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Comparative Assessment of Wood Growth and Specific Gravity of *Myristicaceae* Members in Karnataka

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Abstract

Myristicaceae is one of the ancient families of flowering plants in tropical forests. The Western Ghats of India harbours 5 species of Myristicaceae *viz., Gymnacranthera canarica, Myristica fatua var. magnifica, Myristica dactyloides, Myristica malabarica* and *Knema attenuate*. 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. Present study is directed towards understanding and comparing the responses of obligate swampy and non-swampy species of Myristicaceae with respect to wood growth across different locations in Western Ghats. Samples were examined in laboratory for wood growth rings and specific gravity which indicated that there exists a significant variation in wood growth across the locations in both swampy and non-swampy species. Geographically closer locations showed similar growth pattern, indicating that climatic factors play a role in the wood growth. Compared to the non-swampy species, the swampy *Gymnacranthera canarica* showed higher growth (diameter) and specific gravity was higher in case of non-swamy species. Hence, specific comprehensive strategy and action plan for the long-term conservation of swamps and adjoining species in the central Western Ghats would be beneficial.

Keywords: Evergreen forest, Habitat, Growth rings, Specific Gravity & Variation

Myristicaceae is one of the ancient families of flowering plants in tropical forests. There are about 500 species (21 genera) distributed in lowland wet evergreen forests. The nutmeg, *Myristica fragrans*, a widely cultivated spice is a native of Mollucas Island. Hence, the family is often referred as nutmeg family (Chandran and Mesta, 2001). The members of the family are pantropical, being associated with the rain forests of Asia, Africa, Madagascar, South America and Polynesia. India harbours 15 species of which four are major genera *viz., 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 of India harbours 5 species of Myristicaceae *viz., Gymnacranthera canarica, Myristica fatua var. magnifica, Myristica dactyloides, Myristica malabarica* and *Knema attenuate*. 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.

In a study made on anatomical description of Indian Myristicaceae, The genus *Gymnacranthera* Warb is represented in India by only one species *viz., Gymnacranthera canarica* (King) Warb. Syn. *Myristicacanarica* King. It occurs in the Western Ghats from South Canara Southwards.

Microscopic structure analysis indicated Myristica genus possesses a diffuse porous wood; growth rings are distinct, delimited by concentric lines/ bands of parenchyma in all the species. They also reported that based on the wood properties, Gymnacranthera canarica can be distinguished from other two genera in possessing vessels perforations which are predominantly (94%) simple. However, their differentiation at species level, on the basis of both qualitative and quantitative anatomical features is little difficult.

In recent times, it has been realized that, wood quantity (volume growth) and wood quality cannot be treated as independent traits and that wood quality improvement should form. therefore, form an integral part of tree breeding programs. Wood specific gravity is one of the most important traits affecting the quality and quantity of pulp and the strength of wood products. 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.

With this background, present study was directed towards understanding and comparing the responses of obligate swampy and non-swampy species of Myristicaceae with respect to wood growth across different locations in Western Ghats.

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, an exhaustive list of swamps, which are having both swampy and non-swampy in the central Western Ghats were prepared. Afterwards, swamps in each district were shortlisted and visited. Then following five locations (Table 1) were selected for the present study.

Gymnacranthera canarica was selected as an ideal candidate for wood growth analysis based on the following criterion; firstly, an obligatory swampy species helps to understand the wood growth behaviour of swampy species (Tambat *et al*., 2014). 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 (Chandran & Mesta, 2001; Vasudeva *et al*., 2003 and Tambat *et al.,* 2007).

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.,* 2007). The species often occurs in and around swamps. The growth habit of both the species is apparently similar.

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 dendro chronological 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 measured from the core (first ring formed) to the outer most rings towards the bark. All growth rings from bark to pith were measured to

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

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.

Specific gravity

The length of the core samples varies depending on the tree GBH. Therefore, handling a long core sample is practically difficult. Hence, the wood core samples were divided into segments (starting from pith to periphery) and then specific gravity of each segment was measured following maximum moisture content method (Smith, 1988).

Segment preparation

The length of the wood core samples was measured using a scale. Then segments were made from each core of size 1 inch (2.54 cm) using sharp knife. Each sample and its segment were numbered. The diameter and length of the segment was measured using digital caliper.

Saturation

The core samples (segments) were soaked in water for 4 days to reach saturation. After saturation of samples again diameter & length were measured by using digital caliper and weight of each core segment was recorded by using weighing machine. after which green volume of each core was calculated.

For convenience each ring was considered as a cylinder and volume was calculated using the volume formula for cylinder. The segment diameter was measured using the digital caliper and then radius *r* was computed. The length of the core segment was treated as the height (*h*) and was measured using the digital calliper. Then volume was calculated using the formula

$V = ðr^2h$, Where r is radius and h is length of segment

Weight (Oven dry condition)

The saturated core samples were kept in oven at 100-102 ^{0}C for 48 hours. Afterwards, weight of dried core segment was recorded by using weighing machine.

Specific gravity was calculated using the formula.

$$\text{Specific gravity} = \frac{\textit{oven dry weight of the sample}}{\textit{volume of water displaced by saturated sample}}$$

Specific gravity of the core

The specific gravity of all the segments of a core was recorded and then average specific gravity of all the segments was computed and treated as the standard specific gravity of core sample.

Results and Discussion

Wood growth analysis of swampy and non-swampy Myristicaceae members across the locations

The wood core samples collected from the trees were brought to the laboratory and processed. The growth rings were observed under microscope. The wood growth rings of obligate swampy species *G. canarica* samples ranged from 0.24 to 5.84 mm across the locations and it ranged from 0.05 to 5.03 mm for non-swampy *Myristica malabarica*. The details of wood growth at each location are given in the (Table 2). The average wood growth of swamps species (pooled over five locations) was found to be higher (1.84±0.87) than the non-swampy species (1.62±0.87). Further, comparison of swampy and non-swampy species within locations also yielded similar results. The results indicated that, out of five locations studied, all the locations showed significant differences except Thorme.

Frequency distribution of annual wood growth rings

Frequency distribution of wood growth values of swampy and non-swampy species were computed. The frequency distribution of growth values between two categories of Myristicaceae members was statistically different (KS test). For both the species the normal distribution pattern was not observed, rather the distributions were skewed negatively (Fig. 1).

TABLE 2

Wood growth analysis of *Gymnacranthera canarica* (swampy) and *Myristica malabarica* (Non-swampy) across the locations

Locations	Swampy		Non-swampy		t-test Significance
	Range	Mean ± SD	Range	Mean ± SD	
Ithalimane	0.39 - 4.45	1.61 ± 0.78 a	0.16 - 4.43	1.44 ± 0.92 a	t = 2.22 p < 0.02 *
Thorme	0.40 - 4.33	1.81 ± 0.77 b	0.40 - 3.92	1.77 ± 0.73 b	NS
Darbejaddi	0.24 - 4.85	2.01 ± 0.87 c	0.05 - 4.55	1.43 ± 0.92 c	t = - 6.88 p < 0.00 **
Sampaje	0.37 - 4.97	2.05 ± 1.08 c	0.37 - 4.86	1.61 ± 0.81 a	t = - 4.29 p < 0.00 **
Makutta	0.39 - 5.84	2.22 ± 1.15 c	0.29 - 5.03	1.69 ± 1.01 ab	t = - 5.39 p < 0.00 **
Overall	0.24 - 5.84	1.84 ± 0.87	0.05 - 5.03	1.62 ± 0.87 t	= - 5.44 p < 0.00 **

Dissimilar letter indicate the‘t’ test significance @ p<0.0, * significance @ 5 %, ** significance @1 %

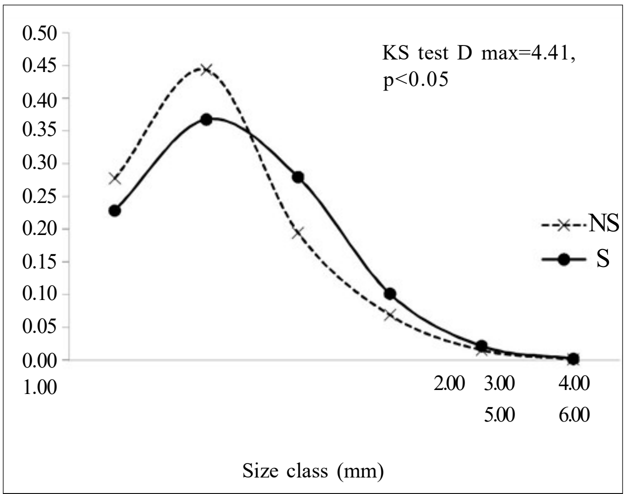

Fig. 1: Frequency distribution of growth ring values across the swampy (S) and non-swampy (NS) species of family Myristicaceae (KS test significant at 5 per cent probability)

Specific gravity of swampy *Gymnacranthera canarica* across the locations

The wood core samples collected from the trees were brought to the laboratory and specific gravity was computed following maximum moisture content method. The specific gravity of *G. canarica* wood core ranged from 0.339 to 0.571. The mean specific gravity varied across the locations (Fig. 2A). The mean specific gravity was lowest for Sampaje (0.375±0.022) and was highest for Darbejaddi (0.506±0.045) samples.

Specific gravity of non-swampy *Myristica malabarica* across the locations

The specific gravity values for *Myristica malabarica* wood core samples ranged from 0.361 to 0.578. The mean specific gravity was varied across the locations (Fig. 2B). The mean specific gravity was lowest for Ithalimane (0.441±0.040) and was highest for Darbejaddi (0.559±0.035) samples.

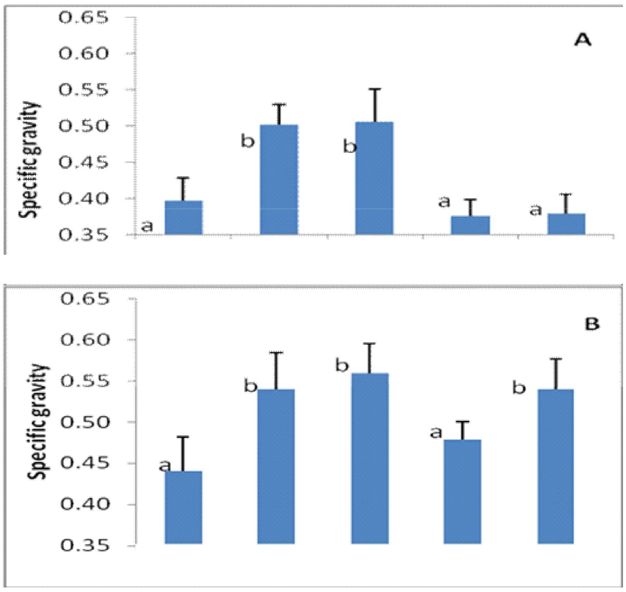

Fig. 2: Wood specific gravity of swampy Gymnacranthera canarica (Fig. A) and non-swampy Myristica malabarica (Fig. B) across the locations in Western Ghats, India. Dissimilar letter indicates the t-test significance at 5 per cent probability.

Average Specific gravity of swampy *Gymnacranthera canarica* and non-swampy *Myristica malabarica*

The mean specific gravities of two species were compared using student's t-tests. The wood specific gravity was higher for non-swampy *Myristica malabarica* than the obligate swampy *Gymnacranthera canarica*. The pooled data from 5 locations (overall) indicated that, *Myristica malabarica* (0.462±0.065) has significantly higher wood specific gravity than its swampy relative *Gymnacranthera canarica* (0.424±0.064). Further, the location wise analysis indicated among the five locations, except Thorme all the four locations indicated that *Myristica malabarica* possess higher wood specific gravity than *Gymnacranthera canarica* (Table 3).

Frequency distribution of specific gravity values

The specific gravity values for each species from the five locations were pooled and then frequency distribution was observed. The frequency distribution of specific gravity was positively skewed for the *Myristica malabarica,* whereas it was negatively skewed for *Gymnacranthera canarica* indicating that specific gravity decreases under swampy conditions and it increases under upland dry conditions (Fig. 3). The frequency distribution of specific gravity for two species was compared using KS test, which indicated that distribution pattern is statistically different.

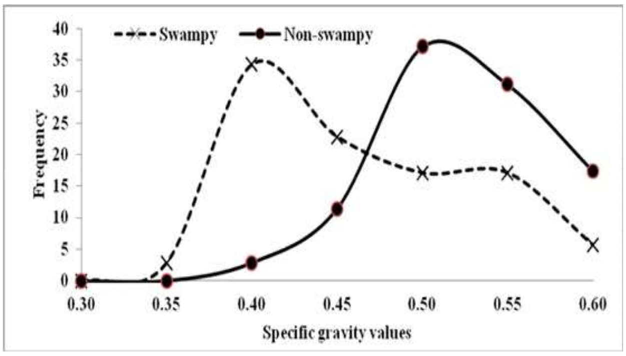

Fig. 3: Frequency distribution of specific gravity values of both swampy and non-swampy species of family Myristicaceae (KS test significant at 5 % probability).

In the present study, the variation was observed in wood growth between trees at a given location. This indicated that wood growth is mostly governed by genetic factor rather than the climatic factors. Thus the variations in wood growth across the locations could be attributed to genetic factor rather than climate. Further, in a given location (similar climatic conditions) variation with respect to wood growth between species strengthens this assumption. Thus, it is likely that wood growth in both the species governed mainly by genetic factor and other factors play minor role. Among the two species, swampy species showed higher wood growth than non-swampy species. This might be due to, species adaptation to the swampy habitat, where throughout the year water is available that influence cells growth and thereby the wood growth. Whereas the non-swampy species though

TABLE 3

Comparison of wood specific gravities of *Gymnacranthera canarica* (swampy) and *Myristica malabarica* (non-swampy) across the locations

Locations	Swampy		Non-swampy		t-test Significance
	Range	Mean ± SD	Range	Mean ± SD	
Ithalimane	0.353 - 0.445	0.396 ± 0.030	0.387 - 0.491	0.441 ± 0.040	t = 2.27 p < 0.04 *
Thorme	0.459 - 0.547	0.503 ± 0.027	0.486 - 0.592	0.540 ± 0.045	NS
Darbejaddi	0.453 - 0.571	0.506 ± 0.045	0.491 - 0.593	0.559 ± 0.035	t = 2.47 p < 0.03 *
Sampaje	0.339 - 0.404	0.375 ± 0.022	0.460 - 0.498	0.478 ± 0.022	t = 8.73 p < 0.00 **
Makutta	0.352 - 0.427	0.379 ± 0.026	0.489 - 0.586	0.539 ± 0.037	t = 9.33 p < 0.00 **
Overall	0.339 - 0.571	0.424 ± 0.064	0.361 - 0.578	0.462 ± 0.065	t = 3.35 p < 0.00 **

* significance @ 5 %, ** significance @ 1 %

grows in a similar habitat but do not grow in water logged conditions. Thus the soil water availability influences the cell and wood growth. The study on understanding genetic diversity with wood growth helps confirm our assumption.

Growth rings are a useful tool for the determination of age and growth rate of the trees in wood production of managed stands. In the present study, we considered the band of parenchyma (brown colour) as an indicator of wood growth. The study indicated that there exists a significant variation in wood growth across the locations in both swampy and non-swampy species. Geographically closer locations showed similar growth pattern, indicating climatic factors play a role in the wood growth. Compared to the non-swampy species, the swampy *Gymnacranthera canarica* showed higher growth (diameter) perhaps due to availability of more water in swampy condition. The wood growth and wood properties analysis indicated that, both the species behave differently, thus the impact of local microclimate change and climate change at large varies.

The study also indicated that the specific gravity of the swampy species *Gymnacranthera canarica* and the co-occurring non-swampy species *Myristica malabarica* varied across the sites. Both the species followed similar pattern indicating sites play important role in determining wood specific gravity. Compared to the swampy species, the non-swampy species possessed higher specific gravity. This may be due to availablity of water; the wood species gravity was related to the moisture availability and nutrient status in the site.

The local factors influencing the Myristicaceae must be identified and appropriate measures should be taken. Developing a comprehensive strategy and action plan for the long-term conservation of swamps and adjoining species in the central Western Ghats would be beneficial.

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