

Assessment of standing stock of thorny bamboo [*Bambusa bambos* (L.) Voss] in the homegardens of Palakkad and Malappuram districts in Kerala

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Abstract

The standing stocks of rural bamboo in Palakkad and Malappuram districts were assessed through a two-stage stratified random sampling scheme in which 600 homegardens in 20 *panchayaths* were surveyed. Total growing stock of thorny bamboo in Palakkad district was estimated as 61 196 clumps or 4 787 041 culms, having a total dry weight of 124 389 Mg. The corresponding figures for Malappuram were 44 215 clumps, 3 399 855 culms, and 86 267 Mg dry weight. Average cash income generation per farmer through bamboo sale during the period from 2000 to 2005 was, however, low with Rs. 4002 and 1834 per garden per year for Palakkad and Malappuram respectively.

Keywords: Rural bamboo, Bamboo growers, Bamboo sale, Growing stock

Introduction

Bamboo, the ‘green gold’, has the potential to conserve natural forest ecosystems through timber substitution (Hunter, 2002), mitigate global warming through carbon sequestration (Das and Chaturvedi, 2006), and substitute non-biodegradable and high energy-embodied materials such as plastics and metals with polymer composites (Okubo et al., 2004). Bamboos occur widely both in the natural and managed ecosystems of the humid tropics (Kumar and Divakara, 2001). Due to over-exploitation, however, this resource has declined substantially. For example, the thorny bamboos [*Bambusa bambos* (L.) Voss], once widely distributed in the homegardens of Kerala, of late has become a shrinking resource base (Kumar, 1997). Bamboo trade, however, has been flourishing in central Kerala and most of the rural bamboo traded is sourced from Palakkad, Malappuram, and Thrissur districts (Krishnankutty, 2005). There are yet no quantitative estimates on the bamboo stocks available in these districts, except for Thrissur (e.g., Kumar et al., 2005a). A survey was, therefore, conducted in the

homegardens of Palakkad and Malappuram districts to assess the standing stocks of thorny bamboo, the predominant rural bamboo resource of Kerala. Additional objectives included gathering information on inter and intra district variability in bamboo growing stocks of central Kerala, besides assessing the rate at which “bamboo growers” harvest this resource and the extent of cash income generation through its sale.

Materials and Methods

The survey was conducted in Palakkad (10°21' to 11°14' N and 76°02' to 76°54' E) from December 2005 to April 2006 and in Malappuram (10 to 12°N and 75 to 77°E) from July 2006 to November 2006. The methodology involved a two-stage stratified random sampling scheme in which about 10% of the *panchayaths* in both districts were sampled, i.e., from 89 *panchayaths* in Palakkad and 94 *panchayaths* in Malappuram (KSLUB, 1995), 10 each were randomly selected, assuming that intra district variability was of a lower magnitude than the inter-district variability. The *panchayaths* selected,

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their predominant soil types, number of households, and other details are presented in Tables 1 and 2. In the first stage, a reconnaissance of the selected *panchayaths* was performed to identify the “bamboo growers”. This was followed by a more detailed household survey in which 30 households per *panchayath* were randomly selected (district-wise total: 300 each). Girth at breast height (GBH) of all clumps of thorny bamboo in the selected homegardens was carefully measured after removing the overhanging thorns. Information on holding size, bamboo felling, revenue generated through bamboo sale during the five year-period from 2000 to 2005, and other socioeconomic parameters were also gathered through a questionnaire survey.

Computations

Mean number of bamboo clumps per household was estimated using the formula for sub-sampling (Chacko, 1965; Eq. 1 to 5) in SPSS 10.0 with *panchayath* as the first-stage unit and household as the second-stage unit. The number of first- and second-stage units selected was 10 (n) and 30 (m) respectively.

Estimate of population mean, $\hat{\bar{Y}} = \bar{y} = \frac{1}{nm} \sum_{i=1}^n \sum_{j=1}^m y_{ij}$

where y_{ij} is the total number of clumps per household. [Eq. 1]

Assuming that the finite population correction (fpc) is unity, the estimate of variance of the population mean was taken as

$$\hat{V}(\hat{\bar{Y}}) = \hat{V}(\bar{y}) = \frac{S_b^2}{n} \quad [\text{Eq. 2}]$$

where $S_b^2 = \frac{1}{n-1} \sum_{i=1}^n (\bar{y}_i - \bar{y})^2$ and [Eq. 3]

\bar{y}_i is the mean of the clumps in i th first stage unit (*panchayath*) and \bar{y} is the estimate of the population mean.

An estimate of total number of clumps in the district was derived as $Y = N \hat{\bar{Y}}$ [Eq. 4]

Where N is the total number of bamboo growing households in the district.

Table 1. Total number of households and bamboo growers per *panchayath* and estimates of the mean no. of clumps, culms, dry weight of live culms and dry weight of live and dead culms per garden in selected *panchayaths* of Palakkad district, Kerala.

Locality	Predominant soil types ¹	Natural regions	Total households (no.)	Bamboo growers (no.)	Bamboo growers (%)	Mean parameters (per garden)			
						No. of bamboo clumps	No. of culms	Culm dry wt. (kg)	
							Live	live+ dead	
Kottayi	Typic Dystrupepts	M	4360	258	5.92	2.33	176	5468	5725
Kulukkallur	Typic Kanhaplustults	M	4379	324	7.40	2.33	176	4096	4315
Mundur	Typic Dystrupepts	H	5908	309	5.23	2.37	212	5808	6073
Muthalamada	Typic Ustrophepts	H	7308	248	3.39	2.10	157	4456	4680
Nenmara	Aquic Ustrophepts	M	7426	320	4.31	2.93	239	6830	7156
Peruvembu	Aquic Ustrophepts	H	3806	270	7.09	2.20	176	4403	4627
Sreekrishnapuram	Ustic Kandihumults	M	4364	297	6.81	2.43	194	4239	4475
Thenkurissi	Typic Ustrophepts	H	5643	354	6.27	2.27	183	4530	4761
Thirumittakode	Typic Dystrupepts	M	5562	279	5.02	2.07	146	2840	3017
Vadakkanchery	Typic Ustrophepts	M	6991	226	3.23	2.80	207	3392	3616
Mean	-	-	5578	289	5.47				
Standard error	-	-	422.5	12.3	-				

¹Source: KSLUB (1995); H= highlands, M= midlands and L= lowlands

Estimate of the standard error of the estimated total was

$$SE(\hat{Y}) = N\hat{V}(\hat{y}) \quad [\text{Eq. 5}]$$

Number of culms, dry weight of live culms, and total dry weight per clump were estimated based on previously published allometric relationships (Kumar et al., 2005b; KAU, 2007; Eq. 6 to 8).

$$\text{No. of culms, } Y = -12.23 + 37.281 \text{ DBH} \quad [\text{Eq. 6}]$$

$$\text{Live culm dry weight (kg), } \ln Y_i = 4.298 + 2.647 \ln(\text{DBH}) \quad [\text{Eq. 7}]$$

where Y_i is the live culm dry weight (kg) and DBH is the clump diameter at breast height (m).

$$\ln Y_i = 4.437 + 2.576 \ln(\text{DBH}) \quad [\text{Eq. 8}]$$

where Y_i is the total dry weight (live+dead culms; kg) and DBH is clump diameter at breast height (m), derived from girth measurements.

Results and Discussion

The survey data show that bamboo was present in

5.47% (range: 3.2 to 7.4%) of the homegardens in Palakkad (Table 1), as against 3.81% in Malappuram (Table 2), and 3.49% in Thrissur (see Kumar et al., 2005a). Average number of clumps, culms, and the standing stock per household were also greater in Palakkad compared to Malappuram (Tables 1 and 2). Estimates of population means for number of clumps (2.38), culms per clump (186), and total dry weight per homegarden (4844 kg) were also higher for Palakkad (Table 3). The corresponding figures for Malappuram were 2.07 clumps, 159 culms, and 4032 kg total dry weight per homegarden.

Using the estimates given in Table 3, the standing stock of bamboo was estimated as $61\ 196 \pm 2\ 283$ clumps or $4\ 787\ 041 \pm 222\ 716$ culms having a total dry weight of $124\ 389 \pm 9\ 750$ Mg culms for Palakkad and $44\ 215 \pm 1\ 454$ clumps, $3\ 399\ 855 \pm 135\ 887$ culms with a total dry weight of $86\ 267 \pm 4\ 649$ Mg for Malappuram (Table 4). The corresponding figures for Thrissur were 32 344 clumps, 2 286 305 culms, and 28 659 Mg culm dry weight (Kumar et al. 2005a). Average number of bamboo growing homegardens per *panchayath* was 289 and 228 for Palakkad and Malappuram respectively (Tables 1 and 2), giving a total of 25 721 bamboo growing households for Palakkad (89 *panchayaths*) and 21 432 for

Table 2. Total number of households and bamboo growers per *panchayath* and estimates of the mean no. of clumps, culms, dry weight of live culms and dry weight of live and dead culms per garden in selected *panchayaths* of Malappuram district, Kerala.

Locality	Predominant soil types ¹	Natural regions	Total households (no.)	Bamboo growers (no.)	Bamboo growers (%)	Mean parameters (per garden)			
						No. of bamboo clumps	No. of culms	Culm dry wt. (kg)	
								Live	live+ dead
Edarikkode	Typic Dystropepts	M	6275	273	4.35	2.23	181	4735	4966
Edavanna	Pachic Argeiustolls	M	5632	211	3.75	1.93	152	4053	4251
Kalikavu	Pachic Haplustolls	M	5905	238	4.03	2.60	203	5178	5443
Keezhattur	Ustic Palehumults	M	4632	198	4.27	1.90	140	3594	3785
Perumpadappu	Typic Dystropepts	M	7416	204	2.75	1.97	142	3798	3999
Thanur	Typic Ustipsammments	L	6255	179	2.86	2.07	157	3582	3780
Urungattiri	Ustic Haplohumults	H	4751	231	4.86	1.93	153	3397	3584
Vattamkulam	Typic Trophaepts	M	6890	284	4.12	1.90	136	2994	3167
Veliyankode	Typic Dystropepts	L	6353	217	3.42	2.03	163	3418	3609
Vettathur	Ustic Palehumults	M	6621	241	3.64	2.10	160	3539	3739
Mean			6073	228	3.81				
Standard error			264.0	9.87	-				

¹Source: KSLUB (1995); H= highlands, M= midlands and L= lowlands.

Table 3. Estimate of the population mean, standard error of the estimate and relative standard error of the estimate of number of clumps, culms, dry weight of live culms and dry weight of live and dead culms together per household in Palakkad and Malappuram districts of Kerala.

Parameter	Mean no. of clumps	Mean no. of culms	Dry wt. of live culms (kg)	Total dry wt. (kg)
Palakkad				
Population mean	2.38	186	4606	4844
Standard error of the estimate (\pm)	0.09	8.67	368.1	379.7
Relative standard error of the estimate	3.73	4.65	7.99	7.84
Lower limit	2.21	169.4	3885	4100
Upper limit	2.56	203.4	5328	5589
Malappuram				
Population mean	2.07	158.9	3829	4032
Standard error of the estimate	0.07	6.35	209	217
Relative standard error of the estimate	3.29	4.0	5.5	5.4
Lower limit	1.93	146.5	3418	3606
Upper limit	2.20	171.4	4239	4458

Malappuram (94 *panchayaths*). In Thrissur, there were 197 bamboo growers per *panchayath* giving a district-wise total of 20 685 bamboo growing households (see Kumar et al., 2005a). Higher clump size (more culms per clump) and greater number of clumps per garden were noted for Palakkad compared to the other two districts. Implicit in this is greater heterogeneity in the distribution and abundance of rural bamboo among the sampled districts than within a particular district, substantiating our experimental approach of random selection of the *panchayaths* within a district.

As regards to intra-district variability (i.e., among the *panchayaths*), the highest mean dry weight of culms per garden was noted for Nenmara in Palakkad and Kalikavu in Malappuram (Tables 1 and 2). Proximity of these sites to forest areas may have eased some pressure on the rural bamboo resources in view of the presumably higher forest bamboo availability (compared to farther locations). The least values were noted for Muthalamada (Palakkad) and Vattamkulam (Malappuram). Yet another factor influencing inter- and intra- district variability is the soil characteristics. Although bamboo is found on a

Table 4. Estimates of bamboo growing stock in Palakkad and Malappuram districts, Kerala, India.

Parameter	No. of bamboo clumps	No. of bamboo culms	Dry wt. of live culms (Mg)	Total dry wt. (Mg)
Palakkad				
Growing stock	61196	4787041	118271	124389
Standard error of the estimate (\pm)	2283	222716	9452	9750
Relative standard error of the estimate	3.7	4.6	8.0	7.8
Lower limit	56721	4350518	99746	105280
Upper limit	65671	5223564	136796	143498
Malappuram				
Growing stock	44215	3399855	81915	86267
Standard error of the estimate	1454	135887	4480	4649
Relative standard error of the estimate	3.3	4.0	5.5	5.4
Lower limit	41366	3133517	73134	77156
Upper limit	47065	3666194	90695	95378

variety of soils, *panchayaths* where the predominant soil types are Aquic Ustropepts, Pachic Haplustolls, Typic Dystropepts, and Typic Kanhaplustults (Tables 1 and 2), generally had higher standing stock and abundance of thorny bamboo, implying the beneficial effects of these soil types in promoting bamboo growth. This hypothesis, however, needs further testing and validation.

Higher standing stock of bamboo in Palakkad is not surprising as trade in bamboo poles has been mostly concentrated in Palakkad (Krishnankutty, 2005). In general, market access determines the production of commercial crops and bamboo is no particular exception to that general rule. Conversely, remoteness from markets may increase species richness because subsistence

production is based on a broad variety of species (Kehlenbeck and Maass, 2004). Consistent with the higher stocking levels, the revenue generated in Palakkad were much higher than Malappuram (Table 5). Again, just as with Thrissur (see Kumar et al., 2005a), bamboo felling in the homegardens of Palakkad and Malappuram was patchy; indeed, many gardeners (e.g., 69% of the bamboo growing households in Palakkad) did not report any felling activity during the past five years, while some of the gardeners indicated extensive clearing.

Overall, the present estimates suggest that the standing stock of bamboo in the homegardens of the two focal districts is low to moderate with only a relatively small proportion of the farmers maintaining bamboo clumps

Table 5. Number of clumps present, those felled, and revenue earned in the sampled households of Palakkad and Malappuram districts of Kerala state.

District/ <i>panchayaths</i>	Clumps present	Clumps felled during the last five years	Revenue earned per garden ¹ (Rs)
Palakkad			
Kottayi	70	15	4311
Kulukkallur	68	8	4492
Mundur	72	10	3944
Muthalamada	63	15	3759
Nenmara	88	11	4679
Peruvembu	66	18	3914
Sreekrishnapuram	73	12	4000
Thenkurissi	67	10	4050
Thirumittakode	62	16	3094
Vadakkanchery	92	20	3777
Mean	72	14	4002
Standard error	3.2	2.8	139.1
Malappuram			
Edarikkode	70	10	1640
Edavanna	71	18	1211
Kalikavu	57	29	1348
Keezhattur	73	12	2053
Perumpadappu	67	17	2664
Thanur	68	10	2035
Urungattiri	66	11	1677
Vattamkulam	58	14	2182
Veliyankode	65	11	1809
Vettathur	78	28	1725
Mean	67	16	1834
Standard error	1.9	2.2	126.5

¹from bamboo felling during the last six years 2000 to 2006.

(3.8 to 5.5%). With increasing fragmentation of holdings especially on account of the rising population pressure, the boundary planted bamboo clumps may suffer further destruction. Yet, there is a sizeable stock of bamboo in the homegardens of central Kerala, implying the need for scientific clump management as highlighted by Krishnankutty (2005). Among the three districts on which published data are available, Palakkad had the highest average number of bamboo growing homegardens and total growing stock, followed by Malappuram, and Thrissur. The estimated numbers of bamboo growers for Palakkad, Malappuram, and Thrissur were 25 677, 21 394, and 20 685 respectively. Palakkad also had higher clump size and mean number of clumps per garden. Total dry weight of bamboo culms in Palakkad, Malappuram, and Thrissur districts were 124 389, 86 267, and 28 658 Mg respectively.

A limitation of the present study, however, is that there may be some underestimation of the bamboo stocks especially if the clumps were non-uniformly distributed among the *panchayaths* constituting a district. Although some variability in the occurrence and abundance of bamboos in a given district is expected, the sampled *panchayaths* did not show any profound effects in this respect. For example, the number of bamboo growers per *panchayath* ranged from 226 to 354 (mean = 289) and the number of clumps per holding ranged from 2.07 to 2.93 in Palakkad (Table 1). The corresponding figures for Malappuram were 179 to 273 (mean = 228) bamboo growers per *panchayath* and 1.9 to 2.6 clumps per holding (Table 2). A more precise approach also should have greater sampling intensity than the presently sampled 30 households per *panchayath*.

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