ON THE SUBTROPICAL CLIMATE AND VEGETATION OF THE INDIAN SUB-CONTINENT

V. M. MEHER-HOMJI

Institut Francais, Pondicherry

ABSTRACT

The term subtropical in phytogeographical literature carries varied significance with reference to latitude, climate and plant-cover. In climatic terms, temperature, rainfall and its seasonal distribution are involved offering considerable variations. Vegetational and floristic features add further dimension to the complex of subtropicality which thus, acquires an array of meanings from several disciplines and lends itself to some confusion. All the subtropical forests described by Champion are in fact montane types, a number of them within the tropic, but latitude-wise exclusively subtropical *Anogeissus pendula* type and the northern desert thorn type are entitled tropical. From phytogeographical view-point, four variants of subtropicality are distinguished in the present work—(1) low elevation latitude-based in Rajasthan, (2) higher elevation tropical montane in the hill ranges of Peninsular India where the temperature and photoperiod regimes differ from those of the subtropical latitudes, (3) motane variant of the Himalayas and (4) mediterranean of Baluchistan. Species typifying these variants have been listed.

INTRODUCTION

The term subtropical has been often used without precision in phytogeographical literature because of its geographic implication and varied climatic interpretations. Physically, the areas between about 23 1/2°—40° latitude N (or S) may be classified as subtropical but as the climatic factors are so much influenced by parameters other than latitude like topography and monsoon mechanism that the vegetation types are not strictly parallel-based. Hyderabad in the Sind and Cherrapunji located at almost the same latitude (25°N) provide strong contrast between a desert ecosystem and a wet hill type.

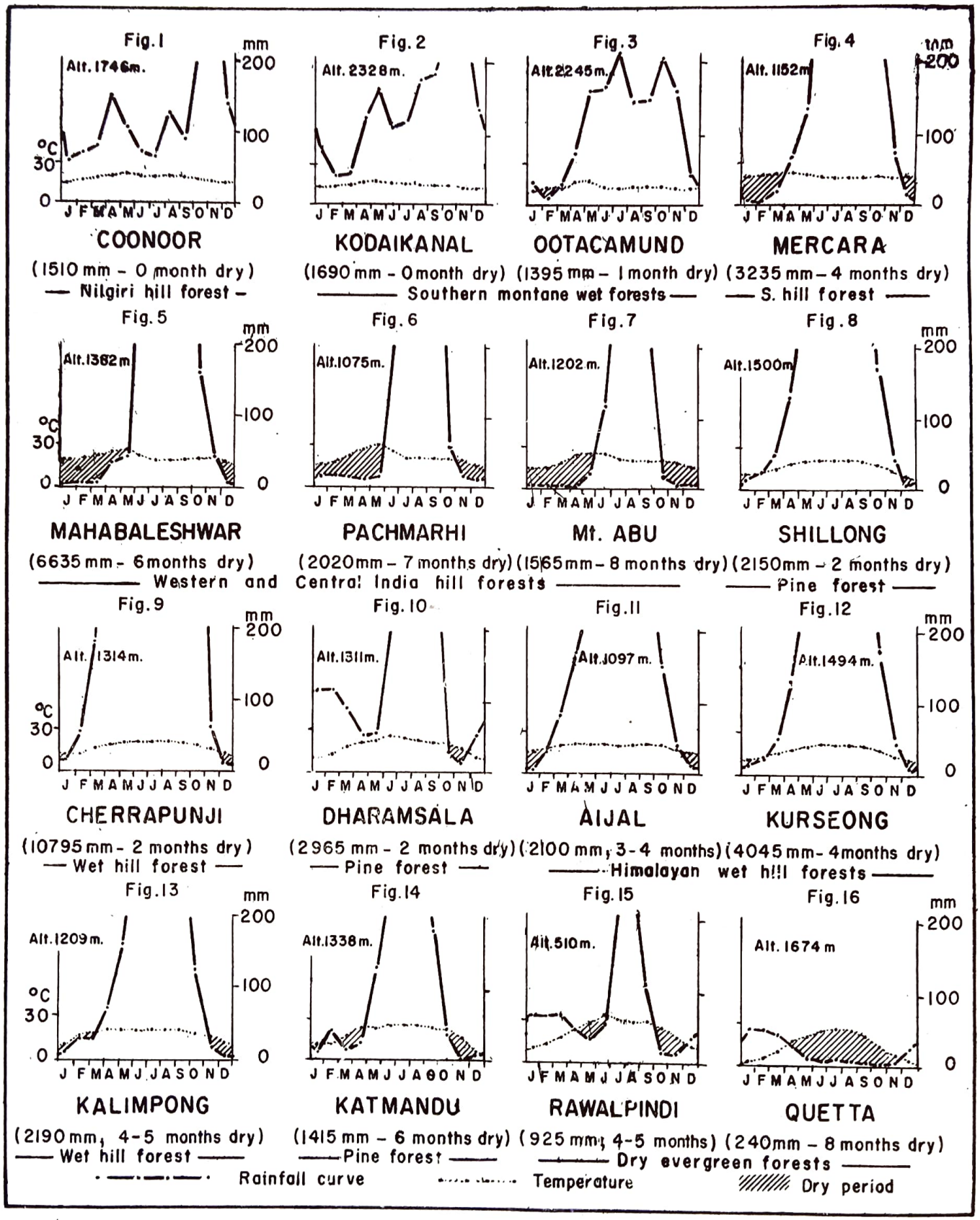
Climatically, the subtropical belt may be assigned three characteristics :

(1) Temperatures are lower than in the tropics. Champion and Seth (1968) define subtropical climate as one being hot with a cool winter, the range of the mean annual temperature being 17°—24°C and that of January 10°—18°C. Tropical hilly regions of moderate elevation are thus, brought within the scope of subtropical climate though in their diurnal and seasonal rhythms of temperature and photoperiod they differ from the conditions prevailing in higher latitudes (Meher-Homji, 1967).

(2) Precipitation is generally lesser than in the rainy tropics. Though most of the Saharo-Tharian desert and the other arid zones of the world occur in the subtropical latitudes, the statement is not wholly true. Cherrapunji, for instance, is one of the rainiest places in the world.

(3) Season of occurrence of rains is different than in the tropical regime where the rains are concentrated during the summer period. Certain phytogeographers use the term subtropical for the areas having mediterranean climate withprecipitation in winter-spring-autumn, summers being dry. It is probably with this view in mind that Champion (1936) placed the dry mediterranean vegetation of N. W. Pakistan under the subtropical dry evergreen forest. Fig. 16, ombrothermic diagram (cf. Bagnouls & Gaussen,

1957) represents the climate of Quetta. However, the stations experiencing typical S. W. monsoon regime like Mahabaleshwar, Pachmarhi, Mt. Abu, Shillong (Figs. 5 to 8) have also been classified by CHAMPION (*l.c.*) as having subtropical vegetation. In fact, the tropical regime itself shows quite some variations of rainfall pattern (LEGRIS & VIART, 1961).



OMBROTHERMIC DIAGRAMS OF STATIONS HAVING SUBTROPICAL VEGETATION TYPES

The various vegetation types described by CHAMPION (1936) and CHAMPION AND SETH (1968) as subtropical are *invariably* montane types, located in the hill ranges at moderate altitude. Figs. 1 to 16 reveal wide climatic variations in terms of annual rainfall, number of dry months and season of occurrence of rains presented by the stations having different types of subtropical forests. On the contrary, CHAMPION's tropical deciduous edaphic forest in the Aravallis at low elevation and in Bundelkhand dominated by *Anogeissus pendula* Edgew., is geographically confined to the subtropical latitude, though many of the associate species of *A. pendula* occur southwards too. Likewise, the northern tropical desert thorn forests of CHAMPION, i.e. the *Calligonum polygonoides* L. "Series" and the "*Prosopis cineraria* (L.) Druce, *Capparis decidua* (Forsk.) Pax, *Ziziphus* spp. and *Salvadora oleoides* Dcne. "Series" of GAUSSEN, MEHER-HOMJI *et al.* (1971) find their maximum development in the arid belt of Kutch and Rajasthan above 23 1/2° N latitude SCHWEINFURTH (1957) rightly refers to this type as subtropical thorn-steppe. The deciduous teak (*Tectona grandis* L.f.) forests rarely surpass the tropical line, maximum limit being 25° N. On the other hand the Sal (*Shorea robusta* Gaertn. f.) forests extend on either side of the tropic of Cancer.

The use of the term extratropical floristic element by MEUSEL (1971) for Western Himalaya is commendable but it is somewhat surprising to note on pages 67 and 71 of his work tropical trees like *Bombax ceiba* L., *Cassia fistula* L., *Lannea coromandelica* (Houtt.) Merr. and shrubs like *Carissa carandas* L., *Dodonaea viscosa* L. being referred to subtropical dry forests.

Of the 29 types recognised by SCHWEINFURTH (1957) in the Himalayas, only three are assigned to the subtropical category, viz. (1) subtropical semi-desert with *Capparis*, *Pistacia*, *Tamarix* as the principal taxa, (2) subtropical thorn-steppe to which a reference has been made earlier and (3) subtropical evergreen sclerophyllous forest corresponding to the subtropical dry evergreen type of Champion. Six types are referred to as tropical, three as temperate, four as alpine or subalpine; thirteen types do not bear any climatic implication.

The transition from the tropical to the mediterranean or temperate type generally takes place either through a desertic climate or a montane climate (MEHER-HOMJI, 1963). CHAMPION AND SETH (1968) created the subtropical category more as a matter of convenience to pass from the tropical to the temperate type; as indicated earlier, the division is purely based on temperature. In the hill ranges of Peninsula, the change from the tropical type of the plains to the temperate type of higher altitude is marked by a certtain overlapping of the representative species of the lower and the upper vegetation belts which again suggests that the appellation 'tropical montane' would be a good substitute for the 'subtropical' types of these hills.

DISTRIBUTION OF THE SUBTROPICAL CLIMATE AND VEGETATION: A GLOBAL VIEW

TROLL AND PAFFEN (1964) have assigned subtropical climate to the plains and hilly country with mild winters, the mean temperature of the coldest month ranging from 2 to 13°C; it is subdivided into seven types. The classification of BAGNOULS AND GAUSSEN (1957) avoids the term subtropical but the following three bioclimates seem to approach the notion of subtropicality : (1) *mediterranean*—summers dry, mean temperature of the coldest month (*t*) 0 to 15°C, (2) *mesoxerochimenic* or *mesotropical*—winters dry, *t* as above, (3) *eumesaxeric*—no dry period, *t* between 10-15°C. TROLL AND PAFFEN classify the Thar and a part of N. W. Pakistan from the sub-continent under subtropical climate, the Thar in the desert category and the latter region in the mediterranean

and steppe category. According to the system of BAGNOULS AND GAUSSEN, apart from a portion of N. W. Pakistan under mediterranean climate (7-8 months dry), the sub-Himalayan tracts under mesotropical climate (1-2 months dry) represent the subtropical category (MEHER-HOMJI, 1963).

The physiognomy of vegetation under mediterranean climate varies from a steppe to a sclerophyllous forest depending on the degree of humidity. The scrub dominated by ligneous evergreen sclerophyllous species is known by different names in different countries: garrigue, maquis (S. Europe, W. Asia), tomillare (Spain), chaparral (California), mattoral (Chile), subtropical dry evergreen forest (Baluchistan).

The following are amongst the genera conspicuous in the mediterranean climes of the northern hemisphere : *Acer*, *Aesculus*, *Alnus*, *Arbutus*, *Argania*, *Castanus*, *Cedrus*, *Celtis*, *Ceratonia*, *Cercis*, *Chamaerops*, *Cotinus*, *Crataegus*, *Cupressus*, *Daphne*, *Fraxinus*, *Juniperus*, *Laurus*, *Lonicera*, *Myrtus*, *Nerium*, *Olea*, *Phyllyrea*, *Pinus*, *Pistacia*, *Platanus*, *Quercus*, *Rhamnus*, *Rhus*, *Sequoia*, *Staphylea*, *Styrax*, *Tetraclinis*, *Viburnum*, *Ziziphus*. Some of the typical S. American mediterranean genera are *Colletia*, *Cryptocarya*, *Lithraea*, *Mimosa*, *Peumus*, *Quillaja*; *Leucadendron*, *Podocarpus*, *Protea* are their counterparts in the mediterranean S. Africa and *Banksia*, *Exocarpus*, *Eucalyptus*, *Melaleuca*, *Protea* in Australia. Whereas in the northern hemisphere, the mediterranean flora is derived from both the tropical and temperate ancestors, in the southern half, the origin is exclusively tropical (RAVEN, 1971).

Mesotropical climate in its drier variant (5 to 8 months dry) occurs in South Africa, South America (Bolivia—Argentina), Mexican plateau, central hill ranges of Ankaratra and Andringitra in the Malagassy Republic, in Kweichow, Yunnan and southern part of Szechwan in China (MEHER-HOMJI, 1963). The vegetation is either a thorny thicket or scrub or yet a savanna locally called *Veld* in S. Africa and *Savoka* in Madagascar. Species of *Acacia*, *Dodonaea* characterise the landscape in S. Africa, whereas, *Prosopis*, *Mimosa*, *Trichocerus*, *Opuntia*, *Aspidosperma*, *Gourliea*, *Schinopsis*, *Ziziphus*, *Celtis* dominate in South America. In Mexico, the conspicuous plants are *Acacia*, *Agave*, *Yucca* and *Opuntia*. In China, species of *Quercus*, *Diospyros*, *Machilus*, *Castanopsis*, *Nephelium litchi* Camb., *Cinnamomum camphora* L. are amongst the important elements in the park-savanna formation.

Mesotropical climate under a wetter variant (1 to 4 months of dryness) is of rare occurrence at low elevation; it is encountered in the southern part of Fukien province of China with a "subtropical" forest and also in parts of South America. Essentially it is a montane climate; examples are South Indian hills, lower elevation of the Himalayas, mountainous tract of Burma, Thailand, Indochina (with *Pinus khasya* Royle, *P. merkusii* Jungh.; species of *Quercus*, *Pasania*, *Castanopsis*, *Schima*, *Podocarpus*, *Styrax benzoin* Dryander, *Michelia champaca* L.), Ethiopia plateau, South Africa, Ecuador, Colombia, Bolivia.

Eumesaxeric climate covers part of the coastal plain of Florida and Alabama ("subtropical" forest with *Pinus caribaea* Morelet, *Quercus brevifolia* Kotschy, *Q. catesbaei* Michx., *Liquidambar styraciflua* L., *Nyssa biflora* Watt., *Acer rubrum* L., *Magnolia grandiflora* L., *Sabal pulmetto* Todd.; *Taxodium distichum* Rich. occurs in swamps); it also prevails along the east coast of New South Wales in Australia (*Eucalyptus* spp.), in southern part of the Northern Island of New Zealand (*Agathis australis* Steud.,), parts of Uruguay, Argentina, and Central China from Tsin-Ling-Shan and the hills to the north of Lower Yangtze up to the hilly region of Kweichow (*Cinnamomum camphora*, *Dryobalanops aromatica* Gaertn., *Gingko*, *Cupressus*, *Pinus*).

This survey reveals that a variety of taxa occurs under the subtropical climate but a few genera like *Pinus*, *Quercus*, *Acer*, *Styrax*, *Celtis* stand out in being more widely distributed than the others, featuring both in the mediterranean and mesotropical or

eumesaxeric category. However, certain species of these wide-spread genera also characterise the temperate climes and therefore, to delimit the subtropical zone, a proper selection has to be made of suitable species typifying this belt and that any species of *Quercus* or *Pinus* will not do to make out the subtropical climate.

Subtropical Forests of the Indian Sub-continent

Champion and Seth (1968) have classified the subtropical forests as follows :

I—Subtropical broad-leaved hill forests :

(A) Southern (900—1800 m) :

(a) *Southern* subtropical hill forests, between 1200-1750 m on the slopes of the Anamalai, Palni, Nilgiri ranges, also in the Western Ghats in Kerala upto Coorg in Karnataka.

(b) *Western :* Above 900 m in the W. Ghats in N. Karnataka and Maharashtra, in the Aravallis above 1200 m (*Anogeissus pendula* forest excluded).

(c) *Central :* In the higher elevations of the Satpura, Vindhya, Chota Nagpur, Parasnath hills.

(B) Northern :

(a^1) East Himalayan subtropical wet hill forests.

(b^1) Khasi subtropical wet hill forests.

II—Subtropical Pine forests.

III—Subtropical dry evergreen forests.

(1) *Southern subtropical broad-leaved forests*

We have selected the Western Ghats to represent the case of the southern subtropical forests as they cover both the 'western' and 'southern' sub-types mentioned by Champion and Seth (*l.c.*). Secondly, the forests are relatively better protected and also floristically more diversified in view of larger climatic ranges in the Western Ghats than in Central India. The forests of all the Peninsular hill ranges possess many deciduous species in common up to an elevation of 900 m in Central India and 1200 m in Southern India; these species also thrive in the plains (Legris & Meher-Homji, 1977).

In Table 1 are enumerated some of the species commonly encountered between 1200-1800 m in the Western Ghats in Kerala, Karnataka and Tamil Nadu including the Anamalai, Palni and Nilgiri ranges. Only noteworthy species are cited in order not to make the table too long. Species which exceed 1800 m and those of lower elevation which manage to reach the altitude of 1200 m are also given in Table 1.

(2) *Himalayan subtropical forests*

The essential floristic composition of the Himalayan subtropical forests including the northern broad-leaved and pine forests is given in Table 2.

(3) *Subtropical dry evergreen forests*

They occur mainly in Pakistan along the foot-hills of the Himalayas, the Salt Range, the Kala Chitta hills in the Punjab, in Hazra and Baluchistan. Winter-Spring rains are a salient feature of the climate (Figs. 15-16).

The natural vegetation of Baluchistan is much disturbed by man and his domesticated animals. The chief conifer is *Juniperus macropoda* Boiss. which forms open forest. Among other trees and shrubs that deserve mention are *Pistacia mutica* Fisch. & Mey., *P. khinjuk* Stocks, *Olea cuspidata* Wall., *Fraxinus xanthoxyloides* Wall., *Acacia modesta* Wall. and *Crataegus oxycantha* L. The Waziristan has also a mediterranean character with *Olea cuspidata* and *Quercus baloot* Griff. which is closely related to *Quercus ilex* L., the holly oak of the Mediterranean Region.

Table 1—Some noteworthy species encountered between 1200-1800 m in the Western Ghats in South India

Hydnocarpus alpina Wt.
Pittosporum floribundum W. & A.
P. neelgherense W. & A.
Mesua ferrea L.
Garcinia travancorica Bedd.
Ternstroemia gymnanthera (W.& A.) Sprague
Eurya japonica Thunb.
Elaeocarpus serratus Linn.
E. oblongus Gaertn.
E. munroii Mast.
E. tuberculatus Roxb.
E. venustus Bedd.
Achronychia pedunculata (L.) Miq.
Heynea trijuga Roxb.
Microtropis stocksii Gamb.
Euonymus dichotomus Heyne
Kurrimia indica (Bedd.) Gamb.
Turpinia cochinchinensis (Lour) Merr.
Filicium decipiens Thw.
Euphoria longana Lam.
Nothopegia colebrookiana Bl.
Humboldtia unijuga Bedd.
Pitheclobium subcoriaceum Thw.
Pygeum wightianum Bl.
Eugenia wightiana Wight
Syzygium bracteatum (Willd.) Raizada
S. arnottianum Walp.
S. montanum Gamble
Memecylon malabaricum Cogn.
M. edule Roxb.
Schefflera wallichiana Harms.
S. venulosa Harms.
Mastixia arborea C. B. Clarke
Ardisia humilis Vahl
A. pauciflora Heyne
Pouteria tomentosa (Roxb.) Baehni
Diospyros nilagirica Bedd.
Symplocos laurina (Retz.) Wall. ex G. Don
S. gardneriana Wt.
S. sessillis Clarke
S. spicata Roxb.
Ligustrum walkeri Dcne.
L. roxburghii C. B. Clarke
Olea glandulifera Wall.
O. dioica Roxb.
Linociera ramiflroa (Roxb.) Wall.
L. courtallensis Bedd.
Alstonia venenata R. Br.
Fragraea obovata Wall.
Clerodendrum serratum Spreng.
C. viscosum Vent.
Myristica beddomei King
Cinnamomum sulphuratum Nees
Cryptocarya wightiana Thw.
C. stocksii Meissn.
Phoebe lanceolata Nees
P. paniculata Nees
P. wightii Meissn.
Litsaea deccanensis Gamble
L. stocksii Hk.f.
Actinodaphne hookeri Meissn.
A. salicina Meissn.
Elaeagnus conferta Roxb.
E. kologa Schlecht.
Antidesma menasu Miq.
Drypetes venusta (Wight) Pax & Hoffm.
Glochidium lanceolarium Dalz.
G. velutinum Wt.
Agrostistachys indica Dalz.
Podocarpus wallichiana Presl.

Some of the species exceeding 1800 m in the Western Ghats

Michelia nilagirica Zenk.
Mahonia nepalensis DC.
Pittosporum tetrasperma W. & A.
Hypericum mysorense Heyne
H. japonicum Thunb.
Garcinia cambogia Desr.
Gordonia obtusa Wall.
Evodia lunu-ankenda (Gaertn.) Merr.
Nothapodytes foetida (Wight) Sleumer
Ilex denticulata Wall.
Euonymus crenulatus Wall.
Meliosma microcarpa (W. & A.) Craib.
M. wightii Planch.
Photinia notoniana W. & A.
Rhodomyrtus tomentosus Wt.
Schefflera racemosa Harms.
Lonicera leschenaultii Wall.
Vaccinium neilgherrense Wt.
Symplocos pendula Wt.
Machilus macrantha Nees
Litsaea wightiana Hook.
Lasiosiphon eriocephalus Dcne.
Daphniphyllum neilgherrense Rosenth.
Croton aromaticus L.
Celtis tetrandra Roxb.
Laportea terminalis Wt.
Salix tetrasperma Roxb.

Examples of species reaching 1200 m

Polyalthea fragrans (Dalz.) Bedd.
Scolopia crenata Clos.
Xanthophyllum flavescens Roxb.
Garcinia tinctoria Dunn.
Calophyllum elatum Bedd.
Poeciloneuron indicum Bedd.
Cullenia excelsa Wt.
Grewia tiliaefolia Vahl
Amoora canarana Benth. et Hook.
Toona ciliata Roem.
Microtropis wallichiana Wt.
Leea indica (Burm.) Merill
Allophylus serratus Radlk.
Lepisanthes decipiens Radlk.
Pittosporum dasycaulon Miq.
Meliosma simplicifolia Hook f.
Gluta travancorica Bedd.
Humboldtia unijuga Bedd.
Acrocarpus fraxinifolius Wt.
Carallia brachiata (Lour.) Merr.
Anogeissus latifolia Wall.
Syzygium cumini (L.) Skeels
S. gardneri Thw.
Careya arborea Roxb.
Palaquium ellipticum (Dalz.) Engl.
Linociera macrophylla Wall.
Heterophragma quadriloculare (Roxb.) K. Schum.
Vitex altissima L.
Beilschmiedia wightii Benth.
Bischofia javanica Bl.
Drypetes elata (Bedd.) Pax et Hoffm.
Glochidion hohenackeri Bedd.
Croton malabaricus Bedd.
Celtis wightii Planch.
Artocarpus hirsuta Lam.
Debregeasia velutina Gaud.
Claamus pseudotenuis Becc.
Bentinckia condappana Berry
Gnetum scandens Roxb.

Table 2—Essential floristic composition of the Himalayan sub-tropical forests

First storey

Acer oblongum Wall.
A. thomsoni Miq.
Aglaia perviridis Hiern.
Alnus nepalensis D. Don
Beilschmiedia roxburghiana Nees
Betula alnoides Ham.
B. cylindrostachys Wall.
Calophyllum polyanthum Wall.
Castanopsis indica A. DC.
C. tribuloides A. DC.
Cinnamomum cecicodaphne Meissn.
Cedrus deodara Loud.
Engelhardtia spicata Bl.
Ficus nemoralis Wall.
Lithocarpus spicatus Rehder et Wils.
Litsaea citrata Bl.
Machilus odoratissima Nees
Macropanax orophilum Miq.
Manglietia insignis Bl.
Michelia champaca L.
Morus laevigata Wall.
Microtropis discolor Wall.
Nyssa javanica (Bl.) Wang.
Ostodes paniculata Bl.
Phoebe attenuata Nees
P. lanceolata Nees
P. paniculata Nees
Pinus insularis Endl.
P. roxburghii Sargent
P. wallichiana A. B. Jack
Quercus fenestrata Roxb.
Q. griffithi Hk. f. et T.
Q. glauca Thunb.
Q. incana Roxb.
Q. semiserrata Roxb.
Q. serrata Thunb.
Q. truncata King
Reevisia pubescens Mast.
Schima wallichi Chois.
Saurauja roxburghii Wall.
Symingtonia populnea (R. Br.) Van Steenis
Talauma hodgsoni Hk. f. et T.

Species typical of the tropical deciduous forests which occur in the first storey are :

Albizia procera Benth.
Anogeissus latifolia Wall.
Bauhinia purpurea L.
Cassia fistula L.
Lagerstroemia parviflora Roxb.
Lannea coromandelica (Houtt.) Merr.
Ougeinia oojeinenis (Roxb.) Hochr.
Shorea robusta Gaertn.
Stereospermum personatum (Hassk.) Chatt.
Terminalia bellerica Roxb.
T. chebula Retz.
T. tomentosa W. & A.
Toona ciliata Roem.

Second Storey

Boehmeria rugulosa Wedd.
Coriaria nepalensis Wall.
Dendrocalamus patellaris Gamb.
D. sikkimensis Gamb.
Drypetes venusta Pax & Hoffm.
Engelhardtia colebrookiana Lindl.
Eugenia kurzii Duthie ex Kurz
Garcinia paniculata Roxb.
Grewia vestita Wall.
Gynocardia odorata Br.
Heynea trijuga Roxb.
Ilex doniana DC.
Ligustrum myrsinites Dcne.
Litsaea monopetala Pers.
Lyonia ovalifolia (Wall.) Drude
Meliosma simplicifolia Walp.
Linociera ramiflora (Roxb.) Wall. ex G. Don
Myrica rubra Sieb. & Zucc.
M. sapida Wall.
Pyrus pashia Ham.
Symplocos crataegoides Ham.
Turpinia pomifera DC.
Vaccinium sikkimense Cl.

Species typical of the tropical deciduous forest occurring in the second storey are :

Acacia catechu Willd.
Albizia chinensis (Osbeck) Merr.
Emblica officinalis Gaertn.
Mallotus philippense (Lam.) Muell. Arg.
Syzygium cumini (L.) Skeels
Terminalia chebula Retz.

Undergrowth

Aechmanthera tomentosa Nees
Berberis lycium Royle
Crataegus crenulata Roxb.
Daphne cannabina Wall.
Debregeasia velutina Gaud.
Euonymus attenuatus Wall.
Flemingia fruticulosa Wall.
Indigofera doona Ham.
Maesa chisia D. Don
Myrsine africana L.
Pittosporum floribundum W. & A.
Rubus ellipticus Sm.
R. lasiocarpus Sm.
Viburnum coriaceum Bl.
V. cotinifolium D. Don

Species typical of the tropical deciduous forest in the undergrowth

Carissa opaca Stapf
Flacourtia jangomas (Lour.) Raeusch.
Glycosmis pentaphylla Corr.
Indigofera cassioides Rottl.
Murraya koenigii Spr.

Climbers

Species of *Cissus, Elaeagnus, Lonicera, Mucuna, Hedera, Smilax, Thunbergia, Entada phaseoloides* (L.) Merr. and *Rosa moschata* Mill.

A number of plants of mediterranean affinity are represented in the Western Himalaya and Baluchistan typifying the subtropical mediterranean regime (Meusel, 1971; Meher-Homji, 1973). Among these may be cited :

Acer pentapomicum Stew., *Aesculus indica* Colebr., *Brachypodium sylvaticum* Beauv., *Cedrus deodara* Loud., *Celtis australis* L., *Cercis grifithii* Boiss., *Cotinus coggygria* Scop., *Cotoneaster bacillaris* Wall., *Daphne oleoides* Schreib., *Fraxinus excelsior* L., *Fraxinus xanthoxyloides* Wall., *Geum urbanum* L., *Juglans regia* L., *Myrsine africana* L., *Nerium odorum* Soland., *Olea cuspidata* Wall., *Origanum vulgare* L., *Pinus roxburghii* Sargent, *Pistacia* spp., *Populus euphratica* Oliv., *Prunus prostrata* Labill., *Punica granatum* L., *Pyracantha crenulata* M. Roem., *Pyrus pashia* Buch-Ham., *Quercus baloot, Rosa pimpinellifolia* Hk. f. & T., *Viburnum cotinifolium* D. Don.

CONCLUSION

The subtropical title conferred on the various vegetation types by Champion is solely derived from the annual and January temperature figures. The term therefore, englobes exclusively the montane areas of moderate elevation (900 to 2000 m approximately) both

in the Peninsula and the Himalayas. Subtropical type is thus implied to occur nowhere in the plains or low elevation in India though in geographical sense *Anogeissus pendula* forests of eastern Rajasthan and northern Madhya Pradesh and the desert thorny vegetation (*Calligonum-Prosopis-Capparis-Ziziphus* type) of Kutch-Rajasthan find their maximum expression in the subtropical latitudes. These types do seem to merit the title subtropical though in climatic terms their areas fail to satisfy the set limits of temperature by small fraction. Whereas the teak forests rarely exceed the tropic of Cancer, the sal forests extend on either side of this line. Thus, the vegetation types do show certain variations north and south of the tropic of Cancer but the floristic-physiognomic limits are also well marked longitude-wise, linked as they are to the rainfall gradients. From east to west, the evergreen forest of the N. E. part of the sub-continent, the moist sal, dry sal, teak forest and the thorny vegetation of the Thar succeed each other according to the isohyet patterns.

The montane vegetation types, especially those located in the tropics that are referred to as subtropical, differ considerably from the geographical subtropical types of plains in the dirunal and sasonal rhythms of temperature and photoperiod.

The stations described by CHAMPION as having subtropical forest (Figs. 1-16) present substantial differences in climatic factors like precipitation amount, seasonal distribution and number of dry months. Apart from a certain broad range of temperature which permit them to be clubbed together, the subtropical climate is highly diversified in other features.

From vegetational point of view, several variant of subtropicality may be distinguished :

(1) In the plains and low elevation :

Geographical or latitude-based, e.g. :

Anogeissus pendula forest and *Calligonum-Prosopis-Capparis-Ziziphus* desert thorny type.

(2) In the hills :

(a) dry mediterranean type as in Baluchistan with species like *Olea cuspidata*, *Pistacia* spp., *Quercus baloot*.

(*b*) Tropical montane type of Peninsular India. A good example is the vegetation of the Western Ghats in South India with species mentioned in Table 1.

(*c*) Montane type of higher latitude : Himalayas (moderate altitude). *Cedrus deodara*, *Pinus insularis*, *P. roxburghii*, *P. wallichiana* are among the characteristic species.

A survey of subtropical vegetation throughout the world reveals that the taxa involved are large in number but genera like *Pinus*, *Quercus*, *Celtis* stand out as more widely distributed. However, at least some of their species also occur in temperate climates and therefore only those species restricted to the subtropical belts (latitudinal or altitudinal) could serve to characterise this zone (climatically or vegetationally) along with the typical local species of each of the variant of subtropicality.

Following are among the genera common to the Western Ghats (of S. India) and the Himalayas at moderate altitude MEHER-HOMJI, 1975).

(1) Those whose species are different in the Himalayas and in the S. Indian hills : *Beilschmiedia*, *Berberis*, *Bhesa*, *Calophyllum*, *Cinnamomum*, *Eugenia*, *Euonymus*, *Garcinia*, *Ilex*, *Lasianthus*, *Ligustrum*, *Litsaea*, *Linociera*, *Machilus*, *Microtropis*, *Phoebe*, *Pittosporum*, *Psychotria*, *Pygeum*, *Sideroxylon*, *Turpinia*, *Vaccinium*.

(2) Those having at least one link species between the Himalayas and the Southern highlands : *Ardisia solanacea*, *Debregeasia velutina*, *Glochidion velutinum*, *Meliosma simplicifolia*, *Phoebe lanceolata*, *Photinia notoniana*, *Schefflera venulosa*, *Symplocos spicata*, *Toona ciliata*.

Amongst such taxa lies the indicator value of subtropical montane variant, not withstanding the temperature, day length differences in South India and the Himalayan moderate elevation belt.

REFERENCES

BAGNOULS, F. & GAUSSEN, H. (1957). Les climats biologiques et leur classification. *Ann. Géogr.* **359** : 193-220.

CHAMPION, H.G. (1936). A preliminary survey of the forest types of India and Burma. *Indian forest Rec.* **1** : 1-286.

CHAMPION, H. G. & SETH, S. K. (1968). *Forest types of India.* Manager of Publications, Delhi.

GAUSSEN, H., MEHER-HOMJI, V. M., LEGRIS, P., BLASCO, F., DELACOURT, A., GUPTA, R. K. & TROY, J. P. (1971). International map of vegetation and environmental conditions : Sheet Rajasthan. *ICAR* New Delhi and *Inst. Fr. Pondichéry. Trav. Sect. Sci. Tech. Hors. Serie* No. 12.

LEGRIS, P. & MEHER-HOMJI, V. M. (1977). Phytogeographic outlines of the hill ranges of Peninsular India. *Trop. Ecol.* (In press).

LEGRIS, P. & VIART, M. (1961). Bioclimates of South India and Ceylon. *Inst. Fr. Pondichéry. Trav. Sect. Sci. Tech.* **3** : 165-178.

MEHER-HOMJI, V. M. (1963). Les bioclimats du Sub-continent Indien et leurs types analogues dans le monde. *Inst. Fr. Pondichery. Trav. Sect. Sci. Tech.* **7**(1-2) : 1-386.

MEHER-HOMJI, V. M. (1967). Phytogeography of the South Indian hill stations. *Bull. Torrey bot. Club.* **94**(4) : 230-242.

MEHER-HOMJI, V. M. (1973). A phytoclimatic approach to the problem of mediterraneity in the Indo-Pakistan sub-continent. *Feddes Repert.* **83**(9-10) : 757-788.

MEHER-HOMJI, V. M. (1975). On the montane species of Kodaikanal, South India. *Phytocoenologia* **2**(1-2) : 28-39.

MEUSEL, H. (1971). Mediterranean elements in the flora and vegetation of the West Himalayas. In *Plant life of South West Asia,* Bot. Soc. Edinburgh ; P. H. Davis, P. C. Harper and I. C. Hedge (eds.): 53-72.

RAVEN, P. H. (1971). The relationships between 'Mediterranean' floras. In *Plant life of South West Asia,* Bot. Soc. Edinburgh ; P. H. Davis, P. C. Harper and I. C. Hedge (eds.) : 119-134.

SCHWEINFURTH, U. (1957). Die horizontale und vertikale Verbreitung der Vegetation im Himalaya. *Bonner geogr. Abh.* **20** : 1-372.

TROLL, C. & PAFFEN, Kh. (1964). Legend to the map of seasonal climates of the earth. *Erdkunde* **18**(1) : 1-3.