SOUTHERN INDIA ELEPHANT CENSUS 2002

DRAFT SUMMARY REPORT TO THE
TAMIL NADU FOREST DEPARTMENT

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I. INTRODUCTION

Population estimation of Asian elephant (*Elephas maximus*) has been carried out using total count method since the late 70s by State Forest Departments in India. However till recently, this method has not been recommended due to several shortcomings like intense labour requirements, fatigue of enumerators, double counting etc. Given that this method requires less specialized training it may however be more broadly applicable than other statistically robust methods. The line transect method developed by Burnham *et al.* (1980) has been used satisfactorily for estimating elephant densities in Asia through direct counting (Varman & Sukumar 1995; Karanth & Sunquist, 1992; Baskaran & Desai 2000) in areas with high elephant density. The line transect method has also been used to estimate densities through enumeration of indirect evidence e.g. dung (Barnes & Jensen, 1987; Dawson, 1990; Varman *et al.*, 1995) in areas with low elephant density and poor visibility. These methods have not been cross-validated against each other and given the directions from Project Elephant, Government of India, for reliably estimating the elephant numbers in southern India during the year 2002, we felt that this was an excellent opportunity to validate results obtained from the dung count method with the sample block count method.

The present census was conducted from 7th to 9th May 2002 in all the four southern states; Tamil Nadu, Karnataka, Kerala and Andhra Pradesh. Here we summarize the census results for Tamil Nadu.

II. METHODS

1.Preparation, training and designing census strategy

For the current synchronized elephant census in southern India, it was decided to use a random block count, waterhole count and line transect indirect (dung) count method. The block count and line transect dung count methods were used for estimating elephant densities and the waterhole count was used to ascertain population structure. The Asian Elephant Research and Conservation Centre, Indian Institute of Science conducted a two days workshop on elephant census techniques during April 2002 at Theppakadu, Mudumalai Sanctuary and Bandipur Project Tiger Reserve for officers from Tamil Nadu, Karnataka, and Andhra Pradesh. During the workshop detailed discussions took place about the different methods existing, the rationale and relevance of the methods chosen, design for sampling divisions where census was to be carried out and proposed data analysis. Data sheets for block, water hole and dung counts were designed and distributed to all officers. The actual census was conducted for three days from 7th to 9th May 2002. Block counts and waterhole counts were conducted respectively on 7th and 8th May 2002 and dung count was carried out on 9th May 2002 over the elephant range in Tamil Nadu.

2. Block count

Elephants were counted from sample blocks selected uniformly across the entire division. A compartment map of the division was obtained and approximately 30-50% of the beats demarcated on the map were randomly chosen and designated census blocks. The sample blocks were systematically surveyed by a team of two to three people and all the elephant sightings were recorded in the block count data sheet. In addition, when possible, the age and sex of all animals seen were recorded. Age and sex classification was carried out using a key described below

3. Water hole count

Approximately 30 -50% of perennial waterholes within each division were observed on 8th May 2002 between 0800 to 1800 hrs by a team located on a *Machaan* or hide. During this period all elephants visiting the waterhole were aged and sexed. Elephant were classified into four major age classes i.e. calf (<1 year old), juvenile (>1 year to 5 years old), sub-adults (>5 year to 15 years old) and adults (>15 years) based on shoulder height as suggested by Sukumar *et al*. (1988). Animals were sexed based on presence or absence of tusks in the case of adults, sub-adults and juveniles. Care was taken to differentiate *Makhnas* from females using body characteristics and shape of genitalia. From this data the sex ratio was calculated for adults in each division.

4. Line transect dung count method

In all divisions, line transects were laid in all blocks where the block count was undertaken. In each sample block, a transect of 2 km length was laid across altitudinal gradients and perambulated once to enumerate dung piles. On sighting dung piles from the transect, information such perpendicular distance, dung pile status etc., were recorded. Elephant density was obtained using a Monte Carlo simulation method (*GAJAHA* Ver. 1.0) developed by Santosh and Sukumar (1995) by incorporating three variables - dung density obtained from line-transect data, defecation rates and dung decay rate. The defecation rate (16.33) calculated by Watve (1992) and decay rate (0.0097) calculated by Varman *et al*. (1995) in Mudumalai Wildlife Sanctuary were used in the present analysis as such data do not exist for each division in Tamil Nadu.

Data analysis

Data on block count were analysed by computing the number of elephants counted in each block, the sampled area and the total area of the division with a standard formula (see Lahiri Choudhury, 1991).

Data on dung count were analysed using *GAJAHA* (Ver. 1.0) by using perpendicular distances, the total transects lengths, dung decay and defecation rates.

Sex ratio of adult male to female was estimated with pooled data of waterhole count and block count and separately for each division.

III. RESULTS AND DISCUSSION

1. Elephant population estimated using sample block count method

The census data were obtained from 12 Forest Divisions of Tamil Nadu and the elephant numbers estimated for these divisions are given in Table 1. Overall, a mean number of 3737 elephants were obtained for the 12 divisions in Tamil Nadu through the sample block count method. The 95% confidence intervals indicate the 12 divisions support anywhere between 3017elephants and 4454 elephants.

The actual elephant distribution area is much smaller in many divisions like Hosur, Dharmapuri, Nilgiri North, Theni and Dindigul due to inaccessible terrain. Since, we do not know whether census was carried out in entire division or only in the elephant distribution area, we have extrapolated the density to the total forest division. These divisions therefore need further verification with the concerned forest officials for confirmation of area sampled. Thus, care needs to be taken while dealing with the total number of elephants estimated for these divisions and the overall number for entire state.

Among the 12 divisions where the elephant numbers were estimated, Sathyamangalam Division, Mudumalai, Nilgiri North Division and Indira Gandhi Wildlife Sanctuaries were found to have numbers of about 500 individuals or greater. It is important to note that Mudumalai Wildlife Sanctuary supports the second highest population in the state within a relatively small area of $321km^2$ and thus also has the highest elephant density (2.19 elephants/km^2) in the state (Table 1). The elephant density estimated for Mudumalai Sanctuary through the block count (2.19 elephants/km^2) method in the current survey is comparable with densities estimated by Baskaran & Desai, 2000 (2.39 elephants/km^2) and Arivazhagan *et al*., 2002 (2.2 elephants/km^2) using the line transect direct count method. Other divisions namely Hosur (274 individuals), Thirunelveli (207 individuals), Coimbatore (178 individuals), Erode (168 individuals) and Srivilliputhur Sanctuary (114 individuals) were also found to have considerable number though densities were lower at 0.2 to 0.8 elephant/km^2.

The number of elephants for Dindigul, Dharmapuri and Theni were less than 100 individuals.

The block size information was approximate for some divisions (Dharmapuri, Coimbatore and Hosur), were unrealistically large for efficient perambulation (*e.g.* 36 and 21 km^2 block sizes in Theni Division) or were uniform in size which is difficult to achieve in the field (24 blocks each of 1.5 km^2 in Thirunelveli Division). These may have biased elephant numbers in these divisions.

Table 1. Elephant population estimated using block count method for various divisions in Tamil Nadu

Division	No. of blocks Sampled	No. elephants Counted	Mean Density	Range of number*		Total Area (Km²)	Mean number
				LCL	UCL		
1 Sathyamangalam	30	191	0.64	556	1193	1360	870
2 Mudumalai WLS	23	368	2.19	647	761	321	703
3 Indira Gandhi WLS	50	185	0.5	412	733	959	480
4 Nilgiri North	36	124	0.65	525	588	854	557
5 Thirunelveli[1]	24**	30	0.8	191	222	248	207
6 Hosur	25	79	0.30	251	296	907	274
7 Coimbatore	44***	53	0.24	125	231	738	178
8 Erode	24	91	0.21	154	181	782	168
9 Srivilliputhur WLS	22	35	0.3	66	165	380	114
10 Dharmapuri	20	49	0.17	81	100	529	91
11 Dindigul	15	35	0.2	70	91	400	81
12 Theni	30****	4	0.02	7	15	510	11
Tamil Nadu	**343**	**1244**	**0.52**	**3017**	**4454**	**7988**	**3737**

* 95% Confidence Interval, ** Block sizes uniform, *** Block sizes approximate, **** Block sizes too big
[1] Total area of division unknown

Elephant population estimated based on dung count method

Number of elephants estimated through the dung count method for the 12 divisions, as Erode Division did not carry out the dung count method due Veerappan problem. Out of the 12 divisions, data from Nilgiri South division could not be analyzed due to low sample size. According to dung count method, the 11 forest divisions in Tamil Nadu harbour 4076 elephants with a lower confidence limit of 0.52 elephant/km^2

(3479 elephants) and an upper confidence limit of 0.70 elephant/km^2 (4684 elephants).

Among the eleven divisions, Sathyamangalam (734 individuals), Mudumalai Wildlife Sanctuary (722 individuals), Nilgiri North (598 individuals), Indira Gandhi Wildlife Sanctuary (547 individuals) and Hosur Division (590 individuals) supported the highest numbers. Sizable numbers of over 100 elephants were found in the divisions of Dharmapuri, Coimbatore, Srivilliputhur and Thirunelveli, while Theni and Dindigul had much lower numbers (Table 2).

Elephant densities estimated through the block count and dung count methods are comparable in about seven of 11 divisions (Sathyamangalam, Mudumalai, Nilgiri North, Indira Gandhi, Coimbatore and Srivilliputhur and Dindigul Division) although marginal differences do exist (Table 1 and 2). In Hosur, Dharmapuri and Theni divisions, the block count method yielded lower numbers than the dung count. In the Thirunelveli division the block count method gave a higher density than the dung count method.

Some variation in densities estimated from two different methods can be expected due to differences in methodology. But a substantial difference in densities across the two methods could be due to sampling errors such as large block sizes, inaccurate estimation of block sizes in block count method or inaccurate estimation and rounding off of perpendicular distances and deviating away from the transect line in search of dung piles while walking the line transects. As already mentioned in the block count method, block sizes of these divisions are either inaccurate (Dharmapuri, Hosur and Coimbatore) or unrealistic as they are either too large to perambulate during the census operation (Theni Division) or as they are uniform in size (Thirunelveli Division). Therefore, the block count figures may not be realistic for these divisions.

Only marginal differences across the densities of elephants estimated using the two methods in Sathiyamangalam, Mudumalai, Nilgiri North, Indira Gandhi, Coimbatore and Srivilliputhur, Dindigul divisions confirms the reliability of the results. Given this

situation, it would be appropriate to deal with dung count densities for all the divisions as this method is statistically more robust than the block count method. Apart from this, confidence interval (difference between LCL and UCL) in the dung count was smaller (1210) than the block count method (1438).

From the dung count results it can be inferred that Sathyamangalam, Mudumalai, Nilgiri North and Indira Gandhi Wildlife Sanctuaries and Hosur Divisions support numbers of >500 individuals. Similarly, other divisions like Dharmapuri, Dindigul, Theni, Srivilliputhur Sanctuary, Coimbatore, Thirunelveli Divisions also supported considerable number of elephants (>100 elephants) and these areas should also be treated equally important, as these are contiguous with other divisions within the state and in Karnataka or Kerala.

Table 2. Elephant population estimated using dung count method for various divisions in Tamil Nadu

S. No	Division	Sample Size	% data of used	Cut off Point (m)	Density of elephants			Total Area (Km^2)	Total Population
					Mean	LCL	UCL		
1	Sathiyamangalam	683	90	10	0.54	0.46	0.62	1360	734
2	Mudumalai WLS	1543	96	15	2.25	1.94	2.57	321	722
3	Indira Gandhi WLS	881	93	10	0.57	0.49	0.65	959	547
4	Nilgiri North	1271	91	15	0.7	0.6	0.81	854	598
5	Hosur	653	91	10	0.65	0.55	0.75	907*	590
6	Dharmapuri	237	98	10	0.46	0.39	0.53	529*	243
7	Srivilliputhur WLS	417	98	15	0.41	0.35	0.47	380	156
8	Coimbatore	317	90	10	0.19	0.16	0.22	738	140
9	Thirunelveli	260	85	15	0.42	0.35	0.49	248**	104
10	Theni	363	96	15	0.27	0.23	0.31	510	138
11	Dindigul	198	99	15	0.26	0.22	0.30	400	104
	Tamil Nadu	6823			0.61	0.52	0.70	7206	4076

* Elephant distribution area used as large division area is inaccessible to elephants, ** Total area of division unknown

Density figures with underline are comparable with respective division block count density

Sex ratio

Aging /sexing elephants is easier at water holes than while carrying out block counts where visibility is often poor due to dense undergrowth. The sample sizes obtained in water hole counts were however very small for some divisions. The overall sex ratio estimated for water-hole counts (Table 3) was similar to that of block count (Table 4) and thus both data were pooled together to obtain sex ratios with a larger sample size.

The overall adult sex ratio estimated for the 12 divisions in the State was 1:5.3 (Table 5). However male to female ratio was found to vary across different divisions. In Srivilliputhur Wildlife Sanctuary not even a single adult male was found out of 60 elephants aged and sexed during block and water hole counts and thus it was the most female biased population among all 12 divisions where the census was conducted. The sex ratios of elephants in places like Dharmapuri, Indira Gandhi, and Mudumalai Wildlife Sanctuaries and Erode were skewed towards females (>1:6). Surprisingly, the sex ratio in Sathyamangalam and Hosur were less skewed than the adjoining divisions of Mudumalai and Hosur respectively. Similarly, sex ratio at adult level was least skewed (1:1.8) in Coimbatore forest division among the twelve divisions in Tamil Nadu, which is quite unreliable (see following paragraph for details).

The sex ratio estimated for all the divisions were based on classifications that had unusual herd or population structures (see Remarks column in Table 6). In many divisions (like Srivilliputhur Wildlife Sanctuary, Hosur, Nilgiri North, Coimbatore) there seem to be misclassifications of adult females as sub-adult females and sub-adult males as adult males. Such misclassifications resulted in more sub-adult females than adult females in some divisions (e.g. Hosur and Srivilliputhur Wildlife Sanctuary) and overall, the number of adult males were two fold higher than sub-adult males (136 and 66 individuals respectively).

In general, the proportion of adults in the population is likely to be higher than sub-adults. This is not surprising as the age range for adults is greater (>15 years ages) than for sub-adults (from 5 to 15 years). However, due to selective poaching of adult males, most of the elephant populations in southern India, have more sub-adult males than adult males. The smaller proportion of sub-adult males than adult males in the overall total of 12 divisions, indicate the possibilities of sub-adult males mis-

classified as adult males. On the other hand in some divisions, the lower number of adult females compared to sub-adults indicates possibilities of misclassification of adults into sub-adults. In total, nearly 10% of 1780 elephants counted during the census were not age and sexed due to various reasons. Most of these unidentified individuals are likely to be from female herds than solitary males or bachelor groups of males and thus there are greater chances of adult females being unidentified than adult males, thereby decreasing the number of adult females included in the calculation of sex ratios.

Therefore, sex ratios estimated with the present census data might not represent the prevailing sex ratios and the skew may be much higher than what is shown here. In support of the above statement, the adult sex ratio calculated for Mudumalai Wildlife Sanctuary by the present census (1:6.8) does not match with sex ratio estimated by Baskaran & Desai, 2000 (1:29) and Arivazhagan & Sukumar, 2002 (1:29) for the elephant population in Mudumalai Wildlife Sanctuary.

Table 3. Sex ratio estimated based on water hole count data for various divisions in Tamil Nadu

S. No.	Divisions	Total	AM	AF	Sex ratio AM:AF
1	Mudumalai WLS	187	17	81	1:4.8
2	Indira Gandhi WLS	101	3	47	1:15.7
3	Hosur	49	5	11	-
4	Nilgiri north	45	6	13	-
5	Erode	44	2	21	-
6	Coimbatore	32	3	12	-
7	Srivilliputhur WLS	29	0	8	-
8	Thirunelveli	14	0	9	-
9	Sathyamangalam	10	1	4	-
10	Didnigul	9	0	7	-
11	Dharmapuri	8	2	6	-
12	Theni	8	0	1	-
	Tamil Nadu	**536**	**39**	**220**	**1:5.6**

Table 4. Sex ratio estimated based on block count data for various divisions in Tamil Nadu

S. No.	Divisions	Total	AM	AF	Sex ratio AM:AF
1	Mudumalai WLS	368	21	178	1:8.4
2	Sathyamangalam	191	25	80	1:3.2
3	Indira Gandhi WLS	185	7	58	1:8.3
4	Nilgiri north	124	11	26	1:2.4
5	Erode	91	8	40	1:5
6	Hosur	79	11	23	1:2.1
7	Coimbatore	53	11	13	1:1.2
8	Dharmapuri	49	1	29	-
9	Dindigul	35	2	21	-
10	Srivilliputhur WLS	35	0	18	-
11	Theni	4	0	3	-
12	Thirunelveli	30	0	15	-
	Tamil Nadu	**1244**	**97**	**504**	**1:5.2**

Table 5. Sex ratio estimated based on water hole and block counts data for various divisions in Tamil Nadu

S. No.	Divisions	Total	AM	AF	Sex ratio AM:AF
1	Mudumalai WLS	555	38	259	1.6.8
2	Indira Gandhi WLS	286	10	105	1:10.5
3	Sathyamangalam	201	26	84	1:3.2
4	Nilgiri north	169	17	39	1:2.3
5	Erode	135	10	61	1:6.1
6	Hosur	128	16	34	1:2.1
7	Coimbatore	85	14	25	1:1.8
8	Srivilliputhur WLS	64	0	26	0:26
9	Dharmapuri	57	3	35	1:11.7
10	Dindigul	44	2	28	-
11	Thirunelveli	44	0	24	-
12	Theni	12	0	4	-
	Tamil Nadu	**1780**	**136**	**724**	**1:5.3**

Table 6. Age sex composition of elephants counted in block and water hole counts in various divisions of Tamil Nadu

S. No	Forest Division	Tot. no. of Elephant counted	AF	SAF	JF	AM	SAM	JM	Calf	UI	Remarks
1	Mudumalai WLS	555	259	86	26	38	30	13	70	33	Total no. of ind. counted and no. of elephants age sexed not tallying and 2 female herds (each <9 ind.) with three adult male in each herd
2	Indhira Gandhi WLS	286	105	34	16	10	11	6	43	61	54 out of 70 elephants (found in 3 herds) were not age sexed and 1 herd of 5 elephants consisted of 4 sub-adult males and a calf
3	Sathiyamangalam	201	84	35	15	26	6	7	19	9	Female herd of 5 elephants with 3 SAF, 1 AM and 1 calf
4	Nilgiri North	169	39	28	18	17	11	9	16	31	Total number of elephants counted less than age sexed
5	Erode	135	61	25	15	10	3	2	19	0	Possibilities of sub-adult males mis-classified as adult males
6	Hosur	128	34	37	5	16	1	2	31	2	12 SAF, 1 AF with 4 calves in herd of 21 elephants (rest 2 AM & 2 UI)
7	Coimbatore	85	25	9	11	14	4	3	10	9	Possibilities of sub-adult males mis-classified as adult males
8	Grizzled Giant Squirrel WLS	64	26	23	9	0	0	0	2	4	18 SAF & 8 AF in herd of 29 animals counted (rest 3 JF)
9	Dharmapuri	57	35	3	10	3	0	0	1	5	6 AF & 2 AM without even a calf, juvenile or sub-adult
10	Dindigul	44	28	2	0	2	0	0	3	9	
11	Thirunelveli	44	24	12	4	0	0	0	3	1	
12	Theni	12	4	6	1	0	0	0	1	0	Female herd with calf without AF
	Tamil Nadu	1780	724	300	130	136	66	42	218	164	More adult males than sub-adult male in overall is unlikely

IV. LITERATRE CITED

Arivazhagan, C., and R. Sukumar. 2002. Ecology of Asian Elephants (1997-2002): *In* Annual report for the period 1.4.2002 to 31.3.2002. Centre for ecological Sciences, Indian Institute of Science, Bangalore. Pp 9-12.

Arivazhagan, C., M. Madhivanan and R. Sukumar. 2002. Monitoring of large mammal populations (1998-2002): *In* Annual report for the period 1.4.2002 to 31.3.2002. Centre for ecological Sciences, Indian Institute of Science, Bangalore. Pp 13-16.

Barnes R. F. W. and K. Jensen. 1987. How to count elephants in forest. IUCN African elephant & Rhino Specialist Group Technical bulletin 1: 1-6.

Baskaran, N. and A. A. Desai. 2000. Elephant population estimation in Mudumalai Wildlife Sanctuary and National Park. *Final report 1999-2000.* Bombay Natural History Society, Bombay.

Burnham, K. P., D. R. Anderson and J. L. Laake. 1980. Estimation of density from line transect sampling of biological populations. *Wildlife Monograph, 72: 1-202.*

Dawson, S. 1990. A model to estimate density of Asian elephant (*Elephas maximus)* in forest habitat. M.Sc. thesis, Dept. of Zoology, University of Oxford.

Karanth, K. U. and M. E. Sunquist. 1992. Population structure, density and biomass of large herbivores in the tropical forest of Nagarahole, India. *J. Trop. Ecol.* 8: 21-35.

Lahiiri Choudhury, D.K., 1991. Direct count of elephants in Northeast India. In: Censusing elephants in forests: Proceedings of an international workshop, Technical Report 2: Asian Elephant Conservation Center of IUCN/SSC Asian Elephant Specialist Group, pp. 33-45.

Sukumar, R., K. Surendra Varman, J. A. Santosh and U. Ramakrishnan. 1991. Methods of estimating elephant numbers: A review. In Censusing Elephants in Forests – Proceedings of an International Workshop, Southern India, 2-10 January, 1991. Technical Report No. 2. Asian Elephant Conservation Centre of IUCN/SSC Asian Elephant Specialist Group. Pp 1-29.

Santosh, J.A. and Sukumar, R. 1995. Some solutions to estimation of elephant densities. Pg 394-404. In: A *Week with elephants.* Proceedings of the International Seminar on the conservation of Asian elephants. Mudumalai Wildlife Sanctuary, 1993 (Eds.) J. C. Daniel & H. S. Datye. Bombay Natural History Society.

Sukumar, R. 1989. The Asian elephant ecology and management. Cambridge Univ. Press, Cambridge.

Sukumar, 1992. Minimum viable populations for elephant conservation. Proceedings IUCN/SSC Asian Elephant Specialist Group meeting, Bogor, Indonesia. pp: 7-11.

Sukumar, R., N. V. Joshi and V. Krishnamurthy. 1988. Growth in the Asian elephant. *In:* Proceedings of the Indian Academy of Science (Animal Sciences), 97: 561-571.

Varman, K. S., U. Ramakrishnan and R. Sukumar, 1995. Direct and indirect method of counting elephants: A comparison of results from Mudumalai Wildlife Sanctuary. Pp 331-339. In: A *Week with elephants.* Proceedings of the International Seminar on the Conservation of Asian elephants. Mudumalai Wildlife Sanctuary, 1993 (Eds.) J. C. Daniel & H. S. Datye. Bombay Natural History Society.

Varman, K. S. and R. Sukumar**.** 1995. The line transects method for estimating densities of large mammals in tropical deciduous forest: An evaluation of models and field experiments. *Journal of Bioscience. 20 (2): 273-287.*

Watve, M. G.1992. Ecology of host parasite interactions in wild mammalian host community in Mudumalai, southern India. Ph.D., Thesis Indian Institute of Science, Bangalore.