THE PRESENT POSITION OF INDIAN HEPATICOLOGY WITH A NOTE ON THE HEPATIC VEGETATION OF THE COUNTRY[1]

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INTRODUCTION

IN 1936 the earlier researches in Indian hepatics were reviewed by one of the authors (PANDE, 1936) at the kind suggestion of the late Professor Birbal Sahni, F.R.S. Since then a number of workers have, through their investigations in the field of Indian bryology, contributed to our knowledge of these plants, so that today, after a lapse of more than a decade, it seems worth while once again to take a census of this work and see how far we have progressed.

India is a vast country. It extends from the tropics in the south to the temperate regions in the north, and, including Pakistan, covers an area of about 1,581,400 sq. miles, with territories presenting very varied geographical and ecological conditions for plant growth. Liverworts, as a rule, grow in shady, moist and cool situations. Such habitats occur in many parts of the country (MAP 1).

The study of liverworts in India has not received as much attention as that of some other groups. Admirable work has been done in phanerogams and ferns and there exist a number of excellent treatises on these plants.

Hooker and Thomson, as early as 1855, as a result of their exhaustive studies of the angiospermic vegetation of the country, recognized the affinities of the angiospermic flora of the Western Himalayas with that of Western Asia and Europe, and of the Eastern Himalayas with that of China and Japan. Hooker (1904), in his sketch of the flora of British India, again drew attention to the same fact, remarking that the Himalayan flora is a mixed flora. The eastern region is dominated by the plants from China and Malaya, while the western abounds in European, African and Oriental plants.

DISTRIBUTION OF LIVERWORTS IN INDIA

The hepatic vegetation of this subcontinent has not been, so far, adequately considered from the distributional point of view. This is largely due to our lack of knowledge of the bryology of the country. The Himalayas have received a little more attention in this respect. The magnificent scenery and the varied fauna and flora of these lofty mountain ranges, their perplexing geology and rich mineral resources have attracted many students of natural sciences. Some of them, with their hobby of plant collecting, have contributed to the advancement of our knowledge of this group; but it is due chiefly to the interest taken by some of the Superintendents of the Royal Botanical Gardens, Calcutta, and the efforts of some of the clergymen, stationed at Kurseong and elsewhere, that our knowledge of the liverworts of this most interesting part of the world has made some progress.

More than 50 years ago Professor V. Schiffner (1899), in an article based on Durel's collection of Bhutan liverworts, pointed out that the hepatics of this area belong to purely tropical forms, most of these corresponding to the species of the East Indian peninsula and the Indian archipelago. He further drew attention to the resemblances between the liverworts of Bhutan and those of the Indo-Malayan region. In later years Kashyap (1920-21) discussed critically the distribution of liverworts of the Western Himalayas and the Punjab plain. He made extensive tours in the Himalayas, including Tibet, to study the hepatic flora; from these he arrived at a number of interesting and noteworthy conclusions with regard to the distribution of liverworts in those areas. His views were

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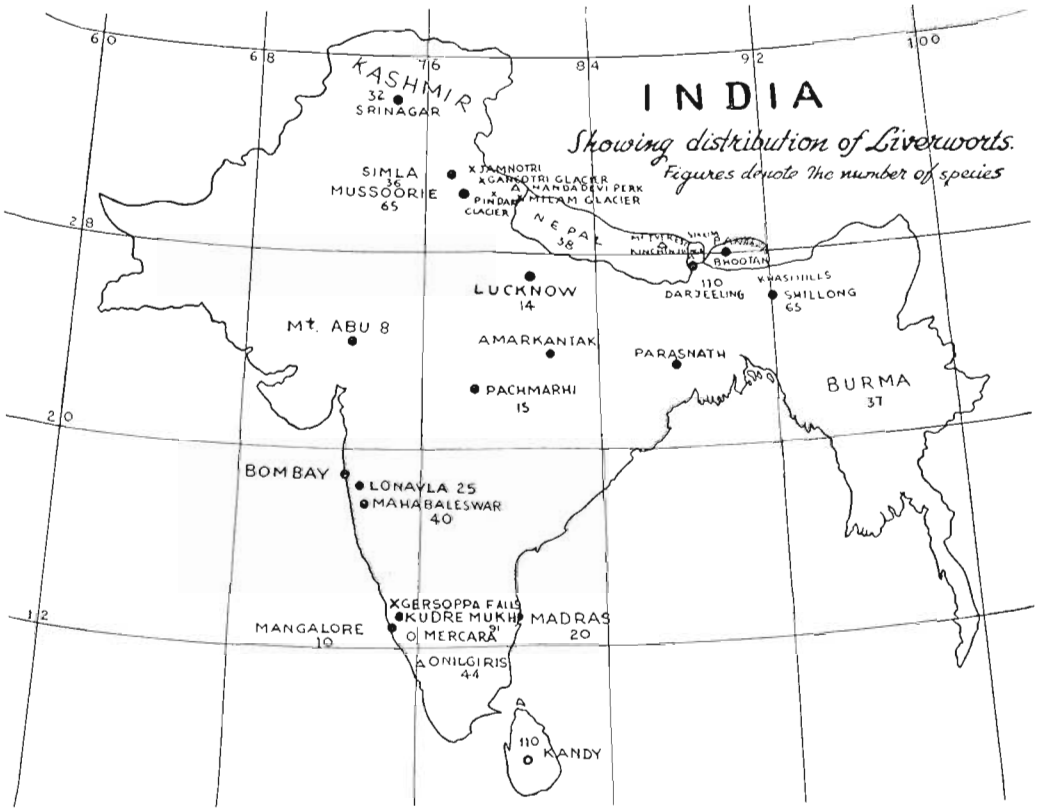


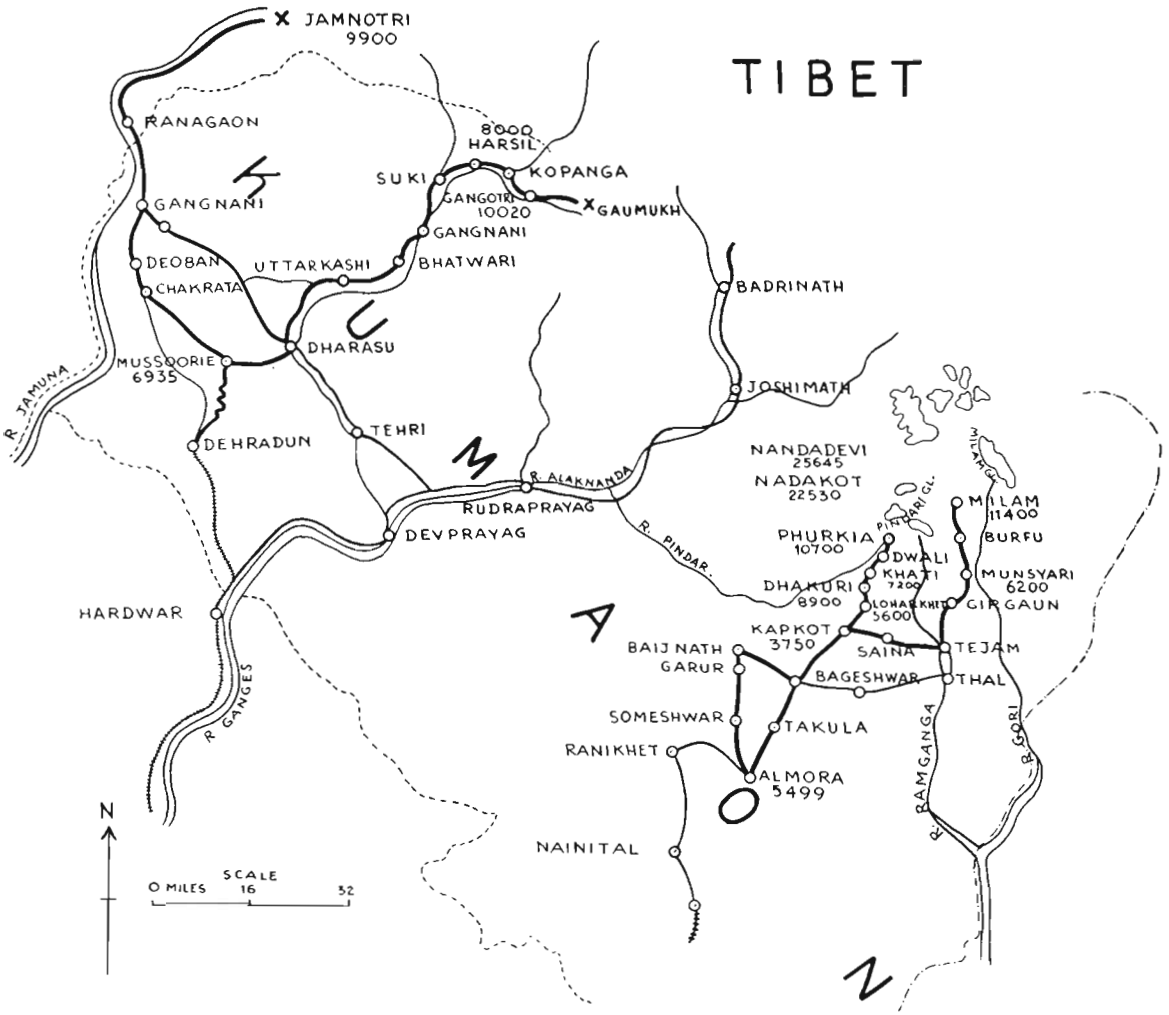
MAP 1

later confirmed by Pande (1936) from his study of the hepatic flora of certain parts of the Kumaon hills.

During the past several years one of us (Pande) has made a number of tours in the Himalayas, South India and Ceylon to collect material and observe the mode of growth, habitat, etc., of these plants (*see* MAP 2). It has also been possible for us to study several other collections, i.e. the rich collection of the Eastern Himalayan hepatics made by Decoly and Schaul during 1897-99 from the neighbourhood of Kurseong (altitude 2,000-8,000 ft.) in Darjeeling district; Pfleiderer's collection of the South Indian hepatics (1912-14), made from Kudremukh and its vicinity in the Western Ghats and from the Nilgiris, and Fleischer's collection of Ceylon liverworts. A number of friends and colleagues have also very kindly placed at our disposal their valuable collections of liverworts from various parts of India. All these specimens are being studied in our laboratory and a detailed discussion of the various aspects of the flora and ecology of Indian hepatics will be presented when these investigations have been completed. Meanwhile, a few preliminary remarks, based on the data already known and the observations made in the course of these travels, supplemented from a study of the specimens so far examined, will be presented in this paper.

PROGRESS OF RESEARCHES DURING THE PERIOD 1937-1950

A. *Systematics and Taxonomy* — A perusal of the literature published during the period under review shows marked progress in the study of the hepatic vegetation of India. The total of known genera has increased and several new or otherwise interesting species have been described. Valuable information on our hepatics has also appeared in some of the contemporary bryological publi-



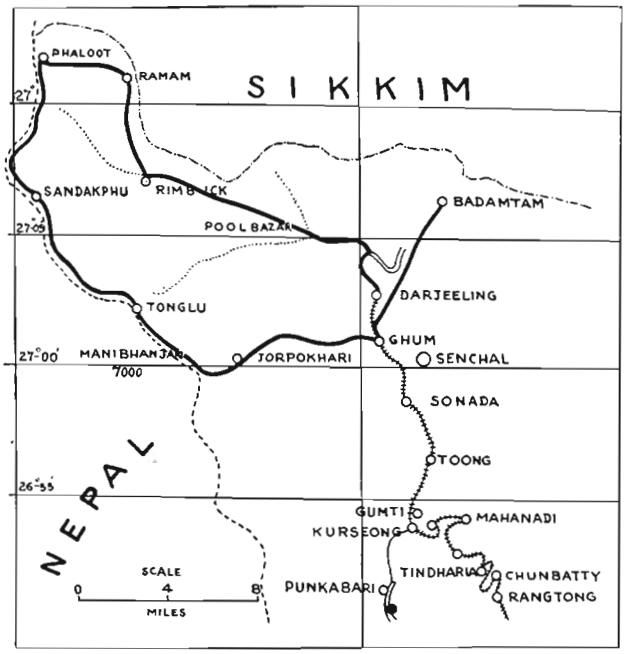
MAP 2 — Kumaon Himalayas. Heavy lines indicate route of the journey.

cations of other countries. Excellent descriptions of some of our hepatics by eminent bryologists like Verdoorn (1930, 1934, 1935), Carl (1931), Evans (1934) and Hoffmann (1935) can be found in them. Similar information on some Indian species is available in Fullford's monograph (1946) of the genus *Bazzania*, Castle's account (1936) of *Radula*, and Eifrig's monograph (1936) of the Indo-Malayan species of *Taxilejeunea* (Spruce) Schffn.

A critical study of Indian species of some of the genera has also been taken up, and a certain amount of progress made in this direction. However, a good deal of work still needs to be done before adequate and accurate information on various aspects of Indian bryology becomes available.

A. R. Chavan (1937) described a new species of *Cyathodium* Kze., *C. barodae* Chavan and the same has been included by Professor V. Schiffner (1938) in his excellent monograph on the genus, which also gives a critical account of all the other Indian species, including a new species, *C. acrotrichum* Schffn., proposed by Schiffner for a specimen collected by Decoly and Schaul from Kurseong (Darjeeling, Eastern Himalayas) in 1899.

R. S. Chopra (1938), on the basis of an examination of collections made by several persons from a number of localities in



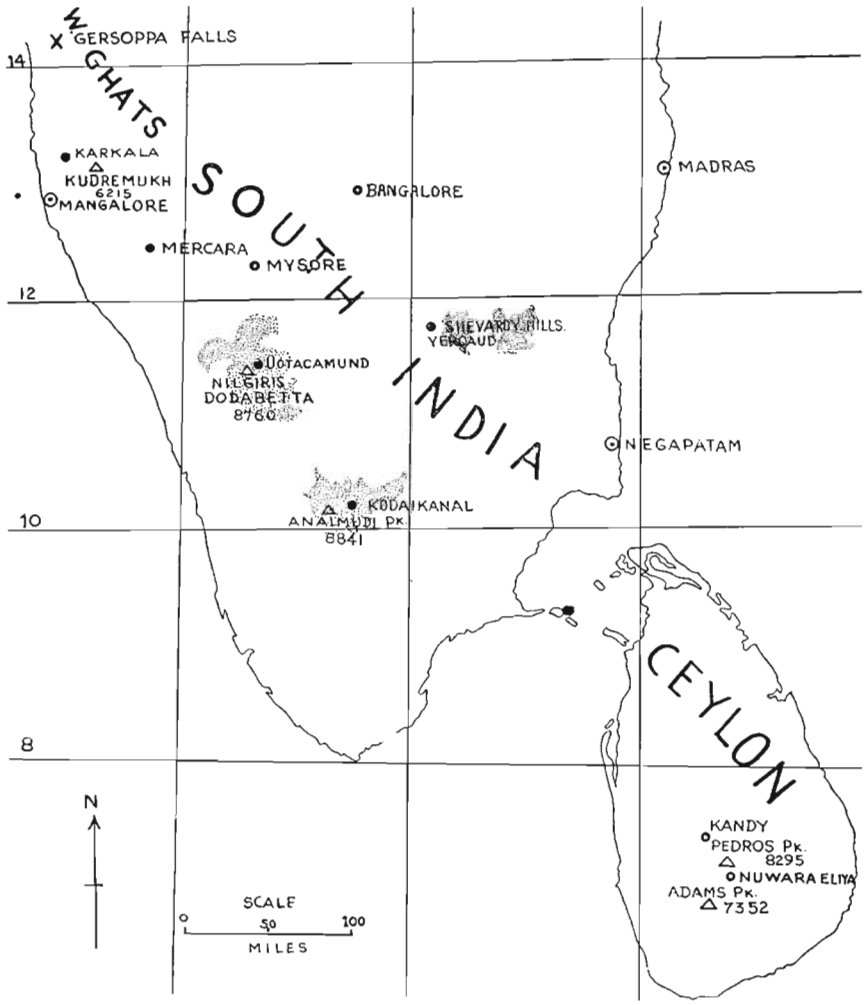
MAP 3 — Heavy lines indicate route of the journey in Darjeeling region of the Eastern Himalayas.

South India, published a list of the hepatics containing more than a hundred species, including several new records and 3 new species. In this census 25 species are assigned to Kotagiri, 20 to Kodaikanal, 18 to Shambaganur, 14 to Madras, 11 to Mahabaleshwar, 8 to Negapatam and 7 to the Nilgiris. In a similar list of the liverworts of the Eastern Himalayas and Bengal, Chopra (1938) gives about 130 species, including again 3 new species and a number of new records. The majority of the species are from Darjeeling while the remaining come from other localities, e.g. Kurseong 13, Phallot 11. Herzog (1939), in a communication dealing with two bryophytic collections from the Sikkim Himalayas, lists more than 50 species of liverworts from this region, including more than a dozen new species proposed by the author. The paper gives a detailed taxonomic account with illustrations of all the new species and some valuable information about several others.

T. S. Mahabale (1941) described a new species of *Aspiromitus* St., *Asp. dixitianus* Mahabale, from Khandala and soon after V. V. Apte and Sane (1942) added two more new species, *Asp. khandalensis* and *Asp. fergussoni*, from the same area. A critical study of all the three species, and a careful comparison with *Asp. mangaloreus* St., known from Mangalore in the Western Ghats, is highly desirable.[2]

Pande and Srivastava (1942) described a new species of *Nowellia* Mitt., *N. indica* Pande & Srivastava, from the Western Himalayas and a year later Pande and Misra (1943) published a new *Leptocoelea* Evans, *L. himalayensis* Pande & Misra, from the same area. The latter is a very variable species. The corticolous form, collected from near Bageshwar (3,500 ft.), shows marked differences, especially in the lobule, from the rupicolous form gathered from the surface of moist rocks in the neighbourhood of Loharkhet (6,000 ft.). In another paper, dealing with the epiphyllous hepatics of the country, Pande and Misra (1943) described two new species of liverworts, (1) *Cololejeunea himalayensis* Pande & Misra and (2) *Leptolejeunea himalayensis* Pande & Misra, from Mungpoo (4,000 ft., Darjeeling, Eastern Himalayas) and added some details to the description of three other liverworts, i.e. (3) *Leptocolea lanciloba* St., (4) *Rectolejeunea aloba* (Sande. Lac.) St. and (5) *Cololejeunea hispidissima* (St.), Herz. The last two of these were recorded in that paper for the first time from India, while for the first one it was the first record from South India. In another paper on this interesting group of liverworts Pande and Ahmad (1942) reported four more epiphyllous species, i.e. (1) *Taeniolejeunea paraffinis* (Schffn.) Zw., (2) *Radula protensa* Ldbg., (3) *Leptolejeunea schiffneri* St., from Gersoppa Falls (Mysore State, South India) and (4) *Leptocolea pseudofloccosa* Horikawa from Pedró's Peak (Ceylon). Finally, Pande and Ahmad (1943) added eight more species to this list. These are: (1) *Micro-*

2. Proskauer (*Bull. Torr. Bot. Club*, 1951, p. 345) suggests that the genus *Aspiromitus* St. should be abolished. He lists *Asp. dixitianus* as *Anthoceros dixitianus* comb. nov., remarking that *A. fergussoni* Apte & Sane may probably be a synonym of the former. He further doubts the identity of this liverwort with *A. weistii* Khanna and of the latter with *A. argillaceous* St. He refers *Asp. khandalensis* Apte & Sane as *Anthoceros khandalensis* comb. nov.



MAP 4 — South India and Ceylon, indicating localities from which liverworts have been examined.

lejeunea Sp., from Rimbick (Darjeeling, Eastern Himalayas), (2) *Drepanalejeunea follicola* Horikawa, (3) *Aphanolejeunea* sp. I., (4) *Aphanolejeunea* sp. II from Jorpokhari, Darjeeling, Eastern Himalayas (the last-named species occurs also at Rimbick), (5) *Frullania* sp., (6) *Microlejeunea* sp. II, (7) *Lejeunea* sp. and (8) *Drepanolejeunea* sp. from Pedró's Peak (Ceylon). The total number of species of this interesting group of hepatics dealt with in these three papers is 18.

Hameed (1942), in a note on liverworts of the Murree hills, records 24 species from this region.

S. Ahmad (1942), from Lucknow, published a brief note on three new Indian species of *Riccia*. One of these, *R. orientalis* Ahmad, a ciliate species, is based on a specimen collected by Pande from the Western Himalayas, in 1936; the second one, *R. gangetica* Ahmad, is a monoecious species, growing during rains in the neighbourhood of Lucknow, often associated with *R. discolor* L. & L. and *R. melanospora* Kash., and the third one, *R. mangalorica* Ahmad, was proposed for a plant collected by A. R. Rao from Mangalore (South India). In suggesting *R. mangalorica* as a new species, Ahmad drew attention to the close similarity

of its spore with that of *R. plana* Tay., and pointed out that it may be a variety of the same.

Sane (1942) described two new species of *Anthoceros* L., *A. dixiti* from Lonavala and *A. sahyadrensis* from Poona, recognizing its varieties, *A. sahyadrensis* var. *purandhar* and *A. sahyadrensis* var. *poona*.

Pande and Ahmad (1944), in a note on *Riccia discolor* L. & L., reduced *Riccia himalayensis* St. to a synonym of *Riccia discolor* L. & L. In another communication the same year Pande and Ahmad listed from Lucknow and its neighbourhood 14 species of liverworts, representing six genera.

In 1943 A. K. Ghose reported a species of *Pallavicinia* from Dacca in East Bengal.

Chavan and Mahabale (1945), in a note dealing with the distribution of hepatics in Gujrat, recognized three well-marked regions in this area. For the dry and arid region, extending from Mt. Abu to Khed Bramha, Vireshwar and Taranga hills, they list such xerophytic forms as (1) *Plagiochasma appendiculatum* L. & L., (2) *Riccia discolor* L. & L. and (3) *Asterella* (*Fimbriaria*) *angusta* St.; for the humid regions of Pavagarh and Rajpipla hills they record: (4) *Conocephalum* (L.) Necker, (5) *Anthoceros himalayensis* Kash., (6) *Cyathodium barodae* Chavan and (7) *Notothylas levieri* Schffn.; and for the southern and western plains on the coastal line, an admixture of the species from the above two regions, e.g. *Riccia discolor* L. & L., *Cyathodium barodae* Chavan, *Riccia frostii* Aust. (noted as *R. sanguinea* Kash.) and *Notothylas levieri* Schffn.

R. L. Nirula (1945) described a new species of *Notothylas* Sull., *N. Chaudhurii* Nirula, a non-columellate monoecious species from Nagpur. The capsules are bivalved and each valve has a row of specially thickened cells along the margin. Nirula holds *Notothylas* as a reduced genus.

Gupte (1945) described a yellow-spored species of *Notothylas* from Poona, drawing attention to its close similarity with *N. decurva* Mitt.

A. R. Rao (1947), in a note on the liverworts of Yercaud (5,200 ft.) in the Shevaroy hills of South India, recorded for this area : (1) *Marchantia* L., (2) *Plagiochasma* L. & L., (3) *Lejeunea* Lib., (4) *Plagiochila* Dum., (5) *Fossombronia* Raddi, (6) *Lepidozia* Dum. and (7) *Hygrolejeunea* (Spr.) Schffn.

P. D. Bhate (1947), in a note on a preliminary survey of the liverworts of Lonavala and Panchgani hills, states that these regions have favourable climatic and edaphic factors for a rich hepatic flora; but due to a long dry period, extending to about eight months in the year, only such species flourish as can greatly tolerate xerophytic conditions and can mature quickly. The hepatic flora of these places, in his opinion, conforms to the " xerogeophytes " type of Gam and Verdoorn.

D. C. Bhardwaj (1948) published an account of a new species of *Aspiromitus* St., *Asp. mamillispora* Bhardwaj, a dioecious species with very characteristic mamillate spore, collected by Pande from Kandy (Ceylon) in January 1940. The paper includes a comparative table noting the diagnostic features of all the known dioecious species of *Aspiromitus*.

This species, as pointed out by Dr. Proskauer in a letter to one of the authors, is apparently identical with the Andaman specimen (co-type) of *A. spinisporous* St., of which we had an opportunity to examine a specimen and a traced copy of the figures of the spore and elater, kindly supplied to us by Dr. Proskauer. The plant from Ceylon, however, does not fit in well with Stephani's description and figures of the spore. The type specimen of Stephani's species comes from New Guinea and without reference to this it is not possible for the authors to settle this issue finally. Should the two be identical, *A. mamillispora* Bhardwaj will be reduced to a synonym of *A. spinisporous* St.

Pande and Bhardwaj (1949), in a note on some liverworts new to Indian flora, dealt with three hepatics, i.e. (1) *Anthoceros crispulus*[3] (Mont.) Douin., previously known from Europe and North America and recorded by Pande and Ahmad in 1943 from Lucknow ; (2) *Conocephallum supradecompositum* (Lindb.) St., a rather rare liverwort originally known from China and Japan and recently collected by Maheshwari from Darjeeling in the Eastern Himalayas ; and (3) *Aspiromitus harrisanus* St., a Jamaican hepatic, previously known to us only through its Latin description by Stephani (Sp. Hep., Vol. V, p. 965). Its discovery near Munsyari (6,200 ft.) in the Western Himalayas is of some interest.

Pande, Bhardwaj and Ram Udar (1949), in a note on South Indian hepatics, listed

3. According to Proskauer (1948), *A. crispulus* is a synonym of *A. punctatus* L.

ten members of the Acrogyneae; nine of these, i.e. (1) *Bazzania nudistipula* (= *Mastigobryum nudistipulum*) St., (2) *Saccogyna alternifolia* St., (3) *Plagiochila richteri* St., (4) *P. wornoffi* St., (5) *Archilejeunea apiculifolia* St., (6) *Cheilolejeunea indica* St., (7) *Harpalejeunea indica* St., (8) *Eulejeunea lindbergii* St. and (9) *Frullania moniliata* (R. Bl. Nees) Dum. from Kudremukh (6,212 ft.), Western Ghats and (10) *Ptychocoleus fertilis* Trev. from Mangalore.

Pande and Ram Udar (1950), in the second paper of the same series, listed seven more acrogynous liverworts adding some valuable information about some of these: (1) *Radula companigera* Mont., (2) *Ptychanthus striatus* Nees, (3) *Thysananthus semirepandus* (Nees) Ver. (= *Thysananthus rotundistipulus* St.), (4) *Taxilejeunea tenerima* St., (5) *Herberta pinnata* St. All the liverworts described in these two papers have been already determined by Stephani. The 17 liverworts enumerated in the last two papers are out of Pfleiderer's rich collection of the South Indian hepatics, running to some 124 species, distributed over 44 genera representing 17 families. The specimens were collected during the years 1911-13 from Udipi, Mangalore, Bajape and Karkal, in the coastal strip of the Western Ghats; Doddabetta and Kotagiri in the Nilgiris; Coorg (Mercara), north of the Nilgiris, and Kudremukh (6,212 ft.) in the Western Ghats.

Recently Schiffner and Pande (1950), in a paper on the East Himalayan hepatics, listed 138 species of liverworts belonging to 45 genera representing 20 families spread over various groups. These specimens were collected by Decoly and Schaul (1897-99) from a number of localities, varying in altitude from 2,000 to 8,000 ft. in the neighbourhood of Kurseong in the Darjeeling district of the Eastern Himalayas. The paper includes several new species and many new records for the province and the country. The discovery of *Megaceros* Campb., representing the first record of the genus from India, is of special interest. This is a very exhaustive treatment of the East Himalayan hepatics.

B. *Morphology and Cytology* — Although only a few species of Indian liverworts have been studied in detail, the investigations have yielded interesting and important results.

Pande (1937) communicated a paper on the morphology of *Riccardia levieri* Schffn., collected from the side of a stream in Ranikhet (7,000 ft.) in the Western Himalayas. He observes that the species is not strictly dioecious, as has been previously recorded, but may bear both antheridia and archegonia on the same thallus, sometimes even on the same branch. Details of the development of the sexual organs and the sporophyte are also given. This follows the same course as in other species of the genus. The elaterophore is well developed, extending to about one-third the length of the capsule, and there are a few short elaters attached to it. It breaks up into four pieces when the capsule dehisces and the pieces of the elaterophore, with the elaters sticking to them, remain attached to the valves of the capsule. Bicellular endogenous gemmae are frequently formed.

Pande and Misra (1937), in a communication on *Sewardiella tuberifera* Kash., an interesting monotypic West Himalayan member of the Codoniaceae, have described some details of development of the sexual organs and the sporophyte of this liverwort and have discussed the systematic position of the genus.

Chavan (1937) described the life-history of *Cyathodium barodae* Chavan, collected from Baroda. He notes that the species is monoecious and the thallus bears only smooth-walled rhizoids and a variable type of ventral scales. The male receptacle is produced from a single cell and is almost sessile, and occupies a variable position. The details of the antheridial development, he states, are of the usual type found in related forms but the septa separating the antheridia are persistent. The archegonial receptacle arises on the upper surface near the thallus margin and each receptacle may produce up to seven archegonia. The involucre is bi-lipped and develops only after the full number of archegonia have been formed. The embryo may be of the filamentous or of the octant type and the structure of the capsule is of the type characteristic of the genus. The haploid number of chromosomes is 8, each of which has a characteristic form.

P. N. Mehra (1938) has studied the chromosome number of three Indian genera of the Codoniaceae, i.e. *Fossombronia himalayensis* Kash., *Petalophyllum indicum* Kash. and *Sewardiella tuberifera* Kash. He gives 18 as the 2X number for these and states that the morphology of the chromosomes of all the three is different. A table show-

ing the chromosome number of the various members of the Codoniaceae is also given. Mehra gives 9 as the basic chromosome number of the family and states that, in the evolution of the species in this family, polyploidy is rather rare.

S. Ahmad (1938) studied the life-history of *Aitchisoniella himalayensis* Kash., a monotypic West Himalayan liverwort. He describes the detailed structure of the gametophyte, noting that the thallus grows by means of an apical cell cutting off segments on four sides. The air chambers originate schizogenously and are empty. The antheridia develop in two rows and lie embedded in the thallus behind the female receptacle, and the latter may be terminal, lateral or may lie in the fork between the two lobes. Ordinarily the receptacle has one or two involucres; occasionally it has three or four. The tissue of the receptacle has empty air chambers, opening to the exterior by simple pores. The embryo is of the filamentous type. Several stages in the development of the sporophyte are described. The classification of the Marchantiales is discussed and, in the light of his observations, the author concludes that *Exormotheca* can no longer be held as the lowest type of the Compositae since *Aitchisoniella* breaks down the line of demarcation between the Compositae and the Targioniaceae. The view that the two families should be merged into one, earlier proposed by Kashyap, is supported by Ahmad.

P. N. Mehra and H. L. Mehra (1938) published an account of the life-history of *Stephensoniella brevipedunculata* Kash., another interesting monotypic genus of the Marchantiales, confined to the Western Himalayas, i.e. Kulu, Simla, Mussoorie (altitude 6,000-7,000 ft.). The authors describe the various structural and developmental details of both the gametophyte and sporophyte. They ascribe the growth of the thallus to an apical cell and state that the air chambers originate schizogenously and are in a row. These are large, empty and directed obliquely forward, opening by a simple pore. The antheridial receptacle is of the simplest type. The female receptacle is terminal and never strictly dorsal. It has a short stalk and two involucres, each of which may have 1-4 archegonia. The tissue and pores of the receptacle are of the same type as those of the thallus, and its stalk has a shallow groove with a few tuberculate rhizoids. The sporophyte is rather simple. The elater-mother-cells belong to 3-5 generations later than the spore-mother-cells. Like Kashyap, the authors assign *Stephensoniella* a place near *Exormotheca*, pointing out that it has a comparatively simpler structure. Arguments are given in support of the view that *Stephensoniella* has been derived from forms like *Exormotheca* by a process of reduction. They also record certain round bodies or " spherules " in the fertilized egg and the embryo. The haploid number of chromosomes is given as 9. Adventitious ventral shoots or tubers serving as vegetative reproductive bodies have also been described. Tubers of the male plants form antheridia which, under unfavourable conditions, become arrested in different stages of their development, completing the process in the next vegetative season.

K. S. Srinivasan (1939) described the development of androgynous receptacles in *Marchantia palmata* Nees, from Ootacamund in the Nilgiris. The narrow, elongated antheridia-bearing lobes, which, according to Srinivasan, are ventral proliferations of the archegonia-bearing lobes of the purely female receptacles, produce in the beginning sexual structures of the intermediate type but later give rise to typical antheridia, suggesting the homologous nature of the sex organs. A fungus, forming pycnidia, associated with the liverwort, is also reported. In another paper Srinivasan (1944) gave a detailed account of the life-history of *Marchantia palmata*. The minute structure of the thallus and the differentiation of the various tissues as well as the behaviour of the apical cell are fully described. The details of the development of the receptacles are also given. Once again he describes androgynous receptacles of the previous type and notes that " the female receptacles always end as androgynous receptacles in their final stages " (SRINIVASAN, 1944, p. 111). The details of the development of the sex organs, the author states, are of the usual type found among the liverworts. The archegonium develops in two ways : " One of these is, more or less, similar to that recorded by Humphrey (1906) in *Fossombronia longiseta* and by Campbell (1896) in *Geothallus tuberosus*. The second type shows a certain amount of similarity to that seen in *Pallavicinia leylii* (Haupt, 1918) and *Preissia quadrata*, as figured by Haupt (Haupt, 1926, Figs. 34 & 35)."

Various details of the sporophyte development have also been described. Details of spermatogenesis and sporogenesis are also given. The haploid number of chromosomes for this species is given as 9 and it is stated that the chromosome complement in the first heterotypic division includes a pair of small chromosomes which, though not differing in size, show a certain resemblance to X and Y chromosomes of *Marchantia polymorpha*, in their behaviour at the anaphase of the first division.

In another paper Srinivasan (1940) described the morphology, life-history and cytology of *Riccia himalayensis* St. The account given is that of a monoecious *Riccia* from Madras (*see* PANDE & AHMAD, 1943). Minute details of the structure and development of the thallus, the origin of air chambers and the development of the sexual organs are given. Some instances of the presence of two archegonia inside an archegonial chamber are also recorded. Various stages in the embryogeny and development of the sporophyte are described. Some sterile spore-mother-cells have also been reported. In spore germination, according to Srinivasan, the germ tube emerges through a germ pore on the convex wall. Perennation by means of tubers is also recorded. The haploid number of chromosomes is stated to be 8, of which 7 are long while 1 is very small and round. The last one shows precession on the spindle at the anaphase.

Mahabale and Gorji (1941) studied the chromosomes of *Riccia himalayensis* St. (a synonym of *R. discolor* L. & L.), and record 8 as the haploid number of chromosomes and note that 7 of these are slender, elongated and irregular in outline while the eighth is much smaller and dot-like. The attachment of the 7 long ones is atelomitic while that of the eighth is telomitic and there is no heterochromosome in this species. In a subsequent paper Mahabale and Gorji (1947) dealt with the chromosomal complex of two species of *Riccia*, *R. discolor* L. & L. and *R. sangiunea* Kash. (a synonym of *R. frostii* Aust.). They state that the chromosomal complex in both the species consists of 8 slender chromosomes (n number), 7 of which are more or less V-shaped or bent and one is a small dot-shaped body, lying in the middle of the other 7. Whether this small dot-shaped chromosome is to be identified as the sex chromosome or not, they could not determine. According to them there is not much difference in the genomic constitution of the two species. They also report some cases of hermaphrodite thalli in *R. sanguinea* Kash.

Mahabale (1942) briefly reviewed the data available on the cytology of liverworts and discussed the bearing of the cytological studies on the phylogeny of the Marchantiales. He analysed the data and, from an examination of the published results on the chromosome numbers of various liverworts, concludes that the basic number of chromosomes (gametophytic number, i.e. n number) for the majority of the genera of the Marchantiaceae and the Jungermanniaceae is 9 and for the Ricciaceae 8. According to him the available cytological data can be interpreted in support of both the progression as well as the reduction hypotheses of evolution in the Marchantiales. He postulates that the pro-Marchantialean complex had 17 chromosomes and from this the Marchantiaceae and the Ricciceae originated independently and polyphyletically, and the ancestral complex has been divided into two series — one with 8 and the other with 9 chromosomes. He supports such an assumption by a parallel case found among the Rosaceae, in which the presence of two basic numbers has been accounted for in the same manner.

T. S. Mahabale and P. D. Bhate (1945) published an account of the structure and life-history of *Fimbriaria angusta* St. In this paper the authors have reviewed the work done on the genus and have given details of the structure and development of the thallus, sex organs and sporophyte. They state that the thallus grows in the usual Marchantiatious manner. The air chambers have no assimilatory filaments and the older thalli contain endotrophic mycorrhiza. The development of the sex organs and embryogeny, according to them, conforms to the type found in other species of the genus but the embryo is of the filamentous type. They also state that the cells of the apical part of the capsule show radial thickenings but the operculum is not so regular as in Plagiochasma or Cryptomitrium. They record 9 chromosomes for this species. The authors consider *Fimbriaria* as a reduced genus and have adduced some evidence in support of this. It is pointed out that *F. angusta* is an ally of *F. pilosum* O. Kutz., *F. gollani* St. and *F. mysorensis* Kash.

Abeywickrama (1945) described the structure and life-history of *R. crispatula* Mitt., giving various details of the sex organs and sporophyte. According to him the species is monoecious and not dioecious, as described by Stephani. He notes that favourable conditions for vegetative growth retard the formation of the sex organs and the size of the sporangium depends upon food supply. The species closely resembles *R. billardieri* M. & N. from Java.

Mahabale and Deshpande (1947) have described the life-history of a common Indian species of *Plagiochasma, P. articulatum* Kash., giving the details of the structure and development of the thallus, receptacles, sex organs and sporophyte. The internal structure of the thallus, they state, is of the normal type. Its characteristic articulated appearance is due to the intermittent development of the thallus lobes. The sessile, often forked, male receptacles and their development, as well as the development of the antheridia, are of the same type as in other species of the genus; but the female receptacle, though terminal at first, becomes dorsal secondarily due to the development of a pseudo-branch from below the growing point. It bears ordinarily four archegonia, one at each corner, and has air chambers, opening to the outside through barrel-shaped pores. Cases of bisexual receptacles are also recorded. The gametophytic number of chromosomes is given as 8 and the embryo is stated to be of the filamentous type. The authors regard *Plagiochasma articulatum* as a transitional form between a type like *Reboulia* Raddi and *P. appendiculatum* L. & L. Attention is drawn to the similarity between *P. articulatum* and *Massalongoa* Nees. A scheme suggesting the derivation of the genera of the Operculatae by a process of reduction from the level of *Marchantia* is given. *Plagiochasma* is assigned the last position in this table. In the end the authors have discussed the importance of the chromosome number in the phylogeny of the genus and suggest that either polyploidy or deletion of a chromosome from the ancestral complex seems to have taken place in the evolution of the species of *Plagiochasma*.

The Anthocerotaceae and the Ricciaceae have been under investigation at the University of Lucknow for some time past. A critical study of the morphology of some Indian genera of the former is being pursued by Pande and Bhardwaj. In this connection, Pande and Bhardwaj (1949) communicated a paper on the morphology of *Anthoceros* L. (*Phaeoceros*), a yellow-spored Indian species, and Bhardwaj (1949) investigated the life-history of a black-spored species, *Anthoceros crispulus* (Mont.) Douin. Various details of the structure of the thallus and sex organs and of the development of the sporophyte are described. Bhardwaj has investigated the life-history of two other Indian species of *Anthoceros* (L.) Prosk., collected by Pande. One of the specimens was collected from near Munsyari (Garhwal) in 1936 and the other from near Manebhanjan, Darjeeling, Eastern Himalayas, in 1939.

A critical study of the various Indian species of *Riccia* is being pursued by Ram Udar and, in a recent paper, he (1950) has communicated the results of his investigations of three common monsoon species of Lucknow.

P. N. Mehra (1950) has described some details of the embryogeny of *Sewardiella tuberifera* Kash.

A monograph on the Indian species of *Asterella* Pal. B. is under preparation by Pande and Sultan Ahmad.

REMARKS ON THE HEPATIC VEGETATION OF INDIA

As we have already stated, in the present state of our knowledge of Indian liverworts, it is not possible for us to say much about the various aspects of the flora and ecology of these plants; but an analysis of the data, gathered in the course of our tours (MAPS 2, 3 & 4) as well as the study of the collections from various parts of the country, so far carried out by ourselves and by others, suggest certain noteworthy features of the vegetation which are presented here.

About 550 species of liverworts, distributed as shown in Map 1 and Table I, are known from India. The figures are, however, only approximate, because so long as a critical study of our hepatics is incomplete, a certain amount of duplication of some species is unavoidable.

In the Himalayas, South India and Ceylon there are vast areas rich in hepatics, the greatest number of species occurring in territories with abundant rain and high humidity (TABLE I). The Vindhya and the

TABLE I

Locality	Altitude	Rainfall	Relative humidity during June-September	No. of species of liverworts
I – Western Himalayas				
Simla	7,000′-8,000′	63″	...	36
Mussoorie	6,000′-8,000′	80·60″	Morning 89% Evening 88%	65
II – The Eastern Himalayas				
Nepal (Kathmandu)	5,000′-7,000′	Over 100″	...	38
Darjeeling	7,000′-8,000′	126·42″	Morning 95% Evening 90%	110
Kurseong	3,500′-6,000′	150″	...	138
Khasi Hills	4,000′-5,000′	200″-300″	...	65
III – Plains of the Uttar Pradesh				
Lucknow	393′	40″	...	11
IV – Madhya Bharat and Madhya Pradesh				
Pachmarhi	3,578′	79·61″	Morning 85% Evening 78%	15
Mount Abu	5,645′	75″	...	8
Lonavala	1,900′	170·08″	...	25
V – South India				
Mahabaleshwar	4,720′	Over 250″	...	40
Kudremukh	6,212′	Over 200″	...	91
Mangalore	Sea level	134″	...	10
Bangalore	3,248′	34·08″	Morning 86% Evening 62%	10
Madras	Sea level	Over 100″	...	20
Nilgiris	8,760′	Over 200″	...	44
Palni Hills	8,841	Over 200″	...	20
VI – Ceylon				
Kandy	1,800′	86·9″	...	18

TABLE II

A

Region	Total No.		Endemic genera	Spp. common to W. Himalayas	Spp. common to		Spp. common to East Indies		Spp. common to		Spp. common to Australia
	Genera	Spp.			South India	Ceylon	Genera	Spp.	China	Japan	
E. Himalayas	83	333	...	40	60	23	23	40	12	26	11

B

Region	Total No.		Endemic genera	Spp. common to E. Himalayas	Spp. common to W. Himalayas	Spp. common to Ceylon	Spp. common to East Indies		Spp. common to		Spp. common to E. Africa
	Genera	Spp.					Genera	Spp.	China	Japan	
South India	64	225	...	60	39	23	29	53	7	23	17

C

Region	Total No.		Endemic genera	Spp. common to E. Himalayas	Spp. common to South India	Spp. common to Europe		Spp. common to		Spp. common to East Indies
	Genera	Spp.				Genera	Spp.	China	Japan	
W. Himalayas	53	170	4	40	39	20	31	12	13	7

Satpura mountains, the Pachmarhi plateau, Mahabaleshwar, Parasnath and Mt. Abu are comparatively less favourable for the growth of these plants. In the plains, over the greater part of the country, the prevailing weather conditions are still less congenial, so that here only a few hepatics grow in favourable localities.

The Eastern Himalayas represent, apparently, the richest liverwort territory in India.

The number of species (330) reported from here is almost one and a half times that reported from South India (225 species), nearly twice the number recorded for the Western Himalayas (170 species) and three times of those found in Ceylon (110 species).

In the Western Himalayas the most luxuriant hepatic vegetation occurs between the altitudes of 6,000 and 8,000 ft. (*see* also KASHYAP, 1920 & 1921), but in the Eastern Himalayas the richest region lies at a comparatively lower altitude.

In the outer Himalayas the number of species of liverworts, as well as the frequency of the individuals of a species, at a particular altitude, decreases as one proceeds from Darjeeling in the east to Kashmir in the west (MAP 1 and TABLE I). This is in conformity with the view expressed by Kashyap (1921) and by Pande (1936).

There are more common species between the Eastern Himalayas and South India and Ceylon than between any of these regions and the Western Himalayas (TABLE II).

The hepatic flora of the Eastern Himalayas shows affinities with the hepatic flora of the Malayan region. It also includes some species in common with the flora of China, Japan and Australia (TABLE II A). The hepatic flora of South India, like that of the Eastern Himalayas, is characterized by the presence of Malayan species. There is a lesser element of Chinese species in this flora but it includes several species common to East Africa (TABLE II B). The flora of the Western Himalayas shows affinities with the flora of Central Asia and Europe. There is a lesser element of common species in the flora of this region and that of the East Indies and Japan (TABLE II C).

The hepatic flora of the Western Himalayas is further characterized by the presence of a few endemic and monotypic genera, i.e. (1) *Aitchisoniella* Kash., (2) *Stephensoniella* Kash., (3) *Sauchia* Kash. and (4) *Sewardiella* Kash. These genera have a very restricted distribution.

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