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Wood Specific Gravity of *Myristica* Swamp Associated Tree Species

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ABSTRACT

Wood specific gravity is one of the important trait influencing the quality and quantity of pulp, strength and other wood properties. Myristicaceae (nutmeg) is one of the important families of flowering plants in tropics. There are more than 500 species which have wide distribution range. The Western Ghats of India, harbours 5 species of Myristicaceae namely Gymnacranthera canarica, Myrtistica fatua var. magnifica, M. dactyloides, M. malabarica and Knema attenuate. Interestingly, among them first two are exclusively associated with swampy habitat (water logged conditions) and possess several structural and morphological traits including aerial/knee roots. The other members occur in non-swampy upland conditions. In this study an attempt was made to understand and compare the specific gravity of obligate swampy and non-swampy species of Myristicaceae across the locations in central Western Ghats. Wood core samples of co-occurring swampy and non-swampy species were collected using increment borer. The samples were processed and specific gravity was assessed and compared across the locations in central Western Ghats. The results indicated that specific gravity of non-swampy species (M. malabarica) is significantly higher than the co-occurring swampy species (G. canarica). Further, the pattern was consistent across the locations. The specific gravity values frequency distribution pattern reaffirm the results. In conclusion, the study indicates that non-swampy species that are subjected to relatively drier environment tend to increase their wood specific gravity as an adaptive strategy. Our finding would help in developing long term strategies and action plans for conservation of swamps and associated species.

Key works: *Myristicaceae, Swampy & Non-swampy, Specific gravity, Western Ghats, Wood*

INTRODUCTION

Western Ghats of India is one of the global centers of the mega biodiversity hotspots and endemism[1,2,3]. It has harbors several distinct forest types. One of the distinct features of the Western Ghats is the presence of certain unique ecosystems namely *Myristica* swamps. The *Myristica* swamps, belongs to the class of freshwater swamps and are dominated by members of the family Myristicaceae.

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They are distributed all along the Ghats but, usually occur in foothills, valleys and along the rivulet and have high watershed value. *Myristica* swamps, as their name indicates are dominated the members of ancient family Myristicaceae but also support many rare, endemic and economically important threatened plant species[4,5]. Most Myristicaceae members are used as spice and also an ingredient in many drugs thus are listed under threatened category[6,7]. Species such as *Gymnacranthera canarica* and *Myristica fatua* var. *magnifica* are associated exclusively with swampy habitat and possess several structural and physiological modifications. Another species of Myristicaceae namely, *Myristica malabarica* occur in both swampy and surrounding non-swampy habitat but also possess aerial roots.

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. A wood property has been noticed throughout the world[8] and therefore, the causes of the change must be known. In order to use wood efficiently, the variation patterns within trees, among trees within the species and among species must be understood[9]. Vijendra *et al.*,[10] for the first time made microscopic structure analysis of Indian Myristicaceae members and described genus *Myristica* possesses diffused porous wood. Further, *Myristica* spp. possesses growth rings that are distinct and delimited by concentric lines or bands of parenchyma. However, genus *Gymnacranthera* possess vessels perforations, which are predominantly (94%) simple thus distinguishing from genus *Knema* and *Myristica*.

Wood specific gravity is one of the most important traits affecting the quality and quantity of pulp and the strength of wood products. It is a complex feature influenced by cell wall thickness, proportion of different kinds of tissues and percentage of lignin, cellulose and extractives[11]. Thus in this study an attempt was made to understand and compare the variations in specific gravity of obligate swampy and non-swampy species of Myristicaceae across the locations in central Western Ghats. Our finding would help to improve the understanding about tree species and thereby helps in management of Myristicaceae members in forest.

MATERIAL AND METHODS

Study site: 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 central Western Ghats in the state of Karnataka account for over 60 % of the entire Ghats and are home to some of the unique swamps in southern India[12,13]. Based on the published literature and primary information gathered a systematic field survey was planed covering the five districts in the central Western Ghats region. Further, in consultation with the state forest department officials a systematic filed survey was undertaken. Finally, five locations (Ithalimane, Thorme, Darbejaddi in Karwar district, Sampaje in Mangaluru district and Makut in Kodagu district) with both swampy and non-swampy Myristicaceae were selected for the present study (Figure 1).

Study species for wood analysis: *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 behavior of swampy species[14, 15, 16]. Secondly, among the species associated with the *Myristica* swamps, only *G. canarica* present across the latitude and longitudinal gradient. Thirdly, it is the most abundant species in the *Myristica* swamps[13,16,17,18]. *Myristica malabarica* was selected as the non-swampy species because phylogenetically it is more closely related to *Gymnacranthera* than other Myristicaceae members[16, 17]. The species often occurs in and around swamps. The growth habit of both species is apparently similar.

Collection of core samples for analysis: The trees which were having uniform girth (around 1.5 mts GBH) were selected for collection of core sample. In each location the wood core samples were collected by using Increment borer (Hegloff, 5.15mm, 2 tread borer) at DBH (1.37m). 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, labelled 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 the samples 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.

Specific gravity: The length of the core samples varied depending on the tree GBH. Besides, the 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[19].

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

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 calliper and weight of each core segment was recorded by using weighing machine. Then 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 calliper 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

$V = \pi r^2 h$, 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.

Sp. Gr. = Oven dry weight of the sample / 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 all the segments was computed and treated as the standard specific gravity of core sample.

RESULTS

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 0.339 to 0.570. The mean specific gravity was varied across the locations (Fig. 2B). The mean specific gravity was lowest for Ithalimane (0.441±0.041) and was highest for Darbejaddi (0.560±0.036) samples.

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 *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 1).

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 specific gravity decreases under swampy conditions and 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.

DISCUSSION

Specific gravity is the ratio of the weight of a given volume of wood to that of an equal volume of water. Zobel and Van[9] indicated that specific gravity is not a simple characteristic but is determined by several characteristics of wood such as cell size and wall thickness, the ratio of early wood to late wood, the amount of ray cells, the size and amount of vessel elements, and other factors. The specific gravity of wood is its single most important physical characteristic. The strength of wood as well as the stiffness increases with specific gravity[20,21]. In addition, specific gravity may also play an important role in determining the growth rate, life span, and maximum size of an individual plant and consequently affecting the function and structure of forest. Specific gravity is considered as an important trait directly connected with biomass production[22]; and wood with higher specific gravity is generally considered less susceptible to decay [23].

The present study 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. Many factors of site, climate, geographic location, and species affect the specific gravity wood. Site-related factors such as moisture, availability of sunlight and nutrients, wind temperature can affect specific gravity. These are determined to a large extent by elevation, aspect, slop, latitude, soil type, stand composition and spacing [23]. Many environmental factors affect wood but the one most commonly cited is the moisture regime. This was shown by Nicholls[24], who marked with *Pinus pinaster* in drier climates. He emphasized that wood quality improvement can only be wholly successful if proper attention is also given to growing conditions, particularly to those factors that are associated with moisture availability to the mature tree. Ferraz *et al.*,[25] in Eucalyptus showed that there was a considerable effect of moisture deficiency on wood properties and that different species and sources did not have their wood affected in the same way. Josefina[26], measured the specific gravity of 220 woody species, in which half of them from a tropical rainforest and another half from a tropical deciduous forest. He compared these two groups using a Student t -test. The results showed highly significant differences in specific gravity between the species from the two areas and results revealed that woods from the dry deciduous forest tend to be much heavier than those from the rainforest. Wood specific gravity is influenced by the moisture availability to trees Sluder, [27] reported that tree species that are subject to drought situation tend to increase their specific gravity by minimizing wood density. Gilmore[28] reported trees at the bottom of a slope, or growing slopes where more rainfall was preserved possess a lower wood specific gravity. Suzuki[29] measured wood properties for trees in lowland Dipterocarp in west Kalimantan. He measured the specific gravities and water contents of the wood including bark. Results showed wide range of specific gravities and suggested that forest had high diversity in wood properties. In the present study, the wood species gravity could be related to the moisture availability and nutrient status. The studies have indicated that swampy habitat possess different physicochemical properties than the adjoining non-swampy habitat. Similarly the nutrient status also varies between the habitats[17, 30, 31]. The swampy species always possess water and the non-swampy species may be subjected to dry period thus the specific gravity is higher, perhaps this could be adaptive strategy of the species. The altitude of the location was correlated with the specific gravity. The correlation indicated, swampy species show no relationship, whereas the non-swampy species show strong positive relationship (data not shown). Indicating the specific gravity depends on altitude. These results perhaps indicating that specific gravity depends on moisture content as the soil moisture content deceases with increased altitude. At lower altitude soil moisture remains higher due to the gravitational pull and lower temperature.

Table 1: Comparison of wood specific gravities of *Gymnacranthera canarica* (swampy) and *Myristica malabarica* (non-swampy) across the locations

Sl. No	Locations	Swampy		Non-swampy		t-test Significance
		Range	Mean±SD	Range	Mean±SD	
1	Ithalimane	0.353-0.445	0.396±0.030	0.387-0.491	0.441±0.040	t=2.27 p<0.04*
2	Thorme	0.459-0.547	0.503±0.027	0.486-0.592	0.540±0.045	NS
3	Darbejaddi	0.453-0.571	0.506±0.045	0.491-0.593	0.559±0.035	t=2.47 p<0.03*
4	Sampaje	0.339-0.404	0.375±0.022	0.460-0.498	0.478±0.022	t=8.73 p<0.00**
5	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 %*

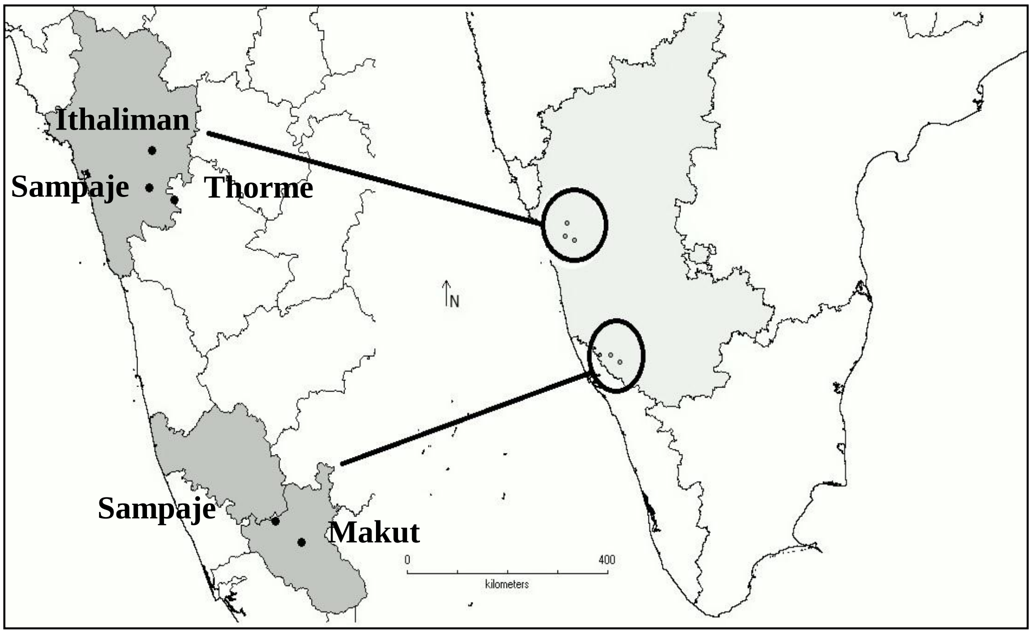

Figure 1: Distribution Map of the study locations in central Western Ghats

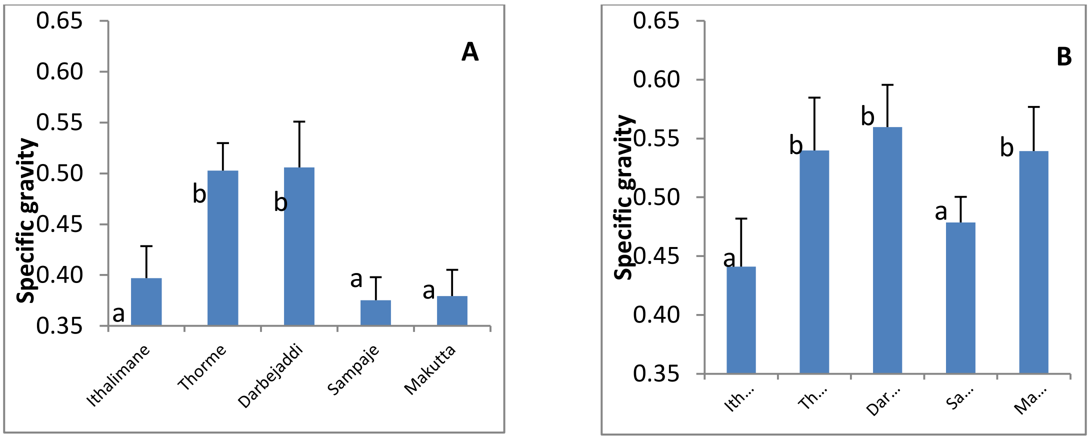

Figure 2: Wood specific gravity of swampy *Gymnacranthera canarica* (figure A) and non-swampy *Myristica malabarica* (figure B) across the locations in Western Ghats, India

(Dissimilar letter indicate the t-test significance at 5 % probability).

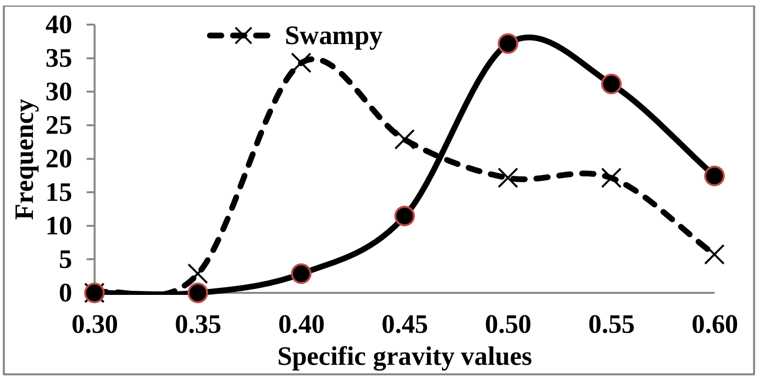

Figure 4: Frequency distribution of specific gravity values of both swampy and non-swampy species of family Myristicaceae (KS test significant at 5% probability).

CONCLUSION

The wood specific gravity analysis indicated that, both species behave differently, thus the impact of local microclimate change and climate change at large varies. The local factors influencing the Myristicaceae members 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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