VEGETATION OF SRINAGAR (KASHMIR VALLEY) WITH SPECIAL REFERENCE TO ECOLOGICAL HABITAT

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The present paper describes the vegetation of Srinagar with major plant communities in different habitats along with frequently occurring plants associated with them. Much of the greenery of the area is contributed mainly by a large number of avenue, ornamental and fruit trees, many of which have become naturalized. The shrubby vegetation is also very sparse as compared with the shrubby vegetation of higher localities. A large number of annuals and perennials, ranging from submerged aquatics and amphibious herbs to psammophytic and semi-xerophytic plants, are encountered in the area. Quite a few among these are representatives of the western flora, while many species are not found at all in the localities lying south of Pir Panjal and Wardwan ranges. The suitable climatic and soil conditions have also provided a ready field for the introduction and commercial cultivation of a large number of medicinal and aromatic plants in the valley. A total number of 279 species, belonging to 205 genera and 65 families of Angiosperms and Gymnosperms, have been recorded as occurring in the area.

INTRODUCTION

Kashmir has been occasionally explored in the past by a number of botanists, prominent among them are Victor Jacquemont (1801–1832), Baron Von Huegal and Godfrey Thomas (1836–1838), Royle's Collectors (1833–1839), W. Moorcroft and G. Trebeck (1841), J. E. Winterbottom (1846), Thomas Thomsan (1847), Schlagintweit Brothers (1854–1857), G. Henderson and A. O. Hume (1873), William Hey (1862), J. L. Stewart (1868) and J. F. Duthie (1892–1893).

The early twentieth century saw the work of A. Meebold (1905), F. Hallberg (1921), B. O. Coventry (1925), E. Blatter (1927-1928), Walter Koelz (1930), S. K. Mukerjee (1940) and W. J. Lambert (1933), who published their work in the form of manuals and floras. Their work was followed by that of F. W. Pennell (1943) and F. Ludlow (1951). In recent years R. R. Stewart of Gordon College, Rawalpindi, and T. A. Rao from Botanical Survey of India extensively explored many places with a view to preparing a comprehensive flora of the region, while R. N. Chopra and his co-workers published a series of papers on the medicinal and aromatic plants of the area. No attempt has, however, been made to conduct a systematic study of the vegetation

pattern in the valley which includes a large area characterized by the flat physiognomy.

The present authors have, therefore, undertaken to study the vegetation of Srinagar in different seasons and habitats and have restricted their observations mainly to an area of 30 sq. km. in and around Srinagar, which possesses the majority of topographical features of the larger expanse of the Kashmir valley.

The Valley—Its Physical Aspects

The vale of Kashmir consists of the upper part of the Jhelum river basin and is situated approximately between 33° 15′ and 34° 30′ N and 74° and 75° 13′ E approximately. Whole of the area is characterized by a level floor with an elevation ranging from 1,500 m to 1,700 m. It is bounded to the north by the great axis of the inner Himalayas. The eastern boundaries are formed by a high spur of the above, called Wardwan range, which forms the watershed between rivers Jhelum and Chenab and eventually joins the Pir Panjal ranges some kilometres west of Kishtwar. On the north-west, another minor spur of the main Himalayan axis branches off near Zojila pass and separates the drainages of the Jhelum and Kishenganga rivers. It gradually curves round to the south until it reaches the banks of the river Jhelum abreast of the western end of the Pir Panjal mountains. Long spurs branch off from the above mountain ranges frequently interrupting the flat physiognomy of the valley.

The valley contains by far the broadest sheet of fresh water known in India. Among the major lakes are Wullar, Dal, Anchar and Manasbal. It also abounds in springs and mountain streams, all of which drain into the river Jhelum, while ponds, waterlogged depressions and marshes are a common feature.

Geology and Soil

The valley is an alluvium-filled basin, a large part of which is of recent formation by the river Jhelum and its tributaries. More than half of its area is however occupied by the outliers of a distinctly much older alluvium which forms low mounds or platforms sloping away from the spurs of the encircling mountain ranges. These are locally known as 'Karewas' and are supposed to be the relics of an old lake basin, which in the past periodically filled the whole valley. The lower spurs and higher reaches of the encircling mountains, which act as catchment area of the Jhelum river and its tributaries, consist of a thick series of pyroclastic slates, conglomerates and agglomeratic products, which are called Panjal traps and Panjal agglomeratic slates respectively (Wadia 1948).

The soils in the area broadly represent the two types of geological formations described above.

1. The soil derived from the 'Karewas' is known as old alluvium and extends at some places from above the banks of the river Jhelum to as far as the 'Karewa' formations. It contains a large portion of clay on the 'Karewa' mounds and platforms while in other localities it contains a rich loam with sandy subsoil. This type of soil is not well drained so that water-logged depressions, ponds and marshes are a common feature (Hoon 1939).

2. The new alluvium, found in the deltas and bays of mountain streams and in the upper reaches of Jhelum banks, is derived from the Panjal trap series. It is on the whole light and well drained and is very fertile. In the low-lying areas near the swamps, lakes and the banks of river Jhelum a distinct type of peaty soil is also met with.

Climate

Due to the flat physiognomy, the temperature is uniform throughout the valley. Figure 1 gives the monthly mean maximum and minimum temperatures during the past three years (1960–1962) at Srinagar.

The hottest months are July and August, when the maximum temperature generally rises well above 30° C. In September, the nights are cooler while the real winter sets in about the middle of December. The coldest months are January and February, when minimum temperature falls a few degrees below freezing point. The winters vary from year to year; some are severe and produce very heavy snowfall, while others are open and mild.

The precipitation is recorded during two periods, the south-west monsoon period, from July to September, and the cold season, from December to April. The highest precipitation is received during the cold period. During the heavy monsoon in the hills, south of Pir Panjal, the rainfall in the valley is scanty. The period of heavy precipitation also varies from year to year as evidenced from Table I of rainfall recorded during 1960–62 at Srinagar.

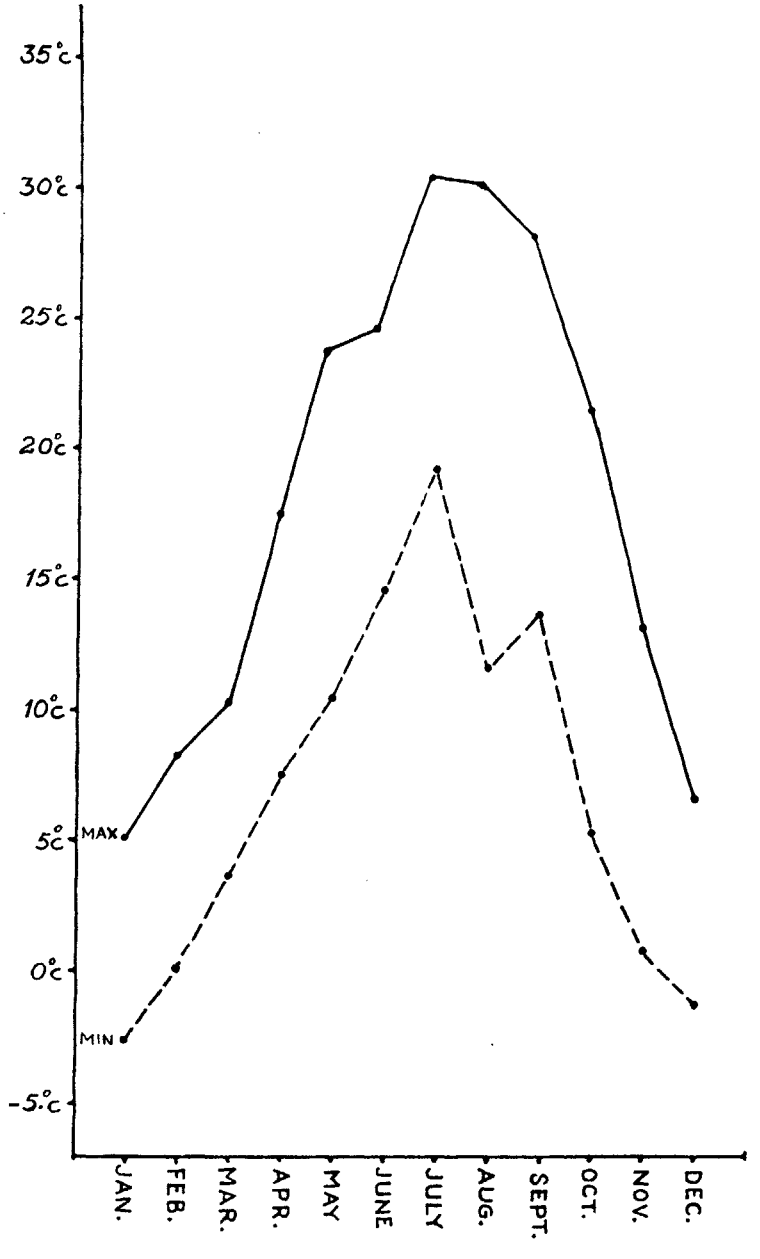
During the months of January and February the precipitation occurs mostly in the form of snow, which starts melting in March, when the percentage of relative humidity is fairly high.

The Area Under Study

For convenience an area of about 30 sq. km. in and around Srinagar was taken for the study of vegetation. It includes a major portion of Srinagar tehsil and Pampur area of Anantnag district (Fig. 2).

Topographically the area can be divided into the following zones :

1. *South-eastern portions.*—This extends from the south-eastern slopes of Shankaracharya Hill to the Saffron fields of Pampur. A major portion of the area is under cultivation as irrigation facilities are available from the river Jhelum passing through this area. The chief characteristics of this area are numerous fan-like projections, sloping away from the lower slopes of



GRAPH SHOWING MEAN MAXIMUM & MINIMUM MONTHLY TEMPERATURE OF SRINAGAR DURING 1960-1962.

FIG. 1.

TABLE I

Monthly rainfall during the years 1960–62 at Srinagar

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	33·3	5·8	150	117·8	57·1	20·4	64·3	75·4	14·5	0·0	5·9	58·8
1961	80·6	50·5	76·1	114·3	54·7	48·6	49·9	45·6	20·7	32·4	39·9	14·1
1962	12·2	80·4	29·9	111·3	33·4	31·3	48·2	34·3	105·4	7·4	80·9	4·1
Mean	42·3	45·6	85·3	114·5	48·4	33·4	54·1	51·8	48·6	13·2	42·2	40·6

the nearby mountain ranges. In fact the whole of the flat land on the banks of the Jhelum is composed of old 'Karewa' alluvium. The low-lying areas are frequently flooded by the river. The soil is rich and consists chiefly of clay with sandy subsoil.

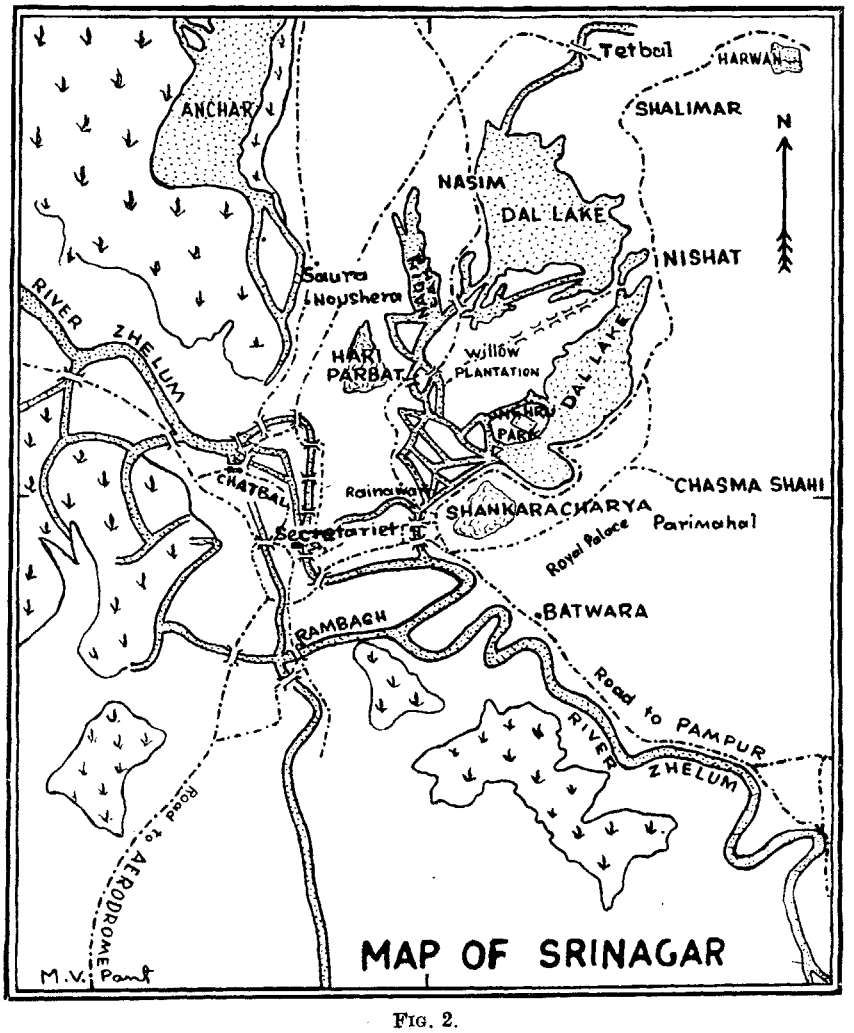


FIG. 2.

2. *North-eastern portions.*—It includes Dal and Nagin lakes and extends from Shankaracharya Hill to Shalimar Garden on the extreme north-east. The lower slopes of the mountain ranges lie in close proximity to this area. While two minor hills, viz. Hariparbat and Shankaracharya, are situated on the two sides of the lake, a major portion of the land is submerged by the stationary waters of the lakes and numerous marshy depressions, lagoons and pools. The soil is rich and is used for cultivating a variety of cash crops.

The area has a large number of fruit orchards and gardens, some of which, such as Nishat and Shalimar, are a great attraction for the tourists.

3. *Southern and south-western portions.*—It includes the thickly populated area and the colonies in the heart of the city. The area is strewn with a number of grass fields and lawns, while in the outskirts the land is under cultivation. Some portion of the land in this area is occupied by marshes and lagoons, otherwise the general condition is dry.

The authors have restricted their observations to the following habitats:

1. *Shankaracharya and Hariparbat hills.*—Situated in the heart of the city of Srinagar, these two hillocks reveal an interesting change in vegetation pattern, which is in contrast with that of the surrounding flat land. Hariparbat is only about 150 m high, on the top of which is situated an old fort. Whole of the area is under much biotic interference. The frequent grazing by the cattle has resulted almost into a complete denudation of the vegetation on the higher reaches of this hill. *Iris* is the commonest herb on the slopes. The base of the hill, however, shows an assemblage of *Peganum harmala* Linn., *Thymus serpyllum* Linn., *Lotus corniculatus* Linn., *Eryngium billardieri* Delar., *Erodium cicutarium* Leman., *Urtica dioica* Linn., *Herniaria hirsuta* Linn., *Malva, Plantago* and a number of thistles.

The other hill, commonly known as Shankaracharya, is about 320 m high. The vegetation in the base of the hill is represented by *Ailanthus altissima* (Mill.) Swingle, *Salvia, Centaurea, Euphorbia, Veronica, Marrubium* and *Iris.* The flora actually comes into view when one climbs some 80 to 90 m on the hill. The vegetation is chiefly shrubby and is dominated by the gregarious aromatic shrub of *Plectranthus rugosus* Wall., which restricts itself mostly to the exposed localities. Other common shrubs in this zone are *Rosa webbiana* Wall., *Rubus fruticosus* Linn., *R. lasiocarpus* Smith, *Cotoneaster nummularia* Fisch. and Mey., *Indigofera gerardiana* R. Garh. and *Lespedeza stenocarpa* Maxim. Frequently associated with these are a number of herbs, the common among which are *Linaria dalmatica* (Linn.) Mill., *Trigonella emodi* Benth., *Oxytropis cachemirica* Camb., *Medicago sativa* Linn., *M. laciniata* All., *Hypericum perforatum* Linn., *Phlomis spectabilis* Falc. ex Benth. and a number of grasses. While *Thymus serpyllum* Linn. forms the ground cover, *Cuscuta capitata* Roxb. with its shining yellow heads is found to twine on the various herbs and shrubs. *Ephedra intermedia* Schrenk. and Mey., with its red fruits, is also observed growing in these parts of the hill. On the western aspects, these localities are dominated by the low medicinal shrub of *Zizyphus vulgaris* Lamk. Higher up, the above formation is succeeded by *Daphne oleoides* Schreb., *Rubus fruticosus* Linn. and *Crataegus oxycantha* Linn. The ground cover in *Plectranthus* zone is mainly composed of *Iris* and a number of grasses such as *Koeleria cristata* Pers., *Cymbopogon jwarancusa* (Jones) Schult., *Pennisetum orientale* L. C. Rich., *P. flaccidum* Griseb., *Chrysopogon gryllus*

(Linn.) Trin., *Eragrostis nigra* Nees ex Steud., *Brachypodium sylvaticum* (Huds.) P. Beauv., *Dichanthium annulatum* (Forssk.) Stapf, *Hordeum murinum* Linn. and a few species of *Bromus* and *Poa*.

Higher up, in mostly exposed localities, an assemblage of various psammophytic herbs, viz. *Tribulus terrestris* Linn., *Herniaria hirsuta* Linn., *Lotus corniculatus* Linn., and the lithophytic *Rumex hastatus* D. Don and *Sedum adenotrichum* Wall., are noticed, while the exposed grassy slopes are inhabited by *Taraxacum officinale* Wigg., *Anemone biflora* DC., *Thymus serpyllum* Linn., *Tragopogon pratense* Linn., *Polygala sibirica* Linn. and *Malva rotundifolia* Linn. The path leading to the shrine is lined with planted trees of *Cedrus deodara* Roxb. Other common trees which line the way are *Celtis australis* Linn., *Robinia pseudacacia* Linn. and *Pyrus pashia* Buch.-Ham. ex D. Don. Among the shrubs, mention need be made of *Daphne oleoides* Schreb., *Crataegus oxycantha* Linn. and *Plectranthus rugosus* Wall. The herbs are represented by *Carduus nutans* Linn., *C. acanthoides* Linn., *Tragopogon pratense* Linn., *Medicago*, *Convolvulus*, *Thymus*, *Marrubium*, *Hypericum* and *Salvia*. Except for a few planted trees of *Platanus orientalis* Linn. and a few shrubs and herbs like *Crataegus*, *Robinia*, *Malva*, *Convolvulus*, *Polygonum*, *Sonchus*, *Hordeum*, *Sisymbrium*, etc., the hill-top is devoid of any forest communities. The flora on the various zones and aspects of the hill is chiefly of psammophytic type, with a number of lithophytic herbs and shrubs which inhabit the barren rocks in the higher localities. The composition of the flora on these hillocks differs considerably from that of the flat portions of the valley, and is more akin to that on the lower ranges of encircling mountain ranges.

2. *Dal lake and its extension Nagin.*—The great expanse of still water in Dal and Nagin lakes represents a veritable emporium for many aquatic, semi-aquatic and amphibious plants. The whole of the lake is full of several metres thick interwoven mass of the aquatic weeds composed mainly of *Potamogeton lucens* Linn., *Hydrilla verticillata* Casp. and *Myriophyllum spicatum* Linn., which at some places is so thick that even moving of a 'Shikara' becomes difficult. Associated with the above dominating submerged species are *Ceratophyllum demursum* Linn., *Potamogeton pectinatus* Linn., *P. crispus* Linn. and *Chara* sp., a member of Chlorophyceae. Except for the flowering terminal spikes and a few accompanying leaves in the case of *Potamogeton* and *Myriophyllum* spp., all other parts of the lake weeds are submerged in the water. Among the free-floating forms in the lake, the most conspicuous is the water fern *Salvinia natans* (Linn.) All. and a few species of *Lemna*. Towards the water margins *Nymphoides peltatum* Kuntze, a free-floating yellow-flowered herb with small lotus-like leaves, is very common. *Trapa natans* Linn., a submerged aquatic with floating leaves, is frequently cultivated in the lake and has become an important member of the aquatic community. *Hydrocharis morsus-ranae* Linn. is also encountered in the lake.

The lake abounds in a number of beautiful water lilies, quite a few of which have been introduced for ornamental purposes. These grow mainly in the shallower regions of the lake and near the floating islands. The major species represented in the Dal lake are rosy-pink-flowered *Nelumbo nucifera* (Willd.) Gaertn., *Nymphaea alba* Linn. and *Euryale ferox* Salsib., the prickly-lotus, which yields 'Makahna' seeds of commerce. Towards the water margins and side projections, the shallow portions are full of tall reeds and cat-tails, viz. *Phragmites communis* Trin. and *Typha angustata* Bory. and Chaub. The swampy portions of these localities have a good assemblage of many semi-aquatic and amphibious herbs, the more common among these are *Sagittaria sagittifolia* Linn., *Sparganium ramosum* Curt., *Alisma plantago* Linn., *Butomus umbellatus* Linn., *Rumex dentatus* Linn., *Ranunculus lingua* Linn., *R. scleratus* Linn., *R. muricatus* Linn., *Naturtium palustre* DC., *Malva silvestris* Linn., *Veronica anagallis* Linn., *Portulaca oleracea* Linn., *Polygonum aviculare* Linn., *P. amphibium* Linn., *P. hydropiper* Linn., *Pimpinella acuminata* C. B. Clarke, *Juncus lampocarpus* Ehrh., *J. bufonius* Linn., *Carex pseudocyperus* Linn., *Eleocharis palustris* R. Br., *Sium latijugum* C. B. Clarke and a number of *Scirpus* and *Cyperus* spp.

The most interesting aspect in the study of the vegetation of the lake lies in the stabilized and floating gardens. The skeleton of floating gardens are artificially made of long reeds of *Phragmites communis* Trin., so abundantly available around the lake. The floats from reeds are strong enough to bear the heavy weight of lake weed and the mud, heaps of which are placed on it from time to time. These are known as floating gardens and are used for cultivating a number of vegetables. A large number of wet meadow and semi-aquatic weeds invade these gardens in different seasons of the year and one finds a good assemblage of various species of *Potentilla, Veronica, Ranunculus, Fragaria, Oxalis, Polygonum, Nasturtium, Taraxacum, Setaria, Chloris, Smilacina* and *Spiranthes* associated with the cultivated crops.

The stabilized islands on the other hand are made in the shallower regions of the lake. The cultivator selects his site and plants willows (*Salix acmophylla* Boiss. and other species) along its four sides. Lake weed and mud are then transported into the demarcated area until the latter is above flood level. The land thus prepared is used for cultivating sweet-corn and a number of vegetables such as cucumbers, tomatoes, radish, etc. In some of the very old lands some fruit trees have also been planted. The weeds associated with these are *Potentilla supina* Linn., *P. wallichiana* Wall., *Taraxacum officinale* Wigg., *Hartmannia rosea* G. Don, *Galium aparine* Linn. and various species of *Veronica, Ranunculus, Plantago, Cyperus, Rumex, Euphorbia, Artemisia, Sonchus, Myriactis* and *Erigeron.*

3. *Marshes, lagoons and springs.*—In addition to the vast stretch of fresh water in the shape of Dal lake, the area abounds in a large number of

swamps and lagoons which are formed by the seepage and accumulation of sub-soil water in the old alluvium areas. These localities can frequently be seen in the depressions on both sides of the road and on the boundaries of rice fields. A lush growth of aquatics, amphibious and wet meadow herbs, is met with here. The commonest submerged herb in the running streams is *Ranunculus aquatilis* Linn. var. *trichophyllus*, which at some places is associated with *Ceratophyllum demursum* Linn. The marshy areas around springs show lush growth of *Acorus calamus* Linn., while interspersed between them are species of *Sagittaria*, *Sium*, *Alisma*, *Ranunculus*, *Butomus*, *Polygonum*, *Agrostis* and *Eleocharis*. Dense colonies of *Menyanthis trifoliata* Linn. are also observed around Barzalla. The moist muddy localities towards drier soil are full of the various species already described as growing in the marshy localities of Dal lake. *Lythrum salicaria* Linn., a recently naturalized plant, is frequently met with in these localities during the summer, while *Utricularia flexuosa* Vahl, an insectivorous herb, is also encountered at some places.

At places where the marshes turn into lagoons, due to deep stationary water, strands of reeds and cat-tails along with some members of Cyperaceae are noticed. *Sparganium ramosum* Curt., a tall member of Typhaceae, is frequently associated with these plants in the localities lying nearer to the Dal lake.

4. *The waste land and land along the roads and the river.*—Studies on the waste-land vegetation were conducted at a number of spots around Srinagar. For example, the area along the Srinagar Stadium in the south of the city is a repository of such species. The place is typical waste land, where there has been no biotic interference because of the protection afforded to it. Similar localities are scattered throughout the valley, and the vegetation, whether on the land on both sides of the road or on the banks of the river, is characterized by similar features; wherever there is a minor change in vegetation pattern it is mainly due to the presence or absence of moisture in the locality. The soil in most of the cases is dry and sandy and receives no water except for annual precipitation in the form of rain or snow. There are a few shrubs which are occasionally seen on these lands, the commonest of them being *Rubus fruticosus* Linn., *Daphne oleoides* Schreb. and *Berberis lycium* Wall.

With the advent of spring, a number of plants come into bloom; the commonest among these are *Ranunculus arvensis* Linn., *Conium maculatum* Linn., *Silene conoidea* Linn., *Capsella bursapastoris* Moench, *Cynoglossum denticulatum* DC., *Ranunculus falcatus* Linn., *Goldbachia laevigata* DC., *Polygonum tubulosum* Boiss., *Hyoscyamus niger* Linn., *Lotus corniculatus* Linn., *Verbena officinalis* Linn. and *Anagallis arvensis* Linn.

Further additions during the summer months are *Verbascum thapsus* Linn., *Cichorium intybus* Linn., *Euphorbia helioscopia* Linn., *E. thymifolia* Linn.,

Xanthium strumarium Linn., *Sisymbrium loeselii* Linn., *S. sophia* Linn., *Bupleurum lanceolatum* Wall., *Galinsoga parviflora* Cav., *Urtica dioica* Linn., *Marrubium vulgare* Linn., *Cousinia microcarpa* Boiss., *Centaurea iberica* Stev. and several species of grasses, some of which are *Digitaria marginata* Link., *Setaria verticillata* (Linn.) P. Beauv. and *Eragrostis nigra* Nees ex Steud. In somewhat moist localities, mostly near the banks of the river Jhelum, the ground cover is formed by the dense growth of prostrate creeping herbs such as *Coronopus didymus* (Linn.) Sm., *Tribulus terrestris* Linn. and species of *Oxalis*, *Herniaria*, *Geranium* and *Veronica*. Near city drains and other similar localities *Caucalis anthriscus* Scop. and various species of *Ranunculus* along with some other herbs are frequently seen clustered together in dense growth.

During the months of August and September, a number of Umbelliferous and Compositaceous herbs flower. The exposed waste places are full of *Artemisia scoparia* Waldst. and Kit., *Artemisia tournefortiana* Richb., *A. moorcroftiana* Wall., *Cannabis sativa* Linn., *Caucalis leptophylla* Linn., *Chenopodium album* Linn., *Chrozophora obliqua* A. Juss., *Plantago lanceolata* Linn. and *P. major* Linn., while on moist sciophytic habitat the major herbs are *Trifolium pratense* Linn., *Euphorbia helioscopia* Linn., *Epilobium roseum* Schreb., *Hartmannia rosea* G. Don, *Gnaphalium luteo-album* Linn., *Hypericum perforatum* Linn. and *Hibiscus trionum* Linn. *Datura stramonium* Linn. and *Cannabis sativa* Linn. inhabit the dry sandy places. On river banks a lush growth of *Mentha longifolia* Huds. and *Datisca cannabina* Linn., along with several species of *Veronica*, is noticed. In a majority of cases, the waste-land flora is dominated by semi-xerophytic and dry meadow herbs. It is only in the localities near the river banks or city drains that a lush growth of various herbs is noticed.

5. *The ruined buildings and dust heaps.*—These localities are generally inhabited by dry meadow herbs. On the garbage dumps and dust heaps, so common around the city and villages, a lush growth of *Datura stramonium* Linn., *Hyoscyamus niger* Linn., *Solanum nigrum* Linn., *Amarantus paniculatus* Linn., *Chenopodium album* Linn., *Carduus nutans* Linn. and *Chrozophora obliqua* A. Juss. is seen. Similarly, localities around ruined buildings and graveyards show an assemblage of many dry meadow herbs, viz. *Cannabis sativa* Linn., *Urtica dioica* Linn., *Verbascum thapsus* Linn., *Cichorium intybus* Linn. and *Scrophularia*, *Euphorbia*, *Erigeron* and *Gnaphalium* species. There is a custom in Kashmir to grow various species of *Iris* on and around the graves, which after some time get naturalized in the area and grow profusely around these localities.

6. *Parks, lawns and grass fields.*—There are a number of lawns and parks in and around Srinagar proper. The more familiar among these are Nishat, Shalimar, Partap Park, the Polo Ground and the Stadium. There are nicely kept grass lawns in all these places, the chief component of which is *Cynodon*

dactylon (Linn.) Pers. The other grasses associated with it are *Sclerochloa dura* Beauv., *Poa pratensis* Linn. and species of *Setaria*, *Bromus* and *Eragrostis*. These lawns are frequently subjected to mowing and except for some procumbent spreading herbs nothing is allowed to come up. A study of such herbs, which contribute in the making of multicoloured carpets, reveals a good assemblage of many annuals and perennials, such as pink-flowered *Erodium cicutarium* Leman., *Taraxacum officinale* Wigg., *Malva rotundifolia* Linn., *Launaea nudicaulis* Hook. f., *Plantago major* Linn., *Herniaria hirsuta* Linn., *Oxalis corniculatus* Linn. and *Tribulus terrestris* Linn.

The moist neglected corners in these fields, which escape mowing, show a lush growth of many annuals and perennials. During the spring these corners are full of purplish-white-flowered *Bellis perennis* Linn., white-flowered *Capsella bursapastoris* Moench and *Stellaria media* Linn. Species of *Fragaria*, *Oxalis*, *Medicago*, *Lathyrus*, *Sisymbrium*, *Erigeron*, *Anagallis*, *Veronica*, *Blumea*, *Conium*, *Scrophularia*, *Euphorbia*, *Caucalis*, *Chaerophyllum*, *Carpesium*, *Calamintha* and several grasses such as *Hordeum murinum* Linn., *Bromus japonicus* Thunb. and *Rottboelia exaltata* Linn. f. are found in plenty later during July-August.

Towards the autumn months, the major species are those of Umbelliferae and some species of *Artemisia*. Amongst many, mention may be made of *Caucalis anthriscus* Scop., *Chaerophyllum reflexum* Lindl., *Artemisia scoparia* Waldst. and *Artemisia moorcroftiana* Wall.

7. *Gardens and fruit orchards.*—A systematic census of different herbs and shrubs, which generally grow as an undergrowth of fruit and ornamental trees, revealed a larger number of sciophytic and humus-loving herbs in these localities. One frequently comes across a lush growth of various shrubs, viz. *Rubus*, *Rosa*, *Rubia*, *Hedera* and *Spiraea*. During spring common annual and perennial herbs in these localities are the yellow-flowered *Oxalis corniculata* Linn., *Erodium cicutarium* Leman., *Galium aparine* Linn., *Bellis perennis* Linn., *Stellaria media* Linn., *Barbarea vulgaris* R. Br., *Anagallis arvensis* Linn., *Eruca sativa* Linn., *Convolvulus arvensis* Linn., *Poa annua* Linn., *P. pratensis* Linn., *Phleum paniculatum* Huds., *Bromus japonicus* Thunb., *Puccinella distans* (Linn.) Parl, *Setaria viridis* (Linn.) P. Beauv., etc. At certain moist places a lush growth of yellow-flowered *Hypericum perforatum* Linn. is also seen; at others occurrence of *Nasturtium fontanum* Aschers, *Geum urbanum* Linn. and *Scandix pecten-veneris* Linn., is also to be observed.

The summer months show an addition of a number of leguminous herbs, such as *Lotus corniculatus* Linn., *Melilotus alba* Lamk. and some species of *Trifolium*, *Lathyrus*, *Medicago* and *Astragalus*. *Geranium ocellatum* Camb., *G. pratense* Linn., *Calamintha clinopodium* Benth., *Nepeta cataria* Linn., *N. mollis* Benth., *Fragaria vesca* Linn., *Thymus serpyllum* Linn., *Rumex nepalensis* Spreng. and *Taraxacum officinale* Wigg. are of the common herbs in these

localities during this period, while on the exposed dry land in the gardens *Verbascum thapsus* Linn. and *Verbena officinalis* Linn. can be frequently seen.

Late in September, various plants observed in moist shady localities are *Impatiens amphorata* Edgew., *Rubia cordifolia* Linn., *Plantago lanceolata* Linn., *P. major* Linn., *Achillea millefolium* Linn., *Geranium ocellatum* Camb., *Daucus carota* Linn., *Caucalis leptophylla* Linn., *Cyperus rotundus* Linn., *Myriactis nepalensis* Less. and *Siegesbeckia orientalis* Linn., and species of *Rumex, Polygonum, Abutilon* and *Viola* are also to be observed.

8. *Cultivated fields.*—A successional study on the growth of various species associated with cultivated crops obviously revealed the presence of a large number of weeds. The dominating species which grow along with wheat and barley in early spring are *Papaver dubium* Linn. and *Ranunculus arvensis* Linn., which impart a characteristic red and yellow colour to the fields. *Lolium temulentum* Linn., one of the commonest representatives of grasses, is abundantly met with in fields during this period of the year. Associated with it are a number of other grasses, viz. *Bromus japonicus* Thunb., *Poa pratensis* Linn., *Cynodon dactylon* (Linn.) Pers., *Vulpia myuros* (Linn.) Gmel., etc. Other herbaceous species which are often encountered in the area are *Filago germanica* Linn., *Senecio coronopifolius* Desf., *Polygonum tubulosum* Boiss., *Adonis aestivalis* Linn., *Saponaria vaccaria* Linn., *Erodium cicutarium* Leman., *Ranunculus hirtellus* Royle, *Capsella bursapastoris* Moench, *Caucalis latifolia* Linn., *Vicia sativa* Linn. and *Echinospermum minimun* Lehm. The common twining and trailing herbs associated with these crops are the pink-flowered *Convolvulus arvensis* Linn. and the white-flowered *Galium aparine* Linn., and sparsely distributed *Tulipa stellata* Hook.

In June *Silene conoidea* Linn. and species of *Malva, Geranium, Lycopsis* and *Euphorbia* flower in the cultivated fields. The moist patches in the fields at this time are covered with the diffuse growth of the yellow-flowered *Cotula anthemoides* Linn. In the case of major crops of paddy in the valley, quite a number of summer weeds described above are found distributed in the fields. The prostrate, spreading *Kickxia subsessilis* Pennell and the greenish-yellow-flowered *Erigeron bonariensis* Linn. dominate the fields during this season. A profuse growth of *Cichorium intybus* Linn., *Cousinia microcarpa* Boiss., *Carduus nutans* Linn., *Saussurea candicans* C. B. Clarke, *Thymelaea arvensis* Lamk., *Taraxacum officinale* Wigg., *Launaea nudicaulis* Hook. f. along with *Fumaria parviflora* Lamk., *Portulaca oleracea* Linn., *Hibiscus trionum* Linn., *Heliotropium eichwaldii* Steud., *Tribulus terrestris* Linn., *Aeschynomone indica* Linn., *Thymus serpyllum* Linn. and *Euphorbia emodi* Hook. f. also contribute to the density of the summer vegetation.

During the months of August and September the rice fields are invaded by species of *Cyperus, Geranium, Epilobium, Caucalis, Trifolium, Prunella, Lactuca* and *Cynoglossum.* The swampy areas bordering paddy fields are

full of pinkish *Lythrum salicaria* Linn. When the paddy is nearly ready for harvest in October, a number of new-comers make their appearance in the fields ; chief among these are the yellow-flowered *Gnaphalium luteo-album* Linn., *Cnicus wallichii* DC., *Sonchus arvensis* Linn. and the blue-flowered *Cynoglossum micranthum* Desf. Associated with these also grow species of *Nasturtium, Chrozophora, Solanum, Trifolium, Epilobium, Oenothera* and *Euphorbia*. A number of grasses also inhabit the cultivated fields during these months, common among which are *Setaria glauca* (Linn.) P. Beauv., *Sorghum halepense* (Linn.) Pers. and *Sorghum nitidum* (Vahl) Pers., the latter being most abundant and conspicuous by its red-brown spikes.

Discussion

The survey of the local vegetation revealed that level land in the valley is rather deficient in the natural arboreal flora. In contrast to the lower spurs of the nearby mountain ranges, where *Euonymus, Morus, Parrotia* and a number of conifers thrive luxuriantly, the valley can claim only a few trees of walnut, horse-chestnut and mulberry as occurring wild. The geological history of the valley shows that the valley had been subjected to frequent floods even after the stabilization of the dry land in the area. This, together with the unique soil conditions derived from the 'Karewa' formation and most prevalent biotic interference in the area, has probably hindered the growth of forest communities.

Much of the greenery of the area is contributed by a large number of avenue, ornamental and fruit trees and shrubs, which have been quite liberally planted throughout the valley. Some of these, such as chinar, poplars and apricots, were planted during the Mughal period. Among the avenue and ornamental trees common in the area are: chinar (*Platanus orientalis* Linn.), poplars (*Populus alba* Linn. and other species), willows (*Salix acmophylla* Linn., *S. wallichiana* Andrs. and other species), silver oak (*Grevellia robusta* C. Cunn.), *Robinia pseudacacia* Linn., *Ailanthus altissima* (Mill) Swingle, *Laburnum anagyroides* Medic. and *Magnolia grandiflora* Linn.

The valley is one of the major producers of temperate fruits. The common fruits grown in the area are apple (*Malus sylvestris* Mill.), pear (*Pyrus communis* Linn.), cherry (*Prunus avium* Linn.), apricot (*Prunus armenica* Stokes), alu-bokhara (*Prunus cerasifera* Ehrh.) and the walnut (cultivated varieties of *Juglans*).

The main shrubs in the localities are *Spiraea hypericifolia* Linn., *Deutzia corymbosa* R. Br., *Philadelphus coronarius* Linn., *Tamarix dioica* Roxb., *Berberis lycium* Wall., *Daphne oleoides* Schreb. and a few species of the genus *Rubus*. It is very much open as compared with the shrubby vegetation of higher localities where dense formations of a large number of shrubs inhabit the slopes of the lower mountain spurs and of hillocks like Shankaracharya and

Hariparbat. It has also been observed that the localities nearer to mountain streams and nullahs, which are characterized by the rich sandy loam of the new alluvium, have a rich growth of many shrubs such as *Spiraea*, *Indigofera* and *Rosa* while the 'Karewas' with predominantly clay soil are almost devoid of any self-introduced plant.

A large number of annuals and perennials, ranging from semi-aquatic and amphibious herbs to psammophytic and semi-xerophytic, are encountered in the area. Quite a few among these are representatives of European flora, while many species are not found at all in localities lying south of Pir Panjal and Wardwan ranges. In a majority of cases the flora of waste land, which gets minimum water supply, is dominated by such herbs as *Carduus*, *Centaurea* and *Cnicus* which show a xerophytic character. It is only in the localities near the river banks or city drains that a lush growth of various herbs is noticed. As is evident from the foregoing pages all the terrestrial plant communities are very closely related to the amount of water available. As such we see a rich assemblage of various herbs in cultivated fields and grass lands which are frequently irrigated in contrast to the waste-land flora, which with its limited water resources is mainly characterized by chersophytic communities.

The most interesting aspect of the vegetation of the valley is in the aquatic and semi-aquatic communities, which thrive in all sorts of aquatic habitats, which range from marshes to lagoons and deep lakes. The hydrophytes are mainly represented by the submerged aquatic association of *Hydrilla-Potamogeton-Myriophyllum* in deep waters and semi-aquatic complex of *Typha* and *Phragmites* in shallow waters. Interspersed between these are a large number of other submerged, free-floating, amphibious and wet-meadow plants, which comprise the rich aquatic flora of the region. It has been observed that the flora represented in and around Dal lake is very distinctive and many of the plants found here are seldom represented in similar localities elsewhere in the North-west Himalayas.

It has been noticed that a majority of terrestrial annuals and perennials flower during the months of April, May and June. A perusal of the rainfall data given in the preceding pages shows that the valley experiences the heaviest rainfall during the month of April, which is steadily accompanied by a rise in the temperature and an increase in the day length. As all the external requirements of plants, viz. availability of water, optimum temperature and increase in the photoperiod, are available, it is quite natural that the majority of herbs which are so dependent on climatic factors flower during these months. In most of the cases the life-cycle in the herbs comes to a close before the winter sets in.

The suitable climatic and soil conditions in the valley have also provided a ready field for the introduction and successful raising of such important

medicinal, aromatic and insecticidal plants as *Atropa belladonna* Linn., *Digitalis lanata* Ehrh., *D. purpurea* Linn., *Dioscorea deltoidea* Wall., *Solanum aviculare* Forst. f., *Lavandula officinalis* Chaix., *Mentha piperita* Linn., *Chrysanthemum cinerariaefolium* vis. and a number of other exotics.

A total number of 279 species, belonging to 205 genera and 65 families of Angiosperms and Gymnosperms, have been collected in the course of the study.

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