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Origin and evolution of Laccadive Micro Tall, a coconut cultivar from Lakshadweep islands of India

K. Samsudeen, P. M. Jacob[1], M. K. Rajesh, B. A. Jerard and P. M. Kumaran

Central Plantation Crops Research Institute (CPCRI), Kasaragod 671 124, India
[1]CPCRI, Regional Station, Minicoy, Lakshadweep, India

Abstract

Two islands, Amini and Kadamat, of Lakshadweep were explored to study the variability in Laccadive Ordinary (LCT) and Laccadive Micro (LMT) tall populations. Based on the variability observed in the LCT and LMT a concept was developed to explain the origin and evolution of LMT. In LCT there were two distinct types. The type showing high percentage of husk and elongated fruit (*Niu kafa*) could have developed from the coconuts reaching Lakshadweep by floating. The other type with round fruit and low husk percentage (*Niu vai*) may be the ones carried by human settlers from the west coast of India. In Lakshadweep, these two types got chances to hybridize and segregate. As a result of this, new combinations developed. Intermediate types crossing with *Nui kafa* types, the natural population of these Islands at that time, could lead to the development of LMT with small elongated fruits. Later on when the populations of round types (*Niu vai*) increased due to human selection, further crossing of intermediate types with round types could lead to the development of LMT with round fruits. These two types of LMT were reported and confirmed during the present exploration. Field observations supporting the concept are discussed in the paper. Molecular marker studies on the West Coast Tall (WCT), LCT and LMT further confirming the concept is also discussed.

Key words: Coconut evolution, *Niu vai*, *Niu kafa*, Amini and Kadamat Islands, fruit components

Introduction

Tropical islands and coastal lands are natural home to onut palms. Though coconuts are found outside this e, they rarely produce fruits. Wide distribution of onuts in tropics and absence of a wild progenitor made ifficult to assign a place of origin for this tree of life. American origin was argued based on the fact that st of the botanical relatives are from the American tinent. Equally vociferous is the argument that coconut ginated in some islands of Pacific or Indian Ocean rseglove, 1972; Child, 1974). According to Sauer 93), coconut possibly evolved in the Indo-Pacific an region, where tertiary and quaternary fossils have n found.

Wherever it may have originated, coconut has spread ely in the tropical world. Dissemination was achieved loating in sea currents (Harries, 1978) and subsequent mination on the shore, followed by further human persal. Geographic isolation, introgressive hybridization, mutation, and selection are the most likely cause of population differentiation of coconut (Perera *et al.*, 2000). As it spread, cultivars branched out in different geographical situations, which are now known by the name of the place where it occurs. Such diversity is high in Pacific and Indian Ocean islands (Ashburner *et al.*, 1997a,b). This diversity distributed over a vast geographical area makes it difficult to fix a centre of origin for coconut.

Palms are believed to have originated 200 million years ago in western Gondwana (present South America) (Moore, 1973). It is also suggested that palms originated before fragmentation of Pangaea and the Cocoeae tribe differentiated in western Gondwana (Uhl and Dransfield, 1987). Harries (1990) postulated that coconut palm originated in Gondwana coastline and dispersed to islands by floating during the continental drift. Islands in Pacific and Indian Oceans have primitive type of coconuts even today (Sauer, 1967; Buckley and Harries, 1984). Such

wild type coconuts having long and triangular fruits with high husk percentage possibly reached Lakshdweep Islands from other islands like Seychelles (Samsudeen *et al.*, 2006).

Lakshadweep group of islands in the Arabian Sea has been considered as one of the hot spots of coconut diversity. Diverse types of coconuts have been reported from here. These include Laccadive Ordinary Tall (LCT), Laccadive Micro Tall (LMT), Laccadive Dwarf, Kaithathali, Laccadive Small, Laccadive Medium, Laccadive Micro Round and Lacadive Mini Micro. *Niu vai*, *Niu kafa* and introgressed forms were also reported from Lakshadweep (Jacob, 1993; Jacob & Krishnamoorthy, 1981; John and Satyabalan, 1955; Samsudeen *et al.*, 2006). It was suggested that *Niu kafa* type reached Lakshadweep islands from Indian Ocean islands like Seychelles by floating and *Niu vai* types reached from the Indian coast through man. It was suggested that introgressed forms developed as a result of crossing between *niu kafa* and *niu vai* types (Samsudeen *et al.*, 2006). Various workers explained the presence of Laccadive Ordinary Tall and its different types in the islands (Bhaskar Rao and Vasudevan Pillai, 1982; Krishnamoorthy and Jacob, 1982; Samsudeen *et al.*, 2006). However, the occurrence of Laccadive Micro Tall in the islands is still an enigma. This paper aims to explain the origin and evolution of Laccadive Micro Tall in Lakshadweep islands.

Materials and Methods

An exploration was conducted in the month of October, 2003 after the South West monsoon in Amini and Kadamat islands of Lakshadweep. For this survey, Amini island was divided into three regions, north, south and middle. Each region was further divided into four parts and survey was conducted at two sites in each part. Ten palms of LCT were sampled from each site and LMT was sampled as and when it occurred. For the purpose of the survey, Kadamat island was divided into two regions, north and south. Survey was carried out at six sites in north and seven sites in south. Ten palms of LCT were sampled from each site and LMT was sampled as and when it occurred. This exploration trip to Lakshadweep Islands resulted in the identification of three types of Laccadive Ordinary Tall and two types of Laccadive Micro Tall based on fruit shape and husk content. The three types in Laccadive Ordinary Tall were elliptical, pear shaped and round. Only the elliptical and round types were considered for this study. Laccadive Micro Tall had two types, one with round fruits and the other with elongated fruits. Both the types were included in the present study.

Laccadive coconut population conserved at Central Plantation Crops Research Institute (CPCRI), Kasaragod was also used for the study. Observations were made on the morphological characters for the identification of diverse types in the conserved population. Microsatellite analysis was conducted using leaf samples collected from six palms each of West Coast Tall (WCT), LMT and LCT maintained at CPCRI, Kasaragod. DNA was extracted from spindle leaves of palms following the method of Upadhyay *et al.* (1999) with slight modifications. A total of 14 highly polymorphic SSR primer pairs specific to coconut from the microsatellite kit developed at the Centre International de Recherches en Agronomie pour le De´veloppement (CIRAD), France by Baudouin and Lebrun (2002) were used in the present study. The alleles were scored individually based on a comparison with the molecular ladder. A cluster analysis was performed on the similarity matrix using the unweighted pair group method with arithmetic averages (UPGMA) and the resultant phenogram was constructed using the software GDA (Lewis and Zaykin, 2002).

Results and Discussion

The fruit components of the two LCT and two LMT types were compared for the variability (Table 1). The

Table 1. Variability in LCT and LMT population in Amini and Kadamat Islands

Trait	LCT (Elliptical)		LCT (Round)		LMT (Elliptical)		LMT (Round)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Fruit weight (g)	540-1540	1011.74 (207.61)	400-1180	792.22 (274.87)	200-580	360 (105.16)	280-440	367.55 (56.75)
Husk %	49.3-80.6	69.68 (6.85)	42-66	55.14 (7.80)	50-70.3	56.64 (6.03)	36.7-61.4	48.84 (9.40)
Nut weight (g)	120-350	248.26 (67.49)	180-410	273.89 (61.10)	90-210	138.89 (39.24)	140-210	168.3 (20.38)

(SD in parentheses)

Elliptical types were with elongated fruits and 70 percent husk on an average. The round types were with round to oval shaped fruits and an average 55 percentage of husk; but the husk percentage in elliptical type ranged from 81 to 50 and in round types from 66 to 42. Fruit weight in these types ranged from 400g to 1540g. Husked nut weight ranged from 120g to 410g. There were large fruits with very small nuts and high husk content as well as large fruits with large nuts and low husk content.

Though considerably smaller in fruit size, the elongated and round types in LMT were parallel to the elongated and round types in LCT. In LMT, fruit weight varied from 00g to 580g, husk percentage from 37 to 70 and husked ut weight from 90g to 210g.

Fruit weight, proportion of husk and fruit shape had reat influence on the evolution and dispersal of coconut Harries, 1978; Samsudeen *et al.*, 2006). By studying these haracters in different types of coconut growing in akshadweep, it is possible to arrive at some conclusion n the origin and evolution of Laccadive Micro Tall.

Identification of *Niu vai* type of coconut and onfirmation of presence of *Niu kafa* and introgressed orms in the island during the 2003 exploration trip spired us to study in detail these populations. This has esulted in the identification of coconut types with very longated large fruits but very small nuts (Fig. 1) and nother type with large fruit nd large nut (Fig. 2). The irst type had 70 to 80 ercent husk while the econd type had only 40 to 0 percent. The fruit weight n both the types was above 000g. The husked nut veight in the first type was elow 250g while in the econd type it was above 00g. Palms of both the ypes occur scattered in the sland. As these belong to ll types of coconut they are ighly cross pollinated. Random mating between hese types could result in an rray of fruit types that are isible in the island today. Further natural crossing etween these progenies and natural back crossing with arental types eventually will lead to the development of Laccadive **Micro** types with very small fruits and nuts.

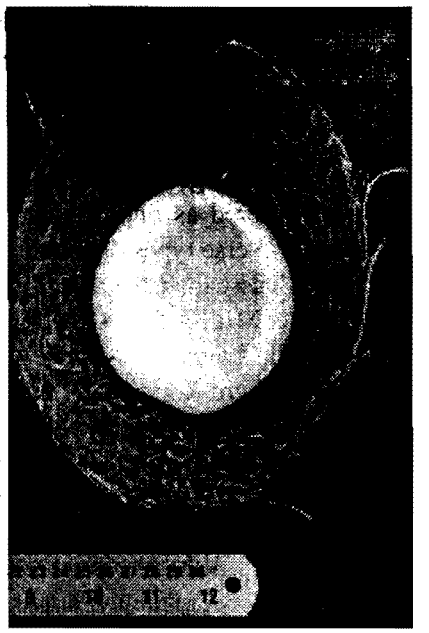

Fig. 2. *Niu vai* fruit

From above, Type I (*Niu kafa*) had large fruit (>1000g) with more than 70 percent husk and small nut (<250g), and Type II (*Niu vai*) had large fruit (>1000g) with less than 40 percent husk and big nut (>400g). Natural crossing between the two is expected to result in following combination of characters.

1. Parental types
2. Fruit - > 1000g ; Husk - >70%; Nut - >400g
3. Fruit - Small ; Husk - <40%; Nut - <250g (Fig. 3)
4. Fruit - Small ; Husk - >70%; Nut - <250g (Fig. 4)

In the third and fourth types, the fruit is expected to be small because the nut is small. The third category is expected to have lower percentage of husk while the fourth will have higher husk percentage. The types, one with low husk percentage and another with high husk percentage have been identified in the Laccadive Micro Tall Jacob, 1993; John and Satyabalan, 1955; Samsudeen *et al.*, 2006. The second type in the above combination is expected to have very large fruit and nut with high husk percentage. Such a palm will have only a few nuts in a bunch and may not be preferred by farmers, but chances are that a few such palms may occur in the islands due to natural segregation.

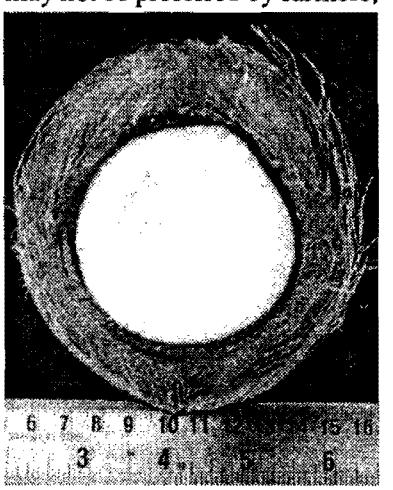

Fig. 3. LMT with low husk %

Human settlers started arriving in Lakshadweep only in the 12th century. Coconut floating from islands on Indian Ocean could have reached these islands much earlier than that. When *nui vai* types carried by

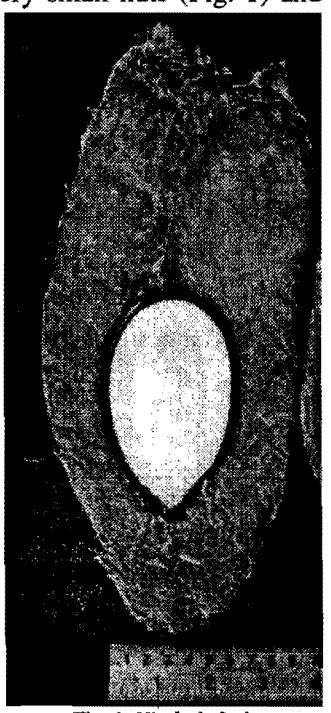

Fig. 1. *Niu kafa* fruit

humans from west coast of India and *nui kafa* types floating from Indian ocean Islands crossed and segregated, recombinants would have developed with intermediate characters. These intermediate types crossing with *nui kafa* types, the natural population of these Islands at that time, could lead to the development of LMT with small elongated fruits. Later on, when the populations of round types (*niu vai*) increased due to human selection, further crossing of intermediate types with *niu vai* types could lead to the development of LMT with round fruits.

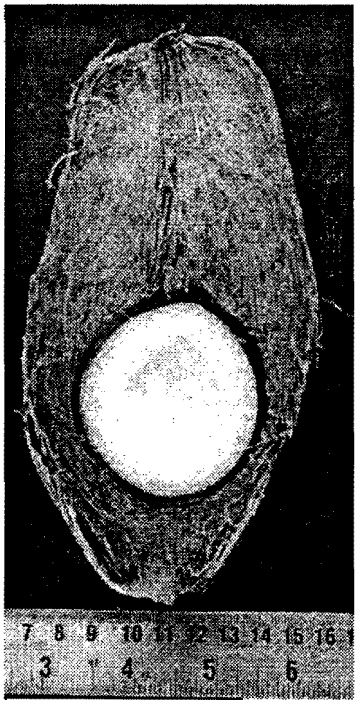

Fig. 4. LMT with high husk%

Only a few palms of Laccadive Micro Tall are seen today and it has been reported to be a dwindling population (Jacob and Krishnamoorthy, 1981; Jacob, 1993). This is because of human selection against the LMT. LMT is not preferred in the island for planting due to its small size and alternate bearing habit. Sporadic appearance of LMT in the population even today against human selection is ample evidence of introgression and segregation still continuing in the Laccadive population.

Germplasm collection from Lakshadweep islands planted at the CPCRI campus in Kasaragod as Laccadive Ordinary consists of some palms that are LMT. Five palms turned out to be LMT out of fifty-seven LCT planted in the year 1965. Evidently, these were collected as LCT but the nuts germinated into LMT. In the same year, 11 LMT were planted, out of which only five developed as LMT and the rest were LCT types. Open-pollinated (OP) nuts were collected from the typical LCT palms of 1965 planting and planted in the year 1989. Out of 197 such palms, 191 are surviving and nine are of LMT type (Table 2). This is expected only when there is segregation as a result of crossing between *niu kafa* and *niu vai* types that could lead to development of LMT.

Table 2. Occurrence of off types in Laccadive population at CPCRI

Year of planting	No. of OP seedlings planted as	Palms observed as		Percentage of off types
		LCT	LMT	
1965	LCT - 57	52	5	8.8
1965	LMT - 11	6	5	54.5
1989	LCT - 191	182	9	4.7

Wide hybridizations generally lead to poor germination of seeds. In the above concept of origin of Laccadive Micro Tall, one parent is of *Niu kafa* (wild coconut) type and the other one is of *Niu vai* (cultivated) type. In the evolution of coconut, these types are geographically separated with *Niu kafa* types being restricted to some isolated islands. In Lakshadweep island, *Niu kafa* type reached by floating and *Niu vai* through human carriers. Wherever wide hybridization between *Niu kafa* and *Niu vai* occurred, germination should be low. Germination in Laccadive Micro has been reported as very poor (Jacob, 1993). This is another reason for low frequency of LMT palms in these islands.

Another consequence of wide hybridization is failure of pollen to germinate on stigma resulting in unfertilized eggs. In Lakshadweep Island, we found many palms of Laccadive Micro with barren or aborted nuts (Fig. 5) indicating that they were the products of wide hybridization. However, the nature of pollen germination, fruit set and production of barren nuts need to be studied in detail to find out the reason for aborted nuts in LMT.

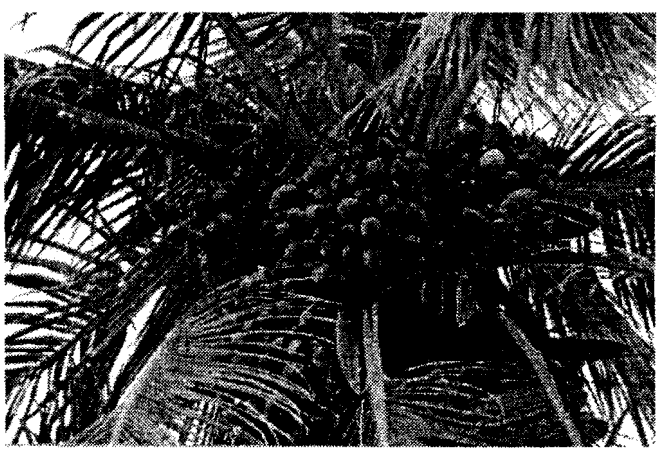

Fig. 5. Bunch with barren nuts

A very valuable piece of evidence for the present concept of LMT origin comes from the molecular study of WCT and Laccadive population conserved at CPCRI, Kasaragod. The dendrogram showing the relationships among the accessions using microsatellites is given in Figure 6. Four major clusters could be visualized. While all six palms each of WCT and LMT formed separate clusters together, LCT palms formed two separate clusters. Four palms of LCT formed one cluster

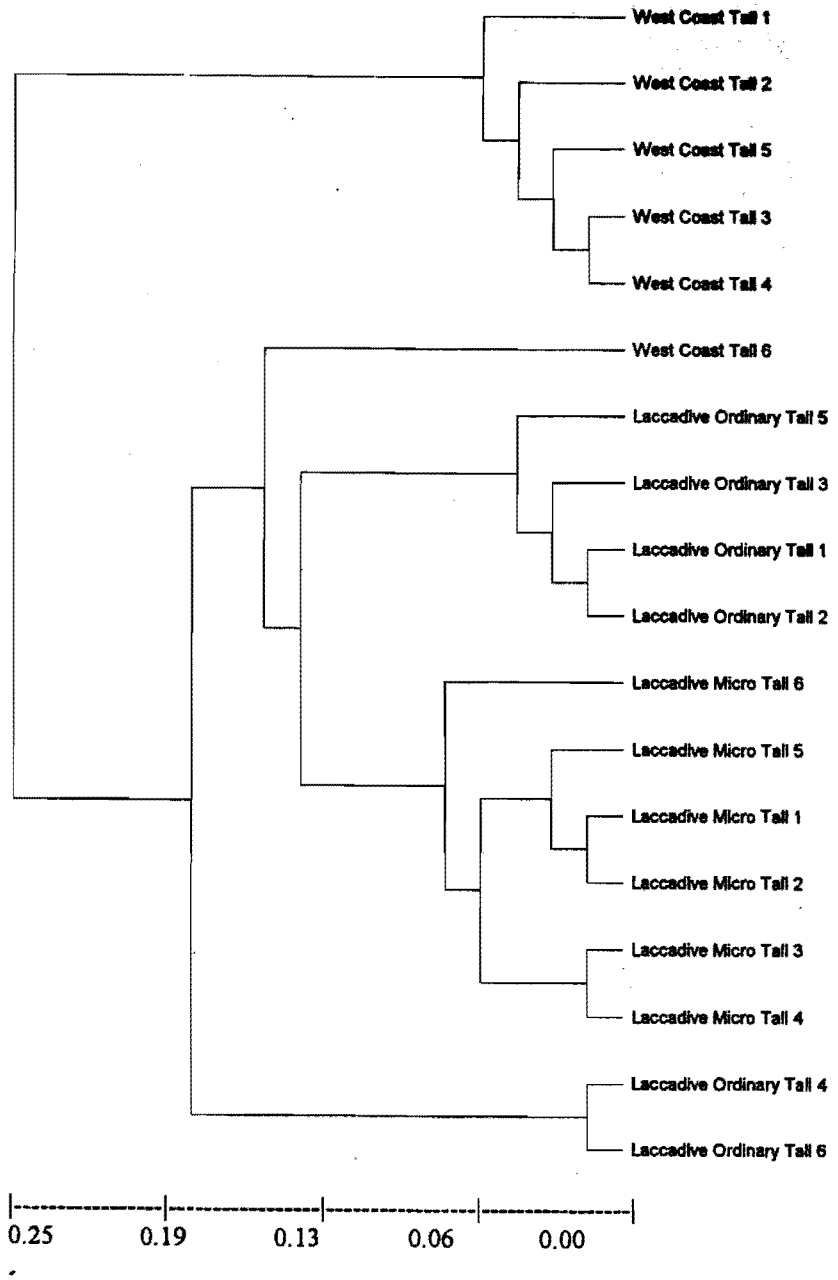

Fig. 6. Dendrogram based on microsatellite analysis for 14 loci

and were placed between WCT and LMT. The second group of two LCT palms formed a distinct cluster. The first group of LCT showed 78.5 percent similarity with WCT (Table 3). It is possible that these LCT types were developed from the WCT types carried to Islands by man. The second group of LCT was different from all other types and had only 65 percent similarity with WCT. Possibly, these were the ones that reached from Indian Ocean Islands by floating. LMT falls between these two groups, suggesting that they developed as a result of hybridization and introgression between the two types.

Table 3. Similarity matrix based on 14 loci

Cultivar	LCT I	LCT II	LMT
West Coast Tall	0.785432	0.654519	0.767397
Laccadive Ordinary Tall I		0.750195	0.861121
Laccadive Ordinary Tall II			0.686357

Conclusion

Lakshadweep is a group of islands lying scattered in the Arabian Sea some 450 km off the Kerala coast. Possibly, coconuts reached here from islands of Indian

Ocean and from West Coast of Southern India. This has resulted in a mixed population of wild (*niu kafa*) and cultivated (*niu vai*) types in a very small geographical area. Natural crossing between the two types and segregation led to the development of Laccadive Micro Tall. The process is still continuing as evident from the occurrence of LMT in the progenies of LCT and *vice versa*. The process will continue as long as *niu kafa* and *niu vai* types co-exist in the Lakshadweep islands. However, human selection could endanger the presence of LMT in the Islands. Only a few palms of LMT are available in the Lakshadweep Islands today. Concerted efforts are required to conserve LMT population both *in situ* and *ex situ*.

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