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Growth of Forest Trees of Mahabaleshwar–I Comparative Account

Madhav Gadgil[1] and V. D. Vartak

Maharashtra Association for the Cultivation of Science, Poona 4.

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Abstract

Mahabaleshwar is located in the Western Ghats at an altitude of 1350 meters, about 110 km. south of Poona. It has an annual average rainfall of 6230 mm. confined mostly to south-west monsoon from July to September. The soil is lateritic. It supports a subtropical hill forest dominated by Jambul, *Syzygium cumini*. Five increment plots totaling an area of 6 acres were established at Mahabaleshwar and a total of 1117 trees marked between 1932 and 1966, mostly at the initiation of the experiment in 1932. All the marked trees were measured for girth at breast height in 1932, 1937, 1942, 1947, 1952, 1957, 1963, 1966 and 1969. This resulted in a total of 6211 comparisons of successive girth measurements for the computation of growth rates. An analysis of this data showed that the mean annual increment in girth ranges from O.13 to 1.44 cms for the various species and sites of various quality. The highest growth rate is exhibited by an early successional species, *Xeromphis spinosa* (Gela) in a rather open habitat. Other early successional species as well as canopy species of mature forest tend to show relatively high growth rates, while the slowest growth rates are exhibited by species forming the second stratum in a mature forest.

Introduction

The sub-tropical hill forests of the Western Ghats constitute one of the most important forest resources of Western India. The forest ecosystem is the only vegetation capable of sustained economic production on the hill slopes, since the destruction of the forest cover leads to a very rapid erosion of the soil. The forests are, therefore, crucial to soil and water conservation and are primarily managed as protection forests. However, their yield of wood and of other economic products such as Hirada (*Terminalia chebula*) nuts is also of significant value. It is, therefore, highly desirable to establish the management of these forests on a sound scientific basis. Detailed information regarding the growth rates of the major tree species of this forest type is an essential pre-requisite towards working out such a management policy.

1. Present address : Centre for Theoretical Studies, Indian Institute of Science, Bangalore 560012.

The forest department of the then Bombay Presidency set up five sample plots of one to two acres in area at Mahabaleshwar in 1932–33 in order to collect this information. These plots have been continuously maintained and the requisite information collected from that date up to the present These data, therefore, represent a very valuable set of forestry statistics, and we are deeply indebted to the authorities of the Maharashtra State Forest Department for availing us of this data for analysis and interpretion from the view-point of forest management policy. The present paper is the first of a series based on the results of this analysis It provides a description of the sites and the vegetation, outlines the procedures of data collection and sets out some comparisons of the rates of girth increment of the different species involved.

Locality

Mahabaleshwar, a famous hill station in the Satara District of the Maharashtra State is located at 17° 56' N and 73° 40'E, one hundred and ten kilometers south of Poona It is situated atop the broad plateau of a range of characteristically flat-topped hills of the Deccan trap at an altitude of 1350 m. It has an annual precipitation ranging between 4000 mm and 8500 mm, with an average of 6200 mm, and a mean annual temperature of 20°C. The soil at Mahabaleshwar is lateritic.

Although the amount of precipitation received is very considerable, it is mostly confined to the months of July to September, and consequently the vegetation supported is not as luxuriant as would be the case with a more even seasonal distribution of the same amount. The natural vegetation belongs to the Western subtropical broad-leaved hill forest type of Champion and Seth[1], and has been described in some datail by Puri and Mahajan[2]. The forest ranges in height from 5 meters on very exposed sites on the plateau with shallow soil, to 10 to 20 meters on somewhat less exposed sites with soil of good depth. It may exceed 20–25 meters in ravines. The natural growth is quite dense and often impenetrable because of the climbers. Two strata of trees are evident in forests with a canopy height of 10 meters or more. A third stratum of herbaceous undergrowth may develop when the canopy is more open. The topmost tree stratum, or stratum A in Richard's[3] terminology, is made up of Jambul (*Syzygium cumini*), Par-Jamb (*Olea dioica*), Kavla (*Symplocos beddomei*) with Hirada (*Terminalia chebula*) and Anjan (*Memecylon umbellatum*) occasionally breaking into the top canopy but often lying a little below it. The second story, or B stratum is made up of Pisa (*Actinodaphne angustifolia*), Gela (*Xeromphis spinosa*), Tambat (*Flacourtia ramontchi*), Bhoma (*Glochidion hohenackeri*). The herbaceous stratum is generally dominated by Karvi (*Carvia callosa*) and Waiti (*Thelapaepale ixiocephala*). Amongst the most prominent climber species are Ambulki (*Elaegnus conferata*), Chimat (*Scutia myrtina*) and Kamgoni (*Celastrus paniculata*).

Materials and Methods

The data which forms the basis of this series of papers was collected on five sample plots first laid out in December 1932–January, 1933. Numbers 1 to 4 of these were of one acre each, while the fifth plot had an area of two acres. Plot Nos. 1, 2, 3 and 5 supported vegetation in fairly advanced stages of succession, and probably closely resembling the climax condition for their site. Plot No. 4 harboured rather poor vegetation, in a moderately advanced stage of secondary succession. The soil on sites 3 and 4 was rather shallow and that on site 4 quite poor besides, that on sites 1 and 2 of moderate depth, but of good humus content and that on site 5 deep and of good quality. Site 4 was subject to considerable human disturbance and illicit felling; the other four sites were free of this. Consequently, the forest developed on site 4 was rather open; the canopy was fully closed in the other cases. The forest developed on sites 3 and 4 was of a low height, around 5 meters, that on sites 1 and 2 of about 10 meters, and that on site 5 of about 15 meters. Sites 3 and 4 may be taken as examples of forests on sites of poor quality, sites 1 and 2 of forests on sites of medium quality, and site 5 of forests on sites of good quality for this type of hill forest.

When the plots were initially laid out, a certain amount of thinning was undertaken. This involved the removal of the largest, overmatured specimens of each species, as well as defective and deformed trees. Subsequent to this thinning, a sample of trees was selected for the study of increment in girth and these were numbered serially. A few trees were also selected and numbered in subsequent years. Girths at breast height (4 feet 6 inches or 135 cms) of all the numbered trees were measured in the year 1932–33, 1937–38, 1942–43, 1947–48, 1952–53, 1957–58, 1963–64, 1966–67 and 1969–70. A total of 1117 trees were thus numbered and measured over the five sample plots involved. Jambul (*Syzygium cumini*) is the dominant species in this forest type and altogether 390 specimens of this tree were numbered, followed by Pisa (*Actinodaphne angustifolia*) with 197, Anjan (*Memecylon umbellatum*) with 134 and Par-jamb (*Olea dioica*) with 124 numbered trees. Some other species were also marked, but in smaller numbers. The ten most numerous species for which a substantial amount of data was obtained are listed in Table 1 along with the number of trees of each species that were numbered individually. Estimates of growth rates may be obtained from such numbered trees by comparing their girths at two consecutive measurements. As noted above, such girth measurements were made for a total of eight times between 1932–33 and 1969–70. This then provides us with seven possible comparisons of girth for a tree that was marked at the initiation of the experiment and that had survived upto 1969–70. Fewer comparisons would be available if the tree was marked later, or if some measurement is missing, or if the tree died before the last measurement. A total number of 6211 such comparisons is aviable for the computation of the growth rates (Table 1).

Results

The basic results of the study are the computations of the growth rates of individual trees in cms. per year from the six thousand odd available comparisons. It is of course, necessary to summarise these results in a number of ways before they can be properly appreciated. Table 2 provides such an overall summary in terms of the mean growth rate for each species on each of the sample plots. This table enables us to assess the differences in growth between species and between different sites. It is also of great interest to compare the growth of a single species on a given plot with respect to the different girth classes. Such a comparison will enable us to determine the growth rate as a function of size; this is necessary for an estimation of the age from the girth which is an important objective of the present series of experiments. The derivation and analysis of the growth curves will be taken up in the second paper in this series.

Discussion

Magnitude of growth rates :

A perusal of Table 2 indicates that the average annual increment in girth ranges from 0.2 to 1.44 cms. It may be noted that these values are roughly of the same order as the values noted for other tropical forest types by Richards [3] Thus the values for the primary equatorial forests of Congo range from 1.6 to 6.3 cms. and for primary rain forest of Mount Maquiling, Phillipine Islands from 0.6 to 1.5 cms. and for secondary rain forest of the same locality from 1.5 to 6.0 cms. It would of course by much more interesting to compare our results with other forest types receiving only seasonal precipitation; we have, however, been unable to locate any such data, though it undoubtedly exists.

Species differences :

The ten species have been arranged in Table 2 roughly in the order in which they colonise a newly opened up habitat. Thus the colonisers which constitute the early stages of a secondary succession such as *Glochidion hohenackeiri*, heads the list, while the species characteristic of the climax stage come at the end. Besides the mean growth rates of a given species on a given plot, the Table also shows the averages for a species computed by giving equal weight to its populations on the five plots; and the averages for the plots computed by giving equal weight to all the species present on that plot.

Glochidion hohenackeri and *Memecylon umbellatum* are the first species to colonise a newly opened up habitat. They come to occupy the lowest tree stratum as the forest matures. Their success crucially depend on rapid growth during the early stages of secondary succession, and accordingly they exhibit amongst the highest growth rates of the ten species studies. During the course of succession, these two are closely followed by *Xeromphis spinosa*, which however retains its advantage longer and grows into the middle stratum of a mature forest, or may constitute a canopy species in a very stunted forest such as that on site 3. This species is also seen to be characterised by relatively high growth rates. The fourth early sucessional species, *Flacourtia ramontchi* does not however exhibit high growth rates as expected. This anomaly deserves further investigation. All these early successional species are shade intolerant, i.e., unable to grow under shade.

During the course of succession, these are followed by a series of shade-tolerant species. These are able to grow in the shade of the early successional species, and eventually come to overtop them. The remaining six species listed in Table 2 are such shade tolerant species. They seem to fall into two categories. The first category includes *Pygeum gardneri, Actinodaphne angustifolia* and *Terminalia chebula*. These grow only upto the middle stratum in a mature forest, though the last one may reach canopy in a very mature forest. These three exhibit the slowest growth rates. The second category includes *Symplocos beddomei, Olea dioica* and *Syzygium cumini*. These constitute the canopy in a mature forest, and are characterised by high growth rates, comparable to those of early successional species.

Site differences :

Plot 4 is located on rather poor soil, and is subject to much illicit felling. It is, therefore, very open and sunlight does not constitute a limitation on the growth of the trees, here, which must be limited by the supply of water and soil nutrients. The two early successional species on this plot, namely *Memecylon umbellatum,* and *Xeromphis spinosa* show high growth rates as these species are adapted to taking advantage of open habitats. The two late successional species, namely *Syzygium cumini* and *Terminalia chubula,* on the other hand, show very poor growth as the site must be too exposed and dry for them.

Plots 1 and 2 represent intermediate conditions. The sites have fairly good soil, and the forest has an almost complete canopy. However, the forest is not fully mature, and early successional species are still able to hold their own. This results in the condition that on the same site *Glochidion* and *Olea* or *Memecylon* and *Syzygium* exhibit high growth rates.

Plots 3 and 5 represent forest close to its climax condition. The two, however, strikingly differ from each other in that the soil is very well developed on Plot 5, and consequently the forest on it exhibits luxuriant growth. The soil on Plot 3 on the other hand is very shallow and stifff, and the tree growth is very stunted and crooked, though quite as dense as on plot 5; the canopy being very complete on both of these. The best growth on plot 5 is exhibited by the climax species, *Olea dioica* and *Syzygium cumini,* while the species characteristic of earlier stages of succession show depressed growth rates. The growth rates of species on plot 3 are uniformly low. However, early successional trees like *Xeromphis spinosa* and *Glochidion hohenackeri* participate in canopy formation of this stunted forest, and are growing better than they would under more normal " climax " conditions.

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TABLE 1

The number of individually marked trees of the various species, and the total number of comparisons available for the computation of rates of girth increment on the five sample plots at Mahabaleshwar.

	Species	Plot No.	1	2	3	4	5	Total
1	*Syzygium*	Individuals	33	68	118	67	104	390
	cumini	Comparisons	213	447	781	280	751	2472
2	*Actinodaphne*	Individuals	50	81	19	1	46	197
	angustifolia	Comparisons	274	304	108	2	182	870
3	*Memecylon*	Individuals	4	9	1	33	87	134
	umbellatum	Comparisons	4	21	7	54	645	731
4	*Olea dioica*	Individuals	30	84	0	0	10	124
		Comparisons	125	563	0	0	64	752
5	*Glochidion*	Individuals	3	13	21	5	13	55
	hohenackeri	Comparisons	22	65	124	5	60	276
6	*Xeromphis*	Individuals	4	11	8	6	24	53
	spinosa	Comparisons	21	25	45	27	131	249
7	*Symplocos*	Individuals	22	6	0	1	19	48
	beddomei	Comparisons	116	6	0	1	128	251
8	*Pygaeum*	Individuals	5	36	0	0	0	41
	gardneri	Comparisons	5	36	0	0	0	41
9	*Terminalia*	Individuals	15	4	2	18	0	39
	chebula	Comparisons	99	24	14	105	0	242
10	*Flacourtia*	Individuals	9	22	2	3	0	36
	ramontchi	Comparisons	53	143	14	17	0	227

TABLE 2 :

Mean annual periodic increment in girth in cms. for the various species on the five different plots based on data from 1932–1970. Increment is recorded only for those cases where at least twenty comparisons were available for a species on a given plot. The species have been arranged roughly in the order of increasing degree of approach to the climax condition for their particular site.

Species	4	2	1	5	3	Mean
Glochidion hohenackeri	—	0.61	0.87	0.48	0.59	0.64
Momecylon umbellatum	0.51	0.97	—	0.70	—	0.73
Xeromphis spinosa	1.44	0.49	0.46	0.57	0.54	0.70
Flacourtia ramontchi	—	0.22	0.50	—	—	0.36
Pygium gardneri	—	0.42	—	—	—	0.42
Actinodaphne angustifolia	—	0.48	0.37	0.32	0.44	0.40
Symplocos beddomei	—	—	0.79	0.53	—	0.66
Olea dioica	—	0.44	1.00	0.91	—	0.78
Syzygium cumini	0.35	0.79	0.60	0.76	0.42	0.58
Terminalia chebula	0.18	0.13	0.31	—	—	0.21
Mean	0.62	0.55	0.61	0.61	0.50	0.58