplankton species composition especially in the vertical axis. Temporal variations of underwater light climate resulting from overcast sky and turbidity (planktonic and inorganic particles) were found frequently related to changes in phytoplankton quantities and growth. Hydrological changes are related to changes in nutrient concentrations and in turn phytoplankton growth. Although noticeable variations in both P- and N-compounds are common, the average nutrient level allows ranking the water bodies along a trophic gradient. Carbon supply is influenced by comparably low alkalinity with the lowest values in highland reservoirs and variations in pH from neutral or slightly acidic to highly alkaline (pH over 8.1) is also influenced by rainfall. Extreme variations of pH occur in the highly eutrophic urban water bodies and in the dry zone reservoirs and it coincides with high and low water levels.

Three distinct trophic categories influenced mainly by rainfall; meso-eutrophic (dry zone reservoirs), oligo-mesotrophic (deep highland reservoirs) and eutrophic-hypertrophic (urban water bodies) are established in Sri Lanka [45], [46].. Besides, it seems that phytoplankton ecology is more influenced by the hydraulic balance, water chemistry and wind and temperature driven mixing processes rather than grazing by zooplankton or phytoplanktivorous fish. The comparison of phytoplankton structure indicates a pronounced gradient of complexity (species richness) positioned along a trophic gradient from the most eutrophic urban reservoirs to the oligo-mesotrophic deep highland reservoirs. Further, water chemistry, basin morphology, and water renewal rate influenced by natural and anthropogenic factors are important for both the selection of dominant taxa and the seasonal shifts of functional species groups [21]. Variability of species richness seems to be more related and much inclined to trophic status than to stability/variability pattern of the environment in Sri Lankan reservoirs as described by Tolotti [59]. Deep upland reservoirs are strongly influenced by monsoon wind, but changes in pattern of phytoplankton are not so clear since these canyon shaped reservoirs have been shielded against wind and the monsoon intensity by surrounding hilly landscape [60]. In shallow reservoirs diurnal variations are stronger than seasonal differences and species succession resulting in phytoplankton stability (equilibrium) is hindered because of re-suspension, but large seasonal variations influenced by the hydraulic balance and mixing were apparent in all types of water bodes. Apparently, the succession rate of phytoplankton in the shallow water bodies is lower than in the deeper water bodies but the factors that drive this obvious disparity remain for future studies.

5. Acknowledgements:

We greatly appreciate the field and laboratory assistance given by Mr. Wajira Kanagara, Ms Swarnapali Samaradiwakara, Ms. Charukshi, Karunathilake and Ms. Rohini Gamlath. The funding was provided by the Institute of Fundamental Studies, National Water Supply & Drainage Board and INCO-DC FISHSTRAT Project.

6. References:

[1] R. Hofer and F. Schiemer, Feeding ecology, assimilation efficiencies and energetics of two herbivorous fish: arotherodon (Tilapia) mossambicus (Peters) and Puntius filamentosus (cuv. Et. Val.). In: Schiemer, F. Ed. Limnology of Parakrama Samudra- Sri Lanka, A case study of an ancient man-made lake in the tropics. Dev. Hydrobiol. vol. 12**:** 155-164, 1983.

[2] Fenchel, T, Marine plankton food chains, Annu. Rev. Ecol. Syst. vol. 19**:** 19-38, 1988.

[3] J.G. Stockne and K.G. Poter, Microbial food webs in freshwater planktonic ecosystems, In: S. R. Carpenter (ed.), Complex Interactions in Lake Communities. Springer Verlag. New York. 69-83 pp. 1987.

[4] W. Vyverman, the Indo-Malaysian North-Australian phycogeographical region revised. In: J. Kristiansen (ed.) Biogeography of Freshwater Algae. Developments in Hydrobiology Hydrobiologia vol. 118: 107-120, 1996.

[5] J. F Talling. The annual cycle of stratification and phytoplankton growth in Lake Victoria (East Africa). Int. Revue. ges. Hydrobiol. Vol. 51**:** 545 – 62, 1966.

[6] J .F. Talling, The seasonality of phytoplankton in Africalakes. Hydrobiologia, vol. 138: 139- 160, 1986.

[7] W.M. Lewis, The thermal regime of Lake Lanao (Philippines) and its theoretical implications for tropical lakes. Limnol. Oceanogr, vol. 18: 200-217, 1973.

[8] W.M. Lewis. Dynamics and succession of the phytoplankton in a tropical lake: Lake Lanao, Philippines. Journal of Ecology vol. 66: 849-880, 1978.

[9] G.G. Ganf, G.G. (1974). Rates of oxygen uptake by the planktonic community of a shallow equatorial lake (Lake George, Uganda). Oecologia, vol. 15: 17-32, 1974.

[10] J. Kalff and S. Watson, Phytoplankton and its dynamics in two tropical lakes: a tropical and temperate zone comparison. Hydrobiologia, vol. 138**:** 161-176, 1986.

[11] S. Biswas,. Observations on phytoplankton and primary productivity in Volta. Lake. Ghana. Verh. Internat. Verein. Limnol, vol. 20**:** 1672-1676, 1978.

[12] R. Henry, J.G. Tundisi and P.R. Curi, Effects of phosphorus and nitrogen enrichment on the phytoplankton in a tropical reservoir (Lobo Reservoir, Brazil), Hydrobiologia, vol. 118**:** 177 - 185, 1984.

[13] L. Ramberg, Phytoplankton succession in the Sanyati Basin, Lake Kariba. Hydrobiologia, vol. 153: 193-202, 1987.

[14] R. Mukankomeje, P.D. Plisner, J.P. Descy and L. Massault, Lake Muzahi, Rwanda limnological features and phytoplankton production. Hydrobiologia, vol. 257**:** 107-120, 1993.

[15] C.W.C. Branco, and P.A.C. Senna, Factors influencing the development of Cylindrospermopsis raciborskii and Microcystis aeruginosa in the Paranoa Reservoir, Brasilia, Brazil. Arch. Hydrobiol. (Suppl.), vol. 75: 85 - 96.1994.

[16] V.V. Sugunan, Seasonal fluctuation of plankton of Nagarjunasagar reservoir A.P., Indian. J. of Inland fish. Soc., India, vol. 12**:**79-91, 1980.

[17] V. Kannan. And S.V. Job (1980). Diurnal, seasonal and vertical study of primary production in Sathiar Reservoir. Hydrobiologia, vol. 70**:**103-117, 1980.

[18] A.R. Zafar, Seasonality of phytoplankton in some south Indian lakes. Hydrobiologia, vol. 138: 177-187, 1985.

[19] P.L. Osborne, Seasonality in nutrient and phytoplankton production in two shallow lakes, Waigani lake, Papaw New Guinea and Barton Broad, Norfolk England, Int. Rev. Ges. Hydrobiol. vol. 76: 105-122, 1991.

[20] M. Alvarez-Cobelas, M.and B. Jacobsen, Hypertrophic phytoplankton: An overview. Freshwater Biological Association. Freshwater Forum, vol. 2:184 -199, 1992.

[21] E.I.L. Silva, Phytoplankton Characteristics, Trophic Evolution Nutrient Dynamics in an Urban Eutrophic Lake: Kandy Lake in Sri Lanka. In: M.V. Reddy (ed.), Restoration and Management of Tropical Eutrophic Lake. Oxford and IBH Publishing, New Delhi 219- 260 pp., 2004.

[22] M.Y. Fatimah, A.K.M. Mohsin and A.S.M. Kamal, Phytoplankton composition and productivity of a shallow tropical lake. Pertanika, vol. **7:**101-113, 1984.

[23] M. Khondker and L. Parveen, Daily rate of primary productivity in hypertrophic Dhamondi Lake. In: M.M. Tilzer & M. Khondker (eds.), Hypertrophic and Polluted Freshwater Ecosystems ecological bases for water resources management. Bangladesh Department of Botany, University of Dhaka, 181–191 pp., 1993.

[24] W.M. Lewis, W.M, Tropical Lakes: How latitude makes a difference In: F. Schiemer and K.T.Boland (eds.),. Perspective in Tropical Limnology, SPB Academic Publishing Amsterdam, 43-64 pp., 1996.

[25] H.J. Carney, P.J. Richerson and P. Eloranta, Lake Titicaca (Peru/Bolivia) Phytoplankton: species composition and structural composition with other tropical and temperate lakes. Arch. Hydrobiol, vol. 110**:** 365-85. 1987.

[26] J. van der Heide, J. (1973). Plankton development during the first years of inundation of the Van Blomestein (Brokopondo) Reservoir in Suriname, Verh. Internat.Verein. Limnol., vol. 24:1171-1173, 1973

[27] T. Matsumura-Tundisi, J. G. Tundisi, A. Saggio, A. L. Oliveira Neto and E. G. Espindola. Limnology of Samuel Reservoir (Brazil, Rondonia) in the Filling Phase. Verh. Internat. Verein. Limnol., vol. 24: 1482- 1488, 1992.

[28] C.W.C. Branco and P.A.C. Senna, Phytoplankton composition, community structure and seasonal changes in a tropical reservoir (Paranoa Reservoir, Brazil). Arch. Hydrobiol. (Suppl.), vol. 114: 69-84., 1996

[29] E.I.L. Silva and M.J.S. Wijeyaratne, the Occurrence of Cyanobacteria in the Reservoir of the Mahaweli River Basin in Sri Lanka. Sri Lanka J. Aquat. Sci. vol. 4: 51-60, 1999.

[30] E.C.T. Holsinger the plankton algae of three Ceylon lakes. Hydrbiologia, vol. 7: 8-24, 1955a

[31] E.C.T. Holsinger, The distribution and periodicity of the phytoplankton of three Ceylon lakes .Hydrbiologia, vol. 7: 25-35, 1955b.

[32] W. West and G.S. West, A contribution to fresh water algae to Ceylon transaction of the Linnaean Society 2nd Series Botany vol. **6:**123-215, 1902.

[33] C. Apstein, Das Plankton im Colombo-See auf Ceylon. Sammelausbeute von A. Borget, 1904-1905, Zool. Jahrb. (Abt. System), vol. 25: 201-244, 1907.

[34] F.E. Fritsch, A general consideration of the sub-aerial and freshwater algal flora of Ceylon. A contribution to the study of tropical algal ecology. Part 1 - Sub-aerial algae and algae of the inland freshwaters. Proc. Royal Society of London. Series B., vol. 79: 197-254, 1907.

[35] E. Lemmermann, Protophyten-Plancton von Ceylon. Zoolog. Jahrb., vol. 25: 263-268, 1907.

[36] W.B. Crow, The taxonomy and variation of the genus Microcystis in Ceylon. New Phytologist, vol. 21: 59-68., 1923a.

[37] W.B. Crow, W.B. (1923b). Freshwater plankton algae from Ceylon. J. Bot... London, vol., 61: 110-114, 138-145, 164-171, 1923b.

[38] N. Foged, Freshwater diatoms in Sri Lanka (Ceylon). Bibliothera Phycology, vol.23 : 1-100, 1976.

[39] B.A. Abeywickrema, B.A. The genera of the freshwater algae of Sri Lanka. Part 1. –UNSECO Man and the Biosphere National Committee for Sri Lanka, Special Publication 6. National Science Council Sri Lanka, Colombo, 103 p., 1979.

[40] M. Dokulil, M., K. Bauer and E.I.L. Silva (1983). An assessment of the phytoplankton biomass and primary productions of Parakrama Samudra, a shallow man-made lake in Sri Lanka, In: F. Schiemer Ed, Limnology of Parakram Samudra -

Sri Lanka: A case of an ancient man-made lake in the tropics. Devel. Hydrobiology. vol. 12: 49-76 pp.

[41] E. Rott, A contribution to the phytoplankton species composition of Parakrama Samudra, an ancient man-made lake in Sri Lanka. In: F. Schiemer, Ed, and Limnology of Parakrama Samudra, Sri Lanka. - Developments in Hydrobiology, vol. 12**:** 209 – 226, 1983.

[42] P.K. De Silva, Physico-chemical characteristics phytoplankton and the fishery of the Victoria reservoir. Ceylon J. Sci. (Biol. Sci.), vol. 34: 29-39, 1993.

[43] E. Rott and R.Lenzenweger, Rare and interesting plankton algae from Sri Lankan reservoirs- Biologia, Bratislava, vol. 49: 479-500, 1994.

[44] M.M. Pathmalal and S. Piyasiri, The chlorophyll-a content, species composition and population structure of phytoplankton in Randenigala reservoir in Sri Lanka. Vidyodaya J. Sci. vol. 5(1): 29-41, 1995.

[45] E.I.L. Silva, Ecology of Phytoplankton in Tropical waters: Introduction to the Topic and Ecosystem, Asian Journal of Water, Environment and Pollution vol. 4 (1), 25–35, 2006.

[46] E. Rott, E.I.L. Silva, E. Enriquez and S. Ingthamjitr, Phytoplankton community-structure with special reference to species diversity in five tropical Asian water bodies**,** F.Schiemer, D. Simon, U.S. Amarasinghe and J. Moreau, Eds. Aquatic Ecosystems, Germany, Margraf Publishers, Weikershim pp. 81-120, 2008.

[47] M. Durrschmidt and G. Cronberg 1989 Contribution to the knowledge of tropical chrysophytes: Mallomonadaceae and Paraphysomonadaceae from Sri Lanka, Algological Studies Archiv für Hydrobiologie, Supplement. vol. 54: 15-35, 1989.

[48] L.P. Jayatissa, E.I.L Silva, J. McElhiney,, and L. Lawton, Occurrence of toxigenic cyanobacterial blooms in freshwaters of Sri Lanka. Syst. Appl. Microbiol. vol. 29: 156 – 164, 2006.

[49] E.I.L. Silva, J. Katupotha, O. Amerasinghe, and H. Manthrithilake, Lagoons of Sri Lanka: From the Origins to the Present, International water Management Institute (IWMI). In print.

[50] E. Rott, H. Kling and G. McGregor, Studies on the diatom Urosolenia Round & Crawford (Rhizosoleniophycideae) Part I New and reclassified species from sub-tropical and tropical freshwaters, Diatom Research. vol. 21(1): 105-124, 2006.

[51] J.F. Talling and J. Lemoalle, Ecological Dynamics of Tropical Inland Waters. Cambridge University Press, 1998.

[52] L. Geitler, Cyanophyceae, In: Rabenhorst's Kryptogamenflora. Akademische Verlagsgesellschaft Lepzig.1196 pp. 1932

[53] T.V. Desikachary, Cyanophyta. Indian Council of Agricultural Research, New Delhi. 686 pp, 1959.

[54] J. Komárek, J. Komárková- Legnerová, L.C. Sant'Anna, M.T.P. Azevedo and O.A.C. Senna Two common icrocystisspecies (Chroococcales, Cyanobacteria) from tropical America, including M.. panniformisspec. Nova. – Cryptogamie/ Algologie vol 23: 159-177, 2002.

[55] M. Řezáĉová and J. Neustupa, Distribution of the Genus Mallomona (Synurophyceae) — Ubiquitous Dispersal in Microorganisms Evaluated Protist, vol. 158, 29—37, January 2007

[56] J. Komárek and G. Cronberg. Some chroococcalean and oscillatorialean cyanoprokaryotes from southern African lakes, ponds and pools. – Nova Hedwigia vol. 73: 129–160, 2001.

[57] A.L. Warusawitrhana and S.K. Yatigammana, The use of plankton as indicators of water quality in Kotmale reservoir (abstract). Challenges Ahead-Water quality and Human Health, Proc. Sec. Internat. Symposium 15-16, March, 2013, Peradeniya Sri Lanka p. 32

[58] Reynolds, C.S. (1986). The ecology of freshwater phytoplankton Cambridge University Press. 284 pp

[59] L. Zubair, El Nino-Southern oscillation influences on rice production in Sri Lanka. International Journal of Climatology, vol., 22: 249-260, 2002.

[60] M. Tolotti, Phytoplankton and littoral epilithic diatoms in high mountain lakes of the Adamello-Brenta Regional Park and their relation to trophic status and acidification risk. Journal of Limnology vol. 60: 171-188, 2002.

[61] W.C. de Lima, M. Marins and J.G. Tundisi (1983). Influence of wind on the standing stock of Melosira indica (Ehr.) Kutz. Revta. Bras. Bioliologie, vol.,43: 317-20.