Result and Discussion

Present work was carried out during August 2006 – March 2008. Aim of this work was to screen various localities in the district for charophytes, locate various spots for the collection of charophytes, correct identification of the taxa collected and work out the chromosome number in some species. During our collection it was found that the district, on the basis of the geography and climate can be divided into two zones. The western side comprises ranges of Sahyadri and approaches the Western ghat while eastern side is with rain shadow and drought prone area. Numbers of localities were identified and collections were made during all possible seasons. (See Table No.17)

Table 17, Species collected from various localities and their zone wise distribution

Sr.No.	Name of Species	Locality	Climatic zone
1	*Chara vulgaris* var.and f. *gymnophylla*	Mhaswad, Rajewadi, Degaon, Rahimatpur	Eastern
2	*Chara globularis* var. and f. *globularis*	Mhaswad, Khatav, Rahimatpur, Aundh	Eastern
3	*Chara zeylanica* var.*zeylanica* f. *elegans*	Pateshwar, Bhartgaon, Angapur	Eastern
4	*Chara braunii* f. *kurzii*	Vairatgadh fort	Western
5	*Chara socotrensis* f. *pashanii*	Kavathe, Ozarde, Medha, Godoli Parali. Pateghar, Pateshwar, Jarandeshwar, Kanher Rajewadi, Masur Urmodi Dam, Shendre	Eastern and Western
6	*Chara socotrensis* f. *nuda*	Pateghar, Urmodi Dam, Godoli	Eastern and Western
7	*Nitella gracilis* f. *minuta*	Pateghar, Godoli	Eastern and Western

Our main aim in the study was to enumerate the chromosome number of collected species, discuss and correlate them with the earlier reports from various parts of our country (See table no.18).

Table 18, Chromosome number determined

Sr.No.	Name of Species	Chromosome No	Plate No
1	*Chara vulgaris* var.and f. *gymnophylla*	14	III, XVII
2	*Chara globularis* var. and f. *globularis*	14	V
3	*Chara zeylanica* var.*zeylanica* f.*elegans*	42	VII
4	*Chara socotrensis* f. *pashanii*	14	XII, XVII
5	*Chara socotrensis* f. *nuda*	14	XIV, XVII
6	*Nitella gracilis* f. *minuta*	9	XVI, XVII

Khan and Sarma (1981) based on their extensive studies on distribution and cytology of charophytes in India concluded that Indian charophyte represents about 31% of world flora of charophytes. The world flora of charophytes constitutes about three hundred twenty species of which eight are reported from all the parts of world. The distribution of charophytes is in between 69^0 North to 49^0 South. Of the five continents, Asia constitutes largest number of charophytes, about one hundred twenty eight species. Of these one hundred twenty eight species about one hundred fifteen are present exclusively in India while European charophytes consist merely sixty eight species. The comparison of European and Indian charophytes shows that only twenty one species are common in Europe and India .Of the world charophytes about two hundred fifty species are said to be endemic. The study shows that large numbers of endemic species were confirmed to Australia.

Table19. Shows comparison between Indian charophytes represent in other parts of world.

Sr. No.	Nature	Number	Percentage (In India)	Chromosome numbers restricted in India
1	Cosmopolitan	8	7 %	N - 15
2	Sub cosmopolitan	25	21 %	C -14, 49; N - 29, 36
3	Indo - African	41	37 %	C - 24, 28, 49; N - 36
4	Indo – American	43	38 %	C - 8, 49; N - 24, 36
5	Indo – Australian	13	11 %	C - 37, 49; N - 15, 36
6	Indo – European	21	18 %	C - 49; N - 36
7	Indo – Pacific	52	46 %	C - 28, 35, 49; L-14; N -21,27
8	Endemic	17	14 %	C-7,14,28; Lych.-14; N-5, 18, 26

C = *Chara* L. = *Lamprothamnium*

Lych = *Lychnothamnus* N = *Nitella*

Compared with the observation on taxonomy and cytology of Indian charophytes and that of our area it may be concluded that large number of species in our area are diploid, only one viz *Chara zelyanica* f. *elegans* showed polyploidy (n= 42). Out of the seven species observed and studied six species belonged to genes *Chara* and one to *Nitella*, three were ecorticate. Two species of *Chara* viz *Chara socotrensis* and *Chara braunii* were ecorticated. All were incrusted with deposition of calcium carbonate, *Chara braunii* and *Nitella* only were with annular incrustation.

Survey of chromosome number of charophytes from various parts of world reveals range of euploidy along with occasional unuploids.

Table 20 shows overall range of chromosome number in six genera of charophytes.

Sr.No.	Name of genus	Chromosome Number reported
1	*Chara*	n = 7, 14, 28, 35, 42, 49, 56, 70
2	*Nitella*	n = 6, 9, 12, 15, 18, 21, 24, 27, 36, 43
3	*Lychnothamnus*	n = 14, 28,
4	*Nitellopsis*	n = 14
5	*Tolypella*	n = 9, 12, 15, 33, 42
6	*Lamprothamnium*	n = 14, 21, 23, 42

The survey of literature shows that chromosome studies in charophytes from Maharashtra have revealed a few reports mainly in *Chara*. The chromosome number reported in *Chara* are n=14, 28 and in *Nitella* chromosome number reported is n = 18. Our studies have revealed a new report of chromosome number of species of *Chara zeylanica* f. *elegans* n = 42. The observation on chromosome number of *Chara socotrensis* f. *pashanii* is the confirmation of earlier report (Karande V. C. and B. B Chagule, 1998) while the chromosome numbers of *Chara socotrensis* f. *nuda*, *Chara vulgaris* f. *gymnophylla* and *Chara globularis* f. *globularis* are being reported for the first time from Maharashtra.

The morphological characters of *Chara zeylanica* f. *elegans* as described by Wood and Imahori (1965) and that of our specimen revealed that all the characters except the dimensions of bracteoles are similar. The bracteoles in our specimens are smaller than mature oogonium. Two reports from India so far on chromosome number of *Chara zeylanica* f. *elegans* have been published. One by Ramjee and Sarma (1971) who claimed chromosome number to be n = 28 and other by Ahmad and Sinha (1973) whose report

claimed the chromosome number to be n = 42. Our observations support the Ahmad and Sinha's observations supporting the chromosome number n = 42. Though the species *Chara zeylanica* has been considered species a par, our study area showed fewer localities of distribution of this species. The form described by Ahmad and Sinha more or less coincides with that of ours. In Satara district distribution of this species is limited to the plains in eastern parts of district. The occurrence of *Chara zeylanica* f. *elegans* has been marked specially at foot hills of Sahydhri ranges. The earlier observations of this species revealed the giantness because of the longer internodes and heavy incrustation. However, our specimens were moderate in size but with heavy incrustation.

Chara globularis as conceived by Wood and Imahori (1965) as a macrospecies forms complex of species of *Chara* namely *C. setosa, C .vulgaris, C. zeylanica* etc. The thorough studies on cytology have revealed that number of polyploid forms exist in *C.globularis* complex. Khan and Sarma (1981, 82, 84) established cytogeographic assessment of charophytes. They considered distribution of around hundred taxa belonging to six genera of charophytes from India. They divide charophytes into eight distinct sections on the basis of ploidy level. These sections were named as cosmopolitan, sub cosmopolitan, Indo – American, Indo – African, Indo – Australian, Indo – European, Indo – Pacific and endemic. According to Khan and Sarma two macro species viz. *C. globularis* f. *virgata* and *C.globularis* v and f.*virgata*. *C. globularis* complex having treated as cosmopolitan due to the higher ploidy level, where as forma *leptosperma*, forma *aspera*, forma *strigosa*, and forma *connivens* having grouped as subcosmopolitan. They have also calculated the frequency of chromosome numbers in charophyta and observed highest frequency in Bihar and Uttar Pradesh. All these studies indicate the cosmopolitan distribution of *C. globularis* all over the world due to their considerable range in polyploidy. Table 21, shows chromosome numbers in *Chara globularis* complex

Table No. 21 Chromosome number in Chara globularis complex

Name of the micro species	Name of the taxon	Chr. Number	Authors
C. globularis. Thuill	*C. globularis* f. *globularis*	42 24 28	Tindall 1966 Gillet 1959, Guerlesquin 1967 Verma 1985
C. connivens Salzm.	*C. globularis* f. *connivens*	28	Bhatnagar and Johri 1987
C. capensis (Meyer ex Kutz.)	*C. globularis* f. *capensis*	28	Bhatnagar and Johri 1987
C. virgata Kutz.	*C. globularis* f. *virgata*	14 28	Ramjee and Sarma 1971 Chatterjee 1975, Khan and sarma 1967
C. fragilis Desv.	*C. globularis* v. *virgata* f. *varigata*	24 28	Guerlesquin 1967 Sarma and Khan 1965,Chatterjee 1971, Bhatnagar 1981
C. delicatula (Ag.)	*C. globularis* f. *varigata*	14 28	Sarma and Khan 1965, Sinha and Noor 1971,Ramjee and Bhatnagar 1978, Khan and Sarma1967 Chatterjee 1971
C. delicatula (Ag.) A.Br.	*C. globularis* v. *varigata* f. *brabata*	21	Bhatnagar and Johri 1987
C. leiopitys Wheld	*C. globularis* v. *varigata* f. *leiopitys*	14	Sarma and Khan 1967
C.chrysospora J. Gr. and Steph.	*C. globularis* v. *varigata* f. *chrysospora*	28	Ramjee and Sarma 1971
C. fischeri Mig.	*C. globularis* v. *varigata* f. *fischeri*	14	Ahmed and Sinha 1973
C. leptosperma A.Br.	*C. globularis* v. *leptosperma*	14 28	Ahmed and Sinha 1973 Ramjee and Sarma 1971, Chatterjee 1971
C. aspera deth.ex Willd.	*C. globularis* v. *aspera*	14	Tindall 1966, Proctor 1971
C. strigosa A. Br.	*C. globularis* v.*aspera* f. *atrigosa*	28	Ahmed and Sinha 1973

The table 21 shows that var.*virgata* is quite frequent in Indian subcontinent while var. *globularis* is restricted to European and North American countries. Wood and Imahori (1965) made the revision of most of the microspecies and preferred merger of some species. In case of *C. globularis* there is wide merger of different microspecies. The problem of merger of species has been discussed by Khan and Sarma and they correlated it with morphological characters. Khan and Sarma emphasized two characteristic features namely tylacanthous and aulacanthous nature rather than chromosome number. On the other hand Ramjee (1969) and Bhatnagar (1981) did not favour the aulacanthous and tylacanthous nature of species but considered chromosome number for the merger. The above Table No.21 shows basic chromosome number for the *globularis* is not same but presence of n = 8 is also a common feature. The basic chromosome number in the genus *Chara* as suggested by Bhatnagar (1983) is n = 7, but Guerlesquin (1984) suggested that the occurrence of n = 7 and 8 for the genus *Chara* is also of frequent nature

As discussed earlier the Satara district can be divided into two climatic zones. Of these the western hilly parts reveals the abundance of ecorticated species of *Chara* viz *C. socotrensis* f. *pashanii* and *C. socotrensis* f. *nuda*. Khan and Sarma have opined that *Chara socotrensis* f. *nuda* has been reported only from India and Burma while f. *pashani* restricted to India and Malaysian country. Our efforts were to identify the chromosome number in both the species. We could successfully carry out the cytology of both of them and found the chromosome number n = 14 in both of the species. The report on chromosome number of f. *nuda* is the first report from Maharashtra. A large number of variations in morphology have been found in f. *pashanii*. This may be because of environmental conditions where the plants grow. Usually the plants were collected along the periphery of pools and puddles or in the mud with ample water. On the other hand plants of forma *nuda* were seen growing submerged in water. Both of the forma were initially considered to be individual species (Pal et al 1962). The merger of two species into a single species viz. *socotrensis* can be justified not only on the basis of chromosome number but also on morphology. Very few characters differentiate them individually. Besides the geminate gametangia and length of branchlets there are no more differences according to Wood Imahori. Our observations after screening of large number of specimens revealed that there is tendency of forming corticated threads in *Chara socotrensis* f. *pashanii* (See Plate XI). The cortication thus may be said vestigial or

imperfect but definitely there is tendency of cortication in these plants. *Chara pashanii* was originally described by Dixit (1935) from a ditch at Pashan near Pune. After that Vaidya and Gonzalves (1963) made a report on the occurrence of the species from Aji river Gujarat. After Dixit a sole report of the species has been made by Chaugule and Patil (1992) from the foothills of Sinhagadh, an offshoot of Sahyadri and other localities. Khan and Sarma (1981) commented on this species as an endemic. However, our search of the charophytes along the western parts of Maharashtra has shown that the species occurs abundantly.

Chara socotrensis f *nuda*, studied in the present investigation was originally described from Burma by Pal (1932) as a distinct species viz. *Chara nuda*. Later collections of this species were made from different parts of India but variable characteristics of the species have been recorded. Sinha and Verma (1970) and Ramjee and Sarma (1971) reported chromosome number, n=14 in populations of this species growing in Ranchi, Bihar and M. P.

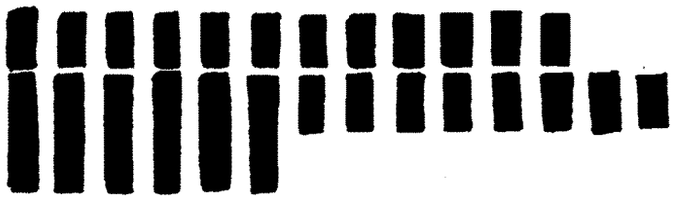
The species is reported to be endemic to India, Burma and Malaya (Khan and Sarma, 1981). In this forma Sinha and Verma (1970) and Sinha and Sinha (1972) showed the chromosome number n = 14. Chatterjee (1976) detected two cytotypes of this forma. One of these cytotypes showed n=28 chromosomes and other showed normal n = 14. Present material from Satara showed chromosome number n=14. The karyotype of the specimen is quite distinctive. Both forma *nuda* and *pashanii* of *C. socotrensis* are ecorticate and monoceious species however; they differ morphologically in many respects from each other. In f. *nuda* stiopulodes are rudimentary and alternate while they are absent in f. *pashanii*. Bracts and bracteoles are also present in f. *nuda*, though it is ecorticated species, imperfect cortication is seen at nodal region of some specimens.

A comparison between the Mecheda specimen and our specimen shows correlation both in form and karyotype. The Mecheda specimen (n = 28) showed large size and presence of distinctly developed stipulodes while our specimen shows smaller size and rudimentary stipulodes. The comparison between karyotype of two specimens showed that only half of the compliment is represented in the Satara specimen. The presence of four long, eight medium and two short chromosomes represent half compliment of Mecheda specimen. It gives a clue regarding the lineage of the two specimens but distributed to distinct localities. Further investigations in this regard are needed.

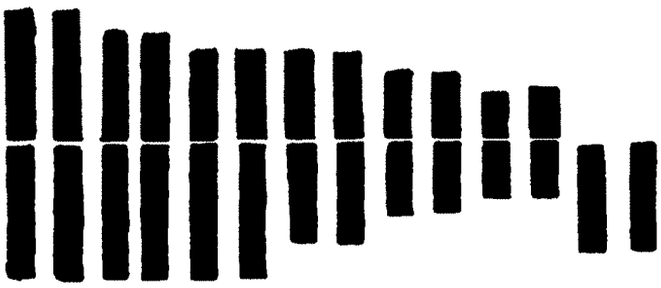
Table 22, Comparison between different forma of *Chara socotrensis*

No	characters	f. *socotrensis*	f. *fulgens*	f. *pashanii*	f. *nuda*
1	Habit	Monoecious,5cm.high	Dioecious,11 (-30)cm high	Monoecious, 4 – 15 cm long	Monoecious, 3 – 12 cm
2	Axes (diameter)	C 450µm	320 – 1000µm	Slender, stout 234 – 460 µm	293 – 410 µm
3	Internodes	About 1 times as long as branchlets	----------	0.5 – 2 cm shorter than branchlet	0.3 – 0.7 cm. Nearly equal or longer than branchlets
4	Stipulodes	In 1 tier, alternate, 1 – 2 times as numerous as branchlets	Obscure ,alternate	Rudimentary in 1 tier.	1 tier rudimentary
5	Branchlets				
	Number	10 – 12 in a whorl,	4 (-8)in a whorl	10 – 12 in a whorl	7 – 9 in a whorl
	Length	0.9 cm long	2.0cm long	0.7 – 2.5 cm long	0.3 -0.9 cm.
	Segments	5 – 6	4 – 6	2 – 5	2 – 3
6	Bract cells	Unilateral, only at lowest nodes	(1-) 3 (-4) small acute	2 , only at fertile nodes	2, 146 – 190 µm long' 45µm wide.
7	Bracteoles	---------	---------	2, shorter or nearly equal to mature oogonium.	2
8	Gametangia	Conjoined at branchlet nodes	Solitary at 1 (-2) lowest branchlet nodes, absent from base of whorl	Conjoined, geminate at lower most 2 branchlet nodes.	Conjoined at lowest 2 branchlet nodes
9	Oogonia				
	Length	705 – 830 µm	c. 900µm	360 – 805 µm	513 – 777 µm
	Breadth	480 – 495 µm	----------	175 – 530 µm	245 – 513 µm.
	Convolutions	12 – 13	?	9	10 – 12
10	Coronula				
	Height	60 – 95 µm	c.170 µm	73 – 100 µm	88 – 147 µm
	Width	150 – 195 µm	180 µm	146 – 175 µm	175 – 250 µm
11	Oospore				
	Colour	Dark brown to black	Brownish black	Orange to black	Black
	Length	520 – 570 µm	c.380 µm to more	215 – 270 µm	513 – 586 µm
	Breadth	320 – 350 µm	c.300 µm to more	210 – 270 µm	293 – 498 µm
	Ridges	3 – 9	9 low	8 – 10	10
	Fossa	65 µm across	----------	58 µm	58 – 74
	Membrane	Minutely papillate	----------	Not seen	----------
12	Antheridia (diameter)	240 – 345 µm octoscutate	Immature	205 – 265 µm octoscutate	Solitary 263 – 293 µm Octoscutate

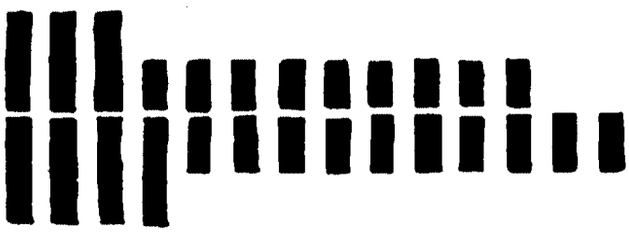
Plate -XVII



Idiogram of *Chara vulgaris* f. *gymnophylla*



Idiogram of *Chara socotrensis* f. *pashanii*



Idiogram of *Chara socotrensis* f. *nuda*

Idiogram of *Nitella gracilis* f. *minuta*

Dixit (1940) described *Chara nuda* with a distinct variety *kolhapurensis*. However, the characters of this variety do not allow us to identify as a separate variety and the inclusion of this variety into forma *nuda* by Wood and Imahori can be justified.

The species of *Nitella gracilis* as conceived by Wood and Imahori has a great variation in form and structure. It has a range of variations exhibited in different corners of world (Wood and Imahori 1964). It is difficult to distinguish and give the proper status to the species. Our specimen closely resembles with *Nitella gracilis f. minuta* as described by R.D.Wood (1965). There are some variations like the length and breadth of oogonium, height of coronula and the dimensions of the oospores. Our specimen is smaller in size, measuring up to 4 cms.

The chromosome number was reported by Lindenbein and Karling (1926) (n = 17). As the other species show higher chromosome number, our specimen shows haploid compliment n = 9. The classification of chromosomes and the karyotype shows variation from the other chromosome compliments of *Nitella gracilis*