DIVERSITY OF CHLOROPHYCEAE IN THE KLING AREA OF RI-BHOI DISTRICT, MEGHALAYA

Bobita Ray[1*], Ranee Das[2]
[1]*Biofuel Research Laboratory, Department of Microbiology, School of Life Sciences, Central University of Tamil Nadu, Thiruvarur, Tamil Nadu, India*
[2]*Department of Botany, University of Science and Technology Meghalaya, Ri-Bhoi, Meghalaya, India*
*For correspondence. (raybobita92@gmail.com)

Abstract: The present study deals with the diversity of algal flora under the class Chlorophyceae, location selected in Kling area of Ri-Bhoi district, Meghalaya. The experiment was conducted from the month of August, 2016 to May, 2017. In this advancing generation, these species made great impact ecologically as well as economically around the world. The species collected were observed and identified under the microscope. Accordingly its pH, temperature, habitats and species found in particular season were all recorded. A total of 25 species with 14 genera and genus Spirogyra leading with 5 species was found. In case of seasonal variation, more number of species were especially observed during the spring season compared to others. Hence, this study will help in leading other necessary experiments to continue in the future and also conserve the Chlorophyceae and other algal diversity in this region.

Keywords: Chlorophyceae; Algae; Meghalaya; Seasonal variation; Diversity

1. Introduction:

Globally, algal diversity is filled with richness in biodiversity at any corner of habitat and mode of temperature. These species consists of no true roots, stems and leaves having motile or non-motile unicellular or non-unicellular forms basically pointed as thallophytic in nature [1]. These algal species of Class Chlorophyceae is the photosynthetic eukaryotic species known to be rich in chlorophyll. Due to its abundance presence of chlorophyll pigmentation it is also named as Green algae referring as fundamental importance [2]. Michael D. Guiry [3] have stated in his journal that Chlorophyceae contains 2292 species according to 2012 data and more are yet to be estimated.

Chlorophyceae are ubiquitous, from the region of Arctic to Antarctic, its growth is found in all the kinds of habitats. Since these algae has the capability of producing their own food as similar to the mechanism of plants, these species are diverse group of autotrophic organism. In aquatic ecosystem, these species are beneficial as primitive sources of food for aquatic organisms [4]. It is known nutrients are the main factor for the growth of algae and basically depends upon the sources such as phosphorous, carbon, nitrate, sulphate, salinity with other trace elements as well as sunlight, pH and water. From the ongoing researches, Chlorophyceae has the capability of bioremediation process in waste and polluted water, since these contains the necessary elements to grow algae. Chorella sp. is known to be common in removing pollutants from wastewater as well as for the production of biofuel [5].

Acknowledging the importance of Chlorophyceae in this advancing time and having higher scope from these species, a study was carried out investigating based on the diversity of algae under the mentioned taxonomical class by observing characteristics of their morphological occurrence, distribution and habitats processing with the identification of the available species belonging to Class Chlorophyceae of Ri-Bhoi district Meghalaya, India, from the duration of mid-summer of 2016 till mid-summer of 2017.

2. Materials and Methods:

The location of the Kling area under Ri-Bhoi district was selected for the experiment that lies in the state of Meghalaya, India. The selected district is bounded in the North by the Kamrup district of Assam, East by the Karbi Anglong district of Assam, South by the East Khasi Hills and West by the West Khasi Hills district. It has

got three blocks namely, Umling , Umsning and Jirang. Ri-bhoi district is well connected with Guwahati and Shillong by the NH40.

The experiment was mostly conducted from August month of 2016 till May month of 2017 in and nearby neighboring sites of Kling area within the district. The materials preferred during the collection of the specimen are the usual necessary collection equipments such as specimen bottle or polythene bags, knife, scalpel, blade, forceps were used. Digital pH meter, thermometer, ocular lens, digital camera, and microscopes were also included. During field survey, specimens were collected very carefully so as not to destroy any of the delicate parts.

For the preservation process of specimens after cleaning, the fraction of the samples was preserved in 2% formaldehyde in sterilized bottles for further study and reference. In order to observe under microscope in microscopic slide the samples were stained with safranin and then mounted with 2% glycerin. Magnification of microscope for the observation of specimen was 40x X 15x and 10x X 15x magnification were adjusted into it. In order to identify the collected specimens, measurements of the specimens were done with the help of ocular lens such as the length, breadth, diameter of the vegetative as well as reproductive structure, thickness of cell and sheath for taxonomical study. Photographs were taken from the microscopic slides with proper magnification and recorded well.

Fritsch classification (1935) has been followed in arrangement of classes, families, orders and genus. However, in arranging the genera and species, alphabetical orders have been followed. Laboratories from Department of Botany of USTM were used during this research.

The distributional pattern of algae was studied by the total number of algal species under each genus available area wise within the Ri-Bhoi district. Hence, its relative frequency (Rf) table was calculated by the formula:

$$\text{Rf} = \frac{Y}{X} \times 100$$

where, X= total no. of algal sp. available in Kling area within Ri-Bhoi district
Y= total no. of algal sp. of each of different genera in Kling area within Ri-Bhoi district

3. Taxonomic Enumeration:

The identification and the details of the investigated species under the class Chlorophyceae is already shown in tabular form (Table 1.) and the details along with the photographs are arranged accordingly in the given numbered Fig. 1 to Fig. 25.

Fig: 1. *Chlamydomonas angulosa* O. Dill.
Cells broadly ovoid to cylindric, often truncated entirely and with a prominent papilla. Contractile vacuoles 2, below the flagella, which are as long or as slightly longer than the cell body. Chloroplast are a massive parietal cup with a large angular pyrenoid in the base; pigment spot anterior and lateral. Cells 10.5 µm in diameter. Habitat-Moist soil; pH-5.85; Temp-24.5°C

Fig: 2. *Chlorella vulgaris* Beyerinck.
Cells small, spherical, thin walled; solitary or in groups of four to sixteen cells; cells 7.5 µm in diameter. Habitat-Attached to the ditches wall; pH- 7.5; Temp-20.3°C

Fig: 3. *Ankistrodesmus septatus* Oettli.
Diverse cells forms from a single culture. Bundle of numerous crescent-shaped, very slender cells. Cells fasciculate in irregular bundles composed of numerous individuals, which as the convexity of each is turned inwards diverse at each extremity of the bundle vary greatly in their compactness, as well as in the number of their cells. Habitat- Planktonic; pH- 6.4; Temp- 22.8°C

Fig: 4. *Microspora tumidula* Hazen.
Cells cylindrical or slightly barrel shaped; chloroplast is parietal, usually of uneven thickness; vegetative cell 12 µm broad and 21 µm long. Habitat- Benthic; pH- 7.4; Temp- 23.2°C

Fig: 5. *Leptosira Mediciana* Borzi.
Cells are elongated and barrel shaped; not encrusted cushions, threads are markedly torulose, cells contain a pale yellow-green chloroplast without a pyrenoid; biflagellate swarmers are here formed by simultaneous division of the protoplast of any cell, zoospores divide to form a number of aplanospores. Elongated cells are 5.4µm and spherical cells are 6µm broad; and cells ranges from 6-7µm long. Habitat-Damp and moist wall; pH- 7.2; Temp-26.8°C.

Fig: 6. *Trentepohlia torulose* Wildmann
Stratum thin, the filaments either being collected in small compact tufts or spreading forming a soft cushion, brown in colour. Vegetative filament torulose and brunched. Cells are ellipsoidal, subspherical and distinctly constricted at the cross walls. Cells are 24.8 µm in diameter and 30-35 µm long. Cell membrane is thin and usually smooth. Habitat- Attached to the ditches wall; pH- 7.5; Temp-20.3°C
Fig: 7. *Spirogyra sp*.
Filaments of cells are cylindrical, cells are coiled regularly, cells are 24µm broad and 102µm long. Habitat-Planktonic; pH-6.5; Temp-25.3°C
Fig: 8. *Spirogyra sp*.
Filaments are irregular in size, cells has no definite size; the coiled cells has vast gap within it, coiled cells are 18µm in broad and 21µm long. Habitat- Planktonic; pH- 6.7; Temp- 26.4°C
Fig: 9. Spirogyra fluviatilis Hilse.
Cells are 30-36µm broad and 105µm long; less chromatophores with 3-4 turns; end walls are plane. Habitat-Planktonic; pH-6.5; Temp-25.3°C
Fig: 10. *Spirogyra inflata* (Vaucher) Rabenhorst.
Vegetative cells 22.5 µm broad and 165 µm long after the time of fertilization. Aplanospore width is 12 µm and length 9 µm. Habitat-Planktonic; pH-6.4; Temp- 22.8°C
Fig: 11. *Spirogyra singularis* Nordstedt.
Cells are 24µm broad and 75µm long with plane end walls; few chromatophores making 3-7 turns. Habitat-Planktonic; pH-6.5; Temp-25.3°C
Fig:12. *Debarya desmidioides* West.
Presence of constrictions between the cells of the filaments; conjugations occurs, cells include 6µm of width and 12µm longer in cells. Habitat-Moist and damp rocks; pH- 6.3; Temp-26.6°C.
Fig: 13. *Mougeotia sp.*
Cells are constricted, barrel shaped size, filament width is 24µm, cell width 18µm and length 27µm; tip part of the cell is slightly curved with broad 21.6. Habitat- Attached to rocks on slightly running water; pH- 6.5; Temp-26.6°C
Fig: 14. *Mougeotia robusta* (De Bary) Wittrock
Vegetative cells are 30µm broad and 150µm long, chromatophores 10-20 irregularly distributed pyrenoid; sporangia not dividing even gamentangia; zygotes ovoid to subglobose, 35-41 x 47-58 µm, spore wall brown in colour. Habitat- Planktonic; pH- 6.4; Temp- 22.8°C
Fig: 15. *Netrium sp*
Cells not constricted, oblong and elongated, cell wall smooth, cell width 9.6µm and cell length 27µm near apices breadth 7.5µm. Habitat- Moist and damp rocks; pH- 6.3; Temp-26.6°C.
Fig: 16. *Netrium sp.*
Cells 2-3 times longer than the broad, generally large, length 136.5µm, width 57µm, the tip part gets narrower in size with 9-12µm broad. Habitat- Attached to the ditches wall; pH- 7.5; Temp-20.3°C
Fig: 17. *Roya obtusa* var. Montana West & G.S West
Cells 9.6 x 36µm, cylindric, 6 times longer than the broad, very slightly curved; apices obtusely rounded, chromatophores with an eccentric notch at the center; pyrenoids 6-8. Habitat- Moist and damp rocks; pH- 6.3; Temp-26.6°C.
Fig: 18. *Closterium acerosum* Ehrenberg
Cells 195µm long, 36µm broad, 5-6 times longer than broad, slightly curved, cells are smooth, attenuated at the poles; contains sixteen pyrenoids. Habitat- Attached to the ditches wall; pH- 7.5; Temp-20.3°C
Fig: 19. C. *lunula(Müll.) Nitzsch*
Cell wall is thick, colourless; cells solitary without median constriction, cells not curved almost straight, 6-7 times longer than cell; inner margin generally straight and very slightly tumid in the median part; 34.5µm broad in size and 195µm longer in cells; apices gradually and gently narrowed. Habitat- Attached to the ditches wall; pH- 7.5; Temp-20.3°C
Fig: 20. C. *Strigosum Bréb*
Cells of moderate size, slightly curved, gradually attenuated to the apices, chloroplasts with a central row of 7 or 8 pyrenoids, 12µm of broad and 60µm of long. Habitat- Attached to the ditches wall; pH- 7.5; Temp-20.3°C
Fig: 21. *Cosmarium davidsonii* J. Roy & Bissett
Cells rather more hexagonal; sides of semicells straighter, apical cells rounded, minute granules present; 24µm length, 12.3µm broad in size. Habitat- Moist and damp rocks; pH- 6.3; Temp-26.6°C
Fig: 22. C. *javanicum Nordst*
Cells consists of 21µm long, 10.5µ broad size. Its orange-yellowish colour. Habitat- Attached to the ditches wall; pH- 7.5; Temp-20.3°C

Fig: 23. *C. moniliforme* (Turp.) Ralfs. (a & b)
Cells small about twice as long as broad, deeply constricted, sinus widely open, but usually acute; semicells circular or subcircular. Length 21µm and breadth 13.5µm. Habitat- Planktonic; pH- 7.2; Temp- 28.3°C
Fig: 24. *C. paragranatoides Skuja*
Cells are greenish in colour; 33µm long and 15-18µm broad size. Habitat- Attached to the ditches wall; pH- 7.5; Temp-20.3°C
Fig: 25. *Euastrum sp.*
Cells are flattened, pale greenish or bluish in colour. Frond oblong, cells compressed; apical and lateral incisions shallow; length 52µm, broad size 21µm. Habitat- Moist and damp rocks; pH- 6.3; Temp-26.6°C.

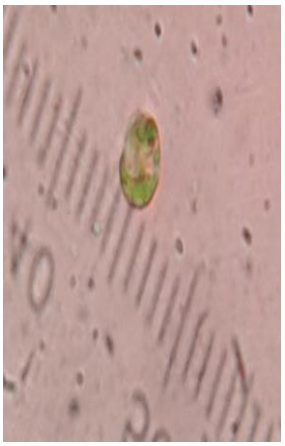
Fig 1. Chlamydomonas angulosa

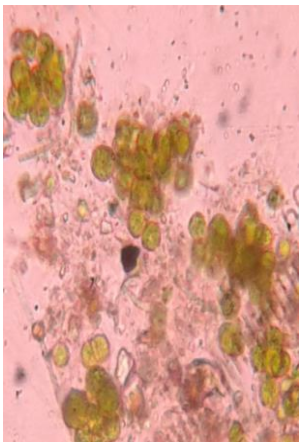
Fig 2. Chlorella vulgaris

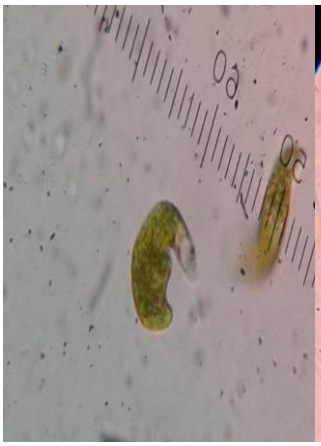
Fig 3. *Ankistrodesmus septatus*


Fig 4. Microspora tumidula

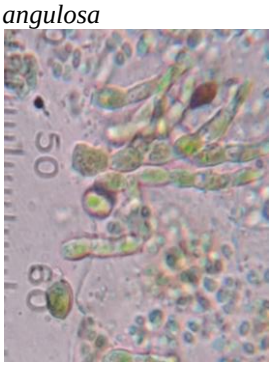
Fig 5.Leptosira Mediciana


Fig 6.Trentepohlia torolusa

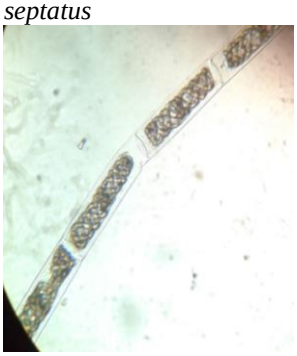
Fig 7. Spirogyra sp.


Fig 8. Spirogyra sp.

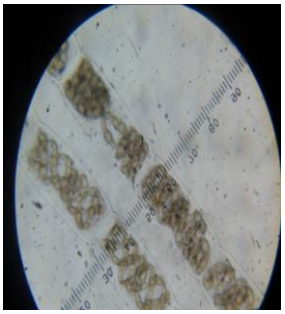
Fig 9. Spirogyra fluviatilis

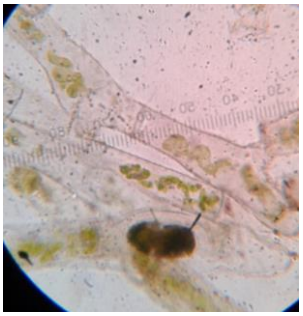
Fig 10. S. inflata conjugating stage


Fig 11. S. singularis

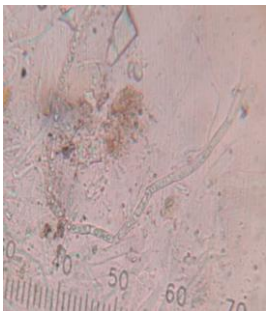
Fig 12. Debarya desmidioides

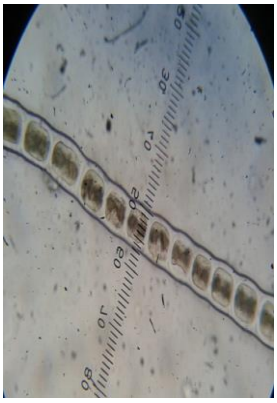

Fig 13. Mougeotia sp.

Fig 14. M. robusta

Fig 15. Netrium sp

Fig 16. Netrium. sp

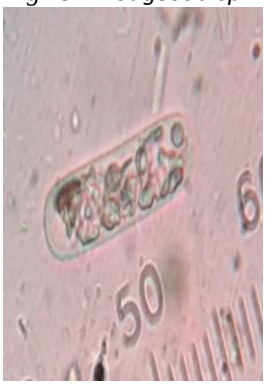

Fig 17. Roya obtusa var. Montana

Fig 18. Closterium acerosum

Fig 19. C. lunula

Fig 20. C. strigosum

Fig 21. Cosmarium davidsonii

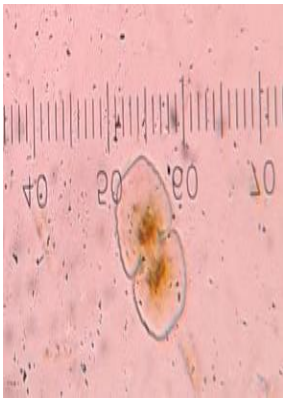

Fig 22. C. javanicum

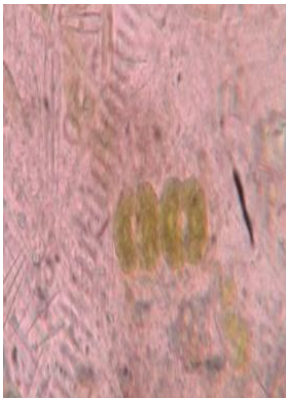

Fig 23(a). C. moniliforme

Fig 23(b). Conjugating stage of C. moniiforme

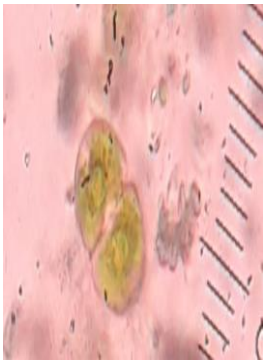

Fig 24. C. paragranatoides

Fig 25. Euastrum sp.

Table 1: Taxonomic Enumeration of the investigated species under Chlorophyceae.

Class	Order	Family	Genus	Species
CHLOROPHYCEAE	1.Volvocales	1.Chlamydomonaceae	*1.Chlamydomonas* Ehrenberg	*1.Chlamydomonas angulosa* O. Dill
	2.Chlorococcales	2.Chlorellaceae	*2.Chlorella* Beijerinck	*2.Chlorella vulgaris* Oettli
	3.Chaetophorales	3.Selenastraceae	*3.Ankistrodesmus* Corda	*3.Ankistrodesmus septatus* Oettli
	4.Ulotrichales	4.Microsporaceae	*4.Microspora* Thuret	*4.Microspora tumidula* Hazen
	5.Trentepohliales	5.Trentepohliaceae	*5.Leptosira* Borzi	*5.Trentepohlia torulosa* Wildman
			6.Trentepohlia Martins	*6.Trentepohlia mediciana* Borzi
	6.Zygnemales/Conjugales	6.Zygnemaceae	*7.Spirogyra* Link	*7.Spirogyra sp.* *8.Spirogyra sp.* *9.S. fluviatilis* Hilse *10.S. inflate* Vaucher 11.*S. singularis* Nordt.
			8.Debarya Wittrock	*12. Debarya desmidioides* West.
		7. Mougeotiaceae	9.*Mougeotia* Agardh	*13.Mougeotia sp.* *14.M. robusta* (De Bary) Wittrock
		8. Desmidiaceae	10.*Netrium* (Nageli) Itzigsohn & Rothe	*15.Netrium sp.* *16.Netrium sp.*
			11.*Roya* West	*17.Roya obtuse var. Montana* West & G.S. West
			12.*Closterium* Nitzsch	*18.Closterium acerosum* (Schrank) Ehrenb. *19.C. lunula* Nitzsch. *20.C. Strigosum* BREB.
			13.Cosmarium Corda	*21.Cosmarium davidsonii* J. Roy *et.* Bisset *22.C. javanicum* Nordst *23. C. moniliforme* Ralfs 24.*C. paragranatoides* Skuja
			14.Euastrum Ehrenberg	*25. Euastrum sp*

Table 2: Relative Frequency Distribution of Class Chlorophyceae

Sl. No.	Name of Genus	No. of species found	Relative frequency of species (%)
1	*Chlamydomonas*	1	1.11
2	*Chlorella*	1	1.11
3	*Ankistrodesmus*	1	1.11
4	*Microspora*	1	1.11
5	*Leptosira*	1	1.11
6	*Trentepohlia*	1	1.11

7	*Spirogyra*	5	5.55
8	*Debarya*	1	1.11
9	*Mougeotia*	2	2.22
10	*Netrium*	2	2.22
11	*Roya*	1	1.11
12	*Closterium*	3	3.33
13	*Cosmarium*	4	4.44
14	*Euastrum*	1	1.11

Table 3: Occurrences of growth pattern of algal species in different seasons of Kling area

Sl. No.	Name of species	Autumn	Winter	Spring	Summer
1	*Chlamydomonas angulosa*	-	-	+++	++
2	*Chlorella vulgaris*	+	-	+++	+++
3	*Ankistrodesmus septatus*	++	-	+++	++
4	*Microspora tumidula*	+++	+++	-	-
5	*Leptosira Mediciana*	-	-	+	-
6	*Trentepohlia torolusa*	-	-	++	-
7	*Spirogyra sp.*	+++	+++	+	-
8	*Spirogyra sp.*	+++	+++	+	-
9	*S. fluviatilis*	+++	++	-	-
10	*S. inflata*	-	+	++	-
11	*S. singularis*	++	++	-	-
12	*Debarya desmidioides*	+	-	-	-
13	*Mougeotia sp.*	+++	++	-	-
14	*M. robusta*	-	-	+	++
15	*Netrium sp.*	++	+	+	-
16	*Netrium sp.*	-	++	+	-
17	*Roya obtusa var. montana*	++	++	-	-
18	*Closterium acerosum*	-	+++	++	+
19	*C. lunula*	-	+	+	-
20	*C. Strigosum*	-	+	++	-
21	*Cosmarium davidsonii*	++	-	-	-
22	*C. javanicum*	-	-	+++	+
23	*C. moniliforme*	-	-	+	-
24	*C. paragranatoides*	-	-	+	-
25	*Euastrum sp.*	-	-	+	+

"-"Absence of species "+" Scanty growth "++" Less dominant "+++" More dominant

4. Results and Discussions:

During the investigation of diversity of Chlorophyceae species, occurrence, distribution, dominance and species diversity were all studied deeply. Including pH and temperature were even studied from all the collected specimen habitats. The relative frequency given in Table 2 were shown in details about the genus Spirogyra > Cosmarium > Closterium and so on. The area of Ri-Bhoi district, Meghalaya has vast diversity of algae. Already few researchers have collected the algal specimens and recorded it from different areas of Meghalaya [6,7].

Total 25 number of species were found along with 6 order, 8 family and 14 genus. Habitats are generally found from moist soil, ditch, planktonic, surface of damp or submerged rocks. The pH were ranged from 5 to 8 and temperature were in between 20°C-26°C. In this survey, the occurrence of algal species in a particular habitat was given importance because algal growth in these habitats influenced the ecosystems. From the number of species found in planktonic habitat it was observed higher efficiency of algal diversity in water bodies.

The distribution patterns of the species were also considered to see the occurrence in seasonal variation. In Table 3, pointing the four seasons i.e. Autumn, Winter, Spring and Summer, the species name are shown in details about the dominance and less occurrence of species in all the four seasons.

5. Conclusions

During the one year period of research experiment in Kling area, Ri-Bhoi district, Meghalaya undoubtedly, have found widespread of species during the survey work. Since, the climate condition in this region is mostly suitable in dense algal growth, it has vast abundance of diversity. After the investigation, a total of 25 species, 6 order, 8 family and 14 genus were observed under the class Chlorophyceae. Spirogyra showed the highest number of genus with 5 different species. Temperature maximum was till 26°C and pH ranged 5 to 8 of their habitat growth. Occurrence in their seasonal growth was mostly found dominate in spring season of Kling area. Thus, from the above details, we can conclude Meghalaya offers high and vast diversity of algal species and are yet to explore more and uncover new discoveries from each corner of this region. These species are beneficial not only in ecological side of way but also through economical and commercial point.

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