Estimating elephant numbers in Tabin Wildlife Reserve, Sabah, Malaysia

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Introduction

The Asian elephant *(Elephas maximus)* is a highly endangered species throughout its present geographic range. Total pupolation size is estimated to be between 45,000 - 55,000 individuals. The methods used to arrive at this estimate are varied and in many critical cases only educated guesses (Santiapillai & Jackson, 1990). Assessing current statues and population trends using these estimates is hence very difficult and often meaningless.

The Asian Elephant Specialist Group (AESG) recognized the need to develop census techniques that could be widely applied in different habitats and since 1987 has been actively promoting standardization of methodology to estimate elephant numbers. An indirect method was adopted, modified and tested extensively in India during 1988/89 (Sale *et al.* 1990). The same method has been endorsed by the AESG and recommended as being most useful in dense elephant habitats (Ramakrishnan *et al.* 1991).

Sabah has the largest, and possibly the only population of elephants on Borneo and there is some evidence that it constitutes a distinct race from other populations of the species. The Sabah population is small (several hundred) and, being subject to serious habitat loss due to logging of the rain forest and its clearance for large-scale agriculture, is highly endangered. At present only one (recently gazetted) protected area, Tabin Wildlife Reserve, contains a significant number of elephants. Damage to crops is fairly widespread and frequent. A species management plan for elephant will shortly be prepared with assistance from the UNDP project now providing technical aid to Sabah wildlife Department. It will consider all possible management options, including further protected areas, erection of barriers such as electric fencing and translocation of pocketed groups.

In the light of the above, clearly it is of utmost importance to obtain a more accurate estimate of elephant numbers and their seasonal distribution than that presently available - which due to the great difficulty of sighting the animals in dense rain forest is somewhat sketchy. The estimation of numbers from dung density appears to be a promising method for Sabah conditions, and as it had never been used here before had to be demonstrated to local personnel. Therefore, the Sabah Wildlife Department initiated this Project to demonstrate the usefulness of the indirect method to census elephants in Tabin, and while doing this to give hands-on training to their personnel in all aspects of this technique.

Objectives of the study

- To estimate the size of the discrete elephant population in Tabin Wildlife Reserve.

- To demonstrate the effectiveness of the indirect method of estimation of elephant numbers under Sabah conditions.
- To teach the method to the Sabah Wildlife Department personnel in volved in elephant management and to a Sabahan graduate researcher, with a view to it being adopted (with any appropriate modifications) as standard methodology.
- To provide a basis for collecting objective information of elephant numbers as the foundation of a management plan for the species in Sabah.
- To assist standardisation of Asian elephant census methodology which will facilitate comparison between various populations / countries by the Asian Elephant Specialist Group.

Study area

Tabin Wild life Reserve (=Tabin or Reserve) stretches across 120,000 ha of the central portion of the Dent peninsula in eastern Sabah (between 5°15' and 5°10' N and between 118°30' and 118°45' E. It was gazetted in 1984 as a Wildlife Reserve primarily to conserve three endangered large mammal species, including the Asian elephant, *Elephas maximus* (Andau, 1987). The topography in most of Tabin is highly dissected with steep hills and deep valleys and covers an altitudinal range from sea level to about 500 m, although in much of the Reserve the altitudinal range is between 100 and 300 m (WWF, 1986). The north eastern and central parts of the Reserve have the only stretch of flat lowlands. Tabin is well drained by a number of seasonal and perennial streams which originate in the hills and form the five major rivers of the area. Sungai Tabin and Sungai Lumpongon (a tributary of Sungai Maruap Besar) flow into the Segama Bay in the north-east. Sungai Lipad, Urit and Teagas-tegas Besar tributaries of Sungai Segama which flows near the western boundary of the Reserve. Tabin has a number of natural mineral sources, themost important of which are the two active mud volcanoes found near Sungai Lipad in the west and Sungai Tabin in the central portion of the Reserve. (Map 1)

Apart from a 8000 ha core area and four small patches of Virgin Jungle Reserve (VJR), Tabin represents a former logging concession in which active extraction only ceased in 1989. The area is still criss-crossed with old logging tracks. The primary vegetation was mainly lowland dipterocarp forest; the north-eastern corner contains freshwater swamp forest and a small amount of mangroves. The remaining primary forests are dominated by species belonging to the family Dipterocarpacaea - over 40 species have been identified and include *Shorea leptoclados, S. Symingtonii* and *Dipterocarpus caudiferus* (WWF, 1986; Ismail, 1989). Today, apart from the core area and the VJRs, the rest of the vegetation is typical secondary dipterocarp forest with open canopy and dense tangled vegetation in the lower layers. Here *Macaranga spp* dominate together with woody climbers (dominated by the genus *Uncaria*), gingers (over 30 species belonging to 11 genera) and ferns in the understorey (Ismail, 1989). Tree regeneration is slower on the slopes compared to the flat areas. And in areas that have been recently logged elephants frequently use logging tracks to move around.

Mean daily minimum and maximum temperature is 22° and 32° respectively. Rainfall is distributed unevenly throughout the year, the wettest period being between October and March. Total annual rainfall ranges between 2900 - 3000 mm (WWF, 1986). This study was planned for the period of least rainfall (dry season) to facilitate access to the more remote areas. It was generally dry during the study.

Other significant Wildlife in Tabin includes a small population of Sumatran rhino *(Dicerorhinus sumatrensis)*, banteng *(Bos javanicus)*, sambar *(Cervus unicolor)*, barking deer *(Muntiacus muntjac)* and mouse deer

Map 1: Tabin Wildlife Reserve

(Tragulus javanicus and *T. napu).* Seven of Sabah's eight primate species occur in the Reserve, including low densities of proboscis monkey *(Nasalis larvatus)* and orang - utan *(Pongo pygmaeus).* In addition to clouded leopard *(Neofelis nebulosa)* there is a considerable diversity of small carnivores including several species of civets.

Tabin Wildlife Reserve was selected as the study area for two main reasons. First, it is presently the only protected area which contains a significant population of elephants with long - term viability. Secondly, the Reserve boundary to the north, south and most of the west, is shared with oil palm and/or cocoa plantations, restricting the movement of elephants. The eastern boundary until recently was contiguous with large forest tracts within which elephants ranged. However, these forests are being systematically cleared for a FELDA scheme (only a few thousand ha are left), drastically reducing the range of the elephants and potentially restricting them to the Reserve. This situation calls for active management of the Tabin elephant population, and the results of this study will provide baseline data on abundance with which to follow population trends in the years to come. In addition, a management plan for the Reserve is under preparation and will require distribution and abundance information on all major species, including elephants.

Methods

Introduction

Three factors influenced the choice of the method to be used to census elephants in Tabin - the dense tropical vegetation, its size and the expected low densities based on previous surveys (Davis & Payne, 1982). In this situation a method that depends on sighting elephants directly cannot be used unless one is prepared to spend a disproportionate amount of time (and money). Therefore, the indirect method pioneered by Barnes and Jensen (1987) for similar circumstances in central Africa, and widely tested and adapted for Asian conditions (Dawson 1990), was used. Briefly, the method translates the density of dung in an area to elephant density by taking into consideration the rates at which dung enters and leaves the environment through deposition and decay. If these rates are more or less equal, then the quantity of dung in an area will be constant. Hence, if the density of dung is known, this can be correlated to elephant density by applying correcting factors for the daily rate of deposition and decay to it. The equation is thus:

$$E = \frac{D \times R}{d}$$

where E = elephant density; D = dung density; R = rate of decay; d = rate of defaecation.

Dung density estimates

Dung density is estimated by sampling based on standard sampling principles (Cochran, 1963; Norton - Griffiths, 1975) as applied to any other object. The line transect sampling technique described by Burnham *et. al.* (1980) is used to measure dung density as the assumptions it makes are realistic and readily applicable in field conditions.

A reconnaissance of the Reserve was carried out, by vehicle and on foot, over a period of two weeks with two objectives in mind. Primarily, it was to establish any significant elephant usage patterns within the Reserve with a view to stratifying the census area to obtain precise results. This was done by making a note of the frequency with which signs of elephant presence - feeding signs. dung, tracks, calls, elephants themselves - were encountered in an area. In addition information was also gathered by talking to local people and managers of surrounding estates. The second objective of the reconnaissance was to ascertain access to different parts of the Reserve in order to plan the logistics for the actual survey.

The reconnaissance showed typical localised spatial aggregation patterns expected from a long ranging, herding species. However, no distinct patterns of elephant distribution emerged except that the south western and central parts were least used. Because of the limited time available for the reconnaissance it was not possible to investigate distribution patterns further, and firm conclusions could not be drawn to stratify the area. Therefore, it was decided to treat the core area as a separate stratum where the vegetation was mainly primary forest, and the remainder of the Reserve was divided into 3 units of more or less equal sizes for logistic purposes. The aim was to carry out 20 transects of 2 km each in these units, including the core area. However, there was a proviso that if data collected showed definite use patterns by elephants, poststratification would be attempted while analyzing the data. Further, if no clear pattern emerged but variance levels were high within one or more units, more sampling would be carried out according to standard sampling principles.

In each sampling unity line transects were carried out on foot by a team with a minimum of three observers. Each transect ran along a predetermined compass bearing, oriented perpendicular to logging tracks and / or rivers. Right - angle distances to all dung piles seen on either side from the transect line were measured using a tape measure. Transect length was measured by a topofil (an instrument that measures distance by trailing cotton thread from a fixed point at the transect starting point).

The dung density estimate is derived from the transect data, i.e transect length, number of dung piles seen and their respective right - angle distances, using the perpendicular distance model and the Fourier Series estimator via the computer programme ELEPHANT (Dekker and Dawson, 1992).

Dung decay rates

The rate at which dung disappears depends mainly on the agents of decomposition and climatic factors such as rainfall, humidity and temperature (Coe, 1977). Decay rate is also established by sampling. In order to do this a number of samples with known dates of deposition are monitored on a weekly basis, from day 1 until they completely disappear (Dawson, 1990). Any recent evidence of elephant presence was followed up and the site visited to locate fresh samples. Although elephants themselves were seen in only one site, in three further areas calls were heard and fresh tracks encountered, during the reconnaissance.

A total of 70 samples were located in three different parts of the Reserve. Two plots with 9 and 25 samples respectively are located in the north - eastern extreme of the Reserve. One plot with 20 samples is located in the north - central part near Sungai Tabin, while the fourth is near Sungai Urit in the western extreme of the Reserve and has 16 samples. Each sample is given a number and marked with a wooden stake for easy location and identification in subsequent weeks. It is also ranked into one of five decay "stages" which is characterised by the physical appearance of a dung pile, rather than age (Dawson, 1990). At subsequent inspections the samples are recategorised if they have changed, and monitoring continues until they reach the final decay stage when they are deemed to have disappeared. The mean survival time (in days) of a given dung piles is calculated and its reciprocal is the decay rate.

Defaecation rates

The rate at which elephants produce dung is dependent on the quality of food ingested, which in turn is influenced by climatic factors (Dawson, 1990). It is therefore not advisable to use figures from the literature unless it is absolutely impossible to obtain this data by direct observations in the field. If using published figures is the only option available then it must be ensured that figures have been derived from areas with similar environmental conditions.

The best way to obtain comparable data on defaecation rates of wild elephants is to monitor domestic elephants that are allowed to free - range in the census area or those fed entirely on natural fodder. Secondly, whether monitoring domestic or wild elephants, it must be done over 12 - hour periods as there are distinct diurnal/nocturnal rhythms in defaecation times (Dawson, 1990). Rates derived from short observation periods added together may give biased results.

The steady state assumption

The central assumption of the method is that the number of dung piles in the census area is stable, i.e the proportion of fresh dung produced per day is equal to the proportion of old dung disappearing through decay. Although this is a fair assumption to make when censusing within a season or a closed population, the result can be validated if it is shown that this assumption holds. A simple way of doing this, using data collected during transects and decay rate experiments, is described in Dawson and Dekker (1992).

Counterpart training

In order to fulfil objective 2.3 all wildlife officers and senior rangers, and selected rangers and assistant rangers were assigned by roster to join the census team in Tabin, for an average period of one week. This was to give field personnel first hand experience in census design and data gathering for two of the three components of the method, ie, dung density and dung decay. In addition, two workshops were planned; one to discuss theoretical aspects of the method and how to plan a census operation, and a second one to give hands-on training in data handling, analysis and interpretation.

Further, efforts were initiated at the beginning of the consultancy to locate a Sabahan graduate student who could spend the entire consultancy period with me to undergo intensive training in all aspects of an elephant census. In addition to passing on the expertise to someone who could possibly be employed by the Wildlife Department for future elephant censuses, I planned to form a second census team after being fully satisfied that the candidate was proficient enough with the method to collect data independently. This would effectively increase the amount of sampling possible during the survey.

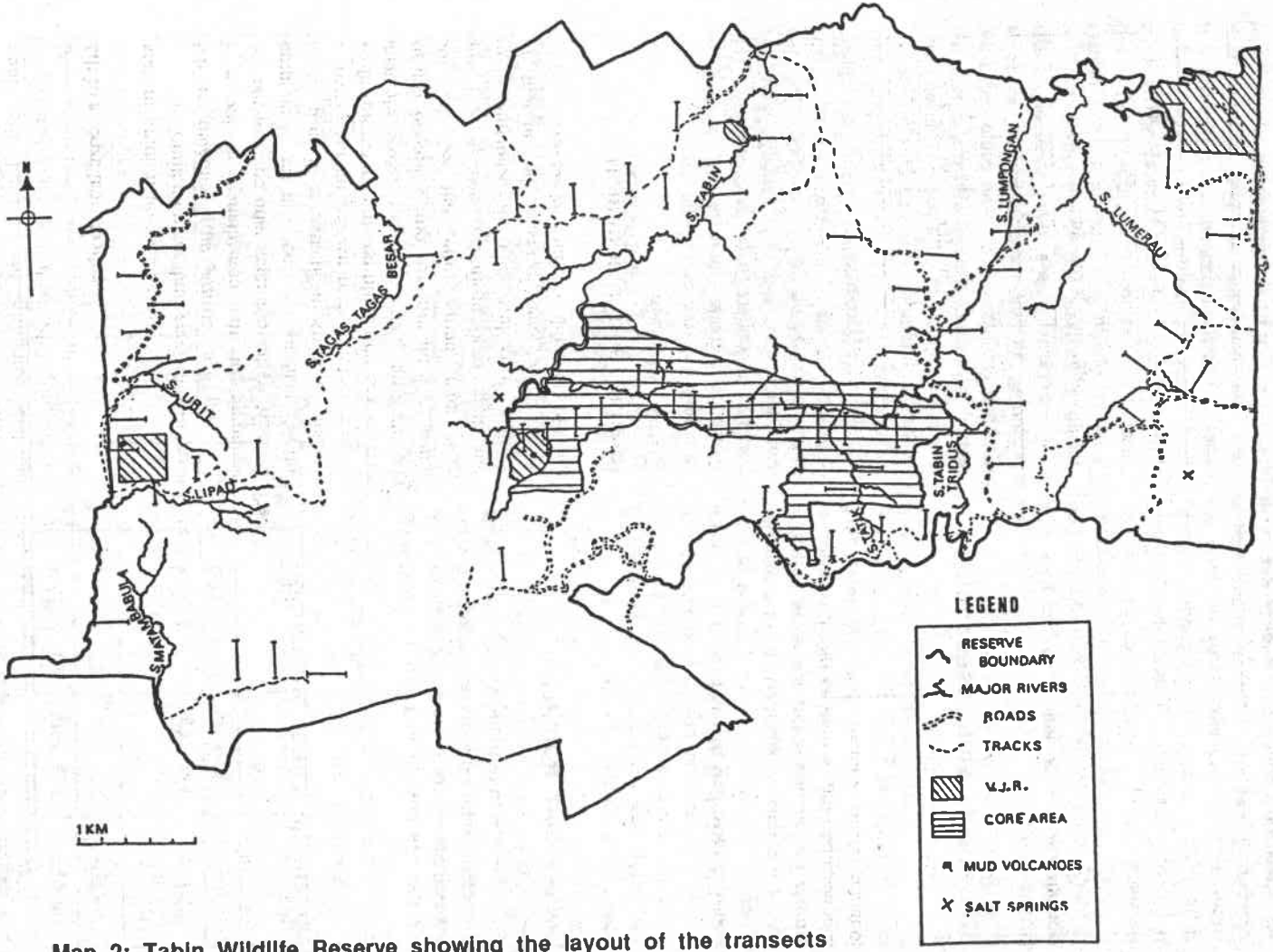
Results and discussion

Dung density

A total length of 118.2 km in 79 replicate transects was completed in the Reserve (Map 2). It was not always possible to complete the target transect length of 2 km in one working day due to the dense vegetation and undulating terrain. The mean transect length was 1.6 km

Sampling unit		Transects			Sample size (dung piles)	Density ± 1.96 SD	Covariance of density estimate
Stratum	Area	RL	L(km)	W(m)			
High Use	60 km^2	8	12.5	7.0	171	162± 480	12.53%
Moderate Use	245 km^2	19	35.5	11.0	288	834± 244	13.15%
Low Use	520 km^2	42	57.7	10.0	105	323± 121	14.84%
Not Used	373 km^2	10	12.5	-	5	-	-

RL = replicate lines; W(m) = transect width in metres.



Map 2: Tabin Wildlife Reserve showing the layout of the transects

(0.434 SD). Although the reconnaissance did not indicate clear use patterns, the data (transect location and number of samples seen per km) showed that within each sampling unit there was some localized clustering, invariably in the vicinity of the river valleys. All transects and their respective sample sizes were mapped and some distinct distribution patterns emerged. On the basis of this the Reserve was post - stratified into four units: high use, moderate use, low use and not used areas. The size and respective densities was calculated for each stratum separately and the results are given in the Table below.

Dung decay

Five cohorts of dung ranging between 5 and 25 dung piles have been monitored for between 16 to 19 weeks. Being located in different parts of the Reserve, the samples are subject to varying environmental conditions. All samples have not decayed completely to date and monitoring continues by staff in the Reserve. However, a decay rate has been estimated by extrapolation. Number of dung piles surviving to date is plotted against time and a regression curve is fitted to the data (a second order polynomial gives the best fit). By extending the regression to beyond the actual observation time, it is possible to predict future dung survival. Actual and predicted values indicate that the mean survival time of a dung pile is 140.84 days, which gives a decay rate of .0071 (.0084 - .0053). This rate is slow when compared to those found in India, the slowest there was 0.0081 (0.0010 - 0.0088).

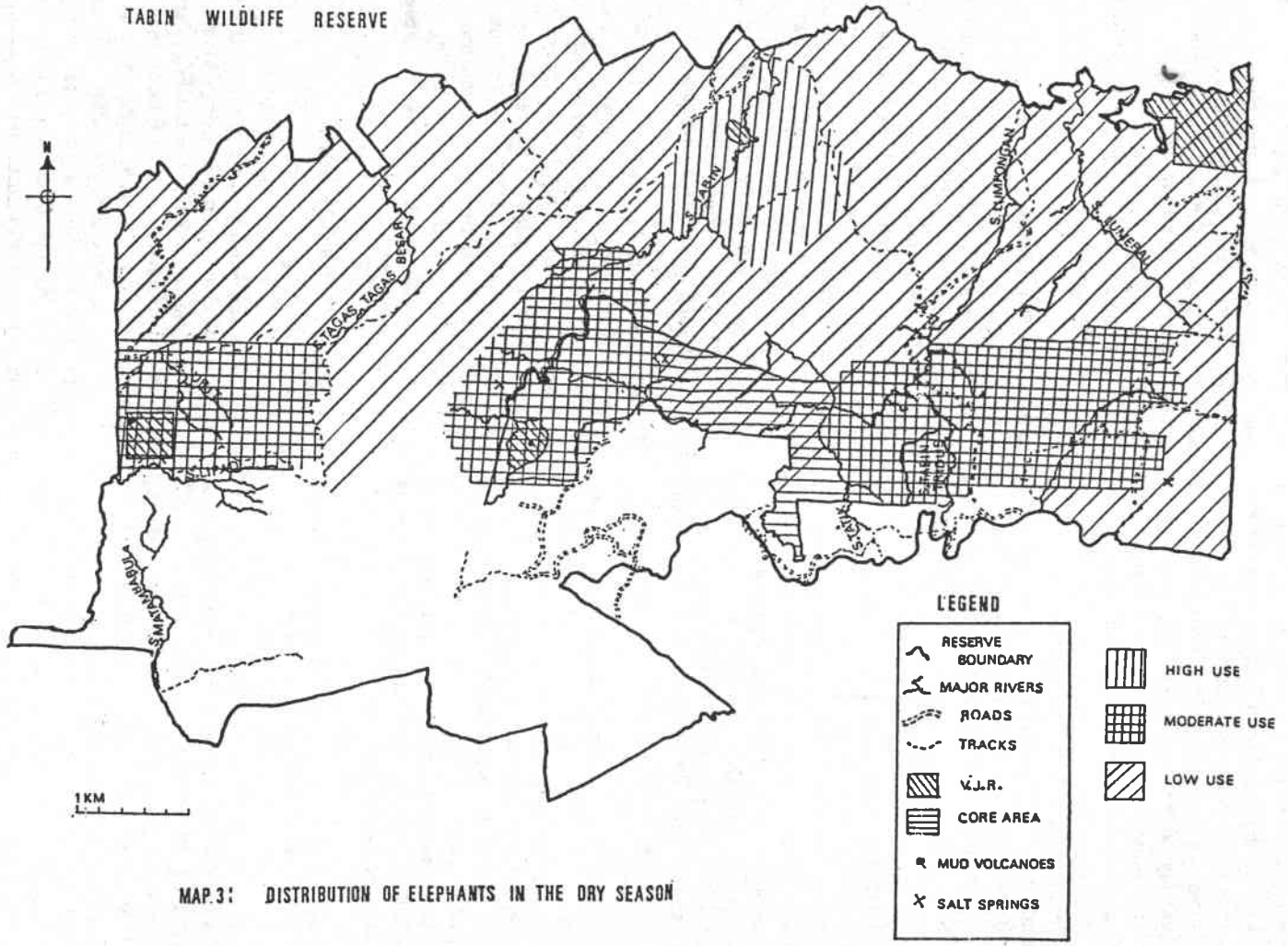
The slow decay rate may be due to two reasons. Firstly, it has been an unusually dry year. Rainfall immediately prior to the study and during the study was itself lower than the previous year (490.1 mm of rainfall during December to February compared to 833.9 mm the previous year, and 509.68 mm from March to June 1992 as opposed to 894.9 mm). Secondly, the conspicuous absence of large decomposing agents such as dung beetles and termites acting on elephant dung. Dung beetles and mechanical breakdown due to heavy rain cause dung to decay at very fast rates in the wet season in other pars of the Asian elephant range, while in the dry season decay rate is relatively slower as termites are the main agents of dung removal (Dawson, 1990); Wiles, 1980). In the case of Tabin, however, it appears that the decay process is almost entirely by bacteria, and therefore very prolonged.

Defaecation rates

Establishing the rate of defaecation for Sabah elephants proved difficult as there are no domestic elephants here. Locating and following wild elephants for continuous periods was next to impossible in the dense, vegetation of Tabin. There was a possibility that some data could be gathered from a recently radio - collared individual, but this was also not possible due to logistic problems. In the circumstances, I have to resort to using published information from other parts of the Asian elephant's range. Olivier (1978) reports defaecation rates of elephants in Peninsular Malaysia. However, there is very little indication on how these rates were obtained and hence not entirely satisfactory. Therefore, I am using the figures applied to estimate elephant densities in the rainforests of southern India which is 13.2033 ± 0.789. It must be noted that similar figures were obtained in Thailand from domestic elephants feeding on natural fodder in lowland dipterocarp forests (Mattana Srichakrachan, pers. comm.).

Elephant densities and distribution

Elephant densities have been calculated for each stratum separately using common decay and defaecation rates. These densities are extrapolated to stratum size to estimate numbers. The sum of the three strata in which elephants occur is the total population in Tabin Wildlife Reserve. (Stratification has greatly enhanced the precision of the results.). It must be reiterated that both distribution and population size of elephants in Tabin obtained by this



MAP.3: DISTRIBUTION OF ELEPHANTS IN THE DRY SEASON

Sampling unit		Elephan densities		Elephant numbers	
Stratum	Area	Mean	Range	Mean	Range
High Use	60 km^2	0.87	0.80 - 0.96	52	48 - 58
Moderate Use	245 km^2	0.44	0.37 - 0.51	108	91 - 125
Low Use	520 km^2	0.17	0.14 - 0.22	88	73 - 114
TOTALS	825 km^2			248	212 - 297

survey pertains to the dry season only (Map 3). Distribution of elephants in Tabin during the dry season appears to be influenced by terrain, food and water availability. Notes of these characteristics were made during the reconnaissance and while doing the dung density transects.

The high use area represents optimal habitat for elephants in Tabin. It is situated in the north central part of the Reserve and includes the Tabin river valley and a patch of primary forest (VJR). Terrain in this part of the Reserve is mainly flat with some gently undulations. Although the surrounding area has been selectively logged, such activity ceased some time ago. Unlike those areas that have been recently logged, these forests have regenerated well possibly due to the higher soil fertility in low-lying areas. Natural regeneration here is characterised by a great diversity of climbers / vines, shrubs and ginger species which are an important source of food for elephants. The tall forest also provide ample shade while Sungai Tabin is a permanent source of water. Very little human disturbance was noted in this part of the Reserve which is bounded by an oil palm plantation in the north. So a combination of all these factors may be the reason for this concentration of elephants during the dry season.

In the moderate use areas some of the same habitat characteristics occur, especially density of undergrowth. A common factor in the three units that make up the stratum is the presence of mineral sources either in the form of mud volcanoes or salt springs. Although this can influence densities, it is not conclusive as there are parts of the Reserve with known mineral sources but have low densities or no elephants at all. On the other hand, the high use stratum has no known mineral source. Having said that attention must be drawn to the fact that terrain in the moderate use areas was generally undulating and may deter greater use of these parts.

An interesting common factor between the high and moderate use strata are the patches of primary forest within them. Although it has been observed that primary forests have a lower density of elephants in general because of lower food availability (Olivier, 1978), this appears not to be the case within Tabin during the census period, ie, dry season. In fact this forest type shows a higher density of dung, and therefore elephant use. Sixty - four percent of samples detected in the high and moderate use areas were found in primary forests. It could be argued that this is a function of better visibility in primary forests, but where dung is concerned it does not hold as dense leaf litter on the forest floor can influence detection. Another point that may be raised is that elephants defaecate more during or after resting periods (Dawson, 1990). Tall primary forests provide good shade, especially important in the dry season, where elephants rest and dung density may be related to this activity. If this is one reason, the usefulness of tall forests to elephants should not be under-estimated and all efforts must be made to retain them.

Although it would appear that water would not be a limiting factor in tropical rainforests for elephants, in Tabin rainfall immediately prior to the study and as well as during the study was much lower than the previous year (total rainfall from December 1990 to June 1991 was 1728.8 mm while it was 999.68 mm for the same period in 1991/92). This dry spell may have limited water availability to the main rivers. In the circumstances, the combination of secondary forests (food) with primary patches (shade) and permanent water sources found in the high and moderate use areas influenced elephant distribution in the period of least rainfall.

The low use stratum, in most parts, had a combination of very undulating terrain and dense secondary forest which were recently logged with little or no natural regeneration. Seventy-eight percent of the samples detected were seen on logging roads or within 50 m on either side. It appears that in these parts elephants used available logging roads to move around and fed on the prolific ginger stands enroute. It can be argued that visibility on logging roads is better than inside dense secondary vegetation, but when taken in conjunction with the fact that other signs of elephants presence (including feeding, spoor and resting areas), were seldom noted within these forests in this stratum, the difference in local distribution of dung appears to be real. The concentration of dung on logging tracks was especially noted in the more recently logged areas.

Steady state

The dung piles in the decay rate experiments are a sample of the dung "population" and the changing decay categories effectively represent how the state of dung changes over a period of time. Dung samples encountered on the transects are also categorised into decay state using the same criteria. This data is a representative sample of the state of dung in the environment at a given time. From the decay rate experiment, which is monitoring a dynamic process, the relative proportion of a given decay stage can be observed. If this sample is truly representative of the changes that occur in the environment, then similar proportions of each decay stage can be expected in the "static" sample obtained on transects at any given time during the survey. Hence, if the observed and expected results show no significant difference, then it is deemed that the environment is in a steady state. This is tested using the simple one-tailed chi-square test. In the case of Tabin the observed and expected values were strikingly similar ($X^2 = 0.157$; $P = <0.05$ with 4 df) indicating that the steady state assumption holds and validates the census results.

Counterpart training

A total of 19 staff members including 6 Wildlife officers / Game wardens, 7 senior rangers and 6 rangers / assistant rangers have been trained. This includes a lady ranger who was assigned to the project for two months to receive intensive training and it is envisaged that she will be a key person in the Department for future elephant censuses. Although it was planned to train a Sabahan graduate student, a suitable candidate could not be found even until a month into the study. Instead, an undergraduate (third year) student was located through the University Kebangsaan Malaysia (UKM) and trained over two months. A one-day seminar was held on 15 May 1992 where all aspects of planning and conducting a census were discussed. Selected senior level staff (6 officers and 3 senior rangers) were invited to a 3 day workshop where data handling, analysis and interpretation was discussed. They also got hands-on experience in data analysis via computer. The two long-term trainees were also given training in data analysis.

Conclusions and recommendations

The density and resulting population size of elephants in Tabin Wildlife Reserve (121-297 individuals) has been obtained for the first

time using a method that is easily repeatable and mathematically sound. The method used isvalidating the results. These results provide the baseline data for comparison with future censuses to monitor the elephant population. This is especially important in the light of the fact that there will be an influx of elephants into Tabin from the east where forests are currently being cleared systematically for large scale oil plantations.

The results of this survey also demonstrate the appropriateness of the dung based estimates for tropical rain forest conditions. Even while using an indirect method, a long duration of field data collection is shown to be necessary, especially when working in predominantly secondary vegetation and highly undulating terrain, with very limited access for vehicles. Estimating elephant densities using a direct sighting technique in these conditions would be next to impossible. As similar conditions occur in other parts of the elephants range in Sabah, this method can be used to obtain comparable results to form the basis of a conservation strategy for the species. With the increasing incidents and levels of conflict between elephant and humans, a pragmatic management plan is urgently required.

The training objectives of this project have been amply fulfilled. The long-term training of one ranger is deemed to be especially important as it is envisaged that she will be a key person to carry out field data collection for future elephant surveys. The training of nearly all Wildlife officers and senior rangers of the Department in all aspects of planning and conducting and elephant census, data handling and interpretation is a vital output of the project. This means that the method can be applied by those presently involved in elephant management, or by those who may be involved in the future.

Recommendations

a. The results obtained by the present survey provides baseline data on population size. In the light of ongoing logging activity on the eastern boundary and the likely influx of elephants into the Reserve, a replicate survey should be carried out by the Wildlife Department in 1994 to ascertain any increase in population size through emigration.

b. Thereafter, censuses should be carried out every five years using the same technique, and preferably during the same time of year, to monitor population trends.

c. A survey should be carried out by the research staff of Tabin to ascertain the relative index of dung in different parts of the Reserve, to establish the distribution and relative abundance of elephants during the wet season.

d. A minimum network of access roads into the reserve should be maintained for vehicular use to facilitate logistics in future surveys (including those of species other than elephants).

e. Dung decay experiments should be carried out be research staff in the key elephant areas over a one year period to ascertain any seasonal differences in decay rates. The results can be used as a data base for use in future surveys when environmental conditions are similar.

f As a foundation for a species conservation plan, the Wildlife Department should carry out, as soon as possible, surveys in the two other key elephant areas, first the proposed Kinabatangan State Reserve and second the Ulu segama including the proposed Greater Danum Valley Wildlife Reserve.

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