Comparison of tiger (*Panthera tigris*) population estimated using noninvasive techniques of pug mark, camera trap and DNA based analysis of hair and scat in Ranthambhore Tiger Reserve. Phase-II: Estimation of tiger population

Final Report

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CONTENTS

EXECUTIVE SUMMARY

1. Reliable estimates of status and population trends are critical for the conservation of large terrestrial carnivores as they play an important role in evaluating the effectiveness of conservation efforts and also provide benchmark data for future management decisions. But the population estimation of large carnivores has always been controversial. Several methods have been employed to estimate tiger populations in India; "The Pugmark" based expert system (Choudhary, 1970; 1971; 1972; Sawarkar, 1987) and "Camera Trapping" in a mark-recapture framework (Karanth, 1995; Karanth & Nichols, 1998; Karanth *et., al.,* 2004) being the most widely used. However, methods used for population estimation of large carnivores have always been marred with one or the other problem on account of low numbers and poor detection probability of large carnivores which makes it extremely difficult to arrive at reliable estimates. Also reliable estimates of status and population trend of large carnivores are lacking due to high cost of sampling across large geographical areas (Smallwood & Fitzhugh, 1995). Methods for censusing endangered carnivores need to be practical and cost effective with regard to the prevailing socioeconomic conditions of the region.
2. This study was carried out in RTR (25° 54′ to 26° 12′ N, 76° 22′ to 76° 39′ E), in Sawai Madhopur district of Rajasthan, India. Intensive data collection was undertaken in the core zone, which has an area of 233 km^2. RTR is located mainly on the Aravalli and Vindhya hill ranges. The vegetation of RTR is representative of a typical dry deciduous *Anogeissus pendula* forest. Apart from *Anogeissus*, the other species commonly found are *Sterculia urens, Boswellia serrata, Acacia leucophloea, Cassia fistula, Butea monosperma, Diospyros melanoxylon, Cordia myxa, Mitragyna parviflora,* and *Syzigium*

cumini. Ranthambhore is characterized by a subtropical dry climate with four distinct seasons: summer (March–June), monsoon (July–August), post-monsoon (September–October), and winter (November–February). Large predators include the tiger, leopard (*Panthera pardus*), and striped hyaena (*Hyaena hyaena*). RTR supports five species of wild ungulates, including the chital (*Axis axis*), sambar (*Cervus unicolor*), nilgai (*Boselaphus tragocamelus*), chinkara (*Gazella gazelle*), and wild pig (*Sus scrofa*).

3. Phase II is being envisaged to estimate tiger population using standardized sampling strategies under Phase I. Thus in present study, we aimed to estimate and compare tiger population by utilizing all existing methods used for population estimation of large carnivores such as pugmark, camera trap, and DNA based techniques using scat and remotely collected hair samples in Ranthambhore Tiger Reserve to determine accuracy and precision in estimates as well as its replicates. After completion of this project, it would be possible to suggest different protocols for monitoring and estimating abundance and population of tiger in such dry tropical deciduous type habitat. Phase-II of the project is aimed to: (i). determine tiger population employing pugmark, camera trap (sight and re-sight) and non-invasive DNA based techniques using scat and remotely collected hair in intensive study area of ca. 300-400 sq. km of Ranthambhore Tiger Reserve, Rajasthan, and (ii). compare tiger estimates determined by various methods and seasons with respect to precision and accuracy and suggest appropriate protocols which are practical, suitable at variety of scales, and cost effective for estimating tiger numbers for dry tropical habitats.

4. The intensive study area 233 km^2 was divided in to 1x1 km grid and a reconnaissance survey was carried out in each grid to locate and select suitable camera trap sites and track plot for deploying sampling unit from October 2007 to November 2007. The trap sites were selected based on indirect sign of tiger such as scats, scrapes, and pugmarks and consultation with forest guard familiar with area. This was verified by walking on trails and dry river beds. Location of tiger signs were marked using a hand held Global Positioning System (GPS) Garmin 72 (Garmin corp, Olathe, KS). Locations were overlaid on the 1x1 km grid map with the help of Arc View 3.1 (ESRI©,) to determine the spatial spread of trap sites and coverage of the area. If large gaps were detected in the spatial coverage more trap sites were added. In the intensive study area, a total 224 grids were selected in which remotely triggered camera trapping stations and a track plot were deployed. Replicate road survey sampling for collection of scat samples were conducted in these grids. We used two types of 100 remotely triggered camera trap systems in this study: in that 20 were Active infrared system Trail Master® TM 1550 (Goodson Associates, Inc., Kansas, USA) and 80 digital passive infrared system {(40 digital were Wildview (WILDVIEW, Grand Prairie, USA), 20 were Stealth Cam, (STEALTHCAM, Grand Prairie, USA), 20 were Moultrie (MOULTRIE GAME FEEDERS, Alabaster, USA)}. Even we have 100 camera trap but we could not used all 100 traps for sampling because some camera traps were not functional properly and some camera traps were damaged by local peoples (Stolen and broken down). So we had 72 camera traps were in actually functional and were used for sampling.

5. Pugmarks were collected during study period from November 2007 to June 2011. In the present study, the digital photograph (DP) of left hind pugmarks was recorded for each individual. To determine the accuracy and precision of identifying individuals from pugmarks, quantification of pugmarks were done using Sigma Scan Pro-4^{TM} software (SPSS Science, 1998). Each image was transferred to Sigma Scan Pro-4 and calibrated with a known linear measurement (measuring scale along the image was used for this purpose) applied to the same dimension in the digital image. The potential variables for measurement of pugmark and cast were selected based on the survey of literature (Grigione *et al.,* 1999, Lewsion *et al.,* 2001, Sharma *et a.,* 2001). Twenty (15 linear and 5 area) (Fig. 3.2) variables were used for differentiation of individual as well as gender from pugmark. Population was estimated using under mark recapture frame work. The results presented here are based on pugmark data collected during 540 days of surrey in 3 spatially separated blocks from November 2007 to June 2011. Total sampling effort of 19800 track plot monitoring days yield a total 336 pugmarks set (digital photograph) of 27 (16 female and 11 males) known individuals with photo-identity. 20 variables (15 linear and 5 areas) were selected that has maximized information from tiger pugmarks for individual discrimination. Stepwise DFA on least correlated 17 variables, for left hind pugmark of 21 tigers were correctly classified with 100 % accuracy and this classification accuracy decreased, when pugmarks of $\geq$ 21 individuals (sample size increases) were classified by these 17 variables. The estimated tiger densities were 4.1 ± 1.1 to 8.3 ± 0.7 in winters and 2.7 ± 0.9 to 5.42 ± 1.5 in summers, and 3.51 ± 1.4 to 4.31 ± 1.6 in post-monsoon seasons.

6. A detailed camera trapping was conducted from November 2007 to June 2011. A total 224 grids were selected based on tiger sign presence. As we had a total of 72 camera traps the study area were divided in to 3 to 4 consecutive trapping blocks and sampling was done systematically in phase manners, each block were sampled continuously for 20 days. During camera trapping the area was divided into blocks, following Karanth and Nichols (2002). Three blocks were combined to form one final matrix, with all animals captured during the survey making up the rows, and the combined 20 sampling occasions making up the columns. The sampling occasions of the blocks were combined so that the first day in all blocks formed occasion number one, the second day in all blocks combined formed the second occasion and so on (Karanth & Nichols 2002). The population estimation ultimately leads to the derivation of estimates of density (D) of tiger for the sampled area. For this purpose population size (N) is divided by the effective sampled area (A(W). Karanth and Nichols (1998) suggested that the minimum sampling area (A) should be calculated directly from the trapping area maps by connecting the outer most trap points and adding the boundary strip (W) around the perimeter to obtain the effective sampled areas (1/2MMDM).
7. A total 10 sampling replicate of Intensive Sampled Area (233 sq km) in three different seasons (four replicate in winters, four in summers, and two in post monsoon) for 540 days (260 day in winter, 200 days in summer and 80 days in post monsoon) amounted 33340 trap nights (15150 in winter, 11620, and 6540 in post monsoon). The intensive monitoring, of trapping stations was done for 20 days in each replicate documented a

total of 1780 tiger photographs (932 in winter, 516 in summer and 332 in post monsoon season).

8. During the study period a total 13 adult female bred in Ranthambhore Tiger Reserve, out of that six females gave birth twice during study period and a total 20 litters were reported and the minimum period between successive birth was ranged from 24 to 48 months (mean birth interval= 33.4 ± 3.8 month, *n* = 7) (Table 8.3). The mean litter size was 2.3 ± 0.12 (*n* =20, range = 1–3). There were 3 cubs per litter given by 35 % (n=7) females, two cubs/litter given by 65 % (n=12) females and 5% female (*n*=1) gave one cub/litter which is minimum litter size reported during study period. Out of 46 cubs born from 20 litters, we knew the sex of 32 cubs littered by 12 breeding females. Sex-ratio was 1.3:1.0 (male: female). Our long term monitoring of population indicates that density ranged from 3.36 per 100 km² (2005) to 9.77/ 100 km² (2007). Density of adult males (>36 month) appears to increase, through significantly, from 0.87 animal per 100 km² in 2005 to 2.38 animal per 100 km² in 2010, while during this period density of adult female (>36 month) remain constant between 3.4 per100 km² to 3.30 per 100 km². The density of sub-adults tigers (male and females, age 12 to 36 months) appears to be constant, sub-adult male density was 0.85 per 100 km² in 2006 and 1.0 per100 km² in 2009, and female was 1.13 in 2006 to 1.19 in 2009.

9. Information on population demographic such as survival rate and sex ratios studies needed to understand social structure is lacking for Bengal tiger, therefore it is proposed for a need to collect information for their population for a period of another four year to get such information for 10 years which is needed for understand population

demographic processes and use of species by tiger individuals in respect to their social relationship.