Distribution of Lucidophyll Oak-Laurel Forest Formation in Asia and Other Areas

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ABSTRACT  Summer-rain warm-temperate, wet subtropical and tropical zones in East, South and Southeast Asia are widely covered by evergreen broad-leaved forests. These forests are dominated mainly by evergreen tree species of Fagaceae, Lauraceae, Theaceae, Magnoliaceae and Hamamelidaceae. Trees have leathery smooth leaves ready to reflect the sunshine and brighten, and Kira (1977) put forward a proposal of lucidophyll forest as a new nomenclature of this type of evergreen broad-leaved forest. It was first reported as Lorbeerform by Griesebach (1872) in Canarias Islands. The lucidophyll oak-laurel forests are found in ranges among 85 and 180°C month of Kira's warmth index, which corresponds to warm temperate zone and among 180 and 240°C month to subtropical zones in Japan.

Such lucidophyll oak-laurel forests have a wide range of distribution in Asia, New Guinea, Macaronesia and southeastern United States. The northern limit of its distribution is at about 40°N of the seashore or islets of Northeast District of Japan in the Pacific and at 39°N in Açores Islands in the Atlantic. The altitudinal limit goes up to about 1,000 m from sea shore in warm-temperate Japan, and upwards to about 3000 m in the wet tropical Asia.

The constituent species of the forests becomes diversified as it goes to the tropics. In the area of northern limit the forest is dominated only by a laurel, Persea thunbergii, but forests are diversified with many species of a number of genera and families as shown in Appendix. In the tropics they are mixed with some tropical species such as climbing bamboos, screw pines, palms and climbing species of Araceae. On the other hand, some species of Lauraceae and Fagaceae are found in the lowland tropical rain forests, but they are minority of tall lowland rain forests.

In Africa temperate and montane forests (afromontane forests) do not have lauraceous and fagaceous dominants but for Ocotea as a companion, and their species composition is not similar with the Asian lucidophyll oak-laurel forests. Southeastern evergreen hardwood forests of the United States are dominated by Quercus (Quercus) species under summer-rain climate with hot and humid summer and not so severe winter. As their leaves also reflect sunshine and brighten, this type of forest should be included into lucidophyll forest formation as well as Macaronesian laurel forests.

The nomenclature of the lucidophyll oak-laurel forest is diversified, and a number of names have been used. They are largely classified into five groups of terms based on vertical zonation, climatic zone, leaf characters, species composition and plant sociology. The author thinks that it is desirable to give a standard name like summer green forest formation to the forest formation widely distributing in the lowland of warm-temperate, and montane areas of subtropical and tropical regions dominated by oaks and laurels. Lucidophyll oak-laurel forest formation is a recommendable name of the formation.

Evergreen Nothofagus forests evolved and developed only in the southern hemisphere under similar climate to that of lucidophyll oak-laurel forest formations, could be included into the latter formation, because trees in evergreen southern beech forests are also lucid under humid climate and both forests assembled only in New Guinea and its adjacent islands. Discussion is carried out on other types of vegetation in the Middle and South America.

Key Words: evergreen broad-leaved forest / lucidophyll oak-laurel forest / tropical montane forest / oak-laurel forest / Asian vegetation / Southeast Asia / vertical zonation / forest formation / Nothofagus forest
Laurus azorica of Portugal, (1930) will hereafter the dominanted Jerosch Ericaceae; carpus thunbergii, Lauraceae, Theaceae, between warmth index a new nomenclature Imanishi Himalayas forests composition The distribution from proposed cultural lucidophyll lucidophyll commonly Asia. This type be made on the relationship between lucidophyll oak-laurel forest and Nothofagus forest. ‘Laurisilva’ known from the Canarias Islands is composed of a few species of Lauraceae; Laurus azorica (canariensis), Persea indica, Ocotea foetens, and Apollonias barbujana, Ericaceae; Erica arborea and E. scoparia, and species of a few other families. Brockmann-Jerosch & Rübel (1912) included Knysna of the Cape dominated by Olea laurifolia, Podocarpus thunbergii, and P. elongata into conifer laurel forest (Koniferen-Lorbeerwald). These forests are found in a climate with warmer winter and hot summer with high humidity or high rainfall, but it is suspicious to include such a podocarp forest into laurisilvae except for a transitional forest from laurisilvae into another forest zone.

Laurisilvae in southwestern Japan mainly dominated by evergreen species of Fagaceae, Lauraceae, Theaceae, Magnoliaceae and Hamamelidaceae are called in Japanese ‘Shōyō-jurin’ which means forest with evergreen leaves ready to reflect the sunshine and brighten. Imanishi & Kira (1953) and Kira (1977, 1991) put forward a proposal of lucidophyll forest as a new nomenclature of Laurisilvae. Lucidophyll forests are found in a wide range of Kira’s warmth index between 85 and 180°C month, which corresponds to warm temperate zone, and between 180 and 240°C month to subtropical zone in East Asia.

This type of forests is widely distributed in the world from south facing slope of the Himalayas as described by Rübel and also in the other areas of Asia (Korea, China, Taiwan, India, Sri Lanka, Myanmar, Thailand, Viet Nam, Malaysia, and Indonesia), and New Guinea Island. In this paper the author would like to discuss the distribution of lucidophyll oak-laurel forests in Asia and in the areas other than Asia including New Guinea Island, Macaronesia, Southeast of North America, Australia, New Zealand and South America, and their species composition and terms used for this type of forest formation.

REFERENCE STUDY ON THE LUCIDOPHYLL OAK-LAUREL FORESTS IN ASIA, MACARONESIA AND SE OF NORTH AMERICA

The distribution and the species composition of lucidophyll oak-laurel forests have known from various places in Asia by many botanists and ecologists. A wide and long corridor from the south-facing slope of the eastern Himalayas to the southwestern Japan through Yunnan, Southern China from the Chang Chiang River and Taiwan is covered by various types of lucidophyll oak-laurel forest. This type of forest has also caught attention of ethnobotanists and cultural anthropologists, since a Japanese ethnobotanist, late Prof. emer. S. Nakao (1967) proposed a primitive farming culture, ‘Shōyō-jurin bunka,’ which is thought to have developed commonly in the lucidophyll oak-laurel forest zone in this corridor. Besides this corridor, lucidophyll forests are also found in higher altitudes of mountains in the humid tropics of SE Asia. In the following the author would like to introduce and discuss altitudinal ranges,
The Himalayas (Nepal, Sikkim and Bhutan)
The eastern Himalayas and Bhutan receive a great quantity of monsoon rains in summer from June to September, and evergreen forests occupy a large area. According to researches on the altitudinal zonation of the Himalayas made by Numata and Ohsawa and his colleagues (Ohsawa, 1977; 82a; 83a & b; 87a & b; 90; 91; Ohsawa & Numata, 1983; Ohsawa, 1983), Castanopsis-dominated forest (in the following description the name of forest is used after author’s term) composed of Castanopsis indica, C. tribuloides, Schima wallichii was found from 600 m to 2000 m in the Eastern Himalayas, but a large area of the forest has lumbered and replaced mainly by agricultural cropland. The lumbered area was partly occupied by secondary vegetation which is dominated by Mallotus, Macaranga, Rhus, Ilex and Pandanus, etc. In a cloud zone the dominants of the natural forests are replaced by Quercus (Cyclob.) incana, Q. lanuginosa, Q. dilatata and Q. semecarpifolia. At higher altitudes from 2000 m to 3000 m in Sikkim between Nepal and Bhutan forests are dominated by Castanopsis tribuloides, C. hystrix, Lithocarpus pachyphylla and Quercus lamellosa. In the western Himalayas mountain area is covered by Castanopsis incana forest, of which dominant is adapted to winter rain climate and come into flowers in October. In rainy regions in eastern Himalayas the dominants of lucidophyll forests are composed of such Lauraceae as Machilus (Persea) duthei, M. odoratissima, M. sericera, Phoebe lanceolata, P. pallida, Cinnamomum tamala, Actinodaphne reticulata, Litsea citrata, L. oblonga, Lindera neesiana, Neolitsea umbrosa, N. lanuginosa, etc., and there are only one dominant, Michelia kisopa, other than Lauraceae.

According to the results of cluster analysis of Bhutanese vegetation made by Ohsawa (1987b) following two zones are recognized as a laurel-leaved forest zone in the eastern Himalaya; (1) Schima-Lithocaprus-Castanopsis forest zone between 1000 m and 2000 m, which corresponds to subtropical zone, and (2) Castanopsis-Quercus (Cyclob.)-Acer forest zone from 2000 m to 2500 m in the warm-temperate zone. Dominant and canopy species in the former zone are Schima wallichii, Castanopsis tribuloides, Lithocarpus elegans, Altingia excelsa and Exbucklandia populnea. Leaves of the last two species of Hamamelidaceae are fallen in winter in the areas near the northern and upper limits of their distribution. In the latter zone Castanopsis tribuloides is a dominant and mainly composed of species of Quercus, Persea and Litsea.

![Fig. 1. Vertical zonation of vegetation around Mt. Jolmo Lungma (Everest). (Chang & Chiang, 1973)](image-url)
Chang & Chiang (1973) made a study of the vegetation of Mt. Jolmo-lungma (Everest). On the south slope the montane evergreen broad-leaved forest zone was recognized among 1000 and 2500 m, and it is mainly dominated by Castanopsis indica, Engelhardtia sp. and Schima wallichii with many subdominants of Quercus (Cyclob.) lamellosa, Q. lineata, Q. glauca, Michelia excelsa and Lithocarpus spp. In the upper part of the zone one conifer species, Tsuga dumosa (yunnanensis), was mixed with evergreen broad-leaved trees and emergent above the canopy. In the montane mixed conifer forest zone (2500-3000 m) T. dumosa and Quercus semecarpifolia made a canopy. While on the north-facing slope of the Himalayas (Fig. 1), plants are exposed to severe desiccation, and no forests were found. Grasslands below 4400 m were dominated by Pennisetum flaccidum on fine soil, Orinus thoroldii (Gram.) on sandy soil and Carex moorcroftii on the soil of shallow water level.

Table 1 synthesized by Ohsawa (1977) shows altitudinal distribution of forest types in the Nepal Himalayas. The terms used for lucidophyll oak-laurel forest are diversified by authors.

**China**

The lucidophyll oak-laurel forests in China are classified into subtropical and warm-temperate forest groups by the Editing Committees for Vegetation of China (1980), for Vegetation of Yunnan (1987) and for Forests of Yunnan (1986). Forests of warm-temperate group are found in the South of Huai He and Qin He River and middle altitudes of Yunnan Province.

Based on the result of the synthesized research in Jiulianshan Forest Reserve (ca 24°30'N), Jiang Xi Province carried out by Jiang Xi University (Management Station of Jiulianshan Forest Reserve, Jiang Xi Province 1987), various types of evergreen broad-leaved forest are found from 280 m to about 1200 m on Mts. Jiulianshan (the highest peak at 1434 m), and they are all classified into subtropical evergreen broad-leaved forest. However, in the coldest month the air temperature goes down to -3°C and there are frost days, so the present author considers that this forest reserve is under a warm-temperate zone. According to the classifi-

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ocation of climate of China, a range of annual mean air temperature, 2-14°C, corresponds to temperate (the northern limit of temperate zone is almost at 50°N latitude), 14-22°C to subtropical (34°N) and higher than 22°C to the tropical zones (South from the Tropics of Cancer). So the temperate and subtropical zones of China are far in the North in comparison with warmth index conceived from vegetation zone. Tsutsumi & Li (1989) showed that water stress might be caused by little rain from October to January.

The forests in the Jiulianshan Forest Reserve are classified into 16 types; dominants and their distributional ranges are Adinantra milletii (440 m), Schima superba (300-760 m), Castanopsis fordii (530 m), C. fargettii (600-800 m), C. carlesii (460-1180 m), C. eyrei (750 m), C. lamontii (740-960 m), C. fabri (500-1000 m), Cyclobalanopsis glauca (400-600 m), Cy. oxyodon (1000 m), Cy. nubium (1100 m), Lithocarpus calophylla (900 m), Michelia mauudiae (900 m), Litsea elongata (900 m), Machilus thunbergii (1100 m) and Adinantra bockiana (1200 m).

In Yunnan Province, 9 types of evergreen broad-leaved forest are recognized in the warm-temperate zone at altitudes from 1500 m to 3000 m. Their dominant, main component genera and distributional range are;

i) *Rhodoleia parvipetala* forest (2000-2600 m)
   *Actinodaphne, Alseodaphne, Machilus, Neolitsea, Cyclobalanopsis, Lithocarpus, Manglietia.*

ii) *Lithocarpus echinophorus* forest (2000-2500 m)
   *Cyclobalanopsis, Schima, Michelia, Actinodaphne, Cinnamomum, Lindera, Machilus.*

iii) *Lithocarpus craibianus* forest with deciduous species (2500-2600 m)
   *Acer, Betula, Prunus, Quercus (Quercus).*

iv) *Lithocarpus variolosus* forest (2500-3000 m)
   only one dominant and an uppermost type of evergreen broad-leaved forest.

v) *Lithocarpus cleistcarpus-Castanopsis platyacantha* forest (1500-2600 m)

vi) *Cyclobalanopsis glaucoides* forest (1300-2300 m)
   *Lithocarpus, Machilus, Photinia, Magnolia, Pittosporum.*

vii) *Castanopsis delavayi* forest (1700-2200 m)
   *Pinus, Populus, Quercus (Quercus).*

viii) *Castanopsis orthacantha* forest (1900-2600 m)
   *Cyclobalanopsis, Lithocarpus.*

ix) *Cyclobalanopsis delavayi* forest (1900-2500 m)
   *Lithocarpus,* single layered forest.

In the subtropical zone, 4 types of forests are recognized, and their distribution is limited at the lower altitudes about 1000 to 1500 m. They are;

x) *Castanopsis hystrix-C. indica* forest (1000-1500 m)
   *Schima, Engelhardia, Machilus, Mischocarpus.*

xi) *Castanopsis fleuryi-Lithocarpus truncatus* forest (1300-1900 m)
   *Cyclobalanopsis, Anneslea, Machilus, Syzygium.*

xii) *Castanopsis fabrii-Lithocarpus calathiformis* forest (1300-1500 m)
   *Machilus, Elaeocarpus, Diospyros, Manglietia, Engelhardia.*

xiii) *Machilus-Castanopsis* forest (1200-1500 m)
   *Sloanea, Cyclobalanopsis, Lithocarpus, Elaeocarpus, Cinnamomum, Carpinus.*

The laurel-leaved forests in this subtropical zone contain, to some degrees, constituents of tropical forests in the lower altitudes.

Vegetation of Hainan Dao Island off from Chanchiang was reported by Hibino &
Yoshikawa (1942) that the evergreen broad-leaved forest was to be found from 800 to 900 m, but it had been almost replaced by farmland and secondary forests dominated by deciduous trees of *Quercus acutissima, Liquidamber formosana, Sapium sebiferum*, etc. and it was hard to find natural stands of the laurel-leaved forest.

Watanabe & Abe (1988) defined 6 zones of natural vegetation in Hainan Dao; seashore xerophytic thorn scrub, savanna, tropical deciduous monsoon forest, tropical evergreen monsoon forest (400-800 m), tropical mountain rain forest (750-1100 m), mossy forest on top of mountain (>1100 m). Altitudinal range was shown in case of the Mt. Chienfeng Ling. The tropical mountain rain forest in the Chienfeng Ling Forest Reserve is composed of such tropical dipterocarp species as *Hopea hainanensis, H. excelsa* and *Vatica astrotricha* mixed with the warm-temperate species of *Quercus, Lithocarpus, Castanopsis, Livistona saribus, Altingia, Betula alnoides, Dacrydium pirei*, *Podocarpus hainanensis, Keteleeria hainanensis*, etc. Watanabe & Abe considered that coexistence of the tropical species with warm-temperate species in the narrow range of altitudes may be ascribed to mass elevation effect (Massenerhebung).

**Taiwan**

Northern Taiwan from a line connecting Tainan and Taitung is under a subtropical and summer-rain climate (Hosokawa et al., 1977). Hosokawa (1958) described Castanopsidion taiwanianae at about 400 m to 1500 m and Shion longicaudatae between 800 m and 2000 m both in the southwestern wet climate of Taiwan, while in northeastern Taiwan there are Shion stipitatae from 300 m to 1500 m and Cyclobalanopsidion paucidentatae from 1100 m to 2600 m. Main component species are of Fagaceae, Lauraceae, Theaceae, Symplocaceae and Aquifoliaceae.

The lowland (subtropical climate at 600-1800 m a.s.l.) and lower altitudes of mountains (warm-temperate at 1800-2250 m) in Taiwan are covered by dense laurel-leaved forests (Kanehira, 1936; Hsu, 1971). The forests in subtropical zone are dominated and subdominated by *Actinodaphne musquensis, A. nantoensis, Beilschmiedia erythrophloea, Cinnamomum camphora, C. japonicum, Cryptocarya chinensis, C. konishii, Persea kusanoi, P. thunbergii, P. zuihonensis, Neolitsea konishii*, *Phoebe formosana, Castanopsis hystrix, C. kawakamii, Pasania ternaticupula, Lithocarpus amygdalifolius, Quercus (Cyclop.) gliva, Q. semecarpifolia ssp. glabra, Michelia compressa*, and *Schima wallichii ssp. noronhae*. In the forest such conifer species as *Podocarpus macrophylla, P. nankoensis, P. nagi* and *Cephalotaxus wilsoniana* are mixed with above-mentioned evergreen oaks and laurels.

In the upper part of the forest belonging to the warm-temperate zone the evergreen broad-leaved forests are gradually replaced by conifer species such as *Pinus armandi, P. taiwanensis, Cunninghamhamia konishii, Chamaecyparis obtusa, C. formosensis, Taiwania cryptomerioides* and *Libocedrus formosana*. Hosokawa (1958) treated these coniferous forests as those in the cool temperate zone. In northern Taiwan Indocalameto-Fagetum hayatae appears in a limited area at about 1000-1500 m in altitude, so he included this beech forest into warm-temperate zone. Values of warmth index based on the weather data of Taipei show that this range of altitude is entirely in the warm-temperate zone or in the lucidophyll oak-laurel forest zone.

**India and Sri Lanka**

Whole country of Bangladesh is in the lowland, and the lucidophyll forest may not be found there.

According to Gopal & Meher-Homji (1983), the temperate forests of India are grouped into the following three types on the basis of rainfall; montane wet temperate, montane moist
temperate and Himalayan dry temperate forests. Only the montane wet temperate forests are dominated by broad-leaved evergreen species which occur both in the Himalayas and in the south Indian ranges (Nilgiri and Palni Ranges) around 10°N. On Naga Hills, at altitudes from 1750 m to 2750 m on the Sikkim mountains between Nepal and Bhutan, and near Kalimpong of West Bengal two types of lucidophyll oak-laurel forests are observed. The first is mainly composed of lauraceous species such as Beilschmiedia erythrofloia, Cinnamomum obtusifolium, Machilus edulis and Litsea japonica. The other canopy species are Castanopsis tribuloides, Lithocarpus spicatus, Schima wallichii, Michelia cathcartii, Magnolia campbellii, Engelhardtia spicata, and undergrowth species are Eurya acuminata, Symplocos theaeifolia, Ilex spp., etc. Canopy of the second type is mainly composed of fagaceous species, Quercus (Cyclob.) lamellosa, Castanopsis tribuloides, Acer campbellii, Michelia doltsopa, and undergrowth are of Quercus lineata, Q. pachyphylla, Persea, Litsea, Viburnum, Daphne and so on.

Southern wet temperate forests known as ‘shola’ forests in the south Indian ranges (Gopal & Meher-Homji, 1983) are largely confined to steep slopes and sheltered areas in the higher altitudes of mountains, and its lower part connects subtropical and tropical wet forests in the lowland areas. The stature of the shola forests is about 25 m at most with dense closed canopy, and many tree species in the shola of the western Ghats are Actinodaphne spp., Apollonias arnotti, Cinnamomum spp., Phoebe wrightii, Elaeocarpus spp., Gordonia obtusa. Euonymus crenulatus, Litsea wrightiana, Meliosma wrightii, Michelia nilgirica, Photinia lindleyana, Symplocos spp., Syzygium spp. and no fagaceous species. The existence of abundant epiphytic ferns and mosses means a wet climate of the areas. Shola forests have long been known under the human or biotic influences to some extent.

Gopal and Meher-Homji consider that the Himalayan element in the south Indian ranges is refugees from the Himalayas in Pleistocene glaciation, and the heavy glaciation also destroyed oak-laurel forests in the drier western Himalayas, but those in the East Himalayas were protected under the wet condition.

According to the description by Werner (1995), Sri Lanka (Ceylon) receives two monsoons from northeast and southwest. So slopes facing to a monsoon collect high precipitation and those on lee-wards are exposed to desiccation due to dry foen wind. At altitudes from 600 m to 900 m wet zone of southwest slope of central highland is covered by tall forest dominated by Doona gardneri, Stemonoporus (Dipterocarpac.), Myristica dactyloides (Myristicac.), Ostodes zeylanica (Euphorbiac.), Calophyllum (Guttif.), Syzygium, and species of Lauraceae. On the dry zone forests are free from dipterocarps, and laurels (Litsea, Cinnamomum, Cryptocarya, Neolitsea) become important in the forest together with Calophyllum, Syzygium, Myristica, and Oncospernum (Palmae). These laurel forests are, to some extent, similar with the shola forests in floral composition.

Myanmar and Thailand
According to Stamp’s monograph (1924), oak forests which are locally called ‘thicha’ are found from 900 m to 2100 m in altitude in the mountain ranges of Arakan Yoma and Patkoi and on the Shan Plateau.

In the Arakan Yoma Mountains the canopy of thicha forests is composed of Quercus (Cyclob.) spicata, Q. brandisiana and Q. serrata. Near Mogok north of Mandalay Quercus helleriana, Q. mespiliforma and Q. fenestrata are frequent and common to the forests. In the Patkoi Mountains Quercus pachyphylla and Q. thomsoni are dominant in the thicha forests. On the Maymyo Highland Quercus serrata forest occupy a large area. In every thicha forest several species of Castanopsis are found. In Kachin State of north Myanmar the thicha forests have undergrowth of Ilex spp., Prunus spp. and Ficus elastica, while in the forests on the
Shan Plateau the dominants are accompanied by Schima, Albizia, Salix, Cicca macrocarpa (acida ?), Bridelia retusa, Barringtonia racemosa (Lecythidac.) and Cephalotaxus griffithii.

In the classification of vegetation of Myanmar by Davis (1964), the lucidophyll forests were grouped into lowland subtropical hardwood forest and high mountain hardwood forest (temperate forest) with the altitudinal range from 1100 m to 2600 m. The forests are mainly composed of Castanopsis, Lithocarpus, Quercus, Magnolia, and other evergreen hardwood species. The upper part of the high mountain hardwood forest contains some elements of cool temperate flora such as Rhododendron, Tsuga and Abies. While in the lower part of the lowland subtropical hardwood forest, there are some tropical species of Dipterocarpus, Ficus, and Terminalia (Combretac.).

In Thailand temperate evergreen forests are recorded from the northwestern highland from 1200 m in altitude in the humid places to the top (2576 m) of the highest mountain in Thailand, Don Inthanon (Ogawa et al., 1961). The lowest limit of the forest rises up to about 1400 m in the arid places of Thailand. The main component species and genera of the forest (Ogawa et al., 1961; Yoda & Sahunalu, 1991) are Castanopsis (C. diversifolia, C. acuminatissima), Quercus spp., Schima wallichii, Magnolia, Michelia, Cinnamomum, Gluta usitata, Helicia erratic, Diospyros (D. ehretoides, D. ferrea), Turpinia, etc. Lower part of the forest contains some genera of tropical rain forests such as Artocarpus, Terminalia and Ficus. In the northwestern highland the forest has been used as shifting cultivation, and a large area of the forest is replaced by ‘alang-alang’, a grassland spreading on the barren soil and is composed of Imperata cylindrica (Gramin.) and Eupatorium adenophorum (Comp.).

The author do not have any information of vegetation of Cambodia, Laos and Vietnam. In these three countries there are many higher mountains than 1000 m, and it may be possible to find out small areas of lucidophyll oak-laurel forests at higher altitudes as seen in Myanmar and Thailand, even though they are almost replaced by cropland and damaged by prolonged wars.

**Malay Peninsula**

Symington (1943) classified climax formations of Peninsular Malaysia into 5 types where he defined montane oak forest.

i) Lowland dipterocarp forests (0-300 m)

ii) Hill dipterocarp forests (300-750 m)

iii) Upper dipterocarp forests (750-1200 m)

iv) Montane oak forests (1200-1500 m)

v) Montane ericaceous forests (1500 m<)

Wyatt-Smith (1964) showed a vegetation map of western Malaysia, where montane oak forest is found between 1000 and 1700 m. While, Burgess (1969) described the altitudinal zonation of Malayan mountains, and oak-laurel forest zone is found between 1320-1650 m. The main genera and species of the oak-laurel forest are Lithocarpus spp., Quercus (Cyclob.) spp., Weinmannia blumei, Gironniera spp., Podocarpus imbricatus and Melanorrhoea spp. Exbucklandia populnea is characteristic of the forest edge of clearings. In the lower part of the upper montane rain forest formation (montane ericaceous floristic zone) still oak-laurel forests exist, but the number of oak-laurel species decreases. Whitmore (1988) stressed his description on lowland evergreen rain forest, and he used lower montane rain forest for so-called oak-laurel forest. Serial forests of lower montane forest zone have abundant Homalanthus populneus (Euphorbiac. ), Cyathea contaminans and Symingtonia (Exbucklandia) populnea.
Sumatera Island

Ohsawa (1982a) made a research on a forest reserve on Mt. Kerinci in the Barisan Mountains, Sumatera. Lowland and hill areas were already cultivated and natural forests were found only in the forest reserve and restricted areas in higher altitudes than 1900 m. From 1900 m to 2000 m Schima wallichii var. noronhae forest is found with an emergent tree species, Exbucklandia tricuspis. Around about 2300 m in altitude, forest canopy is made by Engelhardia spicata and Lithocarpus bennetti (?). From 2350 m to 2700 m there is a bracken of Gleichenia volubilis or Gleichenia zone which might be brought about by an edaphic factor (Jacobs, 1958). Ohsawa (1982a) wrote that this bracken zone might be arisen from a characteristic enviroment due to overlapping the transition of vegetation zone with clouded zone, and that an intensive research was needed. Prof. Hotta has another idea that this Gleichenia bracken is a priseral community developing under the influence of volcanic activity of Mt. Kerinci (oral comm.). Van Steenis (1950) thought 2400 m a.s.l. as a border between montane and subalpine zones in Malaysian floral region. Upward of 2400 m there are no tall trees, and many types of scrub were found.

Hotta and his colleagues made a long-term observation of forest change on Mt Gadut north of Mt. Kerinci. According to Ogino et al. (1984), hill oak forest is found higher than 1000 m, and its canopy is made by Quercus (Cyclob.) lineata, Lithocarpus spp., Schima wallichii with the understories of Adinandra durnosa, Ternstroemia japonica, Cinnamomum javanica, Litsea spp. and Syzygium spp. In a montane oak forest found in the higher altitudes than 1600 m, Tristania bakhuisenii and Lithocarpus cf. elegans are codominant, and other important species are Elaeocarpus stipitatus, Anneslea fragrans (Theac.), Ellipanthus tomentosus, Weinmannia blumei and Myrica javanica.

Jawa Island

The lowland of Jawa is under the monsoon climate, and southeast monsoon from Australia brings dry season and northwest monsoon from the Asian continent brings rainy season. The length of both seasons is determined by the distance from the Asian continent and Australia (Encyclopedia Britannica, 1972; Nakamura et al., 1994). In general East Jawa has long dry season and the West short. According to a monograph by van Steenis et al. (1972) and the observations by the present author lucidophyll oak-laurel forests are well reserved in Gede Pangrango Halimun (shortly Gede Paha) National Park around Mts. Gede and Pangrango above the Cibodas National Botanical Garden. The lucidophyll oak-laurel forests are found in the submontane (1000-1500 m) and montane zones (1500-2400 m), but they have been replaced by secondary forests or cultivated land below the Cibodas Garden (1300-1425 m).

Species composition of the first layer of montane forests on Mt. Pangrango (3019 m), West Jawa, changes gradually from 1600 m to the top (Yamada, 1977) as follows.

1600 m: Schima wallichii, Castanopsis javanica, Persea rimoso, Lithocarpus pseudomoluccus, Vernonia arborea (Comp.) (cf. Photo 2)
1700 m: Podocarpus imbricatus, Sch. wallichii, V. arborea, Engelhardia spicata
1900 m: Sch. wallichii
2100 m: Sch. wallichii, Acer laurinum, Astronia spectabilis (Melastomatic), Prunus arborea, Weinmannia blumei, Acronodia punctata
2300 m: Lithocarpus elegans, Ast. spectabilis, Sch. wallichii, Myrsine affinis, Eurya obovata
2600 m: M. affinis, Polysoma ilicifolia (Saxifragac.), Symplocos sessilifolia, Leptospermum flavescens
2800 m: M. affinis, Schefflera sp., E. obovata, Viburnum coriaceum, Sy. sessilifolia
3000 m: M. affinis, Photinia notonian, E. obovata, Vaccinium varingiaefolium
The main species of the second layer are *Phoebe excelsa*, *Castanopsis tungrut*, *Magnolia blumei*, *Sloanea sigun*, *Villebrunea rubescens*, *Syzygium pyenanthum*, *Toona sureni* and climbing species *Elaeagnus latifolia*.

In higher altitudes forests become lower and look like scrubs. Around the crater rim of Mt. Gede (2958 m) the author observed priseral scrubs of *Vaccinium varingiaefolium* and *Gaultheria leucocarpa*. The red new shoots and leaves of blue berries were beautiful like flowers in full bloom when the author visited in early May. Hosokawa (1942) assigned this type of scrub to alpine heath on Mt. Apo, Mindanao Island, but it is hard to apply Mt. Gede because he is active volcano and this *Vaccinium* dominated vegetation is a pioneer community. On the southern outer slope of the crater there was a stunt mossy forest dominated by *Myrsine affinis* as well as on Mt. Pangrango.

**Borneo Island**

Kobayashi & Hotta (1978) discriminated 8 altitudinal vegetation zones on Mt. Kinabalu (4101 m), the highest mountain in Borneo Island. Their altitudinal range and vegetation are in the following.

- **i) Alpine zone**  >4000 m
- **ii) Ericoid scrub zone**  3800-4000 m
- **iii) Conifer forest zone**  3200-3800 m
- **iv) Edaphic variation of upper montane oak forest zone**  2800-3200 m
  - *Leptospermum* forest, *Dacrydium* forest with *Daphniphyllum* and *Syzygium*; 
  - Oak scrub with *Dacrydium*, *Phyllocladus*, *Vaccinium* and *Rhododendron*
- **v) Upper montane oak forest zone**  2100-2800 m
  - Oak forest (10-20 m height) with *Leptospermum*, *Prunus* and *Xanthomyrtus*
- **vi) Lower montane oak forest zone**  1000-2100 m
  - Mixed oak forest (20 m height) with *Podocarpus* (without Dipterocarpaceae, Musaceae and Araceae)
  - Mixed oak forest (20-30 m height) with Dipterocarpaceae, Musaceae, Araceae, Pandanaceae and Palmae
  - (1600-2100 m)
  - (1000-1600 m)
- **vii) Tropical rain forest (Hill type) zone**  600-1000 m
- **viii) Tropical rain forest (Lowland type) zone**  0-600 m

Kitayama (1987 & 1995) classified tropical montane rain forest zone of Borneo Island into two subzones, the lower and the upper. Tropical lower montane rain forest zone (1200-1800 m) is dominated by the species of *Lithocarpus*, *Quercus* (*Cyclob.*), and *Castanopsis*. Companions are *Eugenia*, *Tristania*, *Dehaasia*, *Dysoxylum*, *Schima*, *Ternstroemia*, *Phyllocladus*, *Dacrycarpus* and many other species. *Trigonobalanus verticillata* which absorbed phylogenic attention in relation to the evolution of *Castanopsis*, *Chrysolepis*, *Lithocarpus* and *Quercus* (Forman, 1964 & 1966), was growing on the ridge.

The tropical upper montane rain forest zone (1800-3000 m) corresponds to the cloud zone, and every surface of the standing and fallen trees and rocks were covered by bryophytes and lichens to make mossy forest. The forests are dominated by the species of *Lithocarpus*, *Castanopsis* and *Quercus* (*Cyclob.*), and they are accompanied by *Dacrydium beccarii*, *Phyllocladus hypophyllus*, *Schima wallichii*, *Leptospermum flavescens* and *Elaeocarpus* spp. At higher elevation than 2400 m only two species of Fagaceae, *Lithocarpus turbinatus* and *L. havilandii*, are found, and at 2700 m *L. turbinatus* disappear and at 3000 m *L. havilandii*.

Kitayama et al. (1993) also reported a similar oak forest from Mt. Trus Madi (2642 m) to those of Mt. Kinabalu, but they are, to some degrees, disturbed and destroyed by logging and
unregulated climbers.

**Sulawesi and Seram Islands**

Whitten et al. (1987) described vertical zonations of vegetation in Sulawesi (Celebes) Island as follows.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Altitude Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subalpine forest</td>
<td>&gt;3000 m</td>
</tr>
<tr>
<td>Upper montane forest</td>
<td>2400-3000 m</td>
</tr>
<tr>
<td>Lower montane forest</td>
<td>1500-2400 m</td>
</tr>
<tr>
<td>Lowland and hill forest</td>
<td>0-1500 m</td>
</tr>
</tbody>
</table>

The lower montane forest zone in Sulawesi is characterized by a forest of which canopy is dominated by *Castanopsis* and *Lithocarpus*. On the mountains of Donggala and Gorontaro in the altitudes among 800 and 1200 m which are lower than the proposition of Whitten et al., this oak forest is accompanied by *Phylocladus*, *Agathis* and *Eugenia* (Steup, 1931). The present author noticed *Castanopsis acuminatissima* zone around Lake Lindu at about 1500 m in Lore Lindu National Park, Central Sulawesi.

In Sulawesi Island diversity of faigaceous species is lower than in Borneo Island; 2 species of *Castanopsis* (*C. acuminatissima* and *C. buruana*) and 4 of *Lithocarpus* (*L. glutinosus, L. elegans, L. celebicum, L. havilandii*) in Sulawesi and 50 *Castanopsis* and 21 *Lithocarpus* species in Borneo (Soepadmo, 1972).

Ueda et al. (1986) made a botanical research on Seram Island and five vegetation types were recognized; mangrove, lowland forest, montane forests, mossy montane and elfin forests. The montane forests occur higher than 500 m. *Castanopsis buruana* is a dominant of the forest on the slope from 400 to 1400 m, and *Lithocarpus celebicus* on ridges. In these forests common species are *Elmerrillia sericea, Galbulimima belgraveana* (Himantandraceae), *Kadsura ultima* (Schisandraceae), *Talauma celebica, T. oleadum*, *Cyathea biformis*, and many species of dioecious *Ficus*. Trees in the montane forests develop rather poorly due to calcareous soil, but a common species, *Agathis celebica*, has a large diameter. They noticed many sucker shoots around a trunk of *Castanopsis buruana*.

**The Philippines**

Climate of the Philippines is, in general, the eastern part of each island receives much rain and in the wet condition, but little rain in the western part from December to April. Monthly mean rainfall is high in Mindanao Island throughout a year.

Dickerson (1928) discussed precisely the relationship between the flora of the Philippines and neighboring islands and countries, but he mentioned only a few words on the oak forest. The lowland areas were occupied by a number of dipterocarp species of *Isoptera, Balanocarpus, Dipterocarpus, Anisoptera, Parashorea, Pentacme, Shorea, Hopea* and *Vatica*, but such dipterocarp forests give gradually way to one in which miscellaneous trees, *Quercus* (*Quercus*) and other genera, are more prominent above 800 m. In higher altitudes more or less dwarf trees are prominent with *Podocarpus imbricatus, Dacrydium elatum, Drimys piperita* and with shrubs of *Eurya, Eugenia, Vaccinium* and *Rhododendron*. Dwarf trees may be produced under the strong winds, typhoons, which attack many times a year.

Hosokawa (1940) reported laurel-leaved forest up to 2800 m on Mt. Apo (2965 m, highest mountain of the Philippines). He did not mention the lower limit of the forest.

According to Penafiel (1995) mossy forest above 900 m elevation in the Central Cordillera, Luzon Island was dominated by about 10 m-high trees of *Lithocarpus jordanae, L. scleriana, L. coopertus, Vaccinium* spp., *Melastoma topingii, Eurya acuminata* with a few conifers such
as *Taxus sumatrana*, *Phyllocladus stugii*, and *Dacycarpus cumingii*. The diameter of these trees is not more than 40cm.

**New Guinea Island**

Brass (1941), who made an expedition to the Irian Jaya, Indonesia in 1938–1939, revised the Lane-Poole’s classification (1925) of the altitudinal distribution of New Guinean vegetation, and proposed a new system of forest zonation.

<table>
<thead>
<tr>
<th>Monsoon forest</th>
<th>0-450 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savannah and Savannah</td>
<td>0-1700 m</td>
</tr>
<tr>
<td>forest</td>
<td></td>
</tr>
<tr>
<td>Rain forest</td>
<td>0-2400 m</td>
</tr>
<tr>
<td>Mid-mountain forest</td>
<td>480-2350 m</td>
</tr>
<tr>
<td>Beech forest</td>
<td>850-3100 m</td>
</tr>
<tr>
<td>Mossy forest</td>
<td>1500-3200 m</td>
</tr>
<tr>
<td>Subalpine forest</td>
<td>3000-4050 m</td>
</tr>
<tr>
<td>Alpine grassland</td>
<td>≥2900 m</td>
</tr>
</tbody>
</table>

His classification system has a characteristic that there is duplications of altitudinal range of forest zonation, which shows that each forest is found in different ranges of altitude in different locations. Mid-mountain forest is dominated by *Castanopsis acuminatissima* with a few canopy species of *Lithocarpus* sp., *Engelhardia* sp., *Podocarpus imbricatus*, *Phyllocladus* sp., and *Araucaria cunninghamii*. Brass used the term oak forest for this type of *Castanopsis* forest. Johns (1982) also recognized oak forest from 1000 m to 1500 m and *Araucaria* forest (1500-2000 m) as lower montane forest formation. The former is characterized by *Castanopsis acuminatissima* and fagaceous species of *Lithocarpus*. At its lower levels these species are mixed with *Calophyllum* and species of tropical lowland forests such as *Anisoptera*, *Hopea*, *Intsia* (Legum.) and at higher altitudes with *Engelhardia*, and upwards it intergrades with *Nothofagus* forest which makes mid montane forest formation. In *Araucaria* forest *A. cunninghamii* and/or *A. hunsteinii* are emergent from a canopy which was made by oak forest components. Johns wrote that both *Araucaria* species are heliophilous and regenerate well in openings. The present autor also witnessed this phenomenon, and this means that *Araucaria* forest may be a seral one. Womersley (1958) pointed out that *Araucaria* forests are relict forests developed in temperate climate. *Nothofagus* forest is often found as mossy forest between 2000 m and 2700 m, and it is dominated by *N. grandis* at lower altitudes and *N. pullei* at higher altitudes.

Paijmans (1975, 1976) gave 7 major environment types and many forest types in each major type of environment.

- Beach ridges and flats 5 forest types
- Saline and brackish swamp 7
- Lowland fresh water swamp 14
- Lowland alluvial plains and fans 9
- Hills and low mountains 8
- Lower montane zone 11
- Upper montane zone 3

*Castanopsis acuminatissima* forest is one of 11 forests of lower montane zone, and is found between 500 m and 2300 m, which corresponds rightly to mid-mountain forest of Brass’ system. The author observed *Castanopsis* forests in 1400-2300 m at Dauro Pass and Bulolo (cf. Photo 4) (Tagawa et al., 1980). *C. acuminatissima* makes sometimes a pure stand with flat canopy, and a number of coppice shoots are growing around a main stem. This forest is in
places mixed with emergent conifer species of *Araucaria, Podocarpus, Dacrycarpus, and Phyllocladus*.

**Japan and Korea**

Evergreen laurel-leaved forests (this term is familiar with the Japanese ecologists) are commonly found in the lowland and montane region in western Japan. In Kyushu, the forests occupy a large area from lowland to about 1000 m in altitude. Dominant species of the forests upwards from lowland are *Persea thunbergii, Castanopsis sieboldii, Lithocarpus edulis, Quercus* (Cyclob.) *salicina, Q. gilva, Distylium racemosum, Castanopsis cuspidata* and *Q. acuta* (cf. Photo 3). Seashore of South Kyushu is partly fringed with hard-leaved scrubs dominated by *Q. (Quercus) myrsinæfolius* and *Cinnamomum daphnoides*.

In Yakushima Island the upper part of the forest is mixed with conifers such as *Cryptomeria japonica, Chamaecyparis obtusa, Tsuga sieboldii* and *Abies firma*, and these conifers but for *Ch. obtusa* increase their importance among 1200 and about 1800 m. In Kyushu main island this type of conifer forest makes vertically a transitional zone between evergreen laurel-leaved and summer green forests. Among emergent canopies of conifer trees there are evergreen broad-leaved trees such as *Quercus* (Cyclob.), *Camellia, Illicium, Distylium* and deciduous hardwood trees as *Stewartia, Kalopanax* and *Acer*. In Yakushima there is no summer green forests because of too short period of last ice age to introduce beech and deciduous oak species from Kyushu mainland in the north, but their potential area is largely occupied by *Cryptomeria japonica* forest extending to the summit area of the mountains (1935 m). In this connection many Japanese ecologists agree with the idea that this type of conifer forest is included into the evergreen laurel-leaved forest zone.

The Nansei Islands are under humid subtropical climate. They are covered by a luxuriant growth of laurel-leaved forests dominated by *Castanopsis sieboldii, Quercus* (Cyclob.) *miyagii, Persea thunbergii, Schima wallichii ssp. liukiensis*, but on the seashore and fresh and sea water swamps there are some elements of tropical strand communities and mangroves; *Ipomoea pes-caprae, Spinifex littoreus, Thespesia populnea, Heritiera littoralis, Terminalia catappa, Macaranga tanarius, Bruguiera gymnorrhiza, Rhizophora stylosa, Avicennia marina, Sonneratia alba, Nypa fruticans*, etc.

The northernmost distribution of the laurel-leaved forest was studied by Hattori & Nakanishi (1985). The forests go northwards to Oshima Island, Iwate Prefecture (39°15′N) on the Pacific coast and to Iwasaki Village, Aomori Prefecture (40°34′N) on the Japan Sea coast (Ishikawa, 1972). The laurel-leaved forests are found only on the beach area and islets in the northern limit of their distribution. Dominants near the northern limit of the forest are limited to *Persea thunbergii, Quercus* (Cyclob.) *acuta and Q. salicina*.

In the last ice age, evergreen broad-leaved forests in the lowland were driven away from Korean Peninsula as well as a beech (*Fagus multinervis*) forest in the mountain. The evergreen broad-leaved forest remained in the lowland of Cheju Do and Tsushima Islands in the Korean Strait at that time. After the last ice age evergreen broadleaf tree species invade again onto the southern seashore of the Korean Peninsula and make forests in the lowland, but Korean beech has never returned. The evergreen forests of Korea in the present time are classified into 2 associations and a community by Song et al. (1990); Cyrtomio-Litseetum japonicae, Rumohro-Castanopstietum sieboldii, and *Quercus acuta-Daphniphyllum macropodum* community. The north limit of the forest distribution is at about 35°26′ N south of Kampo (Yim & Kira, 1976). This northern limit in Korea is far south from that in Japan. The Korean Peninsula is under the influence of severe continental climate in winter, while in the northern Japan it is milder especially in the beach areas where two warm currents running north along
both coasts; Tsushima current along the Japan Sea coast and Kuroshiwo along the Pacific coast.

On the small islands off from main island Kyushu, warm temperate evergreen broad-leaved forests do not have fagaceous species (Itoh, 1984; Tagawa & Suzuki, 1985; Tagawa, 1992) as well as the Canarias Islands (Bramwell & Bramwell, 1990). It may be arisen from that acorns are more difficult to migrate into remote places over the waves than laurels with berry fruits.

Macaronesia and North America

Macaronesia

Rivas-Martinez et al. (1993) classified laurisilva of Tenerife Island, Canarias Islands into three associations; Persea (Lauro azoricae-Perseetum indicae), Ocotea (Diplazio caudati-Ocoteetum foetentis) and Erica arborea forests (Fayo-Ericetum arboreae). Little rain (300 mm in a year at maximum) in the lowland under the subtropical climate of the Canarias Islands has driven evergreen laurel forests up to the higher altitudes of mountain, and fog is the main water source there. In this situation total diversity of tree species is extremely low, and those three forests share the common tree species as shown in Table 2, and the main constituent genera of those three forests show an affinity with those of the Asian lucidophyll forest.

In a short summary of geography, vegetation and flora of Açores Islands (39°N) by Dias (in press), he wrote six vegetation zones; littoral communities, wetlands, forests, shrublands, grasslands and volcanic seral communities. Açores Islands receive much water from rain in contrast with Canarias Islands, and “laurissilva” develops from lowland to wet mountain area. In the lowland Myrica faya-Picconia azorica (Oleac.) forest was seen on the mesic soils, but nowadays it is difficult to find its living samples. In the montane area the first layer of laurissilva is composed of such endemic species as Laurus azorica, Ilex perado ssp. azorica, Frangula azorica (Rhamnac.) and Erica azorica. The statue of the forests is not higher than 10 m in the present, but historical data shows that the forests grow up to 20 m. In the high mountain over 1000 m hyperhumid and stunted laurissilva (5 m tall) or cloud-forest are found. It is dominated by Juniperus brevifolia, Laurus azorica and Vaccinium cylindraceum with abundant bryophytic epiphytes on the surface of trees. Juniper forest is on a Sphagnun carpet. Over 1900 m laurissilva changes into subalpine scrub which is dominated by the following ericaceous species, Calluna vulgaris, Daboecia azorica and Erica azorica.

Sjögren (1973) made a plant sociological study of vegetation of Açores Islands, and laurissilva is classified into an alliance, Juniperion brevifolii, and an association, Erico-Myrsinetum, where Laurus azorica is not a dominant.

<table>
<thead>
<tr>
<th>Table 2. Species compositions of laurisilva of the Canarias Islands. Main species are shown in the order of dominance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest type</td>
</tr>
<tr>
<td>Dominant</td>
</tr>
<tr>
<td>Main species</td>
</tr>
<tr>
<td>Persea indica</td>
</tr>
<tr>
<td>Ilex canariensis</td>
</tr>
<tr>
<td>Prunus hixa</td>
</tr>
<tr>
<td>Myrica faya</td>
</tr>
</tbody>
</table>
Southeastern United States

According to Knap (1965) and Olson (1983) immergrünen Eichen-Küstenwälder are found mixed with deciduous trees and conifers from Virginia to central Florida along the gulf of Atlantic coasts and to Texas and NE Mexico, but they occupy a small proportion in the total forest area of the United States. Quarterman & Keever (1962) wrote this forest as southern mixed hardwood forest. This forest is commonly seen as a small stand or a fragment of the forest along the coastal plain. In the northcentral Florida it is composed of Gymnostalma lasianthus, Ilex opaca Quercus (Quercus) myrtifolia, Q. virginiana and its two varieties, maritima and fusiformis, Magnolia grandiflora, M. virginiana, M. cerifera, Persea borbonica, Sabal palmetto (Palmae), etc. (Monk, 1965). The forests are mixed with deciduous trees in the northern limit of the distribution, and the rate of evergreens fluctuates from 7 to 100%.

The Society of American Foresters (Eyre, 1980) identified 4 types of forests in southern mixed hardwood forest;

1. Sabal palmetto forest
2. Quercus (Quercus) phellos-Q. nigra-Q. laurifolia forest
3. Q. virginiana forest
4. Magnolia virginiana-Nissa aquatica-Persea borbonica forest.

Küchler (1964) classified lowland climax forest near the shore into 3 minor types;

1. Oak-hickory-pine forest
2. Southern mixed forest
3. Southern flood plain forest.

Quercus in these forests belongs to subgenus Quercus not to subgenus Cyclobalanus seen in Asia (Soepadomo, 1972). Quercus laurifolia leaves remain on branches even in winter and in the early spring they fall simultaneously just like Cinnamomum camphora in Southeast China, Taiwan and Japan. Olson wrote shiny evergreen leaves and widespread branches of Quercus virginiana were good elements for a landscape tree. The present author thinks that these oak forests are regarded as one of lucidophyll oak-laurel forest formation. It is the same situation to that evergreen sclerophyll Quercus species are dominants of hard-leaved forest formation in the Mediterranean region and the deciduous into those of summergreen forest formation in the cool temperate region of the northern hemisphere. Elias (1971) thought that those oak species belong to the third subgenus, Erythrobalanus which is an endemic group of oak in the North America.

ALTITUDINAL AND HORIZONTAL DISTRIBUTION OF LUCIDOPHYLL OAK-LAUREL FORESTS

Horizontal distribution

A number of references cited above show that the lucidophyll oak-laurel forest has a wide range of its distribution in latitude from about 9°S to 40°34’N and at altitudes from the sea level in the cool-temperate zone to about 3000 m in the Asian humid tropics. A suggested distribution area of the lucidophyll forests in Asia is shown in Fig. 2.

Lucidophyll oak-laurel forest (shola forest) in southern India is separated at a great distance from the main area in the north, and it is a laurel forest without oak species. Gopal & Meher-Homji (1983) described that the shola forest was a biotic climax or subclimax under the biotic influences of burning and grazing. The author thinks that the probability of extermination of oak species from shola forests by such a biotic agency is extremely low, because
species of *Castanopsis*, *Lithocarpus* and some of *Quercus* (*Cyclob.*) produce vigorously suckers and sprouts around a main trunk after cutting or damaged by strong winds and herbivores (Tagawa & Suzuki, 1985). In these considerations plants of oak family might have never existed in the original shola forest.

A few stands without fagaceous species are known from the lucidophyll oak-laurel forests in Asia such as a few stands of East Himalayas, small islets off from a large island in southwestern Japan and Macaronesian islands described before. It may be arisen from the difficulty of acorn dispersion into remote places, especially across the sea.

The origin of the Canarias Islands is back to the Miocene, about $2 \times 10^7$ BP (Araña & Carracedo, 1978). Plant fossils common to the Canarias Islands were widely found in the Mediterranean region. In the upper Miocene era the Mediterranean region was on the fringe of the Tethys Sea. After closing the Tethys Sea by the connection of the Africa with the Eurasia, warm temperate evergreen vegetation that had developed along the sea coast of the Tethys was enclosed into the Canarias, Madeira and Açores Islands, which is attributable to the low temperature and xeric condition in the last ice age of the Tertiary (Bramwell & Bramwell, 1990). As the North America was already isolated far remote from the Laurasian Continent in the Cretaceous Period, laurel forests on the Canarias Islands and other small Macaronesian islands in the temperate Atlantic Ocean have little correlation with southern
evergreen hardwood forest of the United States.

Except for a few examples described above, the Asian lucidophyll oak-laurel forests have species of both Fagaceae and Lauraceae, but in New Guinea Island they are mainly composed of the species of Fagaceae (Castanopsis and Lithocarpus), and C. acuminatissima makes pure stands in many places, for which Brass (1941) used the term 'oak forest'.

Vertical distribution of the Asian forests was intensively studied by Kira (1948) for the contribution of rational land use in cool highlands. He classified vertical vegetation zones by making use of warmth index originated by himself (Kira, 1945). The warmth index is a kind of integrated temperature, that is, a total of monthly mean air temperatures above 5°C which is regarded as a threshold of low temperature stress for the physiological function and plant growth. According to a number of studies it became clear that each vegetation zone is included in a certain range of the warmth index; tundra in 0-15°C month, evergreen conifer forest zone in 15-45/55°C month, summergreen forest zone in 45/55-85°C month, lucidophyll oak-laurel forest zone 85-180°C month, subtropical rain forest zone in 180-240°C month, and tropical rain forest zone above 240°C month.

**Altitudinal distribution**

With reference to the descriptions in the first chapter vertical distribution of lucidophyll oak-
laurel forests in Asia is illustrated in Fig. 3. A downward arrow in the figure shows that the lower limit of potential distribution of the forest zone was not recognized by human disturbance given to the forests such as lumbering, firing, grazing and cultivation, and an upward arrow shows that the higher limit of the forest zone is not known because the highest peak in small islands is lower than the higher limit of the forest zone.

The lucidophyll oak-laurel forests are found between 1000 m to about 2600 m in a range of 10° in the north and south from the equator. In Tienhsi District (western Yunnan), China, the upper limit of the evergreen broad-leaved forest zone reaches 3000 m. At Kunming as the capital of Yunnan and a center of Tienchung district (central Yunnan) warmth index is about 200°C month, and 85°C month is comparable to about 2400 m in altitude in Tienchung district. So the upper limit of the evergreen broad-leaved forest zone in Tienhsi is about 600 m higher than that estimated from the value of warmth index. Evergreen forest in this higher altitude is composed of evergreen tree species such as Lithocarpus variolosus, L. hancei, Cyclobalanopsis glauca, Schima argentea, with the undergrowth of Sinarundinaria nitida (dwarf bamboo) and a few evergreen shrubs and ferns. The upper part of this forest is mixed with Tsuga dumosa and gradually changing into conifer forests dominated by Pinus yunnanensis.

Another example is given on Mt. Pangrango, montane forest there is found even in a high altitude at 3000 m. The upper limit of lucidophyll oak-laurel forest zone on Mt. Pangrango is much higher than that estimated as 2550 m by means of warmth index. At the top of the mountain it is calculated as 50.5°C month.

This extraordinary ascending of the higher limit of lucidophyll oak-laurel forest may be ascribed to two reasons, the first is due to a special local climate condition in Tienhsi, Mt. Pangrango and other high mountains in the tropical Asia, and the second is that 85°C month as the upper and northern limit of lucidophyll oak-laurel forests in the warm-temperate region cannot be applicable to the upper limit of distribution in the tropics. The author thinks the latter reason may be suitable. In the cool-temperate summergreen forest zone appear below 85°C month or upwards of lucidophyll oak-laurel forest zone in the montane areas, but in the tropics there is no summergreen forest zone, and evergreen forests extend up into alpine conifer forests mainly composed of Podocarpaceae in the tropical Asian islands and of Tsuga, Abies and Pinus in the Asian tropical continent.

On Mt. Huang Shan (1700 m) at about 30°N, Anhui Province, Cyclobalanopsis gracilis-Cyc. nubium forest was reported from 1200 m in altitude and Castanopsis eyrei-Schima wallichii var. superba forest from 630 m (Editing Committee for Vegetation of Yunnan, 1980). As far as the vegetation maps concern, northern distribution limit of the evergreen broad-leaved forests in the Asian Continent does not extend to the North from 33°N because of low temperature in winter and low humidity stress. Southern small islands and sea coast of larger islands of Japan are, as already described, warmer in winter and humid condition by the effect of two warm currents, Kuroshio and its tributary, Tsushima current, so the northern limit extends far north to about 39°N in the Pacific coast and 40°N in the Japan Sea coast.

Ohsawa (1993) gave a vertical profile of vegetation zones in southern and eastern Asian mountains in his discussion on latitudinal pattern of montane vegetation zonation. His idea is agreeable as a whole. He also used Lauro-Fagaceous forest to tropical montane forest. Upper limit of the laurel-oak forest in the tropics, though it is also called cloud forest or mossy forest, was drawn at about 2500 m by him, goes up to nearly 3000 m in some places with decreasing species diversity and lowering tree stature. At such high altitudes the forest is mixed with conifers of Dacrydium and Dacrycarpus in SE Asian islands and Tsuga, Pinus and Abies in the Asian continent, so the discussion will divagate whether such a mixed
Distribution of lucidophyll oak-laurel forest formation

Fig. 4. Altitudinal distribution of vegetation zones in Papua New Guinea. Transverse section of Papua New Guinea along 140°E (A) and the eastern Owen Stanley Range (B)-(Johns, 1982).

coniferous forest or stunted mossy forest should be included into lucidophyll oak-laurel forest or not. The present author does not think that such conifer forests on tropical high mountains should be included into lucidophyll oak-laurel forest. Mixed forest is thought to be a transitional type of forest between two.

Only in New Guinea and New Britain Islands there is Nothofagus zone above Castanopsis zone and these two zones appear in higher altitudes in the main island than in the appendant small islands, which is known as a 'mass elevation effect', as shown in Fig. 4 (Johns, 1982). This effect is widely observed in the island of Japan. On Kyushu mainland, a number of lucidophyll tree species, Distyrium recemosum, Quercus salicina, Persea thunbergii, Castanopsis sieboldii, etc. makes forest zone respectively, but they are mixed with each other without making vegetational zone on the Nansei Islands.

Now I return to my subject, evergreen Nothofagus forest occupies from 2200 m to 3000 m in the mainland of New Guinea as seen in Fig. 4. These altitudes correspond to 108.3 and 50.7°C month (based on the weather data at Lae), respectively, and this range of altitudes includes upper part of lucidophyll oak-laurel forest to almost all range of summergreen forest, if it was in the warm-temperate region. So the upper limit of Castanopsis zone in New Guinea would be uplifted in much higher elevation as well as on Mt. Kinabalu, if there were no Nothofagus zone. Castanopsis zone is in a range of 1000 m-2200 m and 194.7-108.3°C month, which correspond to the distributional range of upper part of subtropical and lower part of warm-temperate lucidophyll oak-laurel forest zones. It can be understood that lucidophyll oak-laurel forest zone in New Guinea is depressed to the lower altitudes by the invasion of Nothofagus zone between lucidophyll oak-laurel and conifer forest zones. Coexistence of both zones is observed only on New Guinea and New Britain Islands.
NOMENCLATURE OF THE FOREST

A number of authors used a great many terms for the lucidophyll oak-laurel forests in Asia as seen in Chapter I. The terms are classified into following five groups by means of various characters of the forest. The following shows the terms, altitudinal distribution of forests, country or a part of the country, and authors.

1 Terms showing vertical distribution:
   i. High mountain hardwood forest (1500-2100 m), Myanmar, Davis 1964
   ii. Mid mountain forest (1700-2250 m), Papua New Guinea, Brass 1941
   iii. Montane zone (1000-2400 m), Jawa, van Steenis et al. 1972
      Malay Peninsula, van Steenis 1935
   iv. Montane evergreen forest (1000-2576 m), Thailand, Ogawa et al. 1961
   v. Lower montane zone (1000-2576 m), Papua New Guinea, Peijman 1976
      (1500-2400 m), Sulawesi, Witten et al. 1987
      (1000-2000 m), Thailand, Kunstadter et al. 1978
   vi. Hill evergreen forest (1200 m), N Thailand, Yoda and Sahunalu 1991
   vii. Montane cloud forest, Ohsawa 1995, Kitayama 1995

2 Terms showing combination of climatic zone and character of leaves:
   i. Cool region (1360-2100 m), Jawa, Seifriz 1923
   ii. Temperate rain forest (various altitudes), Canarias Is. etc., Schimper 1898
   iii. Temperate evergreen forest (1000-2576 m), Thailand, Ogawa et al. 1961
   iv. Temperate broad-leaved evergreen forest, USA, Olson 1983
   v. Warm broad-leaved forest (1650-2600 m), China, Editing Committee for Forest of Yunnan 1986
   vi. Warm-heat broad-leaved forest (1000-1650 m), China, Editing Committee for Forest of Yunnan 1986
   vii. Warm temperate mixed forest (700-1800 m), Taiwan, Flora of Taiwan 1975
   viii. Subtropical evergreen broad-leaved forest (600-1650 m), Taiwan, Hsu 1971

3 Terms showing leaf character:
   i. Evergreen broad-leaved forest (0-1000 m), Japan, many authors
   ii. (Evergreen) Laurel-leaved forest (0-1000 m), Japan, many authors
   iii. Lucidophyll forest, Japan, Kira 1977

4 Terms based on species composition:
   i. Laurisilva/Laurisilvae/Laurel forest, Brockmann-Jerosch and Rübel 1912, etc.
   ii. Oak forest (Thitcha) (900-2100 m), Myanmar, Stamp 1924
   iii. Oak-laurel forest (1200-1500 m), Malay Peninsula, Whitmore 1975
   iv. Evergreen oak forest zone (1000-2400 m), Sabah, Hotta 1974
   v. Montane oak forest (1200-1500 m), Malay Peninsula, Whitmore 1975
   vi. Lauro-Fagaceous forest, Asian mountains, Ohsawa 1993
   vii. Fago-Lauaceous forest, Jawa, Junghuhn 1845

5 Terms based on plant sociology
   i. Lauraceo-Fagaceetae, Japan, Tok. Suzuki 1966a, 1966b
   ii. Camellieta japonicae, Japan, Miyawaki & Ohba 1963

In the warm-temperate climate zone lucidophyll oak-laurel forest makes a submontane vegetation zone, and montane zone in the tropics. As going northwards to the limit of the
distribution of the forest, it goes gradually downwards. So the terms expressing vertical distribution introduce various ways of understand in various locations concerning the distribution of the forest.

The terms which mean climate such as cool, temperate, warm, warm-heat, warm-temperate, and subtropical sometimes introduce unnecessary confusion. Southeast Asian countries are mostly under the tropical climate without little fluctuation of temperature through a year, and also in higher mountains the fluctuation of monthly mean temperature is milder than the daily fluctuation of air temperature at higher altitudes. So there are no clear seasons. A cool night and a warm daytime are repeated everyday at higher altitudes in the mountain. It is ridiculous to use terms such as warm-temperate or temperate forests in the tropical and subtropical regions. Abuse of the terms on climate zone above is based on the confusion of Fuchssien-klima with Camellienklima (Köppen, 1918).

In the meanwhile, the term evergreen broad-leaved forest can be applied with tropical rain forest and hard-leaved forest in the Mediterranean climate, as we can learn its meaning from the context. The word oak originally indicates species of Quercus in the sense of subgen. Quercus but not in the sense of subgen. Cyclobalanus. Almost lucidophyll oak-laurel forests in Asia are dominated by Quercus species in the latter sense, and we must extend the meaning of the term oak as a representative term of all species of the genus Quercus and of Fagaceae. So the lucidophyll forests dominated by Castanopsis and/or Lithocarpus are possible to be grouped into oak forest. Laurus species are restricted its distribution to the Mediterranean and Macaronesian regions and no in Asian countries, but if we interpret laurel as laurel family as many ecologists do, many types of lucidophyll forest dominated by lauraceous species are grouped under the name of laurel forest.

The term lucidophyll forest may be applicable to the forests in the tropical, subtropical, and warm-temperate forests if there are evergreen trees with broad and lucid leaves, and to the forests in the mountain, mid-mountain, lower montane, and on the hill. It is little difficulty to use lucidophyll forest for all the forests hitherto been discussed. If we use the term "lucidophyll" oak-laurel forest for the evergreen broad-leaved forest dominated by laurels and/or oak species in warm-temperate and mountain areas of the subtropical and the tropical regions, Nothofagus forest should be included into lucidophyll oak-laurel forest because of its lucid leathery Nothofagus leaves. Nothofagus species have been evolved and diversified only in the southern Hemisphere, and they are distributed in New Guinea, southeastern Australia including Tasmania, New Zealand and the southern Andes. Now, two major lucidophyll forests, oak-laurel forest and Nothofagus forest, are shaking hands with each other in New Guinea and New Britain Islands. Nothofagus forests are evergreen oak forest (except for Patagonian summergreen forests dominated by N. pumilio and N. antarctica, and N. obliqua and N. procrea in tique forest in Chile) developed in the tropic, subtropc and temperate wet climate with mild winter only in the Southern Hemisphere. Discussion will be made after describing Nothofagus forests and other types of forest in the following chapter.

EVERGREEN FORESTS IN AFRICA, CENTRAL AND SOUTH AMERICA, AUSTRALIA AND NEW ZEALAND

The word 'evergreen forest' used here means evergreen forest which are found in the humid temperate, subtropical and tropical regions, and it does not include lowland tropical rain forest. In the previous chapters I examined and discussed lucidophyll oak-laurel forests of holarctic and palaeotropical floral kingdoms. In this chapter I would like to refer to and discuss evergreen forests in palaeo-and neotropical, Cape, and Australian floral kingdoms developing
under a warm and humid climate corresponding to that of lucidophyll oak-laurel forest.

**Africa**

Temperate evergreen forests in Africa have been reported precisely in recent years (Donald & Theron, 1983). These forests have been fragmentally kept in the afro-montane regions as forest reserves. The afro-montane forests stretch from the southern Cape to Ethiopia through the eastern mountain ranges between 1200 and 2500 m in altitude. Afro-montane forests were classified into 6 groups in those east mountain ranges and a west African group by White (1978). The upper limit of the afro-montane forest descends gradually in higher altitudes, but in the lower altitudes than several hundred meters the forest is replaced by a stunted scrub, ‘fynbos’, which was produced by xeric climate.

The main species of afro-montane forests are *Apodytes dimidiata* (Icacinac.), *Ilex mitis*, *Nuxia congesta* (Buddlejac.), *N. floribunda*, *Kiggelia africana* (Flacourtiac.), *Prunus africana*, *Rapanea melanophloeos* (Myrsine), *Halleria lucida* (Styracac.), *Ocotea bullata* (kenyensis), *Xylobalos monospora* (Monimiac.), and two emergent conifers, *Podocarpus latifolius* and *P. falcatus*. The afro-montane forests carry uncommon taxa to lucidophyll oak-laurel forests but for one laurel, *Ocotea*, and their dominant taxa of the forests are species other than Fagaceae and Lauraceae.

Conifer laurel forests introduced by Brockmann-Jerosch and Rübel (1912) is southernmost afro-montane forest which is now found along the Drakensberg escarpment, in the Natal, eastern Cape midlands and on the coast of the southern Cape (Humley, 1984). In South Africa montane forest (Werger, 1978) is found between 1280 m and 1830 m, and dominated by *Podocarpus latifolius* (White, 1978). Common genera of montane forests to other afro-montane forests were *Podocarpus*, *Olea*, *Ilex*, *Pittosporum*, *Rapanea*, *Xylobalos*, and only one laurel species, *Ocotea bullata*. *Podocarpus* are sometimes emergent from forest canopy at 10 m to 25 m in height. According to weather data of Durban, South Africa, warmth index at altitudes of 1300 m and 1800 m is 94.1 and 57.1°C month which are comparable to a range of upper lucidophyll oak-laurel forest and nearly upper limit of summergreen forest zones in Asia.

**Central America**

Mexico belongs to North America, but with a view to vegetational continuity to the Central America it is convenient to discuss montane forests together with those in Central America.

Gomez-Pompa (1973) reported tropical oak forests from lowland (at the sea level) to 1700 m (180°C month; altitudinally upper limit of subtropical lucidophyll oak-laurel forest in Asia) and from drier parts in the northern part of the state of Veracruz. Mexico to very wet portion of the South. The oak forest on a lava flow is dominated by evergreen *Quercus* (*Quercus*) *oleoides*, and other species are *Alchornea latifolia* (Euphorbiac.), *Dendropanax arboresus*, *Ficus maxima*, *Sapindium lateriflorum* (Euphorbiac.), *etc.*. The tropical oak forest on the soil of bad drainage was also dominated by *Q. oleoides*, but other woody species are a little different from that on lava flow. They are *Byrsonima crassifolia* (Malpigiac.), *Conostegia xalapensis* (Melastomatac.), *Quercus* spp. and *Xylophagous*. In these two forest types there are a few common genera with those of Asian lucidophyll oak-laurel forest such as *Quercus*, *Dendropanax* and *Xylobalos*.

According to Breedlove (1973), lower montane rain forest has the same physiognomy of tropical rain forest, but there are no emergent trees over forest canopy at 25-45 m. The canopy was mixed with species of tropical rain forests, and canopy species other than those are *Belotia mexicana* (Tiliac.), *Ulmus mexicana*, *Calophyllum brasiliense* (Guttif.), *Licania platyclus* (Chrysobalanac.), *Nectandra sinuata*, *Ocotea rubiflora*, *Quercus oleoides*, *Q.*
skinneri, *Sebastiana longicuspis* (Euphorbiac.), and *Talauma mexicana*.

Breedlove also introduced montane rain forests found in the range of 900-2200 m on upper slopes of eastern and northern highlands, and eastern escarpment of central highlands of Chiapas State, Mexico. Its canopy layer is made of *Ardisia alba*, *Brunellia mexicana* (Bruneliac.), *Hedyosmum mexicanum* (Chloranthac.), *Matudaea trinervia* (Hamamelidac.), *Meliosma reticulata*, *Mosquitoxylon jamaicense* (Anacardiac.), *Nectandra reticulata*, *Oreopanax sanderianus* (Araliac.), and *Quercus (Quercus) peduncularis*. He also recognized evergreen cloud forests from 2000 m to 2900 m in eastern and northern Highlands and 1900 m to 3200 m in the Siera Madre Mountains, and species composition of their canopies is *Abies guatemalensis*, *Acer negundo*, *Clethra lanata* (Clethrac.), *C. oleoides*, *Oreopanax capitus*, *Persea donnell-smithii*, *Photinia matudae*, *Pinus ayacahuite*, *Quercus acatenangensis* and *Weinmannia pinnata*. The canopy genera of the Central American forests are more common with those of the Asian *lucidophyll* forests as altitude grows higher.

Holdridge & Budowski (1956) classified Panaman life zone into 5 types;

1) tropical moist forest (including transitional type),
2) tropical dry forest (including transition type),
3) subtropical moist forest,
4) lower montane rain forest,
5) montane wet forest.

By placing vegetation map made by Holdridge and Budowski over another map made by Bennett (1968), both maps were cited from Porter (1973), it is clear that montane wet forest and lower montane wet forest had been well reserved until the end of 1960s, but subtropical moist forest was replaced by grassland and deciduous forests.

Subtropical moist forest (premontane rain forest in Porter, 1973) in Chiriqui State contains Asian *lucidophyll* components such as Lauraceae, *Quercus (Quercus)*, *Podocarpus*, *Ternstroemia* and lower montane forest (cloud forest in Porter) in Chiriqui *Persea*, *Quercus*, and *Weinmannia*. Gomes-Poma did not describe dominant species of those forests, but it is properly said that those forests show an affinity to some degrees with the *lucidophyll* forests hitherto been discussed.

The main components of cloud forest or mossy forest in the Antilles Islands classified by Howard (1973) are *Clusia* (Guttif.), *Didymopanax* (Araliac.), *Oreopanax*, *Inga* (Leguminosac.), *Hibiscus* (Malvac.), *Ilex*, *Freziera* (Camelliac.), *Richeria* (Euphorbiac.), *Weinmannia*, *Tabebuia* (Bignoniace.), *Ocotea*, and *Psychotria*. At lower altitude than cloud forest trees are to some degrees sclerophyllous, and this type of forest is hard to classify into the same forest formation of *lucidophyll* forest. The cloud forest includes some taxa as *Ilex*, *Ocotea*, *Psychotria* and *Weinmannia* common to the *lucidophyll* forest.

**South America**

The northern Andes is separated into three tributaries in South Colombia, Mts. Occidental, Central and Oriental, and in North Colombia the last is into Perija and Merida Mountains surrounding Maracaibo Bay.

According to Veillon & Lemprecht (1955, cited from Hueck, 1966), in lower and mid-montane forest zones of which upper limit is at 1800-2000 m in the Merida Mountains, Venezuela there are forests with abundant trees of Lauraceae, Moraceae, Myrtaceae, Bignoniaceae and Araliaceae, and legume species extensive in the lowland rain forests decrease in this zone. In lower cloud forest zone between 2300 m and 2600 m dominant
species is limited to one, *Podocarpus rospigliosii*, and in higher cloud forest zone (3000-3200 m) *Podocarpus montanus*, *P. oleifolius* are the canopy species and the following companions are all evergreen, *Oreopanax moritzii*, *Brunellia integrifolia*, *Hedyosmum glabratum*, *Weinmannia jahnii* and *W. microphylla*.

Lower Andes forest in the altitudes of 1000 m-2400 m (Cuatrecasas, 1958 cited from Hueck, 1966) is composed of a few buttressed trees and many epiphytes and lianes and trees with mesophyll. Hueck described subantarctic species grow in the montane forests of the central Colombia together with such holarctic species as *Quercus* (*Quercus* granatensis, *Juglans columbiensis*, *Podocarpus taxifolius* and *P. macrostachys*. Main taxa of Andes forest between 2400 and 3800 m on Mt. Oriental is *Weinmannia*, *Brunellia*, *Clusia*, *Befaria* (Ericac.), *Drimys* (Winterac.), *Daphnopsis* (Thymelaeac), *Miconia* (Melastomatac.), *Oreopanax*, *Eugenia*, *Ilex*, *Escallonia* (Escalloniac.) and *Berberis* (Berberidac.).

In the tropical rain forest zone not higher than 300 m in Guyana a laurel forest dominated by *Ocotea rodioei* on sandy soil was reported by Davis & Richards (1933, 1934). This forest was extensive in the lower Marazuni Valley, and they gave a few special characters, little or not buttressed, scantiness of undergrowth tree stratum and high resistance for decay. Although this forest includes a few stems of laurels, *O. rubra* and *Nectandra* sp. and a few others of unidentified Lauraceae, but others are components of the surrounding tropical rain forest. So it is doubtful whether this forest should be a type of lucidophyll forest or not, but this phenomenon gives a suggestive hint on the origin of laurel forest in the tropical lowland area. The present author also observed a laurel forest dominated by *Eusideroxylon zwagerii* on wet sandy terrace of creeks and *Lithocarpus* trees on a hill (cf. Photo 5) in East Kalimantan, Borneo Island. In higher altitudes of northern Andes forests are dominated by various species of podocarps (*P. rospigliosii*, *P. montanus*, and *P. oleifolius*).

Hueck (1966) described laurel forests dominated by *Phoebe porphyria* mixed with *Blepharocalyx gigantea* (Myrtac.) at 600-900 m in altitude from the states of Tucuman, Salta and Jujuy, Argentina, north to Bolivia. Dominant species of this type of laurel forest are replaced by other laurels such as *Ocotea* and *Nectandra* in the North. The composition of this laurel forest is *Phoebe porphyria*, *Ocotea*, *Nectandra* (species of both genera are not identified), *Brepharocalyx gigantea* (Myrtac.), *Cedrela lilloi*, *C. balansae* (Meliac.), *Pentapanax angelicifolius* (Araliac.), *Patagonula americana* (Boraginac.), *Jacaranda mimosifolia*, *Tabebuia avellanedae*, *Cupania vernalis* (Sapindac.), *Rapanea laetevirens*, *R. ferruginea*, *Cascaronia australis* (Legum.), *Fagara coco* (Rutac.). From 800 m to 1200 m laurel forest changes into myrtaceous forest dominated by *Eugenia pungens* and *E. uniflora*. Above 1200 m ‘Nogal’ forest of which dominants are *Juglans australis* and *Podocarpus parlatorei*, and ‘Aliso’ forest of *Alnus jorullensis* is found.

Lower ‘Yungas’ forest, or tropical rain forest in the Bolivian Andes below 2000-2500 m shows similar physiognomy to the laurel forest seen in the lower montane from northern Argentina to Bolivia as described above, and it is composed of many species of laurels such as *Hufluandia* (Beilschmiedia), *Endlicheria*, *Nectandra*, *Ocotea* and *Phoebe* (Herzog, 1923 cited from Hueck, 1966). Large area of upper Yungas forest from 2000 m to 2800 m is characterized by abundant epiphytic bryophytes and now replaced by coffee plantations or degraded secondary tree-fern communities. Between 2800 m and 3400 m ‘Ceja’, a secondary scrub, dominated by stunted *Podocarpus nubigenus* covers a large area.

On the bases of plant sociology Schmithüsen (1956, cited from Hueck, 1966) classified vegetation of Chile into two alliances:

1) Lithraeon in xeric habitat with character species, *Lithraea caustica* (Anacardiac.)
2) Cryptocaryon in humid habitat characterized by *Cryptocarya rubra*
i Beilschmiedia miersi forest

ii Cryptocarya rubra forest

The Cryptocaryon is further divided into ‘Belloto’ and ‘Peumo’ forests. The belloto forest is distributed below 1000 m and its dominant is Beilschmiedia miersi (belloto) with canopy species of Schinus latifolius (Anacardiac.), Citronella mucronata (Icacinac.) and Cryptocarya rubra (peumo) having leathery evergreen leaves. Dominant of peumo forest is Cryptocarya rubra reaching 12 m at maximum. According to Oberdorfer (1960, cited from Hueck, 1966) its upper limit of distribution goes down from 1900 m at around 32°S through 900 m at 34-35°S to 200-300 m at 36°40’S.

Various types of vegetation are integrated in the small area of southern Chile (Hueck, 1966), sclerophyll, lucidophyll, evergreen, summergreen, conifer and hardwood forests. On western lower slopes of sea-shore and foothill of the Andes south from Valdivia there is a rain forest named ‘Tique’ forest with “Typ der Magnolia-oder Lorbeerblätter” (Hueck, 1966). Forest canopy reaches 40-50 m under wet climate there. It developed in the Tertiary period and is thought to be a refuge protected under mild winter and humid climate from repeated ice ages in the Dilubium, which was properly described by Kozdon (1958) as “tropischen Wald im nichttropen Gebiet”. Main species of tique forest are Aextoxicon punctatum (Aextoxicac.), Eucryphia cordifolia (Eucryphiac.), Laurelia aromatica, L. serrata (Monimiac.), Drimys winteri, Myrceugenella apiculata (Myrtac.), Nothofagus obliqua, N. proceria, Guevina avellana, Lomatia ferruginea, L. hirsuta (Protec.), Maytenus boaria (Celastrac.), etc. Both species of Nothofagus are deciduous, and they become dominant of a summergreen forest found in the drier and cooler (upper and southern) climate of eastern slope of mountain.

Tique forest gradually reduces its species diversity, and Nothofagus dombeyi and Eucryphia cordifolia make Patagonian evergreen rain forest (Hueck, 1966) reaching 35-40 m in height, and a conifer, Podocarpus nubigenus, is found in the forest. The upper limit of its distribution is about 1000 m in Taitao Peninsula at 46°-47°S. Close to the southern tip of South America Magellanian evergreen rain forest (Hueck, 1966) dominated by Nothofagus betuloides appears. Even in the higher latitudes at 46-47°S only weak frost falls without severe winter. Main component species are Drimys winteri, Lomatia ferruginea, Azara lanceolata (Flacourtic.), Maytenus magellanica and Podocarpus nubigenus. The forest goes up to 400 m in the Island of Tierra del Fuego (at about 54°S). It is the southernmost evergreen broad-leaved forest of the world. At higher altitudes from 400 m vegetation changes into summergreen forest dominated by deciduous Nothofagus pumilio and N. antarctica. At Ushuaia, Tierra del Fuego, warmth index is 19. 5°C month, and it is in a range of sub-frigid zone in the northern Hemisphere, and at 400 m in altitude it decreases to 5.9°C month, which shows it is in tundra zone.

Australia and New Zealand

According to Webb & Tracey (1981) in Queensland, northeastern Australia Cinnamomum propinuum dominates in a semi-evergreen microphyll vine-fern thicket under subtropical seasonal dry climate. This type of laurel forest (canopy reaches 15 m at maximum) is in the driest habitat among that of lucidophyll oak-laurel forests we have seen. In Japan and supposedly in South China Cinnamomum camphora changes simultaneously their old leaves like deciduous trees with new ones in early spring (Nakamura, unpublished). So this species is thought to be acquiring resistance to desiccation of the habitat. A common genus of laurel family in Australia is Cryptocarya and its several species are distributed in the northern tropical forests, but they do not become dominants and in most case they are companions of
sub-canopy stratum.

Southern closed-forests in Australia are represented by *Nothofagus* forests. These forests were called cool temperate rain forests or nanophyll moss forests (Webb, 1959). *Nothofagus cunninghamii* forest is found from the sea level (annual mean air temperature is at 14°C) to 1370 m (8.5°C) in Southeast of Victoria and Tasmania Island, but *N. moorei* can grow in high temperature not more than 17.3°C in the coastal area from South Queensland to New South Wales (Howard, 1981). Another species, *N. gunnii*, is found only in Tasmania, and it does not become a dominant of forest. Both *Nothofagus* forests had a wide range of distribution in Australia in Tertiary era, but they have thenceforth constrained in a limited area by the climatic change and repeated forest fires. The matured *Nothofagus* forests are highly resistant to the fires because of empty undergrowth layer, but many seedlings and saplings of *Nothofagus* in the secondary young forests are ready to catch fire and it is hard to regenerate and grow into mature forests. Tasmanian beech forest is in the range between 91.3 and 15.9°C month, which coincides with warm temperate and subfrigid zones in Asia.

Godley (1975) wrote early settlers found the North Island of New Zealand covered by dense forests except for secondary vegetation recovering from activities of volcanoes and Maori people for their life. Vegetation of the South Island was the same, but eastern side of the island was occupied by grassland under dry climate. Forests in New Zealand are grouped into two major types;

1. *Nothofagus* forests dominated by one or more of the 4 endemic evergreen *Nothofagus* species,
2. Conifer forests dominated one or more native conifers (*Agathis, Libocedrus, Podocarpus*).

These *Nothofagus* species and conifers are not exclusive from each other and coexist in the forest. In comparison with Australian *Nothofagus* forests those in New Zealand are under more favorable condition for regeneration, because it is sufficiently humid for germination and low frequency of forest fire.

As already described Schimper (1898) classified closed forests in Australia and New Zealand as Temperierte Regenwald as well as those in South Japan and South Chile. Cockayne (1926) modified the terminology of two forest types in New Zealand as subantarctic rain forests for *Nothofagus* forests and subtropical rain forests for mixed conifer forest as subtropical rain forests, but Godley described on reference to Holloway (1946) that this terminology was based on the concept of biogeography and was far more than can be accepted by ecologists. The same discussion on the terminology of the forests under discussion in Chapter 3.

According to Godley (1975) *Nothofagus* forest is developed in the humid place with rainfall more than 365 mm to 6350 mm, but not found in Stewart Island and eastern part of the South Island. The forest is usually mixed with some conifers to make southern beech-podocarp forests in the lower altitudes and with *Beilschmiedia tarairi* in some places. Its species composition becomes simple in the higher altitudes. Dominant species of southern beech are *N. fusca*, *N. menziesii* and *N. solandri*. Undergrowth is *Griselina littoralis* (Cornac.), *Pseudowintera colorata* (Winterac.), *Coprosma foetidissima*, *C. pseudocuneata* (Rubiac.), *Pseudopanax colensoi*, *P. simplex* (Araliac.), *Phyllocladus alpinus* (Podocarpac.), etc., and it is abundant in the wetter places but poor in the dry habitat.

The upper limit of the forest is read at about 1400 m at about 42°S from Fig. 12a of Godley’s paper. This altitude is in the range among 78.3 and 9.9°C month on the weather data of Christchurch, and coincides to cool temperate zone at the sea level to frigid zones in East Asia.
Conifer mixed-hardwood forests show a wide range of combination of hardwood and conifers, so we have a pure stand of hardwood species in some places and of podocarps in others. Conifer species are Agathis australis (Araucariac.), Podocarpus totara, P. hallii, P. spicatus, P. dacyryoides, Dacrydium cupressinum and Libocedrus bidwillii. Hardwood trees mixed with conifers are Beilschmiedia tarairi, B. tawa, Metrosideros robusta, M. umbellata (Myrtac.), Weinmannia racemosa and W. sylvicola. Metrosideros robusta germinates on the bark of trees as an epiphyte and becomes a strangler to kill its host tree as it grows. The same character is found by Trochodendron aralioides (Trochodendrac.) in Yakushima Island, Japan. This character is only realized by humid or wet air condition. In Yakushima the host tree is restricted to Cryptomeria japonica (Taxodiace.), and finer aerial roots of T. aralioides extend downwards between layered thin sheets of C. japonica bark into the soil (Shimozono, unpublished).

The underlayer trees in the conifer mixed-hardwood forest are Carpodetus serratus (Escalloniace.), Arishotelia serrata (Elaeocarpaceae), Elaeocarpus hookerianus, Plagianthus betulinus, Melicytus ramiflorus (Viorac.) and so on. The upper limit of mixed conifer forest is at about 1200 m (Godley, 1975, Fig. 12a) around 43°30'S. So the southern beech forests and mixed conifer forests in New Zealand are evergreen forests under the coldest climate together with Patagonian Nothofagus forest.

**IS IT APPROPRIATE TO REGARD LUCIDOPHYLL OAK-LAUREL FOREST AND NOTHOFAOUS FOREST AS THE SAME FOREST FORMATION?**

The key to resolve this problem is in New Guinea and her satellite islands. As shown in Fig. 4, lucidophyll oak-laurel forest and Nothofagus forest coexist by making respective forest zone there. In most places Nothofagus forest is found above the lucidophyll forest, and as an evergreen broad-leaved forest it is highly resistant to low temperature as seen in New Zealand and Patagonian Nothofagus forests. Johns (1982) showed an interesting phenomenon in his figure (Fig. 4). In the eastern Owen Stanley Range lucidophyll forest is also found above Nothofagus zone as well as under it. It may be arisen from dry climate for seven months in the lowland. Fog may be the main source of water. Lower in the Nothofagus forest zone Castanopsis and less common Lithocarpus are mixed with Nothofagus, and in the upper zone conifers of Podocarpaceae, Myrtaceae and Elaeocarpaceae are increasingly common (Pajman, 1976).

Evergreen Nothofagus forest covers from 2200 m to 3000 m in New Guinea Island as described in the second chapter and shown in Fig. 4. These altitudes correspond to 108.3 to 50.7°C month based on the weather data at Lae, respectively. It is in the upper part of Castanopsis forest zone to the lower part of summertime forest zone of East Asia. Castanopsis zone is in a range of 1000 m-2200 m in New Guinea or 194.7-108.3°C month, which is in the distributional range of upper part of subtropical and lower part of Castanopsis forest zones in Asia. In other words, Nothofagus forest has been survived or is now extending its area between lucidophyll oak-laurel forest zone and conifer forest zone in New Guinea by taking a small range of distribution from both forest zones. But for the dominant species of Nothofagus forest, the forest composition is mixed with elements of lucidophyll oak-laurel forest zone and Conifer zone. Someone may hold another view that the lucidophyll forest zone might have been invaded between tropical rain forest zone and Nothofagus forest zone, but it could be denied because some species of Lithocarpus and other elements of the lucidophyll forest are commonly found in the tropical lowland rain forest.
In Yakushima Island, Japan there are no summertime forest, where the summertime forest should be found in the sense of climate, above lucidophyllum oak-laurel forest. Its area to be obtained by summertime forest is actually occupied by a mixed conifer forest made of Cryptomeria, Chamaecyparis, Tsuga, Abies and with evergreen Quercus (Cycloph.), Camellia, Symlocos, Pieris (Ericac.), and deciduous Kalopanax and Stewartia extending nearly to the highest peak, 1936 m. This author thinks that the origin of this mixed conifer forest in Yakushima Island is the subalpine conifer forests in the Himalayas. Vacant niche of summertime forest zone has been filled up by downward and upward extensions of conifer forest and lucidophyllum forest zones. Nothofagus zone in New Guinea is a reverse case of Yakushima. Nothofagus forests of Patagonia are found far south at 54°S. It is the result of nonexistence of such tree species tolerant for low temperature as Picea, Abies, and Betula, or mild winter with small fluctuation of low temperature caused by being surrounded by the sea.

As Nothofagus species have small leaves reflecting sunshine with its glossy surface, it is natural to classify Nothofagus forest as a type of lucidophyllum oak-laurel forest. Nothofagus forests are found in humid habitat from lowland to higher altitudes in the southern Hemisphere. Higher altitudes in the humid tropic are under extremely wet condition. Everyday they are hidden in the dense clouds in the afternoon, and every leaf surface is covered by epiphyllous lichens and bryophytes, which is recognized as a mossy forest. So leaves are not always lucid, but they are not responsible for it.

In this chapter so-called evergreen broad-leaved forests in warm-temperate zone or montane zone in the subtropic and tropic areas were introduced from the regions of Africa, Australia, New Zealand, Central and South America. Some forests in the lower altitudes of the Andes are dominated by a few species of Lauraceae and/or Fagaceae; subtropical moist forest in Panama (Holdridge & Budowski, 1956), laurel forests at low altitude in Argentina to Bolivia (Hueck, 1966), yungas forest (Herzog, 1923), Chilean belloto and peumo forests (Schmithüsen, 1956) and Nothofagus forests in the southern tip of the South America (Hueck, 1966). In subtropical seasonal dry climate a cimarron forest are found in Australia (Webb and Tracey, 1981). These forests show close similarity with lucidophyllum oak-laurel forest in Asia and may belong to the same forest formation.

However, the author is in doubt what he should treat afro-montane forests. They do not carry oak and/or laurel dominants, but carry Podocarpus dominants in common. In the higher altitudes of the Andes some evergreen forests are dominated by or have emergents of Podocarpus species. Forests dominated by such genera of podocarp family as Dacrycarpus, Dacrydium, Phyllocladus and Podocarpus are also found in Australia, New Zealand, New Guinea, and Borneo (Hotta, 1974). They are mixed with Nothofagus in the lowland of New Zealand, but in the high altitude Nothofagus gradually replaced by podocarps. In New Guinea and Borneo Islands conifer forests of Podocarpaceae make a conifer forest zone of which upper limit forms a timber line. This southern conifer forests is quite different from northern conifer forests dominated by Pinaceae (Abies and Picea) and Cupressaceae (Juniperus) in the subfrigid and frigid zone of the Northern Hemisphere. So it may be desirable to consider that the southern conifer forest makes separated forest formation from the northern.

A part of this paper was read at the 36th international symposium of the IAVS "Island and High Mountain Vegetation — Biodiversity, Bioclimate and Conservation —" held at Santa Curz de Tenerife, Spain in 1993.

I would like to give my sincere thanks to Prof. Dr. M. Hotta, Faculty of Science, Kagoshima University for his appropriate advice on evolution of Lauraceae and Fagaceae and for giving me a number of information on species.
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Photo 1. Laurus canariensis forest on Tenerife Island, Canarias Islands.
Photo 2. Castanopsis-Schima forest at 1800 m of Mt. Gede, Jawa.
Photo 3. Persea thunbergii forest on Mt. Kurino, Kagoshima, Japan.
Photo 4. Castanopsis acuminatissima forest near Bulolo, Papua New Guinea.
Photo 5. Lithocarpus sp. found at 190 m in altitude in tropical rain forest of East Kalimantan, Indonesia.
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## APPENDIX

List of main families and genera of trees which appear in the lucidophyll oak-laurel forests

<table>
<thead>
<tr>
<th>Family</th>
<th>Genera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aceraceae</td>
<td>Acer (Evergr. &amp; decid.)</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Lithraea, Melanorrhoea (Gluta), Mosquitoxylon, Schinus</td>
</tr>
<tr>
<td>Aquifoliaceae</td>
<td>Ilex</td>
</tr>
<tr>
<td>Araliaceae</td>
<td>Dendropanax, Dydimopanax, Oreopanax, Pentapanax, Pseudopanax, Scheffler</td>
</tr>
<tr>
<td>Araucariaceae</td>
<td>Agathis, Araucaria</td>
</tr>
<tr>
<td>Berberidaceae</td>
<td>Berberis</td>
</tr>
<tr>
<td>Bignoniiaceae</td>
<td>Tabebuia</td>
</tr>
<tr>
<td>Boraginaceae</td>
<td>Patagonula</td>
</tr>
<tr>
<td>Bruneliaceae</td>
<td>Brunellia</td>
</tr>
<tr>
<td>Caprifoliaceae</td>
<td>Viburnum</td>
</tr>
<tr>
<td>Celastraceae</td>
<td>Maytenus, Euonymus</td>
</tr>
<tr>
<td>Cephalotaxaceae</td>
<td>Cephalotaxus</td>
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<tr>
<td>Chloranthaceae</td>
<td>Hedysosumum</td>
</tr>
<tr>
<td>Chrysobalanaceae</td>
<td>Licania</td>
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<tr>
<td>Connaraeae</td>
<td>Ellipanthus</td>
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<tr>
<td>Cunoniaceae</td>
<td>Weinmannia</td>
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<tr>
<td>Cupressaceae</td>
<td>Chamaecyparis, Libocedrus</td>
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<tr>
<td>Cyatheaceae</td>
<td>Cyathea</td>
</tr>
<tr>
<td>Ebenaceae</td>
<td>Diospyros</td>
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<tr>
<td>Elaeagnaceae</td>
<td>Elaeagnus</td>
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<tr>
<td>Elaeocarpaceae</td>
<td>Elaeocarpus, Sloanea</td>
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<tr>
<td>Ericaceae</td>
<td>Befaria, Rhododendron, Vaccinium</td>
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<tr>
<td>Escalloniaceae</td>
<td>Escallonia</td>
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<tr>
<td>Eucryphiaceae</td>
<td>Eucryphia</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>Alchornea, Bridelia, Cicca, Daphniphyllum, Photinia, Richeria, Sapium, Sebastiana</td>
</tr>
<tr>
<td>Fagaceae</td>
<td>Castanopsis, Lithocarpus (Pasania), Nothofagus, Quercus (including</td>
</tr>
<tr>
<td></td>
<td>Cyclobalanopsis, Trigonobalanus</td>
</tr>
<tr>
<td>Flacouriaceae</td>
<td>Azara, Xylosma</td>
</tr>
<tr>
<td>Guttiferae</td>
<td>Calophyllum, Clusia</td>
</tr>
<tr>
<td>Hamamelidaceae</td>
<td>Altingia, Distylium, Exbucklandia (Symingtonia), Liquidamber (decid.), Matsudaea, Rhodoleia</td>
</tr>
<tr>
<td>Himantandraceae</td>
<td>Galbulimima (Himantandra)</td>
</tr>
<tr>
<td>Icacinae</td>
<td>Citronella</td>
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<tr>
<td>Juglandaceae</td>
<td>Engelhardia</td>
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<tr>
<td>Lauraceae</td>
<td>Actinodaphne, Alseodaphne, Beilschmiedia (Huflandia), Cinnamomum,</td>
</tr>
<tr>
<td></td>
<td>Cryptocarya, Dehaasia, Endlicheria, Lindera, Litsea, Machilus (Persea), Nectandra, Neolitsea, Ocotoe, Phoebe (Apollonias)</td>
</tr>
<tr>
<td>Leguminosae</td>
<td>Albizia (evergr. &amp; decid.), Cascaronia, Inga</td>
</tr>
<tr>
<td>Magnoliaceae</td>
<td>Drimys, Elmerrillia, Magnolia, Manglietia, Michelia, Talauma</td>
</tr>
<tr>
<td>Malpighiaceae</td>
<td>Bylsomina</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Hibiscus</td>
</tr>
<tr>
<td>Melastomataceae</td>
<td>Conostegia, Miconia</td>
</tr>
</tbody>
</table>
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Meliaceae  Cedrela, Dysoxylum, Toona
Monimiaceae  Laurelia, Xylosma
Moraceae  Ficus (evergr. & decid.)
Myricaceae  Myrica
Myrsinaceae  Ardisia, Maesa, Myrsine (Rapanea)
Myrtaceae  Blepharocalyx, Eugenia, Leptospermum, Myrceugenella, Syzygium, Tristania, Xanthomyrtus
Palmae  Livistona
Pinaceae  Abies, Keteleeria, Pinus, Tsuga
Pittosporaceae  Pittosporum
Podocarpaceae  Dacrydium, Phyllocladus, Podocarpus, Dacrycarpus
Proteaceae  Helicia, Guevina, Lomatia
Rosaceae  Prunus (evergr.)
Rubiaceae  Coprosma, Psychotria
Rutaceae  Fagara
Sabiaceae  Meliosma
Sapindaceae  Cupania, Mischocarpus
Schisandraceae  Kadsura
Staphyleaceae  Turpinia
Symplocaceae  Symlocos
Taxodiaceae  Cryptomeria, Cunninghamia, Taiwania
Theaceae (Camelliaeceae)  Adinandra, Anneslea, Camellia, Cleyera, Eurya, Freziera, Gordonia, Schima, Ternstroemia
Thymelaeaceae  Daphne, Daphnopsis
Tiliaceae  Belotia
Ulmaceae  Gironniera
Urticaceae  Villebrunea
Winteraceae  Drimys, Pseudowintera
田川日出夫 照葉樹林のアジア地域及び地球上での分布 — Lucidophyll oak-laurel forest formation の提唱

日本の照葉樹林は Griesebach (1872), Schimper (1898), Brockmann-Jerosch (1912) などによ り, Lorbeerform, Lorbeerwald, temperierte Regenwald, Laurisilvae として西欧に紹介さ れた。その後日本ではこれらを Evergreen broad-leaved forest, Evergreen laurel-leaved forest と表現して西南日本の代表的な極相森林を世界に紹介してきた。最近 Kira (1977) は照葉 樹林を Lucidophyll forest と表現することを提唱している。日本の照葉樹林の優占種はブナ科, クスノキ科, サンサクラ科の植物からなるが, このような森林は日本だけではなく, いわゆる照葉 樹林帯を生じる東アジアからヒマラヤ山脈の南斜面にかけて, 更に東南アジアの半島部及び島嶼 部の山地帯, マカロニア, 北米東南部, にも分布しており, 各々の地域について森林の組成 と分布する高度を多くの文献を引用して紹介した。これらの森林は大部分ブナ科の Castanopsis, Lithocarpus (Pasamia), Quercus (Quercus 亜属と Cyclobalans 亜属) 属, やはいはクスノキ科の Acinodaphne, Alseodaphne, Beilschmiedia, Cinnamomum, Cryptocarya, Endlicheria, Listea, Machilus (Persen) 属, もしくはその両方が優占する森林である。その分布は熱帯多雨林の分布上 限から熱帯域では3000メートルに達し, 分布の北限域では低地にのみ存在している。分布の北限 は, 太平洋域では青森県登別村の北緯40度34分, 大西洋域ではアゾレス諸島の北緯39度付近に あり, 南限は緯度9度のジャワ島にある。アジアにおける照葉樹林の水平分布と垂直分布につい て文献を元に図示した。

対象とする照葉樹林には多くの名称があり, これらを整理するために垂直分布帯を意味する名 称 (Lower montana forest など）, 気候帯と葉の特徴を表す名称 (Temperate broad-leaved evergreen forest など), 葉の特徴を表す名称 (Evergreen laurel-leaved forest, Lucidohyll forest など), 種組みを表す名称 (Oak-laurel forest など), 植物社会学上の命名 (Camellia japonicae など) の5区分をまとめ, 植検を行った。照葉樹林は分布的には暖帯から熱帯まで, 低地から3000メートルまでの範囲で見られ, 場所によって高山であったり低地であったりするので, 構成樹種とその葉の特徴で表現することによって, 共通の表現が可能ではないかと考え, Lucidophyll oak-laurel forest formation として一つの群系を提唱した。

上記の地域の他に, アフリカ山地林, アンデス山脈の森林, オーストラリア, ニュージーラン ドの植生を文献上に検討した。アジア型の照葉樹林とミナミブナ林が唯一同所的に分布している ニューディニアでは, ミナミブナ林がミナミブナ林のないキナバル山に比べてアジア型の照葉樹林 の上部と, イヌマキ科からなる森林の下部との間に入っている。両者の間には共通種も見ら れるので, 両者は優占種を異にした同じ群系に属するのではないかと考える。垂直带に分類化し たミナミブナ林を構成する Nothofagus の葉も革質で太陽光を反射することから, 照葉樹林を Lucidophyll oak-laurel forest とすると, ミナミブナ林も含めるべきではないと考える。そうすれば 照葉樹林の主な分布域はアジアだけでなく, オーストラリア, ニュージーランド, アンデスまで の広い面積を占めることになる。中米, 南米にもブナ科 (Quercus), クスノキ科 (Beilschmiedia (Huflandia), Cryptocarya, Endlicheria, Nectandra, Ocotao), を優占種に持つ森林がアンデス山中 にもあり, 照葉樹林がかなり広く分布していることが分かった。

アンデスではこれらのより上に Podocarpus を優占種または卓越木として持つ森林があり, ニュー ギニアやボルネオ島の高所ではイヌマキ科の樹木 (Dacrydium, Dacrycarpus, Phyllocladus) が植生 带を作っており, ニュージーランドでも, アフリカ山地林でも同様である。これらの森林は亜寒 帯や亜高山帯の針葉樹林とは異なり, 優占種はイヌマキ科に限られる。この型の森林を Podocarp forest 又は Southern conifer forest としてまとめることを考えているが, 結論を出すに はもう少し検証が必要である。