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Influence of Major Environmental Parameters on Wood Growth of Swampy and Non Swampy Myristicaceae Members: A Study in Karnataka

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Abstract

The present study is an attempt to assess the influence of major environmental parameters like rainfall, temperature and humidity on wood growth of swampy and non swampy species of myristicaceae. Based on the literature, an exhaustive list of swamps, which are having both swampy and non-swampy in the Karnataka was prepared. Then through field visits five locations were selected for the present study. At each location trees (having uniform girth) were selected randomly. Wood core samples were collected by using increment borer (Hegloff, 5.15 mm, 2 tread borer) at DBH (1.37 m). Two cores were collected from each tree and three replications were maintained for each location. The core samples were labeled and transported to the laboratory. Samples were dried in laboratory conditions. Collected samples were examined in laboratory for wood growth rings. Environmental parameters data viz., rainfall, temperature and relative humidity was collected from Karnataka State Natural Disaster Monitoring Centre (KSNMC), Yelahanka, Bengaluru. The data was correlated with wood growth ring width. Both the swampy and non-swampy species showed no relationship with the mean annual rainfall and means annual temperature. Thus further studies are needed in this area to understand the response to these species to environmental parameters.

Keywords: Swamps, Wood growth, Temperature, Rainfall, Relative humidity, Correlation

Myristicaceae is one of the ancient families of flowering plants in tropical forests. There are about 500 species (21 genera) that are distributed in lowland wet-evergreen forests. The genus *Myristica* is the largest genus with 120 species and most of the species occur in New Guinea. Among the 120 species, *Myristica fragrans* Menities (nutmeg) native of Mollucas Island is the only widely cultivated spice. Hence, Myristicaceae is often referred as nutmeg family. India harbours 15 species, belongs to genera namely, *Horsfieldia, Gymnacranthera, Knema* and *Myristica*. The members occur in the evergreen forests of Andaman and Nicobar Islands, Meghalaya and the Western Ghats. The Western Ghats, India one of the 'hot-spots' of biodiversity in the world harbours 5 species. They are namely *Gymnacranthera canarica* (King) Warb., *Myristica. fatua* Houtt. Var *magnifica* (Bedd), *Myristica dactyloides* Gaerten., *Myristica malabarica* Lam. and *Knema attenuate* (J.Hk and Thw.) Warb. Among the five species, the first two are exclusively associated with swampy habitat and possess aerial/knee roots. The other species occur mostly in non-swampy habitats. However, *Myristica malabarica* Lam. is known to occur in both habitats.

Among the various characters, the wood growth and property appears to be the key feature that helps to understand the tree adaptations to the environmental conditions. Vijendra Rao *et al.* (1992) made wood anatomical studies of Indian Myristicaceae members and reported that all the species possess diffuse porous wood comprising of wood growth rings which are delimited by concentric lines / bands of parenchyma. Ring width indicates the resultant annual growth patterns of the trees, representing the aggregate effect of many environmental factors including climate, biological ageing, local endogenous disturbances due to competition amongst the trees and exogenous disturbances caused by fire, pests, disease, pollution, logging, etc. Tree to tree variability is often being strongly influenced by plant's genetic and environmental factors. A difference in environmental condition can result in the production of wood with varying properties. Wood properties are influenced by a few physical and chemical soil properties. The physical and chemical soil properties are associated to the cell division and differentiation of cambial cells, and this interaction is influenced as well by environmental or ecological conditions.

Considering the variations existing in the physical and ecological conditions, in this study an attempt was made to analyse the influence of major environmental variables on wood growth properties of obligate swampy and a non-swampy Myristicaceae member in the Karnataka.

Methodology

The study was carried out in the central Western Ghats of India, one of the 34 mega-biodiversity hot spots of the world (www.conservation.org). The variability in the precipitation and topography generates a wide variety of vegetation types. It has wet evergreen and semi-evergreen forests on the western side and at high altitudes, while it harbours dry deciduous and scrub forest on the eastern slopes and lowlands (Jha *et al.,* 2000). The forests of Western Ghats are some of the best representatives of non-equatorial tropical evergreen forests in the world. Of the 18,000 species of flowering plants recorded from India, about 4000 species are found in the Western Ghats, including 1800 endemic species (Manoharan *et al.,* 1991; Daniel *et al*., 1995; Jha, *et al.,* 2000).

Based on the previous studies (Tambat *et al*., 2007, 2013 and Rajashekaramurthy, 2015), an exhaustive list of swamps that are having both swampy and non-swampy in the central Western Ghats (Karnataka) were prepared. Afterwards, swamps in each district were shortlisted and visited. Then five locations as indicated in Table 1 were selected for the present study.

Species selected for the study

Gymnacranthera canarica was selected as an ideal candidate for wood growth analysis based on the following criterion; firstly because it is an obligatory swampy species that helps to understand the wood growth behaviour of swampy species (Tambat *et al.,* 2013). Secondly, among the species associated with the *Myristica* swamps, only *G. canarica* is present across the latitude and longitudinal gradient. Thirdly, it is the most abundant species in the *Myristica* swamps (Tambat *et al.,* 2007). It has been listed in the Red-listed Medicinal Plants of Karnataka (FRLHT, 2000).

Myristica malabarica was selected as the non-swampy species because phylogenetically it is more closely related to *Gymnacranthera* than any other Myristicaceae members (Tambat *et al.,* 2013). The species often occurs in and around swamps. The growth habit of both the species is apparently similar. It has been listed in the Red-listed Medicinal Plants of Karnataka (FRLHT, 2000).

TABLE 1

Selected locations for Swampy and non-swampy Myristicaceae members

Locations	Districts	Latitude ^{O}N	Longitude ^{O}E	Altitude (m)
Ithalimane	Uttara Kannada	14°25' 967"	74°46' 097"	482
Thorme	Uttara Kannada	14°16' 705"	74°46' 026"	855
Darbejaddi	Uttara Kannada	14°25' 967"	74°46' 097"	482
Sampaje	Dakshina Kannada	12°28' 29.8"	75°35' 30.7"	178
Makutta	Kodagu	12°21' 05.6"	75°45' 22.3"	897

Collection of wood core samples for analysis

The trees which were having uniform girth (around 1.5 m GBH) were selected randomly for collection of core sample (mean height around 21 m). In each location, the wood core samples were collected by using increment borer (Hegloff, 5.15 mm, 2 tread borer) at DBH (1.37 m). Two cores were collected from each tree and three replications were maintained for each swamp. Similarly, the wood core samples were collected from the non-swampy species in and around the swampy. After removing the core, the hole created in the tree was sealed with wax and cycocil to prevent damage to the trees. The core samples collected were removed from increment borer and sealed in a container, labeled and then transported to the laboratory. Samples were dried for 1-2 days inside the laboratory (shade drying) before mounting on to the wooden mounts for further processing. While mounting, care was taken to mount all the samples in such a way that the bark end of the core was placed towards the outer edge of the mount and pith end was towards the inner side of the grove of the wooden mount. The core samples thus prepared were stored at room temperature in a cool and dust free condition.

Wood growth ring analysis

Samples were brought to the laboratory and mounted on the sample holder and were dried. Samples were polished (sanded) according to standard dendrochronological techniques to observe the growth rings (Stokes and Smiley, 1968). Progressively, finer grades of sandpaper (220,320,400 Grit) were used to surface the increment cores until the individual cells were visible. Ring width was established by measuring the ring width from the core (first ring formed) to the outer most rings towards the bark. All growth rings from bark to pith were measured to the nearest 0.01 mm on the radial strips using Leica S8 Stereozoom microscope (magnification 25 X) loaded with software Leica Application Suite (Switzerland) interfaced with computer and using Tree ring measuring system, Linear stage J2 X measurement system software package (New York). Ring width was expressed in mm.

Correlation

The weather data of rainfall, temperature and relative humidity was collected from Karnataka State Natural Disaster Monitoring Centre (KSNMC), Bengaluru and they were correlated to wood growth ring width. Further the relationship was analyzed using the regression test. The data was available for the past 29 years from 1984 to 2013 with regards to rainfall. However, with regards to temperature and humidity, data was available only for the past 11 years (2002 to 2013) thus the analysis was performed accordingly.

RESULTS AND DISCUSSION

Correlation of growth ring width with mean annual rainfall

The growth ring width was observed under the microscope. The outer most rings were considered as the latest ring and were also assumed that this was the last year growth. The rainfall data for each selected location was obtained from the Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Bangalore. Rainfall data was correlated with the wood growth ring, across the locations with the mean annual rainfall (both in swampy and non-swampy). All correlations indicated insignificant relationship between the rainfall and wood ring width (Table 2).

TABLE 2

Correlation (r-values) of *Gymnacranthera canarica* (swampy) and *Myristica malabarica* (non-swampy) wood growth ring width with mean annual rainfall across the locations

Locations	Non-swampy Tree1	Swampy Tree1
Ithalimane	0.34	0.10
Darbejaddi	- 0.22	***0.39***
Thorme	***- 0.39***	- 0.15
Sampaje	-0.02	0.02
Makutta	0.19	-0.11

Bold and italics indicate 'r' values statistical significance @ $p<0.05$

Note: the annual ring width at the each location obtained for 3 trees, however for correlation the average ring width over three trees were used.

Correlation of wood growth ring width with mean minimum and maximum temperature

The temperature data for each selected location was obtained from the Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Bangalore. Then the average minimum temperature and average maximum temperature annually was correlated with the ring width. The data indicated that there was no relationship exists between the ring width and temperature (Table 3).

TABLE3

Correlation (r-values) of *Gymnacranthera canarica* (swampy) and *Myristica malabarica* (non-swampy) wood growth ring width with average minimum and maximum temperature across the locations.

Locations	Non-swampy		Swampy	
	Min.	Max.	Min.	Max.
Ithalimane	0.12	-0.28	0.25	-0.15
Darbejaddi	***-0.59***	0.45	***-0.41***	0.25
Thorme	-0.06	0.50	***-0.41***	-0.25
Sampaje	0.01	-0.63	0.43	-0.25
Makutta	0.35	-0.52	-0.53	-0.46

Bold and italics indicate 'r' values statistical significance @ $p<0.05$

Note: the annual ring width at the each location obtained for 3 trees, however for correlation the average ring width over three trees were used.

Correlation of wood growth ring width with mean minimum and maximum relative humidity

The relative humidity data for each selected location was obtained from the Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Bangalore. Then the average minimum relative humidity and average maximum relative humidity annually was correlated with the ring width. The data indicated that there was no relationship exists between the ring width and relative humidity (Table 4).

TABLE 4

Correlation (r-values) of *Gymnacranthera canarica* (swampy) and *Myristica malabarica* (non-swampy) wood growth ring width with average minimum and maximum relative humidity across the locations.

Locations	Non-swampy		Swampy	
	Min.	Max.	Min.	Max.
Ithalimane	0.27	-0.35	0.13	0.35
Darbejaddi	0.00	0.11	-0.48	0.41
Thorme	-0.35	0.14	***-0.60***	***-0.62***
Sampaje	0.27	-0.35	0.13	-0.35
Makutta	***-0.67***	***-0.75***	-0.31	-0.16

Bold and italics indicate 'r' values statistical significance @ $p<0.05$

Note: the annual ring width at the each location obtained for 3 trees, however for correlation the average ring width over three trees were used.

The variation in wood growth across the locations in both swampy and non-swampy species was observed. Ring width indicate the resultant annual growth patterns of the trees, representing the aggregate effect of many environmental factors, including climate, biological ageing, local endogenous disturbances due to competition amongst the trees and exogenous disturbances caused by fire, pests, disease, pollution, logging, etc.

Worbes (1995) reported that Cambial dormancy and annual rings in tropical trees are induced by annually occurring dry periods or flooding. Growth periodicity is indicated by the leaf fall behaviour and is connected with an annual periodicity of shoot elongation. Changes in stem diameter were measured with a dendrometer or by measurable differences in the electrical resistance of the cambium. Dendrochronological methods applied to carefully prepare samples can serve as proof of the annual periodicity of growth zones. Several studied have indicated that the rainfall has a strong relationship with wood growth (Rigozo *et al.*, 2005).

In the present study, the mean annual rainfall ranged from 2543 to 7277 mm across the study locations. With measurement from the periphery to the pith, last thirty years annual growth was marked. Rainfall data was correlated with the wood growth ring, across the locations with the mean annual rainfall (both in swampy and non- swampy). Both the swampy and non-swampy species showed no relationship with the mean annual rainfall. The growth rings were also correlated with the mean annual temperature and relative humidity. However, here also no relationship between growth ring and mean annual temperature in both the selected species was observed. This might be due to the following reasons; firstly the species used in the study occur in wet evergreen forest that receives relative higher rainfall and the trees might not have been subjected to drought. Secondly these species occur at lower altitude and most of the times possess swampy conditions. Thirdly, the growth rings studied might be pseudo rings as the actual age of the trees were not know to authenticate the rings as annual rings. Further studies are needed in this area to support the results.

Myristicaceae members possess the diffused porous wood and bands of parenchyma to separate the growth rings. Thus in this study, the band of parenchyma (brown colour) as an indicator of wood growth was considered. The distance between the two bands of parenchyma was considered as the annual growth. The outer most (next to bark) growth was assumed as the last year annual wood growth. The annual wood growth of both the species was compared across the locations. Both the swampy and non-swampy species showed no relationship with the mean annual rainfall, temperature and relative humidity. This might be due to the habitat effect; both the species occur in lower altitude that receives high rain fall and are associated with swampy conditions. Since, these species are subjected to wet (swampy) conditions throughout the years and thus have not experience drought situations. Probably these species might require long term growth analysis studies (more than 50 years) to indicate the variation in wood growth with respect to environment parameters. At this juncture it can be concluded that there is no relationship exists between swampy species wood growth pattern and the major environmental parameters. Therefore, further studies are needed in order to analyse the growth pattern of swamp associated tree species that would help in management of these unique ecosystems.

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