بررسی سیتوتاکسونومیکی خزه های تیره Bryaceae درهیمالیای غربی (هندوستان)

Cytotaxonomic Studies in West Himalayan Bryaceae (Musci)

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کروموزومهای میوزی ۱۰گونه ازخزه های قائم (acrocarps) بـه اسـامی زیـر متعلـق بـه چهار جنس از تیره Bryaceae با تاکید برتکامل، پلی پلوییدی، ویژگیهای سیتولوژیکی و ارتـباط بین جنسها و گونه های مورد نظر تحت بررسی قرار گرفت:
Pohlia elongata (n=11), *Anomobryum cymbifolium* (n=10), *Brachymenium acuminatum* (n=10), *B. ochianum* (n=11), *B. sikkimense* (n=11), *Bryum cellulare* (n=10), *B. pseudotriquetrum* (n=10), *B. apiculatum* (n=10), *B. capillare* (n=10) *B. atrovirens* (n=10).

وقوع بیوالان چند شکلی (heteromorphic bivalent) و اهمیت آن در برخـی آرایـه هـا نیز مورد بحث قرار گرفته است. در این تحقیق مشخص شد کـه پلـی پلوییـدی نـه تنـها نقـش مهمی را درتکامل و ایجاد گونه های یک تیره ایفاء می نماید، بلکه به نظر می رسـد کـه جـهت مهاجرت/ بقای گونه ها در شرایط آب و هوایی متغیر و زیستگاههای گوناگـون نـیز یـک مزیـت محسوب می شود (به متن کامل انگلیسی مقاله مراجعه شود).

واژه های کلیدی: سیتوتاکسونومی، خزه، Bryaceae، هیمالیای غربی، هندوستان

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CYTOTAXONOMIC STUDIES IN WEST HIMALAYAN BRYACEAE (MUSCI)

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Abstract

The meiotic chromosomes of 10 species (*Pohlia elongata*, *Anomobryum cymbifolium, Brachymenium acuminatum*, *B. ochianum*, *B. sikkimense*, *Bryum cellulare*, *B. pseudotriquetrum*, *B. apiculatum*, *B. capillare* and *B. atrovirense*), in four genera of the family Bryaceae of acrocarpous mosses are studied with special emphasis on their evolution, polyploidy and cytological features with reference to interrelationship among the included genera and species. The occurrence of the heteromorphic bivalent in some taxa and its significance is also discussed. Polyploidy has played an important role in the evolution and speciation of the taxa in the family and seems to be an advantage for colonising/surviving in diverse climatic and habitat conditions.

Keywords: Cytotaxonomy, Moss, Bryaceae, West Himalaya, India

Introduction

The family Bryaceae comprises 17 genera and about 1330 species which are widely distributed throughout the world. Many of the species are cosmopolitan or show very wide distribution. Some species of *Bryum* are well represented in polar deserts where they form an important part of ecosystem. They are important as indicators of habitat associations.

BROTHERUS (1924) divided the family into three subfamilies, namely, Orthodontioideae, Mielichhoferioideae and Bryoideae, which was followed by NYHOLM (1958). OCHI (1959) agreed ANDREWS (1940) in dividing this family into two subfamilies i. e. Pohlioideae and Bryoideae. The cytological characteristics are helpful in assessing relationship and systematic placement of these two subfamilies.

Quite a large number of species (92 species in 12 genera) have been worked out (FRITSCH 1991). Most genera and species seem to be derived from the basic chromosome numbers x=10 and x=11. A large, rod-shaped, heteromorphic bivalent is reported in a number of taxa of this family. This bivalent always shows peripheral location and tendency to disjoin or agglutinate which points to its heterochromatic character. The heteromorphic nature in some, definitely establishes its role with sex.

Materials and Methods

The specimens studied were collected from various localities of Garhwal Himalaya, India (Table 1) during monsoon (July-Sept.) and fixed in 1:3 acetic-alcohol solution. The meiotic studies were made by squashing the sporogenous tissue in 20% acetocarmine (UNIYAL 1998). The photomicrographs were taken at a uniform magnification of x1900.

Table 1. Localities, altitude and chromosome numbers in the presently studied taxa of Bryaceae

Taxa	n	Locality(Garhwal Himalaya)	Altitude (m)
Pohlia elongata Hedw.	11	Rambara	2580
Anomobryum cymbifolium (Lindb.) Broth.	10	Jangal Chatti	2200
Brachymenium acuminatum Harv.	10	Guptkashi	1500
B. ochianum Gang.	11	Hemkund	4000
B. sikkimense Ren. & Card.	11	Bhyundar	2240
Bryum cellulare Hook.	10	Badrinath	3110
B.pseudotriquetrum(Hedw.) Schwaegr.	10	Kedarnath	3850
B. apiculatum Schwaegr.	10	Bhyundar	2240
B. capillare Hedw.	10	Hemkund	4000
B. atrovirense Brid.	10	Tryuginarayan	1900

Observations

Subfamily: Pohlioideae

***Pohlia elongata* Hedw., n=11** (Fig. 1A)

This taxon is morphologically very close to *P. longicollis* but differs cytologically (n=10,11,20,22,33-cf. FRITSCH 1991) in its genotype. The eleven chromosome complement in the present study, included three distinctly large bivalents. The course of meiosis was orderly resulting in normal tetrads. SMITH & NEWTON (1967), however, observed asynchronous disjunction of bivalents in the British and Irsish populations, but the distribution of bivalents at anaphase was normal. The chromosome number n=11 reported from different parts of the world for this species shows its conservative nature of all cytological features.

The genus *Pohlia* comprises 119 species divided into three sections, namely, *Cacodon*, *Eupohlia* and *Lamprophyllum*.

The section *Cacodon* (does not occur in south-east Asia) is not known cytologically so for. The chromosome numbers known for 11 species of the remaining two sections consistently display n=11 except a few (FRITSCH 1991). The occurrence of n=11 (13 taxa) or its multiple (5 taxa) and of n=10 (3 taxa) or its multiple (2 taxa), suggests that n=10 and n=11 were established early in the evolutionary history of this genus. YANO (1953), studied somatic chromosomes of two dioecious species (*P. faurieri* and *P. longicollis*) and found former species as haploid (n=11) and latter one as diploid (n=22). The presently studied taxon (n=11) is dioecious. Evidently, in this genus, there may be a strong correlation between sexual nature of the taxa and its cytological constitution.

Subfamily: Bryoideae

***Anomobryum cymbifolium* (Lindb.) Broth., n=10** (Fig. 1B)

this species is cytologically as well as morphologically very close to *A. auratum* (distinguished only by cymbiform leaves in *A. cymbifolium*). The ten chromosome complement included two relatively large size bivalents. A largest, peripherally located bivalent (presumably H-bivalent) disjoined precociously and 1-3

bivalents also showed a tendency towards earlier separation. KUMAR & BAKSHI (1972) also observed a large slightly heteromophic bivalent in this species.

Anomobryum comprises 53 species of which only six (*A. auratum*- n=10; *A. filiforme*-n=10; *A. filiforme* var. *concinnatum*-n=10; *A. cymbifolium*-n=10;*A. nitidum*-n=20; *A. japonicum*-n=10 and *A. subnitidum*- n=11, cf. FRITSCH 1991) are known cytologically. The chromosome number x=10 is predominent and regarded as the base number. The consistency of n=10 necessitates reinvestigation of n=11 in *A. subnitidium* (KUMAR *et al.* 1988) so as to see if the departure from n=11 is a real one.

Anomobryum has often been merged with *Bryum* by earlier authors (SCHIMPER 1836-1855, OCHI 1959 etc.), but the leaf areolation and habit are similar to that of Pohlioideae (ANDREWS 1940). The genus lacks in aneuploidy unlike that of *Bryum* and *Pohlia.* Polyploidy is also of rare occurrence.

***Brachymenium acuminatum* Harv., n=10** (Fig. 1C,D)

The material possessed a ten chromosome complement in which one bivalent was noticeably larger than others. Another bivalent (arrow) showed precocious disjunction but its disjonied complements were held together till late metaphase-I. The absence of dimorphic bivalent in this population indicates that the sex bivalent are in varying degree of differentiation (homomorphic to heteromorphic) in different populations of this species.

Morphologically, this species appears very close to *B. walkeri* from which it is distinguished by its slightly larger leaves and a narrower capsule at the apex. The cytological relationship of these taxa could not be commented as latter species is cytologically unknown.

***Brachymenium ochianum* Gang., n=11** (Fig. 1E,F)

Cytologically, this species is worked out for the first time. The eleven chromosome complement observed at first metaphase included six noticeably large bivalents. Three to four (sometimes eight) showed a tendency towards premature

separation. A large heteromorphic bivalent always occupies peripheral position (arrow).

***Brachymenium sikkimense* Ren. & Card., n=11** (Fig. 1G)

The present count (n=11) substantiates an earlier report (ANAND & KUMAR 1986), but differs from the reports of KUMAR & VERMA (1980b, 1981). The complement included three large bivalents as found in *B. acuminatum.* Of the two smaller bivalents, one disjoined precociously. OCHI (1959) considered it to be the same as *B. exile.* It, however, differs from the latter taxon in leaf shape, leaf areolation and the shape of the capsule. It also shows a close morphological similarity with *B. acuminatum.* It would be desirable to make a comparative study of the somatic chromosomes of *B. exile, B. acuminatum* and *B. sikkimense* in order to assess their cytological relationship.

The genus *Brachymenium* is represented by 170 species, widely distributed in tropical and temperate zones of the world.

The section *Peromnium* is not known cytologically. The available cytological data reported for 10 species (FRITSCH 1991) indicates that in *Dicranobryum* and *Orthocarpus* sections, the polyploids co-exist with the haploids while in the section *Leptostomopsis,* they are absent. The base number of this genus appears to be x=10.

The genus *Brachymenium* is closely related to *Bryum* in the morphology of the gametophyte but is differentiated by the erect capsules and reduced peristomes. The monographic and floristic study of OCHI (1959, 1974 and 1976) appears to suggest that both *Bryum* and *Brachymenium* may be polyphyletic, although many of the sections within each genus seem to be natural, presumably monophyletic groups.

***Bryum cellulare* Hook., n=10** (Fig. 1H)

The chromosome count (n=10) confirmed earlier reports (cf. FRITSCH 1991) based on West Himalayan populations of this species. Of the ten darkly-stained bivalents observed at first metaphase, one was conspicuously large, heteromorphic and disjoined precociously. Of the remaining bivalents, three were relatively larger than others. KUMAR & VERMA (1980a) also found a large heteromorphic bivalent in this species.

***Bryum pseudotriquetrum* (Hedw.) Schwaegr., n=10** (Fig. 1I)

The spore mother cells, compared with the preceding taxon, are smaller in size. Of the ten bivalents observed at first metaphase, one larger bivalent disjoined precociously. It showed slight heteromorphy and occupied peripheral position. Of the remaining bivalents, three were noticeably larger than others.

The earlier chromosome count of this species are: n=10, 11,12,20 (cf. FRITSCH 1991).

***Bryum apiculatum* Schwaegr., n=10** (Fig.1J)

The present counter (n=10), agrees with earlier reports (CHATTERJEE & GANGULEE 1970, KUMAR 1973, KUMAR & VERMA 1980a) for Indian populations. The complement included four relatively large bivalents of which one showed precocious disjunction. Two other medium size bivalents also displayed earlier separation.

PANDE & CHOPRA (1957) reported heteromorphic bivalent in this species but the others (and the present authors) failed to observe such kind of bivalents in their material.

***Bryum capillare* Hedw., n=10** (Fig. 1K)

This highly polymorphic, cosmopoliatan species is morphologically close to *B. atrovirense* from which it is distinguished by its relatively taller plants with spirally twisted leaves in dry condition.

It exists in several cytological forms (n=9,10,12,20,21- cf. FRITSCH 1991). In the material studied, ten bivalents were observed at metaphase-I. The complement included a large, precociously disjoined bivalent which consistently occupied peripheral position (presumably because of its heterochromatic nature). The disjoined components were not found to fall apart till late mataphase-I. The course of meiosis was normal.

It would be desirable to re-examine the material reported with n=10+2 m in order to rule out the possibility of two m-chromosomes as dissociated half-bivalents of the smallest bivalent.

Fig. 1. Meiotic configurations at metaphase- I.

A.*Pohlia elongata*-n=11. B.*Anomobryum cymbifolium*-n=10, note the largest precociously disjoined heteromorphic bivalent (bold arrow) and two other bivalents showing a tendency to disjoin precociously. C-D. *Brachymenium acuminatum.* C. n=10 showing precociously disjoined largest heteromorphic bivalent (arrow). D. Anaphase-I, showing 10 chromosomes at each pole. E-F. *B. ochianum*. E. n=11 at metaphase -I, note the precocious disjunction of 2-3 bivalents (arrow). F. Note the precociously disjoined heteromorphic bivalent (arrow). G. *B. sikkimense*-n=11. H. *Bryum cellulare*-n=10, note the precocious disjunction of the largest bivalent (arrow). I. *B. pseudotriquetrum*-n=10, note the largest heteromorphic bivalent (arrow). J. *B. apiculatum*-n=10, showing precocious disjunction in heteromorphic bivalent (arrow). K. *B. capillare*-n=10, note the largest heteromorphic bivalent (arrow). L. *B.atrovirense*-n=10,note the precociously disjoined largest heteromorphic bivalent (arrow).

***Bryum atrovirense* Brid., n=10** (Fig. 1L)

The ten chromosome complement included a conspicuously large, precociously disjoined heteromorphic bivalent as well as three other large size bivalents. ANAND & KUMAR (1986) also reported n=10 in a West Himalayan population.

The genus *Bryum,* represented by 690 species, is one of the largest and taxonomically difficult and puzzling genus.

Cytologically, the genus in known by 45 species. The chromosome numbers recorded in three subgenera formulated by BROTHERUS (1952) are: subgen. *Ptychostomum,* section *Euptychostomum*-n=10,15,20,27,30; subgen. *Bryotypus,* section *Cladodium*-n=10,20,30,40 and section *Eubryum*- n=10,11,12,20,21,22,24, 26,30,33.

In the subgenus *Bryotypus,* section *Eubryum*, the subsections *Areodictyon* and *Leucodontium,* showed a constant chromosome number n=10; subsections *Erythrocarpa* and *Alpiniformia* besides n=10, also showed its multiple (n=20), while subsections *Pseudotriquetra* and *Caespitobryum* showed n=10,11 and their multiple (n=20,22,33).

Fig. 2. Histogram showing distribution of chromosome numbers in *Bryum.*

The present data indicate that n=10 (52 taxa) and its multiple n=20 (23 taxa) is of most frequent occurrence followed by n=11 reported in 39 taxa (Fig. 2). The number n=10 and n=11 are found to co-exist in different populations of the same species. It appears that this genus is secondarily diabasic (x=10 and 11) and original base number, possibly x=5, has been lost during the course of evolution.

Discussion

The family Bryaceae is cytologically known by 92 species in 12 genera (cf. FRITSCH 1991).

The study of histogram (Fig. 3) showing distribution of chromosome numbers indicates that n=10 is the most common number (52 taxa) followed by n=11 (41 taxa). The lowest chromosome number n=6 (RAMSAY 1974), reported only once may have been lost in the present day forms or is still awaiting discovery in some other taxa. In this family particularly in the genus *Bryum*, polyploidy (40 taxa) and aneuploidy (28 taxa) appear to have played an important role in its evolution and speciation. Majority of the reported polyploids are supposed as autoploids, having arisen through apospory or unreduced spores. Polyploidy is often associated with

Fig.3. Histogram showing distribution of chromosome numbers in Bryaceae.

gigantism. WETTESTEIN (1942), however, observed that gigantism associated with experimentally raised polyploids in *Bryum* was lost in subsequent generations and the polyploid plants reverted back to their parental morphologiacl characters. The available data seems to suggest that polyploidy probably confers some selective advantage to such genera for colonising/surviving in diverse and extreme habitats.

The heteromorphic bivalent has been observed in many taxa of Bryaceae which is characterised by large size, heteromorphy and peripheral location during meiotic metaphase. ONO (1970) recognized two kinds of sex chromosomes (morphological and strucutral types) in mosses. The "x" and "y" chromosomes in morphological type differ in size (heteromorphy), while in structural type, these are homomorphic differing in amount and distribution of heterochromatin. The heteromorphic type of bivalent has evolved from the structural type as observed in *Bryum argenteum* and *B. cellulare* (UNIYAL 1998). RAMSAY (1966) stated that the presence of heteromorphic bivalents in numerous taxa coupled with phenotypic dimorphism associated with heteromorphic bivalents favours their being considered as the sex chromosome.

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بسسض é ض éت ç تآâض çوçهé âé ذش è èآé ت éس è Bryaceae
رس èéهآن éآé کسب é (èور çضتآو)

Cytotaxonomic Studies in West Himalayan Bryaceae (Musci)

ئسه نآن آçوéآن ç ضق éر ط éسشآر éآو
رآوط âرè مéآè طوآض é، رآوطمآè ر èن é ç بذط تدل éلآت سضتوèéآ، هçضض è تدل éلآت
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ذنآظ è

Anomobryum ; *Pohlia elongata*, n=11) è çوم 10 é شéçه éآè هçش çهçس â *B.* ; *B. ochianum*, n=11; *Brachymenium acuminatum* , n=10 ; *cymbifolium*, n=10 *B.* ; *B. pseudotriquetrum*, n=10 ; *Bryum cellulare*, n=10 ; *sikkimense*, n=11 هتقنـل ب è خè آس (*B. atrovirense*, n=10 ç *B. capillare*, n=10 ; *apiculatum*, n=10 حـــوض آش ت éس è Bryaceae هســـب çغ ب è ذش è éآè لآه (acrocarps) بـــآ تـــآéâر بست âآهن، ئن é ئن ééçر é، éçصمèéآé ض éت çن çص éâé ç آستبآغ ب éو حوض èآ ç مçوè éآè هçسر وفس تدت بسسض é لسآس مس àت.

çل çق ب çéآنآو خـور ط âن é (heteromorphic bivalent) ç آèهéت ءو رس بسـذé ءسآéè èآ وéش هçسر بدج لسـآس مـس àتè آضـت. رس آéو تـدل éل هطـذظ طـر èâ ئن é ئن éçéé رé وè تـوèآ ولـط هèهé سـآ رس ت âآهـن ç آéحـآر مçوè éآè ت éس è éâ آàéآأ هé وهآéر، بن èâ ب è وفس هé سضر èâ ح èت هèآحست/ بلآé مçوè èآ رس طسآéغ ءب ç ééçèآè هتک éس ç ش éضتمآèéآé مçوآمçو وéش éâ هش éت هدض çب هé ط çر (سح çق ط çر ب è هتو âآهن هلآن è ب è آومن éض é).

çآص è éآè â ن éر é: ض éت çتآâض çوçهé، ذش è، Bryaceae، ééهآن éآé کسب é، è ورçضتآو

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