Monitoring of Gir

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

RR-04/002

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Foreword

We live with hope that society will realize the devastating effect human civilization is having on our planet and that it will reconsider it's consumptive lifestyles. At the rate the human population is expanding and increasingly exerting pressure on the remnants of once flourishing ecosystems, this change of attitude, let alone its implementation, does not seem to be one that will happen in our lifetimes. The only place where nature will be relegated to survive, if at all, will be in protected areas. We, as the custodians of the natural wonders of the planet would have failed in our moral obligation if we do not take a stock of what we have today and what is happening to it. Monitoring of protected areas; their flora, fauna, and life sustaining processes needs to become an integral part of the management activity and plan.

It is essential that the monitoring of wildlife resources and ecosystem processes is done in a systematic and scientific manner keeping in mind the stochastic and dynamic nature of natural systems. It is imperative that the data generated are amiable for scientific trend analysis and comparison over time. Protocols developed should meet the scientific vigor yet not be too complex so as to become impractical. This is especially true in the Indian context where, primarily, monitoring of wildlife would be undertaken by the Forest Department personnel. This does not mean that the role of wildlife scientists and universities be undermined in shouldering this responsibility. I am glad to see that the monitoring protocols for the Gir Protected area and its major fauna presented in this report recognize this. For a monitoring program to succeed the strengths of various institutions and agencies need to be drawn together. The true value of any monitoring methodology can only be appreciated when it is practiced over a length of time. The Gir Protected Area management is renowned for its modern approach and scientific outlook. This report is a product of this farsightedness the park management has shown in formally allocating resources under the India Ecodevelopment Project funding of the Global Environmental Facility to the Wildlife Institute of India for undertaking this task. I look forward to see the implementation of the majority of the methodologies proposed herein that have been tested with pilot datasets.

S. Singsit
Director, Wildlife Institute of India

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The funding for this project was obtained from the GEF- India Eco-development Project through the Gujarat Forest Department. We are grateful to Shri. S. K. Mukherjee, the then Director of WII for his encouragement and assistance in making this consultancy project a reality. It was his persistence that enabled us to obtain permissions for radio-collaring lions prior to the commencement of the monsoon. We thank Shri V. B. Sawarkar, Director WII for his support. We thank Dr. Sanat Chavan, IFS, Principal Chief Conservator of Forests (retd.) and Shri G. A. Patel, IFS, Chief Wildlife Warden (retd.), Gujarat State during whose tenure majority of the work for this project was done, for their support and encouragement.

Shri Bharat Pathak, IFS, CF Junagadh has been the major person from GFD responsible for helping shape the project, see it through the development phase, and making it a reality. It has primarily been his vision in understanding the need of developing a long-term monitoring protocol for the various ecological parameters and impact of management activities on the Gir P.A. We acknowledge his inputs and interests into this consultancy with a feeling of gratitude.

Shri B. P. Pati, IFS, DCF Sasan has played a significant role in helping with the nitty-gritty of project, implementation of the methodologies and assistance with the day to day functioning of the project. Several times the research team and the consultants have knocked on his door at odd hours for assistance with some logistic problems or the other. His enthusiasm in providing assistance, especially for radio-collaring lions, and being a perfect host for the research team is greatly appreciated. Shri Mahesh Singh's support and understanding has been helpful on several occasions when dealing with unconventional objectives and procedures in the field.

The assistance and hospitality provided by Shri K. S. Randhawa, IFS, DCF Dhari with his personal involvement and enthusiasm resulted in an increased motivation amongst our research team and the staff of Hadala range. His interactions and inputs with the consultants, researchers, and his hospitality are acknowledged.

Shri Ram Kumar, IFS, DCF, Gir West Division Junagadh, made available the resources of the GFD including full cooperation of his staff for the smooth conduct of the field activities. Shri Amit Kumar Saxena, DCF Dhari, assisted with accommodation and facilitated work in Gir East. Shri P. P. Raval, DCF Sasan, who was associated with the project towards the end of the tenure, took time to understand the importance of the various components and extended a helping hand for all field activities in their final fieldwork stages. It is his patience that has enabled to compile and analyze the large dataset collected to develop meaningful protocols for monitoring in Gir and put them together in this report.

The timely assistance of Drs. R. K. Hirapara and Bhuva for anesthetizing lionesses is acknowledged with gratitude. The M.Sc. students of WII (2001-2002 batch) collected data on various aspects of the vegetation and ungulate components of this study as a part of their Techniques Tour. Priya and Bindu spent a greater part of their vacation helping collect data on various aspects of the project, we are grateful to them both. Inputs, insights, for selecting the initial sites for radio-collaring by Shri R. D. Jhala, DSP (retd.) is greatly appreciated. Assistance provided by Mrs. R. Y. Jhala in photographing and video-documentation of the radio-collaring exercise is acknowledged.

We gratefully acknowledge the assistance provided by the staff of Gir Protected Area throughout the course of the study without their support it would have been impossible to achieve so much. Naming all individuals that provided assistance from the department would be impossible, however, we specifically acknowledge the help provided by Shri V. S. Patel, ACF Sasan, S. Shrivastava, ACF Talala, . Shir Parmar ACF Banej, Shri V. J. Rana, ACF Sasan, Shri Parmar ACF Talala, G. H. Desai, RFO Sasan Guest House, A. J. Makrani, RFO Hadala Range, Shri B. J. Vadher, RFO Jasadhar, Shri Khimania RFO Hadala, Shri Waghela RFO and Shri Thakkar, RFO Chodawadi.

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CHAPTER – 1

INTRODUCTION

The eco-development projects were conceived primarily to reduce the negative impact of human settlements on protected area (PA) to save the bio-diversity value of these ecosystems (India Eco-development Project 1996). Gir is the only remaining habitat of the Asiatic lion (*Panthera leo persica*). For this reason the monitoring scheme developed for Gir would differ slightly from those developed for PA's valued as centers of endemism and for their species richness. Monitoring scheme for Gir would need to concentrate on indicators that permit Protected Area managers to keep the pulse of the lion population.

Monitoring is a process, not a result, a means to an end rather than an end in itself. Implicit in the rationale for monitoring activities is a recognition of the potential for change. One is concerned, therefore, to device a means of detecting that a change has occurred, of establishing its direction and of measuring its extent or intensity. This stage is the simpler part of the monitoring process. Often it is more difficult to assess the biological significance of the change (Hellawell 1991).

Identifying precise objectives and purpose for any monitoring program cannot be overemphasized. When implementing monitoring with only a vague idea of what the purpose is, one can only hope that after the data have been subjected to elaborate statistical analyses, something will turn up. It is often argued that the collection of all and any data which might be potentially useful in the future is justifiable. Yet hindsight is no substitute for foresight. In most instances, the cost of collecting all possibly relevant data now, in case it proved useful in the future, would be prohibitively high. There has been considerable amount of field data recording of wildlife in protected areas over the past three decades. There are annual reports, species lists, census records, weather records, water quality, soil temperatures, details of habitat management, and all kinds of information. But most of it tells us only that lots of people are keeping lots of records: often for no good reason, using inconsistent and unreliable methods, and producing vast quantities of un-analysed, and often unanalysable, data. It becomes a nightmare collating existing data and trying to make useful sense or comparisons from them since critical information like survey efforts, biases in the methods used, etc are never recorded (Roberts 1991).

To assess the success and limitations of any activity it is imperative that the impact of the activity is monitored on the response parameter, in this case on a) the bio-diversity of Gir (and in particular the lion population), b) the dependency and attitudes of the local communities and c) indirect indices that correlate well with ecological condition.

A common concern in monitoring programs is the establishment of ‘baselines’, a term which has acquired a variety of meanings, including the condition which prevails when monitoring begins, and the basis from which all future change is assessed. In the case of assessing impacts of an activity it becomes essential to have a baseline for the parameter being assessed. Thus, monitoring should ideally commence much prior to the activity whose impact needs to be assessed and monitored. The monitoring process though appearing simple, is inherently complex, since it is not the change but the significance of the change that is of ecological relevance. To evaluate significance of change within the desired framework of objectives, it is essential to establish sound aspatial and spatial methods of data collection, storage and analysis.

There are four basic questions that need to be asked and answered for any monitoring program. Each question is important and should be answered before any monitoring begins; they essentially form a sequential set because a satisfactory answer to any individual question cannot be given until all questions higher on the list have been answered. The questions are:

1. **Purpose** : what is the aim of monitoring?
2. **Method** : how can this aim be achieved?
3. **Analysis** : how are the data to be handled and analysed ?
4. **Interpretation** : what might the data mean?

It has been the mandate of the Wildlife Institute of India to promote the cause of conservation through scientifically informed strategies. In accordance to this mandate we have utilized the opportunity through this consultancy project of developing, testing and commencing long- term monitoring schemes for the Gir Ecosystem and attempt to transfer the know-how for this monitoring to the park managers. This project would be a step towards capacity building of the PA management by acquisition of appropriate equipment and training in ecological, sociological and institutional monitoring. We believe that by undertaking this task in the above manner we would contribute more towards the long-term conservation of the Gir ecosystem which has been the ultimate objective of the India Eco-development project.

Although Gir ecosystem supports, large quantity and good quality palatable grass species, which are being made use of by the wild herbivores and the livestock. Yet the cumulative effect of continuous grazing, fire, illegal activities etc. is believed to have resulted in loss of productivity and degradation. Effort by the State Forest Department has been made to protect these areas by taking protective legal measures and also by adopting sound management strategy. In order to achieve the objectives mentioned above a better understanding of relevant issues is necessary for biodiversity conservation and ecodevelopment. Although individuals and organizations have carried out research in the past and Protected Area management also does monitoring of animal health, population estimation, protection aspects, etc., yet there is an urgent need to conduct systematic, scientifically well designed and planned monitoring and research.

In the chapters that follow we attempt to answer the four basic questions and develop a monitoring program for Gir that encompasses a) Management activity and abiotic factors, b) Carnivores, c) Ungulates, d) Vegetation and Habitat. We have attempted to transfer this monitoring methodology to the Protected Area management staff in the form of designed protocol and training through field data collection. However we feel that formal training by WII in the form of a 10 day to 2 week workshop targeted for 12-15 select motivated staff given the responsibility to carry out monitoring exercises would be extremely useful. Simultaneously a days seminar with senior level Gujarat Forest Department officials and Gir Protected Area Managers for presenting and discussing the protocols proposed in this report would be beneficial in conveying the logic, appropriateness and their usefulness.

We caution that though the consultants have striven to make the protocols as simple as possible so that they are easy to comprehend and implement, there are no short cuts to good science. It would be prudent to involve professional wildlife scientists for conducting, and especially analyzing and interpreting data obtained through many of the monitoring exercises.

The monitoring program developed herein differs from the typical text book approach in the sense that we have designed protocols, collected preliminary pilot data on many of the components, analysed it and shown its merits and pointed to their shortfalls. The efforts made herein have to be viewed in the context of the short timeframe duration of this consultancy. Since data for monitoring take time (several annual cycles) to accumulate, it would be impossible to go through all the stages for all parameters proposed in this report. In such cases we have drawn on our experiences elsewhere and on published literature form other parts of the world.

We do not profess that the monitoring program proposed herein is all encompassing. There are aspects of monitoring that we have not covered in this project by design. These include monitoring diseases and health of wildlife and domestic livestock in and around the protected area, monitoring social attitudes of stake holders monitoring poaching pressures, monitoring fires, and lastly landscape level monitoring and planning. The above aspects were either covered by some other consultancies or addressed by the Protected Area Management. However, their exclusion from this report should not undermine their importance for the continued conservation of Gir.

1.1 STUDY AREA

The Gir Protected Area (21° 55' to 21° 20'N and 70° 25' to 71° 15') is a large compact block of dry deciduous forest with rich biodiversity and several endangered species. The Gir PA has an area of 1412.13 km^2: National Park comprises of 259 km^2 and Sanctuary an area of 1154 km^2, the rest of the area falls under protected and unclassed forests. The unclassed forests occur in patches whose corridors with the Sanctuary have almost been lost to agriculture and human settlements. However, these patches constitute part of lion habitat and have enabled the establishment of four satellite populations outside the Sanctuary (Johnsingh et al 1998).

Rugged hilly terrain of Gir forms catchment of seven perennial rivers and provides a variety of habitat from riverine forests to open grassland and shrubland that provide shelter to numerous birds and animals. Four major reservoirs contribute to agricultural development in the P.A. environs.

The Gir has dry deciduous forest – 5A/C1b of Champion & Seth (1968) classification, with west Gir dominated by *Tectona grandis* and east Gir dominated by *Anogeissus pendula*, *Acacia* and *Zizyphus.* Fifteen vegetation associations and twelve habitat types have been classified in Gir (Sharma & Johnsingh 1996). The present study has merged the vegetation types to five broad categories namely: Moist Mixed, Mixed, Thorn, and Hill forest (see chapter 2, and Figure1&3). Since the target indicators for monitoring are likely to respond at this level of vegetation resolution.

However, the protected area is subjected to tremendous biotic pressure from the 97 peripheral revenue villages having human population of approximately 1,50,000 and cattle population 95,000. In addition there are 54 pastoral settlements (*Nesses*) of *Maldharis* having human population of 2,540 and cattle population of 9811 and 14 forest settlement villages having 4,500 human and 4,200 livestock population.

1.2 OBJECTIVES

After much deliberation between the various consultants, PA management officials, and literature review the following objectives were delineated for the consultancy project.

1) To evaluate and monitor impact of management activity of Eco-development project on ecological indicators.
2) To develop, demonstrate and implement an Ecological Monitoring program for Gir PA that includes monitoring:

- Carnivores,
- Herbivores,
- Vegetation and Habitat
- To transfer this monitoring technology to the PA management staff in the form of designed protocol and training through field data collection

1.3 TEAM COMPOSITION OF CONSULTANTS AND RESEARCH STAFF

Select faculty of the Wildlife Institute of India, having expertise in the various components of the project, were team members (Table 1). Nine of the ten consultants visited the field site and many of them on more than one occasion. The total man days spent in the field by the consultants was just over 200, an equal amount of time was spent by the consultants for data analysis, development of protocols, GIS maps, and reports. The details of the personnel employed by the project for field coordination, data collection, and assisting with report preparation are provided in Table 2.

Table 1:Composition of the Team Personnel and the task which would be assigned to each member

	Name	Position	Task Assignment
1.	Mr. S. K. Mukherjee	Consultant & Task Advisor	Oversee task implementation facilitation, linkages with Gir PA, technical inputs on impact monitoring
2.	Dr. Y. V. Jhala	Consultant, Team Co-ordinator	Coordinate the various aspects of Ecological monitoring (carnivores, ungulates and vegetation). Develop and implement population and telemetry monitoring for lions . Statistical inputs on data collection protocol and analysis.
3.	Dr. P. K. Mathur	Consultant	Co-ordinate the activity of the team, and assess the impact of Management activities within the PA.
4.	Dr.A.J.T.Johnsingh	Consultant	Impact on & monitoring of smaller carnivores.
5.	Dr. Ravi Chellam	Consultant	Monitor and assess impacts of conflicts between carnivores, ungulates and local human population.
6.	Dr. V. B. Mathur	Consultant	GIS application, assessing management input impacts and monitoring.
7.	Mr. Qamar Qureshi	Consultant	Acquisition of satellite imageries, topo-sheets, analysis of Remote Sensing data, statistical inputs on data collection protocol and analysis. Vegetation and Ungulate monitoring.
9.	Dr. S. P. Goyal	Consultant	Monitoring of and impact on Ungulates.
10.	Dr. K. Sankar	Consultant	Monitoring of and impact on birds, and other species.

Table 2 : Composition and tenure of the field team.

Name	Position	Tenure
Dr Nita Shah	Research Scientist	March 01 – April 02
Mr. Shomen Mukherjee	Research Biologist	March 01 –August 02
Mr Chirtranjan Dave	Research Biologist	March 01 – March 02
Mr. Katikeya Singh Chauhan	Part-time Research Biologist	Intermittantly for entire Duration of the Project
Mr. Yogendra Jhala	Research Biologist	April 02 – July 02

1.4 SCHEDULE

The contract for the project was signed on February 20, 2001 and field work commenced in March 2001. The original schedule of the project was for 16 months, however, WII requested a no cost extension for 2 months one month for extending fieldwork (July 2002) and one for completing the report. The inception report of the project was submitted on March 28, 2001, first six monthly progress report in September 2001, and second six monthly report in March 2002. The Final Draft report is being submitted in the first week of October 2002. We had been waiting to receive digital satellite data from Gujarat Forest Department obtained in another consultancy project so as to avoid duplication of effort and expenses. However, it was only in June 2002 that we realized that this data would not be available. It has taken us time to get and analyze satellite data for developing and demonstrating monitoring of vegetation and habitats using satellite imageries and GIS. This task delayed the submission of our Final Draft Report.

CHAPTER - 2

VEGATATION AND HABITAT MONITORING

Qamar Qureshi & Nita Shah

2.1 INTRODUCTION

Vegetation is one of the fundamental classes of natural resources. Two major goals of any comprehensive habitat monitoring programme are a) to characterize the vegetation of the region being monitored b) incorporate a procedure for periodic vegetation surveillance. Plant community broadly represents the prevailing biotic and abiotic conditions. The vegetation community of a region acts as an ecological integrate (and indicator) of all aspects of environment (with varying degree of sensitivity) which if ecologically interpreted can serve as a record of the past and a window to the future.

The remote sensing data is widely used in vegetation mapping, management planning, change detection, planning monitoring strategies and a lot more (depending on management priorities). The utility and cost effectiveness of remote sensing data can simply be assessed in comparison to other data collection procedures, their cost and temporal resolution. The digital remote sensing data will be cheaper and less time consuming to procure and interpret, but it will have low spatial and yet high temporal resolution. The ground data will have high spatial but low temporal resolution and require more manpower. The limitation of remote sensing technology should be kept in mind while deciding upon its utility.

The vegetation study was done at two levels a) low resolution classification of remotely sensed data b) semi-quantitative and quantitative ground truth data which was of high resolution. Fifteen vegetation associations (Sharma et. al. 1999) and twelve habitat types were identified in Gir, (Sharma &. Johnsingh 1996, Khan et al 1990). At a coarser resolution, a level for studying the response of ungulates to habitats these categories were clubbed into three habitat types.

A broad level vegetation and habitat map was generated based on 1995 LISS II data (Sharma et al 1999) for establishing sampling protocols for the various components of this study. Permanent monitoring plots were identified in different habitat types and mapped (Chapter 10, Fig. 1). Three major tasks had been identified for vegetation monitoring in Gir:

a) Monitoring long-term trends in vegetation
b) Monitoring habitat for domestic and wild ungulates.
c) Mapping vegetation and administrative themes.

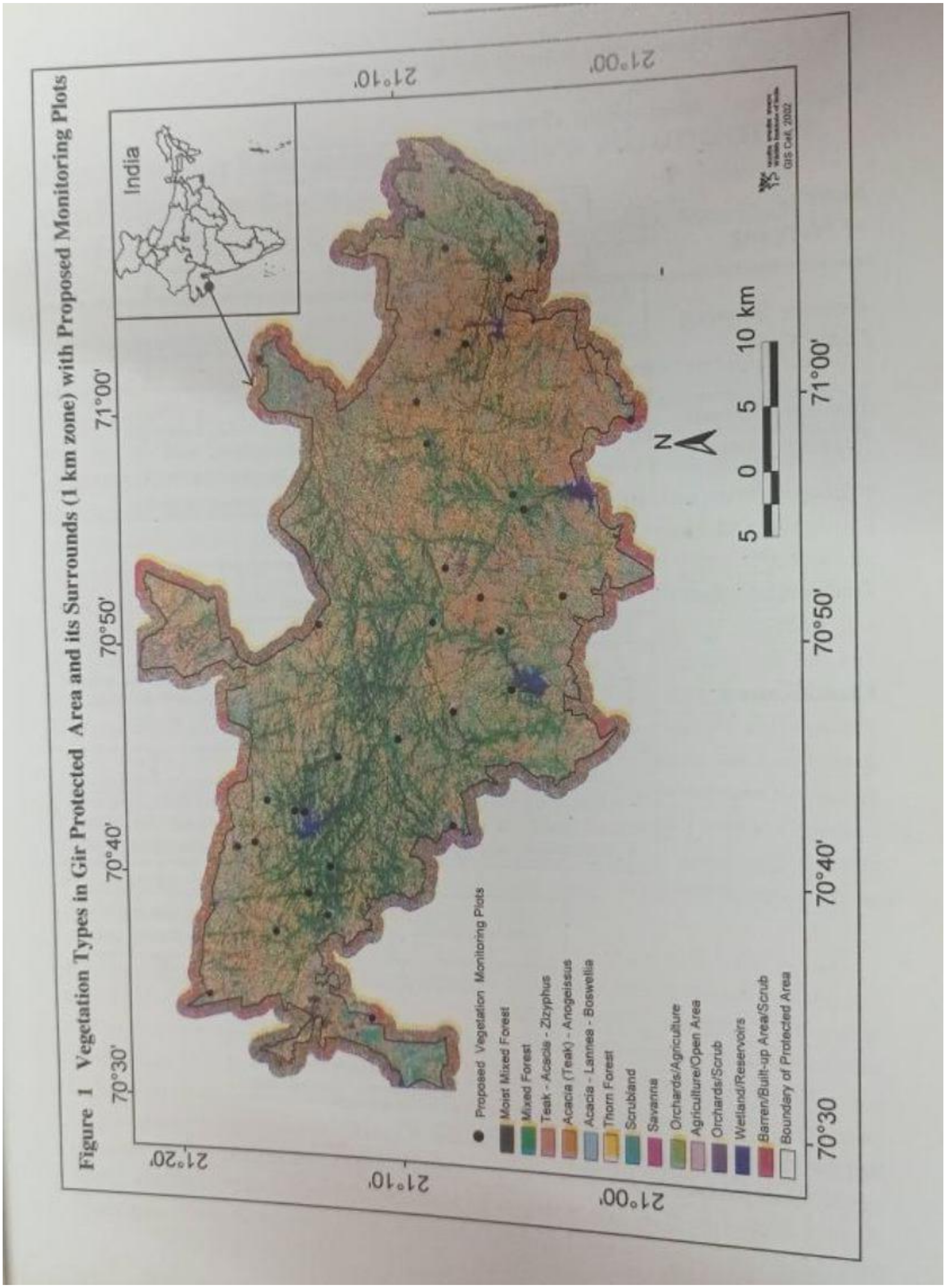


Figure 1 Vegetation Types in Gir Protected Area and its Surrounds (1 km zone) with Proposed Monitoring Plots
India
70°30'
70°40'
70°50'
71°00'
21°20'
21°10'
21°00'
N
5 0 5 10 km
Proposed Vegetation Monitoring Plots
Moist Mixed Forest
Mixed Forest
Teak - Acacia - Zizyphus
Acacia (Teak) - Anogeissus
Acacia - Lannea - Boswellia
Thorn Forest
Scrubland
Savanna
Orchards/Agriculture
Agriculture/Open Area
Orchards/Scrub
Wetland/Reservoirs
Barren/Built-up Area/Scrub
Boundary of Protected Area
GIS Cell, 2002

The objectives mentioned above were assessed as follows:

1) **Laying permanent plots in different habitat types**. Sampling plots were permanently marked on transects and geographical co-ordinates of each sampling unit was recorded. In every sampling unit circular plots were laid to enumerate trees, shrubs and ground cover in 10m, 5m, and 1m radius plots respectively. metre radius plots.

   The parameters recorded in the tree plots were species abundance, girth, height, canopy cover, phenology, signs of cutting /lopping. Information for shrub plots collected was on abundance, height of shrubs, cutting/lopping, indirect evidences of domestic/wild ungulates regeneration of tree/shrubs was recorded. Parameters for herbaceous vegetation was occurrence (percent) of species and weed cover was noted.

   These plots should be monitored on a regular basis i.e every three years during September and October (Chapter 10) on a prescribed pro-forma to assess vegetation trends (Appendix 2, 24, 25 & 26)

2) **Vegetation Mapping and Monitoring**: A Broad level vegetation and habitat map was generated based on 1995 LISS II data (Sharma et al 1999) and established sampling protocols for the various components of this study. Permanent monitoring plots were identified, quantified and mapped (Fig 1.). Over 400 vegetation plots were ground truthed using semi-quantitative Releve method and plots for mapping. Remote sensing data of IRS 1D - LISS III scenes 91-57 (22/Nov/2001) and 92-57 (19/Nov/2001) were procured from National Remote Sensing Agency, Hyderabad.

   The Maps of Gir Protected Area were digitized at 1:50,000 scale which were procured from Survey of India (SOI) and Gir Management (Table 3). We have used LISS III digital data for mapping vegetation types. Remotely sensed digital data was georectified with toposheets (SOI, 1974), total positional error was estimated to be 15 meter (Table 3). We have used hybrid classification technique to classify remote sensing data into different vegetation classes.

Table 3 : The details of Digital remote sensing data used for vegetation mapping

Satellite ID and Sensor	Indian Remote Sensing Satellite IRS- 1D, LISS III
Scene ID's- Path-Row	91-57 and 92-57
Number of Bands	4
Band Wavelength (nm)	Green=520-590, Red=620-680, Near Infrared=770-860 and Shortwave Infrared=1550-1750
Date of Aquisation	22nd Nov 2001 and 19th Nov 2001
Georectification –Source data and Positional Error	SOI, Topograhic data and 15 meter
Projection, Datum and Spheroid	Polyconic, Everest
Number of Classes Mapped at Broad and Fine Scale	5 and 10 classes
Overall Accuracy at Broad and Fine scale	90 - 95% and 70 - 90 %

Gir vegetation was classified into three broad classes namely Moist Mixed Vegetation, Thorn Forest and Hill Forest which were further divided into eight types (Table 4, Figure 1). The monitoring of ungulates and vegetation has been designed on the basis of these three classes of vegetation types. These would provide the changing trends for better understanding and implementation of actions for the management if periodically monitored as prescribed in this chapter. The three broad vegetation classes are as follows:

I) Moist Mixed Vegetation

a) **Moist Mixed Forest** : The dominant species in the **west** was characterised by ***Tectona grandis*** which was displaced by ***Anogiessus spp*** and ***Acacia*** **spp**. in **east** and to larger extent in Central Gir. The species associated with the dominant species were *Acacia spp., Wrightia tinctoria, Syzygium spp., Mitrragyna parviflora, Bauhinia racimosa, Diospyro melanoxylon and Emblica officinalis.* The under storey comprised of *Acacia spp., Zizyphus spp., Grewia tiliaefolia, Helecters isora, carissa carandas, Manilkara hexandra and Ixora arborea.*

b) **Mixed Forest** : The dominant species in the **west** was characterised by ***Tectona grandis*** which was displaced by ***Anogiessus spp*** and ***Acacia*** **spp**. in **east** and to larger extent in Central Gir. The associates of the dominant species were *Diospyro melanoxylon., Garuga pinnata, Gmelina arborea and Mallotus phillipensis*. The understorey is composed of *Zizyphus spp., Wrightia tinctoria, Acacia spp., Grewia tiliaefolia, Helecters isora,Carissa carandas, Manilkara hexandra and Caparis sepiaria.*

II) Thorn Forest

a) **Teak** in west (displaced by *Anogeissus* spp in the east)- ***Acacia - Zizyphus*** association : The co- associates were *Acacia* spp. *T. grandis* (replaced by *Anogeissus* spp in East and to larger extent in Central Gir) , *Zizyphus spp and Terminalia* spp. the understorey had C. *carandas, C. sepiaria* and *Zizyphus* spp.

b) ***Acacia* spp - *Zizyphus* spp Thorn forest** association : The *Acacia* spp and *Zizyphus* spp characterise this association with co-associates like *C. sepiaria* and *C. carandas.*

c) **Scrubland** : This association was characterised by patchy and stunted growth of scrub species like *A. catechu, A. leucophloea, Zizyphus numularia* with co- associates as stunted *Zizyphus* species, C. sepiaria and *Balanites aegyptica*.

d) **Savanna** : Had scattered growth of trees like, *Acacia* spp. *Zizyphus* spp., *T. crenulata, B. racemosa, T. grandis Anogeissus* spp, *Boswelia serrata* and *Balanites aegyptica*. The grasses like *Apluda mutica , Heteropogon contotus, Themeda quadrivalvis* and *Sehima nervosum* formed the ground layer.

III) Hill Forest

a) ***Acacia – Anogeissus (Teak displaces Anogeissus in West Gir)*** : The co- associated species were *Acacia* spp., *Anogeissus latifolia, Terminalia spp, W. tinctoria, G. tiliaefolia,Boswellia Serrata,, Flacourtia indica, B. racemosa* and *Zizyphus* spp.

b) ***Acacia – Lannea – Boswellia***: The association is characterised by *Acacia spp., Lannea coromandelica, B. serrata, T. grandis, T. crenulata, W. tintoria, Soyamida febrifuga* and *Stercula urens*.

Apart from natural vegetation the water bodies (reservoirs, rivers, ponds & lakes) within and and around protected area were mapped. The agriculture, orchards and natural vegetation within one kilometer buffer around Gir PA was also mapped (Table 4)

2.2. RESOURCE MAPPING

Four layers were digitized at 1:50,000 from survey of India maps (SOI, 1974) and maps of Forest Department. Gir (Appendix 1). The maps are

1) Boundary
2) Block
3) Drainage

The vegetation in Gir is largely influenced by natural calamities like droughts and cyclones and man induced effects of grazing and fire, vegetation monitoring should address some of these issues. The Remote sensing based monitoring should be done at an interval of three years (Fig 2). Expert opinion and park management will decide the need of mapping in case of any catastrophe. Mapping at 1:50,000 scale is appropriate for monitoring trends and changes at a broad scale. If management is interested in landuse pattern changes around Gir and encroachment by agriculture or mining then 1:25,000 scale maps will be more appropriate. This requires more intensive ground- work and use of different digital data. (Fig 2, Table 5) .

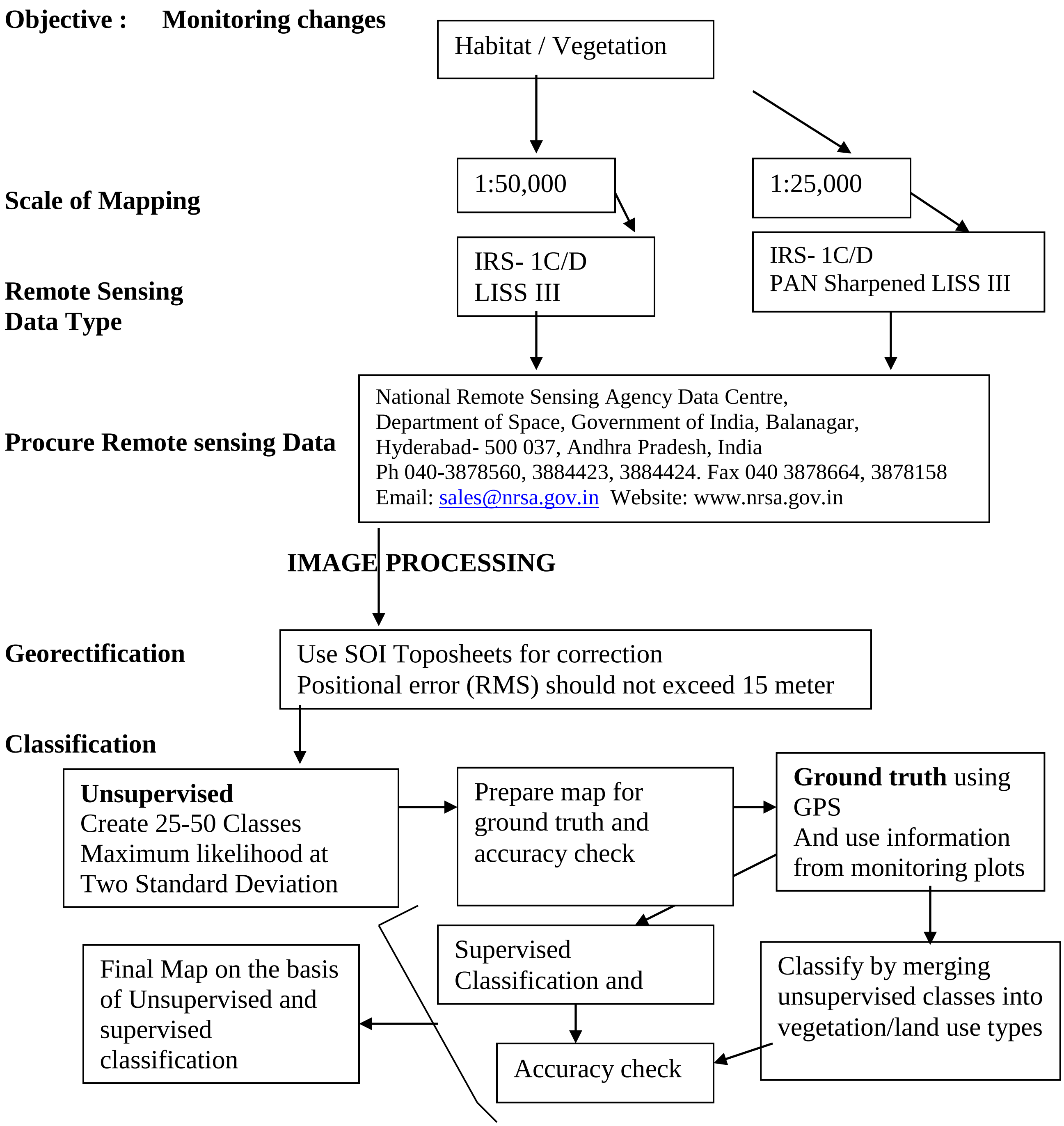
Table 4: The percent contribution vegetation types (or land use) in Gir Protected Area

Vegetation Type	Percent Area
Wetland	0.69
Moist Mixed Forest	12.76
Mixed Forest	16.95
Teak - Acacia - Zizyphus	29.71
Acacia (Teak) - Anogeissus	13.48
Acacia - Lannea - Boswelia	12.54
Thorn Forest	7.73
Scrublands	4.48
Savanna	1.38
Agriculture/Open Area	0.29

Table 5: The percent area under different land use category around one kilometer zone of Gir Protected Area

Land Use Classes	Percent Area
Wetland	0.51
Acacia (Teak) Zizyphus	3.09
Orchards/Scrub	18.56
Orchards/Agriculture	40.70
Agriculture	21.19
Barren/Built-up Area/Scrub	15.95

Fig - 2. The Monitoring Scheme for Gir Vegetation



Step II) Repeat Process of Step I every THREE YEARS

Compare Changes if any with previous Vegetation map

CHAPTER - 3

MONITORING UNGULATES
RELATIVE ABUNDANCE AND DENSITY ESTIMATION

S.P. Goyal, Shomen Mukherjee, Qamar Qureshi, K. Sankar, Nita Shah, Chitaranjan Dave & Yogendra S. Jhala

3.1 INTRODUCTION

Ungulates form the major bulk of the primary consumers on which several components of the ecosystem depend. Realizing their importance to Carnivores that are on the top of the food chain, a need of proper protocols for monitoring wild herbivore population has been an important concern for all protected areas throughout the world. Such information along with information on predator populations enables understanding of Predator-Prey relationship as exemplified Kanha National Park (Schaller, 1967), Nagarahole National Park (Karanth & Sunquist, 1995), Pench Tiger Reserve (Biswas and Sankar, 2002) and Ranthambore National Park (Bagchi et al., 2002). During the last decade, strong emphasis has been made that ecological monitoring should be a vital component for any conservation project which would enable managers to assess the effects of management (Kremen *et al*., 1994). This is reflected in most of the current management plans for conservation areas have special emphasis on monitoring ecological parameters. A major concern to define the limits of acceptable change beyond which management action should intervene (Alexander, 1996). However, the question remains whether our survey techniques are sufficiently sensitive to detect such changes or to determine errors in our estimates which would result in erroneous decisions for conservation management (Plumtre, 2000).

Relative abundance and population estimation of animals have been one of the key issues for most wildlife managers. Better management of prey-predator relationship in Gir Conservation Unit (GCU) requires a thorough understanding of the distribution and abundance of wild prey population and factors responsible for their fluctuations. This stresses, a need of sound monitoring protocols for estimating prey population abundances. Direct count on line or vehicle transects and indirect methods such as track index; pellet counts have been widely employed for estimating spatial distribution and relative abundance of ungulate species (Seidensticker, 1976; Dinerstein, 1980; Khan *et al*., 1996; Singh *et al*., 2002). Distance sampling has become much more popular during last two decades for estimating animal population densities since the easy availability of the computer packages “TRANSECT” (Laake *et al*., 1979) and subsequently “DISTANCE” (Buckland *et al*., 1993; Laake *et al*., 1994).

We attempted to address related issues for monitoring ungulate populations by using "Line Transect" as well as "Vehcile Transects" which are considered to be most simple, unbiased and robust methods for estimating ungulate abundance (Laake *et al*., 1993) in comparison to various other methods such as water hole, track and pellet group counts. Among various methods employed for population estimation, accuracy and precision are both important for good survey estimates without which comparison over time or between area is difficult (*Gill et al*., 1983; Plumtre, 2000). Major wild prey species for Asiatic lion in GCU are chital (*Axis axis*), sambar (*Cervus unicoolor*) and nilgai (*Bosalephas tragocamlus*). In addition, domestic buffalo and cattle reside inside GCU also form a considerable proportion of diet of Asiatic lion. Therefore, we envisaged to concentrate our efforts for preparing protocols for major prey species and determine relative abundance of other ungulates of GCU such as chinakra (*Gazella benneti*) and chowsingha (*Tetracerus quadricornis*) as well as other species recorded on line transect.

3.2. SCOPE OF THE TASK

We proposed to provide suitable protocols based on data collected during study period for monitoring prey species in view of long-term management goals of the GCU.

3.3 APPROACH

Sub-Task consultants Dr. S.P. Goyal, Dr. K. Sankar and Mr. Qamar Qureshi visited Gir during study period for preliminary assessment and designing proper approach for this component.

3.3.1. Line Transect

Based on heterogeneity of vegetation and terrain features, nine transects were laid in various habitats (Fig. 3) to prepare a monitoring protocol for animal abundance (Table 6) and were marked at every 100 m to quantify habitat variables. During early phase of the study, reconnaissance was done by walking each transect at least three times to plan systematic sampling and preparing proper approach for estimating animal densities subsequently. For line transect method, we recorded data on species, group size, angular sighting distance at the center of group using "Laser Range Finder" and sighting angle by compass on data sheet for each animal sighting on the transect.

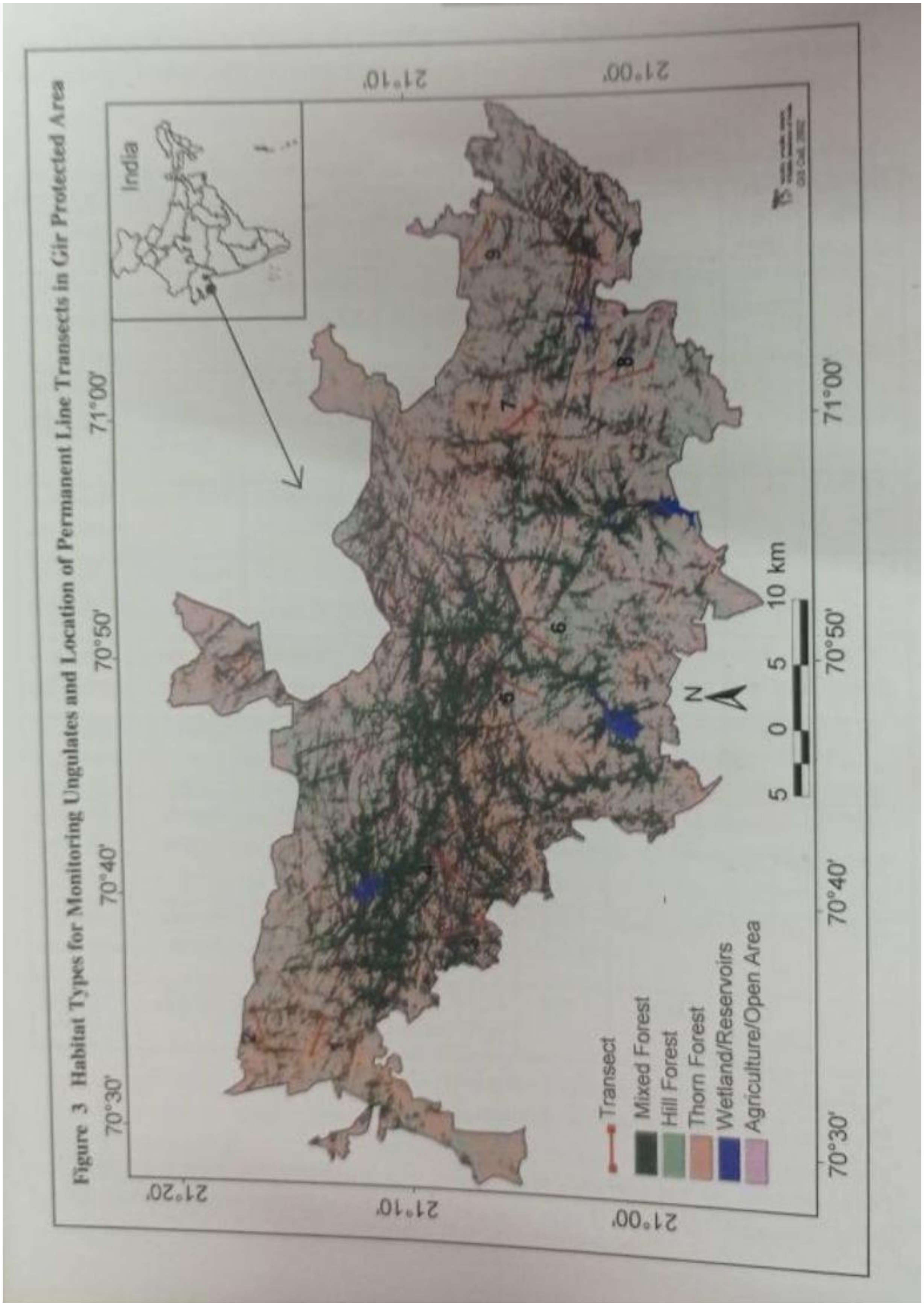


Figure 3 Habitat Types for Monitoring Ungulates and Location of Permanent Line Transects in Gir Protected Area

Table 6. Location of transects in relation to vegetation and terrain features

Transect No.	Total length (km)	Name	Bearing	GPS location		Vegetation type	Terrain category
				Start	**End**		
T1*	3	Paravia-Khada	290	21° 13'35.2" 70° 34 45.6"	21° 14' 07.7" 70° 33' 10.4"	Thorn-*Boswellia Forest*	Highly undulating
T2*	3	Dedakari-Kheramba	255	21° 16' 23.7" 70° 34' 53.8"	21° 15' 59.45" 70° 33' 13.7"	*Acacia-Anogiessus-Boswellia*	Moderately undulating
T3*	3.1	Amrutvel	340	21° 07' 07.9" 70° 38' 58.2"	21° 08' 46.7" 70° 38' 20.2"	Teak mixed	Moderately undulating
T4**	2.8	Nimma	220	21° 09' 15.2" 70° 42' 0.02"	21° 08' 08.6" 70° 40' 53.1"	Teak mixed	Highly undulating
T5**	3	Gola	202	21° 06' 23.9" 70° 49' 4.58"	21° 04' 54.95" 70° 48' 20.90"	Thorn-*Boswellia*	Slightly undulating
T6**	3	Chhodaudi	200	21° 05' 5.05" 70° 50' 52.7"	21° 04' 04.35" 70° 50' 11.95"	Thorn forest	Relatively flat
T7*	3	Jainagar	134	21° 05' 58.4" 70° 59' 19.6"	21° 4' 39.4" 71° 00' 26.4"	*Boswellia-Lannea*	Slightly undulating to flat
T8*	3	Motamainda	160	21° 01' 42.9" 71° 01' 18.8"	21° 00' 9.5" 71° 01' 50.95"	*Boswellia-Lannea*	Highly undulating
T9*	3	Bhania	340	21° 06' 31.2" 71° 07 '46.6"	21° 07' 30.0" 71° 06' 23.4"	Scrub	Moderately undulating

*** - Transect in Gir Sanctuary**
**** - Transect in Gir National Park**

Data collected on line transects may be analyzed for estimating animal density (D) using "Distance" program (Laake *et al*., 1999) in case sightings are more than forty for a each species in a stratified sampling unit or by using the following formula:

$$D\ (nos./km^2) = \frac{\text{No. of animals seen}}{\text{Total length of transect (km) x 2 x mean PSD (km)}}$$ (Buckland *et al*., 1993).

Group density (GD) of a species may also be calculated as follows:

$$GD\ (Group./km^2) = \frac{\text{No. of group seen}}{\text{Total length of transect (km) x 2 x mean PSD (km)}}$$ (Buckland *et al*., 1993).

Perpendicular Sighting Distance (PDS) = Sin Φ x Angular Sighting Distance

where Φ is the angle between the transect and the center point of the animal group sighted

3.3.2. Vehicle transect (Road sidemonitoring)

Another approach commonly used wherever there is a good road network is monitoring animal abundance using appropriate vehicle (like Open Jeep or Gypsy) on these roads moving with a constant speed not more than of 20 km/ hr. It is an important to have consistency in data collection, e.g. using the same type of vehicle, same speed, same no. of experienced observers etc. so that the data becomes comparable between areas and years. It is important that these aspects of data collection are recorded so as to improve the usefulness of the data for future comparisons. Information was recorded on species, group size, perpendicular sighting distance at the center of group, on data sheet for each animal sighting. Animal density may be calculated using formula as indicated above.

3.3.3. Data collection

Table 7 and Table 8 indicate data collected on Line transects and Vehicle transects during study period from May 2001 to June 2002. Nine line transects marked and cut were monitored during the study period. We also monitored 36 vehicle transects (VT) for ungulate abundance during morning and evening respectively during study period (Table 8).

Table 7. Efforts made on line transects for collecting data during study period during May 2001 to June 2002

Transect No.	Transect length, km	No. of walks	Total efforts	Dates
Summer-1 (May 2001 to June 2001) (Total efforts = 70.7 km)				
T1	3	Three	9	May 2001: 06, 27; June 2001: 03
T2	3	Three	9	May 2001: 27; June 2001: 03, 09
T3	3.1	Three	9.3	June 2001: 04, 10, 26
T4	2.8	Three	7.4	May 2001: 14; June 2001: 06, 08
T5	3	Three	9	May 2001: 08, 11, 31
T6	3	Three	9	May 2001: 16, 31; June 2001: 11
T7	3	Three	9	June 2001: 01, 12, 25
T8	3	Three	9	May 2001: 25, June 2001: 01, 12
T9	-	-	-	-
Winter (October 2001 to January 2002) (Total efforts = 119.7 km)				
T1	3	Five	15	October 2001 : 24; 27; January 2002 : 18; 25 February 2002: 06
T2	3	Five	15	October 2001 : 24; 27; January 2002 : 16; 22; 27
T3	3.1	Five	15.5	October 2001 : 24; 25 ; January 2002 : 14; February 2002: 7; 8
T4	2.8	Four	11.2	October 2001: 25; January 2002 : 17; 24 February 2002: 10
T5	3	Three	9	December 2001: 21; January 2002 : 20 February 2002: 7
T6	3	Four	12	December 2001: 21; February 2002: 8; 9; 10
T7	3	Five	15	October 2001 : 31; November 2001: 01 January 2002 : 29; 30; 31
T8	3	Six	18	October 2001 : 25; 31; November 2001: 1 January 2002 : 29; 30; 31
T9	3	Three	9	February 2002: 1; 2; 3
Summer –2 (April 2002 to June 2002) (Total efforts = 79.7 km)				
T1	3	Three	9	May 2002: 03, 08, 18
T2	3	Three	9	May 2002: 03, 09, 18
T3	3.1	Three	9.3	May 2002: 06, 11, 19
T4	2.8	Three	7.4	May 2002: 07, 12; June 2002: 01
T5	3	Three	9	June 2002: 03, 04,05
T6	3	Three	9	June 2002: 03, 04,05
T7	3	Three	9	April 2002: 08, 12, 27
T8	3	Three	9	April 2002: 07, 11, 27
T9	3	Three	9	April 2002: 06, 09, 28

Table 8. Data collected during roadside count using Vehicle transects (VT)

Date	VT no.	Start Time	End Time	Locality	Total km
11-May-01	VT1	12:00	13:55	Khutni-Raidi-Dudhala- Bhandargala-Dedakari-Jambuthala-Sandiagaoli-Datianess-Visavadar Naka	26.8
11-May-01	VT1	17:32	18:47	Kasia Ness - Piawa - Dhabardhoyo dam-Badak- Jambudi	18.2
11-May-01	VT1	6:20	9:26	Kankai Naka - Ratanguna-Kadeli Ness-Raidi (Naviz) - Paravia-Kerambe-Jadi Saledi-Jini Koidi Andhari-Khutni-Bhambaphod Naka	28.9
11-May-01	VT1	21:16	23:35	Kanki Naka-Ratanguna-Kadeli Ness -Raidi (Navi) - Paravia -Keramba Jadi Saledi -Juni Raidi Andhari-Kutni- Bhamba Phod Naka	28
13-May-01	VT2	6:43	8:03	Kasia Ness - Piawa - Dhabardhayo Dam-Badak-Jambudi	17.8
13-May-01	VT2	12:35	15:10	Kankai Naka - Ratanguna - Kadeli Ness - Raidi (Navi)- Paravia- Kheramba- Jadi Saledi- Juni Raidi Andhari-Kutni - Bhambaphod Naka	
13-May-01	VT2	17:06		Khutni-Raidi-Dudhala-Bhandargala-Dedakari-Jamkuthala-Kasia Ness	
13-May-01	VT2	21:35	22:30	Kasia Ness - Piawa - Dhabardhoya Dam-Badak-Jambudi	
11-May-01	VT3	21:30	0:10	Sapness-Rampari gola-Bhantha	
12-May-01	VT3	21:05	0:20	Route-2 Jamvadla-Batheswar	
13-May-01	VT3	22:30	0:05	Aboot Route-3	
13-May-01	VT4	6:24	7:26	Munda Chowk Board to Shinghoda Dam Board Route-2	2.9
13-May-01	VT4	7:27	9:10	Route-3 Shing Dam Board to Bareing Chowk	
13-May-01	VT4	12:30		Route-1 Biliyat	
13-May-01	VT4	16:07	19:35	Route-2 Janwadla-Ghodi	
13-May-01	VT4	17:34		Route-2 Singhoda Board-Dami	
11-May-01	VT5	17:45	19:26	Route-3 Janvala	19.6
11-May-01	VT5	6:45	10:02	Tar Road Sapness	30
11-May-01	VT5	13:35	16:21	Route -2 Batheshwar-Janvadla-Ghodi	32
12-May-01	VT5	13:15		Singhoda Dam	3
11-May-01	VT5	17:45	19:26	Route-3 Janvala	19.6
12-May-01	VT6	6:40	8:49	Route-2 Dam	31.4
12-May-01	VT6	13:37	14:50	Route 3 Dam Dhabala	16.2
12-May-01	VT6	17:18		Route -1 Sapness	
13-Jan-02	VTW2	7:30	9:30	GIR (West) VARWANGDA	14
6-Jan-02	VTW1	7:30	9:25	GIR (West) Dedakadi Range	8.9
8-Jan-02	VTW3	7:30	8:46	GIR (West) PATNISAR	7.8
24-Jan-02	VTW4	7:35	10:02	GIR (CENTRAL)	12
12-Feb-02	VTW5	7:30	10:08	GIR (CENTRAL)	10.4
11-Feb-02	VTW6	7:30	10:05		10
10-Feb-02	VTW7	7:30	10:50	GIR CENTRAL	10.5
9-Feb-02	VTW8	7:30	10:41	GIR CENTRAL	11.3
29-Jan-01	VTW9	7:30	10:12	EAST GIR	11.6
1-Feb-02	VTW10	7:30	10:22	EAST GIR JASADHAR	10.1
2-Feb-02	VTW11	7:30	10:25	EAST GIR JASADHAR	9.6
30-Jan-02	VTW12	7:30		EAST GIR	13

3.4. ACHIEVEMENTS

Selected nine transects laid across various terrain and vegetation features were walked three to six times during study period from May 2001 to June 2002 covering total 270.1 km (Table9). Of this, 66 per cent of walks were covered during two summers i.e. May-June 2001 (26.2%) and April-June 2002 (29.5%). Table 4 indicates number of animals seen on various transects. Of the 1159 wild animals seen during study period, 72 per cent are contributed from chital where as sambar and langur were 3.5 and 7.1 per cent respectively. Other species were < 2.6 per cent of total animals seen. It indicates that among wild ungulates, there is need to have proper protocols of estimating chital and samabr density, which are major wild prey species of Lion. Other species may be monitored for their changes in their relative abundance except in cases where management specifically needs more precise information on abundance of these species, one would be required to put tremendous efforts to achieve desired accuracy and precision.

Encounter rates (ER) for various species during three sessions of data collection have ranged from 0.01 to 4.5 (Table 10). Chital was the most frequently seen species having a mean ER of 3.2. It appears that nilgai, chinkara and chowsingha occurred at low-density species (ER <0.1 animal/km walk) in GCU. Table 11 shows the overall mean encounter rate along with associated variance for chital. Data indicates that the vegetation types/ structures have strong influence the distribution of chital causing a vast variation in their encounter rates ranging from 0 to 6.2 animals/km walk. Data strongly suggests that there is a need for proper stratification for improving precision of estimate of chital population as well as other species. Based on overall as well as seasonal variance determined on encounter rates across vegetation types strongly suggests that chital distribution is not homogenous within Teak & Mixed Forest category than other types (Table 12). Therefore, one may required to collect relatively large samples to reduce variation by increasing sampling efforts.

Table 9. Number of animals seen on various transects during study period

Species	Animals seen on various transects									Total
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
Distribution of animals during May-June, 2001 (N= 436)										
Effort, km	9	9	9	9.3	7.4	9	9	9	-	70.7
Chital	78	81	89	10	20	12	0	28	-	318
Sambar	3	1	1	6	6	0	2	0	-	19
Nilgai	0	3	0	0	0	0	5	4	-	12
Chinkara	0	0	0	0	0	0	0	2	-	2
Chowsingha	0	0	0	0	1	0	2	0	-	3
Hare	2	1	4	0	0	0	1	7	-	15
Langur	21		17	5	1	6	8		-	58
Wild boar	2	1	0	0	0	0	1	5	-	9
Distribution of animals on transects during October 2001-January 2002 (N= 384)										
Efforts, km	15	15	15.5	11.2	9	12	15	18	9	119.7
Chital	94	35	90	4	17	6	10	36		292
Sambar	3	1		9	3	2	1			19
Nilgai	1						9	1		11
Chinkara							1	12	3	16
Chowsingha							1			1
Hare	3		2					3	1	9
Langur	6	4					10			20
Wild boar	5	4	7							16
Distribution of animals on transects during April-June, 2002 (N= 339)										
Effort, km	9	9	9	9.3	7.4	9	9	9	9	79.7
Chital	33	73	37	13	31	15	7	15		224
Sambar	1		3	11	11	5	3			34
Nilgai	3		1				9	4		17
Chinkara					2		1		3	6
Chowsingha		3			3	1	1			8
Hare		1						4	1	6
Langur							4			4
Wild boar	2	1	7	13	7			10		40

Table 10. Encounter rate (nos/km walk) and percent contribution of each species during study Period

Species	May-June 2001	October 2001-January 2002	April-June 2002	Mean	Number of animals seen (N=1159)	Per cent contribution
Chital	4.50	2.44	2.81	3.2	834.0	72.0
Sambar	0.27	0.16	0.43	0.3	72.0	6.2
Nilgai	0.17	0.09	0.21	0.2	40.0	3.5
Chinkara	0.03	0.13	0.08	0.1	24.0	2.1
Chowsingha	0.04	0.01	0.10	0.1	12.0	1.0
Hare	0.21	0.08	0.08	0.1	30.0	2.6
Langur	0.82	0.17	0.05	0.3	82.0	7.1
Wild boar	0.13	0.13	0.50	0.3	65.0	5.6

Table 11. Overall mean encounter rate of chital and observed variance during study period on various transects.

Transect No.	Mean ER	Variance
T1	6.2	6.253
T2	6.5	13.115
T3	6.6	8.824
T4	0.9	.284
T5	2.9	1.361
T6	1.2	.362
T7	0.4833	.178
T8	2.3	.569
T9	0.0	.000

Table 12. Overall mean encounter rate and variance of chital across vegetation type

Vegetation category	Overall			Combined Summers			Winter		
	N	ER	Variance						
Teak & Mixed Forests (T3-T4)	6	3.7750	13.243	4	4.1200	16.644	2	3.0850	14.851
Thorn forests (T2, T5, T6)	9	3.5244	9.204	6	4.5000	10.935	3	1.5733	.912
Thorn-Hill Forests (T1, T7, T8)	9	2.9822	8.178	6	2.9833	9.661	3	2.9800	8.560

Values in parenthesis are Transect No

Data on variation on ER also suggests that it might be possible to detect changes in ER if it is more than of 10 to 15 per cent in the population by adopting proper monitoring protocols in GCU. In case, changes < 10 per cent in the chital population required to be detected, more transects would be needed.

Important aspects for having precise and accurate ungulate monitoring protocols depend on the encounter rate of groups or separate sightings of individuals seen in particular strata for a species. This would ultimately determine the amount of efforts needed for particular species. Burnham et al. (1980) and Plumptre (2000) suggested 40 and 100 sightings respectively for reliable estimates of population density of a species in a strata. Table 13 indicates that no. groups seen on various transects have ranged from 0 to 1.7/km walk.

Except in areas of relatively high chital abundance, number of group seen/km walk is between 0.2 to 0.5 (Table13). Data analysis of group seen in response to vegetation types indicates that group seen/km walk is between 0.55 to 0.88 with an overall average of 0.7 (Table 14).

Table 13. Sightings of chital group /km walk during study period

T.No.	Summer-1			Winter			Summer-2		
	Sightings of group	Effort	No. groups/km	Sightings of group	Effort	No. groups/km	Sightings of group	Effort	No. groups/km
T1	11	9	1.2	17	15	1.1	10	9	1.1
T2	10	9	1.1	9	15	0.6	15	9	1.7
T3	7	9	0.8	21	15.5	1.4	9	9	1.0
T4	1	9.3	0.1	1	11.2	0.1	3	9.3	0.3
T5	5	7.4	0.7	6	9	0.7	4	7.4	0.5
T6	4	9	0.4	5	12	0.4	3	9	0.3
T7	0	9	0.0	4	15	0.3	2	9	0.2
T8	6	9	0.7	12	18	0.7	3	9	0.3
T9	-	-	-	0	9	0.0	0	9	0.0

Table 14. Sightings of chital group/km walk in relation to vegetation characteristics

Vegetation types	Mean Sighting of chital group/km walk
Teak & Mixed Forests (T3-T4)	0.700
Thorn forests (T2, T5, T6)	0.8778
Thorn-Hill Forests (T1, T7, T8,T9)	0.5545
Over all	0.70

Thus based on initial reconnaissance on group encounter rate/km walk in a particular strata, one can determine the total transect length needed for obtaining minimum forty sightings: as follows:

$$\text{Total transect length needed} = \frac{40}{\text{No. of groups seen/km walk during reconnaissance in a strata}}$$

Based on our past experience, one can easily cover about three km without getting fatigued and within a specified timer interval. Therefore Transect Length should extend more than 3 km as far as possible. Thus no. of transects needed (each of three km) will be as follows:

$$\text{Total no. of transects needed} = \frac{\text{Total transect length needed}}{3}$$

While sampling these transects, we have recorded number of animals seen in a group for each species as well as attempted to classify animals with respect to sex and age structure. Table 15 indicates sex and age structure of nilgai, sambar and chital. It is interesting to note that percent unclassified were in the order of chital >sambar > nilgai (reflecting their group size). Thus we recommend not to spend time in classifying ungulates into age and sex groups while sampling on transects for density estimation. This data should be obtained by an independent survey effort. If we tried to classify these animals on transects and can also cause delay in completing the transects.

Table 16 indicates parameters determined for various species and the density calculated based on "King Census" (Buckland et al., 1993) during the study period. During study period, chital density has ranged between 34.7 and 57.3 animals/km^2 on these transects. Such variations on same transects may be due to temporal variation in resources like food and water or may be some other factors. Average chital density during study period was 47.2 animal/km^2 (Table 17).

Table 15. Variation in group size, sex and age structure of chital, sambar and nilgai during summer counts.

	Transect No.								
Categories	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**Total**
CHITAL									
No. of female	10.0	7.0	10.0		5.0	2.0	0	5.0	39.0
No. male	17.0	10.0	16.0		3.0	2.0	0	5.0	53.0
No. yearling	1.0	5.0	2.0		1.0	2.0	0	1.0	12.0
No. of fawn		4.0	10.0			1.0	0	1.0	16.0
Unknown	50.0	55.0	51.0	10.0	11.0	5.0	0	16.0	198.0
No. of observations	11.0	10.0	7.0	1.0	5.0	4.0	0	6.0	44.0
Total animals seen	78.0	81.0	89.0	10.0	20.0	12.0	0	28.0	318.0
Average group size	7.1	8.1	12.7	10.0	4.0	3.0	0	4.7	7.2
SAMBAR									
No. of female		1.0		2.0	2.0	0		0	5.0
No. male				1.0	1.0	0	1.0	0	3.0
No. yearling				1.0		0		0	1.0
No. of fawn					3.0	0		0	3.0
Unknown	3.0		1.0	2.0		0	1.0	0	7.0
No. of observations	1.0	1.0	1.0	5.0	4.0	0	1.0	0	13.0
Total animals seen	3.0	1.0	1.0	6.0	6.0	0	2.0	0	19.0
Average group size	3.0	1.0	1.0	1.2	1.5	0	2.0	0	1.5
NILGAI									
No. of female	0	1	0	0	0	0	0	3	4
No. male	0	0	0	0	0	0	3	1	4
No. yearling	0	2	0	0	0	0	0	0	2
No. of fawn	0	0	0	0	0	0	2	0	2
Unknown	0	0	0	0	0	0	0	0	0
No. of observations	0	1	0	0	0	0	2	2	5
Total animals seen	0	3	0	0	0	0	5	4	12
Average group size	0	3	0	0	0	0	2.5	2	2.4

Species	Total no. seen	Unknown	Per cent unknown
Chital	318	198	62.3
Sambar	19	7	36.8
Nilgai	12	0	0.0

Table 16. Parameters recorded on transects and density of various species during the study period

Species	Total nos.	No. of sightings	Perpendicular sighting distance (PSD), m	Density, no./km^2
Summer-1 (Total length of transects = 70.7 km)				
Chinkara	2	1	21.4	0.7
Chital	318	44	39.2	57.3
Chowsingha	3	3	98.5	0.2
Nilgai	12	5	56.3	1.5
Sambar	19	13	36.4	3.7
Wild pig	9	5	27.2	2.3
Winter (Total length of transects = 119.7 km)				
Chinkara	16	12	80.8	0.8
Chital	278	69	33.4	34.7
Chowsingha	1	1	10.2	0.4
Nilgai	11	6	78.8	0.6
Sambar	20	14	29.5	2.8
Wild pig	13	4	78.3	0.7
Summer-2 (Total length of transects = 79.7 km)				
Chinkara	6	4	138.6	0.3
Chital	224	49	28.3	49.7
Chowsingha	8	6	36.6	1.4
Nilgai	17	7	49.5	2.2
Sambar	34	17	33.6	6.3
Wild pig	40	9	29.3	8.6

Table 17 indicates that least variation in PSD estimated for chital (CV=30) and sambar (CV= 12) in comparison to other species having CV ranging from 234 to 3434. High CV of Chinkara, Chowsingha and Wild pig might be due to clumped distribution or of low sample size. It is an important to have relatively large sample size for estimating precise density for these species or one should restrict monitoring only to encounter rates because it would be difficult to detect changes in population density due to high CV on mean PSD values.

Table 17. Variation in Perpendicular Sighting distance (PSD) and density of ungulates during study period

Species	Perpendicular Sighting Distance (PSD)				Density (nos./sq.km)			
	Summer-1	Winter	Summer-2	Mean	Summer-1	Winter	Summer-2	Mean
Chinkara	21.4	80.898	138.6	80.2 (3434)	0.7	0.8	0.3	.60
Chital	39.2	33.453	28.3	33.6 (30)	57.3	34.7	49.7	47.2
Chowsingha	98.5	10.239	36.6	48.4 (2052)	0.2	0.4	1.4	.66
Nilgai	56.3	78.79	49.5	61.5 (234)	1.5	0.6	2.2	1.43
Sambar	36.4	29.512	33.6	33.1 (12)	3.7	2.8	6.3	4.26
Wild pig	27.2	78.31	29.3	44.9 (836)	2.3	0.7	8.6	3.86

Values in parenthesis are estimated variance for the mean

In many cases, it is difficult to obtain proper equipment needed for monitoring of ungulate population. Basic equipment like compass and laser rangefinders ect are a rare commodity at PAs. As we did not find significant differences in PSD values for chital, sambar and nilgai over seasons, we, therefore, tested the expected variation in population estimates of these speciers by using an overall observed mean PSD value for respective species. Table 18 indicates that variation in sambar and chital would be < 17 per cent in population estimates by using mean PSD than from estimates determined using accurate estimates using equipments. While variation in nilgai is relatively higher (8 to 24.5%) which may be due to relatively high variance on PSD (Table 17). Thus, in absence of these equipments, one may use mean PSD determined over seasons for a particular species and estimates would be much more precise than ocular estimation of PSD.

Table 18. Percent deviation in population estimates if an over all mean Perpendicular Sighting Distance is used for calculation of density from the values determined using equipments

Species	**Summer-1**	**Winter**	**Summer -2**
Chital	+ 16.8	-0.4	-15.8
Sambar	+ 9.7	-9.9	+ 2.3
Nilgai	-8.0	+ 24.5	-21.2

Table 19. Parameters estimated for chital abundance in Gir

	Parameters	Standard Error	% CV	95% Per cent confidence Interval	
				Lower	Upper
Summer –1					
Effective strip width, m	43.40	6.98	16.10	31.41	59.97
Group density/km^2	7.06	1.61	22.8	4.50	11.09
Density nos/km^2	58.22	17.71	30.43	32.26	105.07
Summer –2					
Effective strip width, m	39.05	3.79	9.73	32.11	47.50
Group density/km^2	6.97	1.50	21.57	4.53	10.74
Density nos/km^2	32.90	8.84	26.88	19.44	55.7
Winter					
Effective strip width, m	41.08	1.80	4.39	37.6	44.8
Group density/km^2	6.92	1.28	18.5	4.78	10.03
Density nos/km^2	23.9	5.27	22.06	15.49	36.91
Overall					
Effective strip width, m	58.67	1.58	2.7	55.62	61.89
Group density/km^2	4.83	0.53	10.83	3.94	6.05
Density nos/km^2	23.64	3.30	13.97	17.97	31.09

Chital density determined based default model (Half-normal) fitted on observed data for estimating effective strip width using 'Distance Program" (Appendix 5) ranged from 58.22 to 23.9 animals/km^2. It is interesting to note that a relative lower CV on animals density was observed during winter (22%) than during summer-1 (30.48%) and summer (26.88%). It also further corroborate the findings that winter would be a best season for estimating population of chital. Overall density of chital in Gir was 23.64 animals/km2. It is an important to understand the variance caused in density estimates of the species due to detection probability, encounter rate and cluster size because observer will make less error in counting animals but there is likely possibility of making errors in detecting species on the transect which may be due to vegetation cover or other factors. Thus it is an important to select the time of the season having a less variance in detection probability ensuring a less chances of error in missing animals. Therefore, variance on mean was further analyzed in reference to estimated parameters like detection probability, encounter rate and cluster size. Table 19 winter estimates have lowest variance of detection probability in comparison to summer-1 or summer 2, which indicates that there will be less error of missing any animals on transects. This also suggests that winter would be best seasons to have more precise data on density estimates. The variance on encounter rate and cluster size may be due to changes in habitat conditions over season.

Table20. Percent contribution of variance of density in relation to various parameters estimated during study period

Parameters	Percent contribution of variance on desnity			
	Summer-1	**Summer-2**	**Winter**	**Overall**
Detection probability	28.0	13.1	4.0	3.7
Encounter rate	28.1	51.3	66.7	56.3
Cluster size	43.0	35.6	29.3	40.0

Comparison of density estimates determined by two different methods (Table21) indicates variability in data, which is due to use of different approaches in two methods. Therefore, for comparison purposes one should not compare data obtained on density estimates by two different approaches. Thus it is suggested to use same approach for comparison purposes and estimated obtained by using “Distance Program” are more robust and precise.

Table21. Density estimates of chital determined by “Distance Program” and King Census during study period

Study period	Density estimation, nos/km^2	
	Distance Program	**King Census**
Summer-1	58.22	57.3
Winter	23.9	34.7
Summer-2	32.90	49.7
Overall	23.64	47.2

3.5. ESTIMATING RELATIVE ABUNDANCE AND DENSITY BY VEHICLE TRANSECTS

Vehicle transects have very often being employed to monitor habitat use as well as relative abundance and density of various ungulate species though there a number of biases. Distribution of animals along transects are influenced by factors like presence of water, salt lick and if any habitat management or manipulation undertaken especially in tourism zone. This method may be employed in areas having a good road networks in PAs and should only be used to compare variation in density from one year to another not for extrapolating data for whole park because such edge habitats attract more animals than they are distributed rest of the habitats. Of the 36 vehicle transects selected during the study area (Table 8), Data obtained on animal density by line transects during study period has revealed that winter could be the best time to obtain precise data on animal density being of low observed CV on mean density values. Therefore, we analyzed 12 vehicle transacts ran during winter for comparison purposes.

Vehicle transects (54.2 animals /km^2) over estimated an overall density of chital by 2.4 times from the values determined by "Line Transects" (22.3 animals/ km^2). Minimum and maximum chital density was of 25.4 in Gir East to 125.3 in Gir West, respectively (Table22). Overall CV on mean density is around 27 per cent which indicates that it would be difficult to find any change in the population if it is less than 27 per cent. Some areas like Gir West CV has CV of around 54.5 per cent. It would mean that estimates might not be precise in comparison to Line Transects having overall CV of around 11 per cent. Therefore, one should use these data only for comparison purposes or simply knowing trends and no conclusion should be drawn if fluctuations are less than 27 per cent. One can also use encounter rate for comparison purposes. Sightings for other species like sambar and nilgai were < 8, therefore, no further analysis was undertaken using "Distance Program". In view of this, either on has to put tremendous efforts of at least 645 km to get reasonably 40 sightings of these two species or use a simple index of ER.

Table22. Parameters estimated for chital abundance based on the best model selected by "Distance Program" using data obtained on Vehicle Transects in Gir

	Parameters	**Standard Error**	**% CV**	**95% Per cent confidence Interval**	
				Lower	**Upper**
Over all (n =12) (Model: Hazard rate)					
Effective strip width, m	43.8	6.99	15.9	32.0	59.9
Group density/km^2	10.6	2.6	25.3	6.4	17.6
Density nos/km^2	54.2	14.5	26.8	31.7	92.4
Encounter rate (nos/km)	0.92	0.18	19.6	0.6	1.4
Gir Central (n =5) (Model: Hazard rate)					
Effective strip width, m	49.2	6.0	12.3	38.5	63.0
Group density/km^2	9.7	2.5	26.3	5.2	18.1
Density nos/km^2	46.6	13.8	29.6	24.5	88.6
Encounter rate (nos/km)	0.95	0.22	23.2	0.5	1.8
Gir East (n =4) (Model: Hazard rate)					
Effective strip width, m	54.0	7.76	14.4	40.3	72.5
Group density/km^2	5.85	1.24	21.2	3.6	9.4
Density nos/km^2	25.4	7.04	27.6	14.5	44.6
Encounter rate (nos/km)	0.6	0.09	15.6	0.4	1.0
Gir West (n =3) (Model: Hazard rate)					
Effective strip width, m	32.8	3.6	10.9	26.3	40.9
Group density/km^2	19.8	10.3	52.1	2.8	138.8
Density nos/km^2	125.3	68.3	54.5	21.3	734.2
Encounter rate (nos/km)	1.3	0.6	51.0	0.2	10.3

3.6 SUGGESTED RECOMMENDATIONS

A. Line Transects :

Based on the work undertaken on ungulate species during two summers and winter from May-2001 to June 2002, Figure 2 suggests possible monitoring protocols for ungulates in GCU. Others are as follows :

1. Plan population monitoring of ungulate species during winter (October – February) when a lower CV has been observed on mean value to achieve precise estimates.
2. Select a team of dedicated and educated eight staff members for the population-monitoring period.
3. Purchase ten Compass and Laser rangefinder exclusively for this work.
4. Impart training for a week on data collection on line transects to identified staff.
5. Stratify Gir PA (ca.1412 sq.km) based on terrain and vegetation structures.
6. In order to cover spatial heterogeneity in distribution of ungulate species, select at least 6 to 8 transects each of 3 km long initially in each strata for an area of ca. 100 sq.km. Once data are analyzed and based on CV on mean in each strata, transects may be reduced or increased if needed accordingly.
7. Carefully cut and mark these transects for long term monitoring.
8. Walk each transects four times by not more than two persons early morning i.e. after sunrise.
9. Probable work details for Gir PA of 1412 sq.km, are as follows:

    a. No. of maximum transects (each of 3 km) needed

    $$\left(\frac{8}{100} \times 1412\right) = 113$$

    b. No. of total walks @ 4 walks/transects = 452 or ca. 450
    c. Four groups working at least for 23 days in a month for a period of five months may be able to cover desired no. of walks i.e.
    4 groups x 23 day/month x five months = 460 walks.

10. Provide independent transport to each group.
11. Record information in data format on species, total nos. of animal, angle, angular sighting distance from center of the group and other information as indicated in Appendix - 3.
12. Do not classify animals with respect to sex and age-structure on transect.

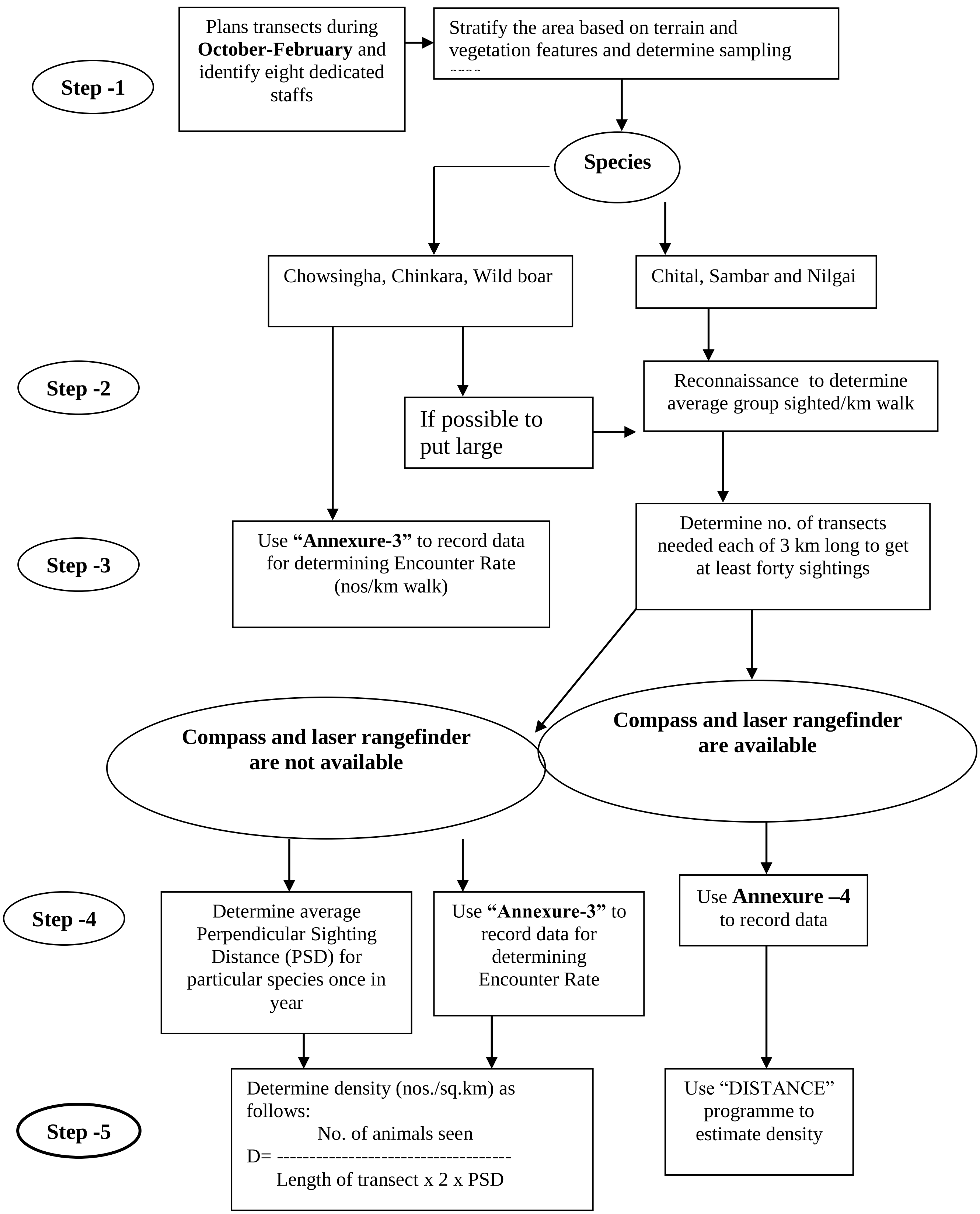
13. Use same method for density calculation for comparison purposes to avoid biases due to different approaches involved in various methods.

14. Conduct a separate survey to determine the age and sex composition of the ungulate population.

B. Vehicle Transects:

1. Select road network of around 15-20 sq.km long.
2. Monitor these road net work with four-wheel drive vehicle (preferably petrol) with a speed not more than 15 km/ hr
3. Record data on species, total nos. and perpendicular sighting distance from the center of each group. (Appendix-4)
4. Do not classify animals with respect to sex and age-structure.
5. If the sightings of a species are more than 40, use “Distance Program” or estimate Encounter Rate (ER).

Figure 4. Ungulate Monitoring Protocols using Line Transects for Gir Conservation Unit



CHAPTER - 4

MONITORING AGE & SEX COMPOSITION, GROUP SIZE, AND CONDITION OF CHITAL AND SAMBAR

Yadvendradev Jhala, Kartikeya Singh Chauhan, Shomen Mukherjee

Ascertaining the age sex and age of an individual animal is the first step toward defining the sex ratio and age structure of a species' population. These characteristics may provide important insight into a population's recent history, current status and likely immediate future trend. Knowing age specific natality is important for many population studies and wildlife management. Thus, determining year classes becomes important (Dimmick and Pelton 1996).

Aging is usually more difficult and many methods for its determination have been developed. Some aging techniques place animals into broad categories (infant, juveniles, sub-adults and adults), while others can be used to place individuals into specific year classes. The latter group of technique is considerably less common and generally more time consuming. A few methods of age determination are of a more general nature and can be broadly applied to several species, depending upon the questions to be answered. (Pletscher 1995).

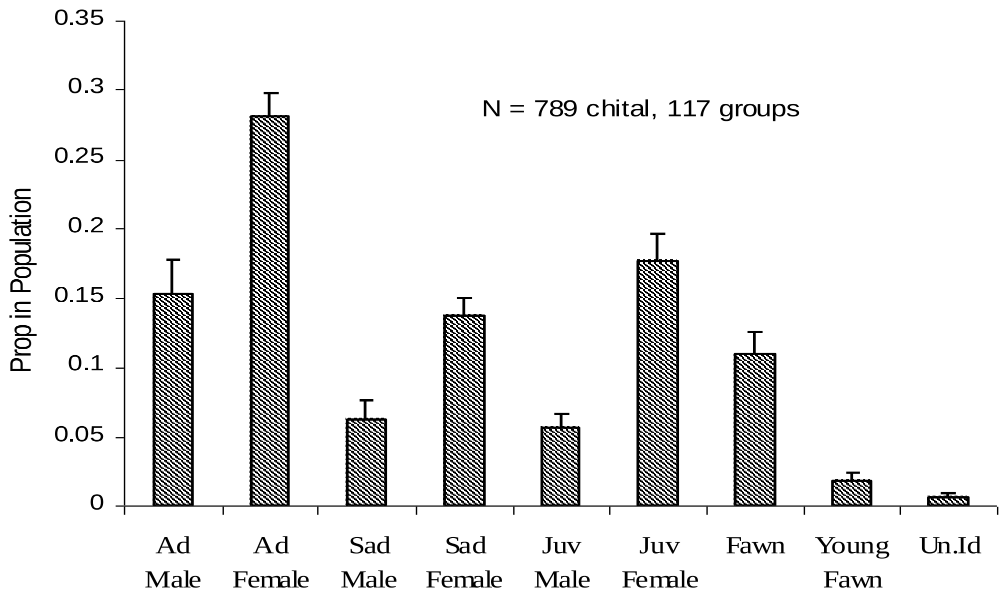
Since it is extremely difficult to get a good reliable estimate of the above characteristics of the ungulate population while walking transects and estimating abundance (as shown in the previous section), we estimated these parameters from a separate sample of these ungulates. The data presented here are from throughout Gir Protected Area. However, it would be possible to sample and analyze data separately based on strata of habitats or administrative boundaries. Actual estimates of age can be obtained by examination of teeth eruption and ware from dead specimens or more accurately by cementum annuli on tooth sections (Dimmick and Pelton 1996). This would be desirous for analysis of demographic parameters and life table analysis (Cughley 1977). However, for monitoring it would be relevant to distinguish the population into easily identifiable age and sex groups. For this we have used five stages for both sexes of chital and sambar. The stages that need to be distinguished in the field are (Schaller 1967):

Fawn (less than 6 months old)
Juvenile (6 m to 1 year)
Sub adult (>1-2 years)
Adult (>2 years old)

It would be possible to distinguish the fawns into 2-3 stages such as neonate (birth to 2 weeks), young fawn (2 weeks to 3 months), older fawn (3-6 months) and the adult males into 2-3 classes based on their antlers. However, this level of classification would require training and experience with both species. It would be possible to reduce the higher resolution classification into the one proposed and used here.

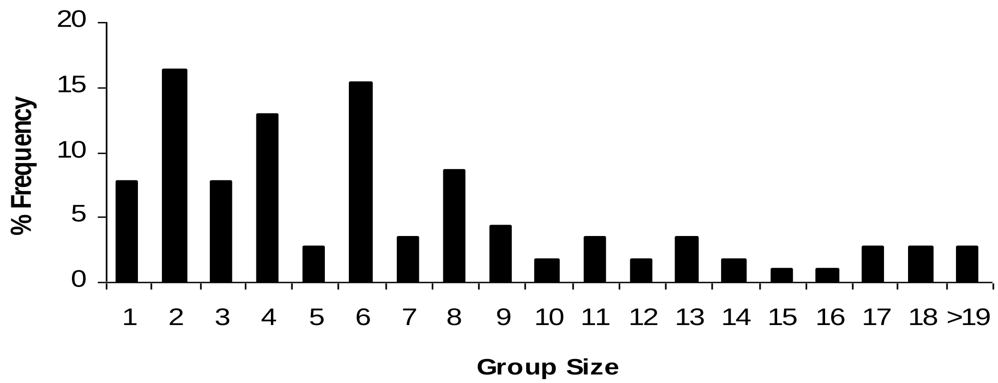
We classified 789 chital from 117 groups for demonstrating this method of classification of age and sex groups (Fig 5).

Figure 5 . Age and sex composition of chital in Gir Protected Area (2002).



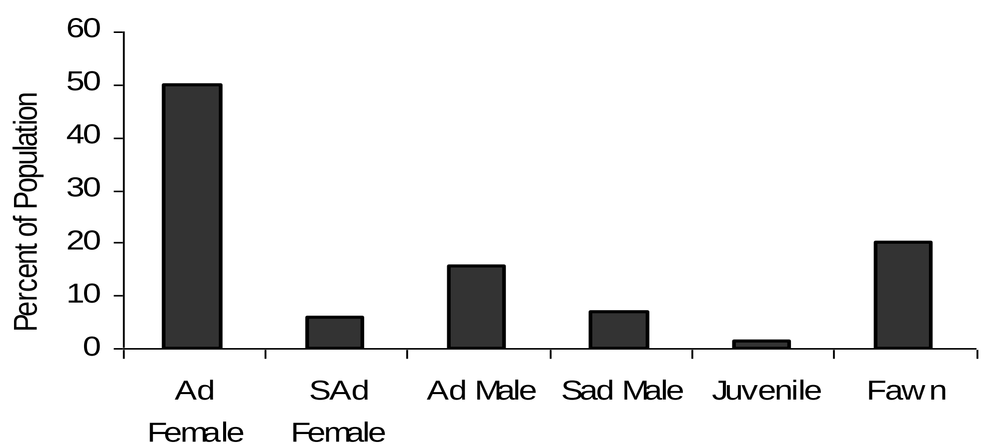
The adult sex ratio for chital was 1 Male : 1.9 Females, the ratio of fawns to adult females was 1 fawn to every 2.21 adult female. The group sizes of chital were extremely variable, with an average group size of 6.74 (Sd 5.4) (Fig6.)

Fig 6 . Percent frequency of observed group sizes of chital in Gir Protected Area (2002).



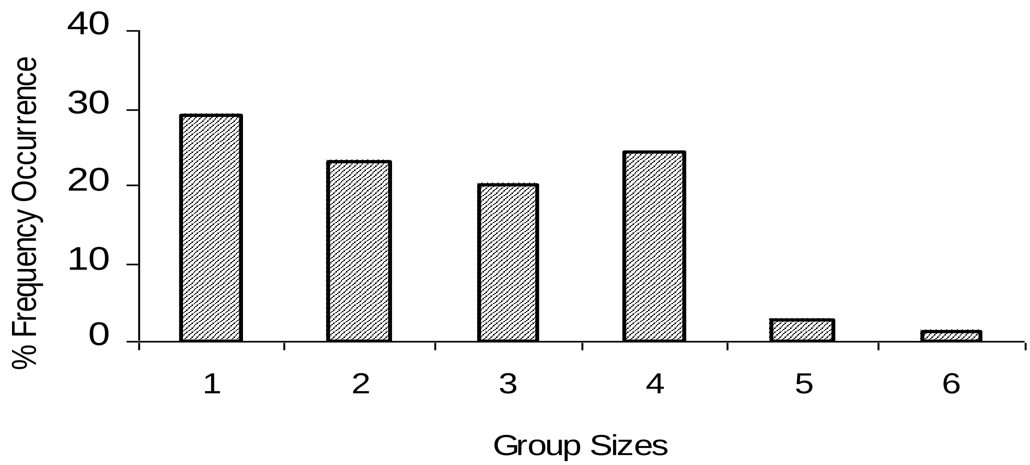
Similarly we classified over 550 sambar into the various age and stage classes (Fig 7). The adult sex ratio was 1 male : 3.15 females and the ratio of fawns to adult females was 1 fawn to every 2.51 adult female.

Figure 7 . Age and sex composition of the sambar population in Gir Protected Area (2001-2002).



Sambar occurred in much smaller groups compared to chital, the average group size was 2.52 (Sd 1.27) Figure 8 .

Figure 8 . Percent frequency of occurrence of various group sizes of sambar in Gir Protected Area (2001-2002).



The age structure of a population is indicative of its health, populations with larger proportion of younger age groups is likely to be a growing population, that dominated by old and senescent individuals is likely declining (Caughley 1977). Group sizes are a function of the social behavior of a species and the availability of food. Thus within a norm dictated by behavior groupsizes increase during times of food abundance and decline when food availability is space (Jarman 1974). The group sizes for chital were smaller while those of sambar were similar to those observed in Nagarahole (Karanth and Senquist 1992).

4.1 CONDITION MONITORING FOR UNGULATES

The nutritional condition of wild ungulates servers as an excellent indicator for monitoring several aspects of the ecosystem. The body condition of ungulates is indicative of the nutritive carrying capacity, competition between wild and domestic ungulates, diseases prevalent and the potential of the population to increase. The condition scores are easy to record with little training. The index consists of scoring different regions of an ungulates body on a score of 1 to 5, 1 being extremely poor while 5 being excellent condition. When ungulates loose body condition, visual signs that become obvious are:

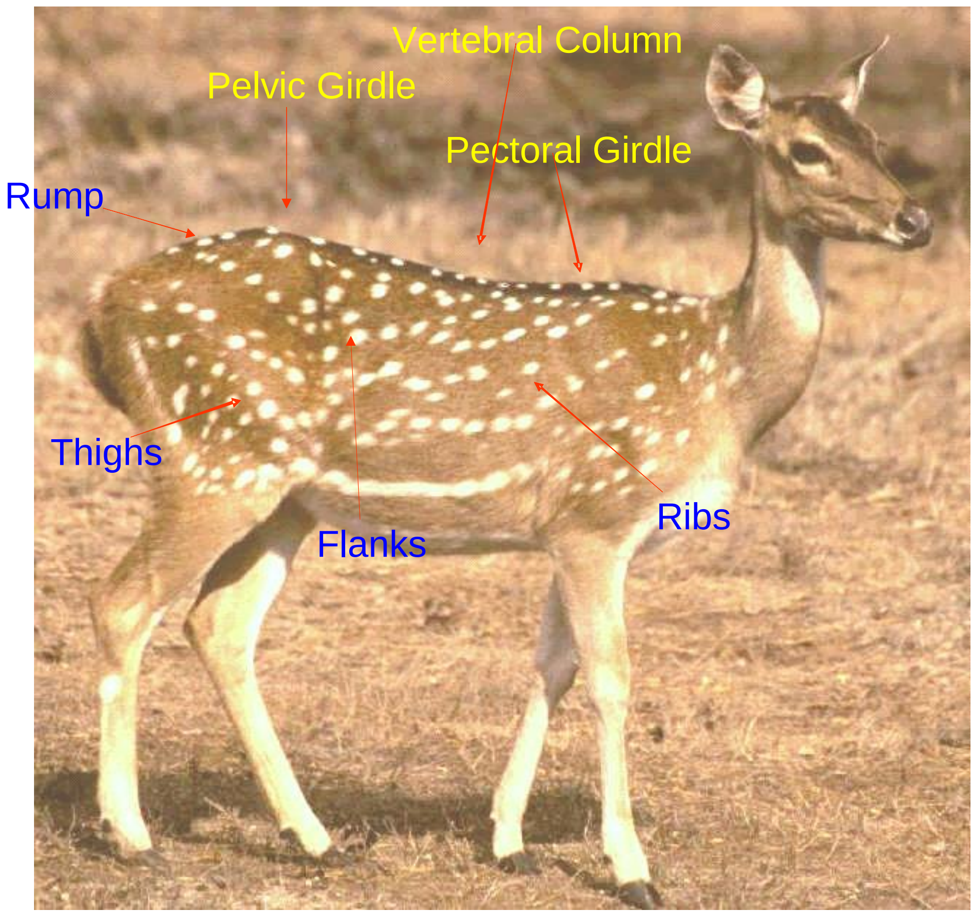
1) First on the rump and flanks: a rounded rump with full flanks and thighs indicate excellent condition as condition deteriorates the rump begins to get flatter and the flanks and thighs leaner.

2) The pelvic girdle: In good condition animals the bones of the girdle are not visible, the tail emerges from the end of the rump, there is no depression. As condition deteriorates pelvic bones become visible and the tail sinks in the bony depression.

3) The pectoral girdle or shoulder bones: as condition deteriorates the shoulder blades (scapula) and the clavicle bones become visible. At first a small ridge is visible on the shoulder. The vertebral column protrudes out with a visible lumbar shelf. In good condition animals there is a good layer of muscle over these bones, making the shoulders smooth and rippling and the spine a without a depression and in excellent condition a concavity.

4) As the animal looses condition further the ribs become visible. Most animals may score well for the ribs even when they have poor condition scores for other parts mentioned above (Fig 9. adapted from Riney 1960)

Figure 9. Various body areas of chital used for condition scoring.



It is important that condition scores are obtained during the same season (preferably within a week to ten days) between areas that are to be compared. If the objective is to compare the same population between years then too the timing between years should be be same. Tropical ungulates loose condition rapidly and even a months difference in timing can give erroneous results. Since some form of judgment by the observer is required while scoring between 1-5 it is important that the observers calibrate their scoring against each other prior to working separately. If a single person conducts this exercise then the biases are reduced. It may be important to age and sex the animal being scored for condition since there are likely to be confounding effects of rutting and fawning peaks on certain age and sex classes. The best time to conduct this exercise is in May and early June, since this is the worst time of the year in terms of food quality and quantity for ungulates. If condition scores in an area are fine during this time of the year then the park management can be assured of good quality forage availability in that range. A data sheet for recording condition data is provided in (Appendix 6).

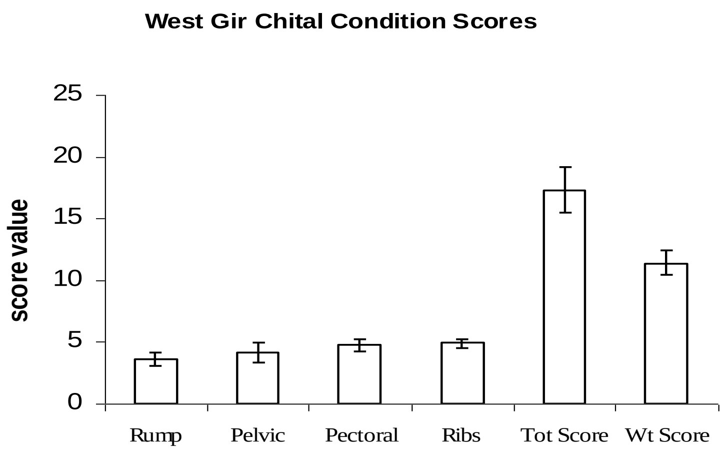
We collected data on condition scores of the chital population in East and West Gir near nesses and in the National Park areas of Central Gir during the second week of May 2002. The objective was to gain an understanding of the nutritional status of chital in Gir and secondly to see if chital herds sharing their resources with cattle were in poorer condition or not.

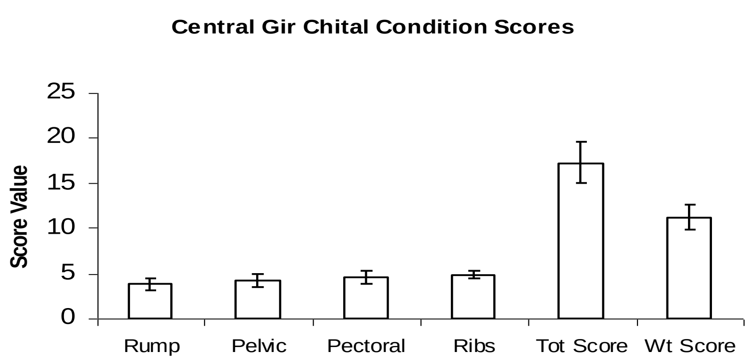
The senior author scored all the chital while the second author recorded observations. Since a score of poor condition on the rump is not comparable to a poor condition score for the pectoral girdle we developed a weighted condition score index. The relative weights of scores were in order of perceived importance of condition depletion to the animal. Thus the weighted condition score index (WCSI) was:

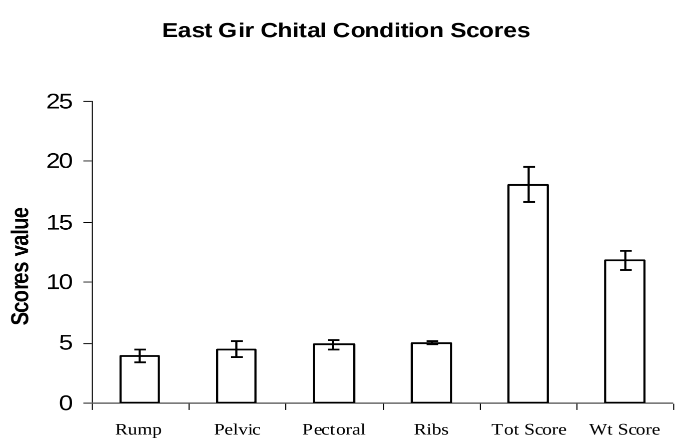
$$WCSI = \{[Rump) \times (2 \times Pelvic) \times (3 \times Pectoral) \times (4 \times Ribs)] \div 4\}$$

A linear sum of all indices (Total Condition Score TCS) was also used for comparison. Chital throughout Gir were in very good condition suggesting good forage availability and neglible effect of any diseases (Figures 10).

Figure 10. Condition scores of chital in west, central and east Gir in May 2002.

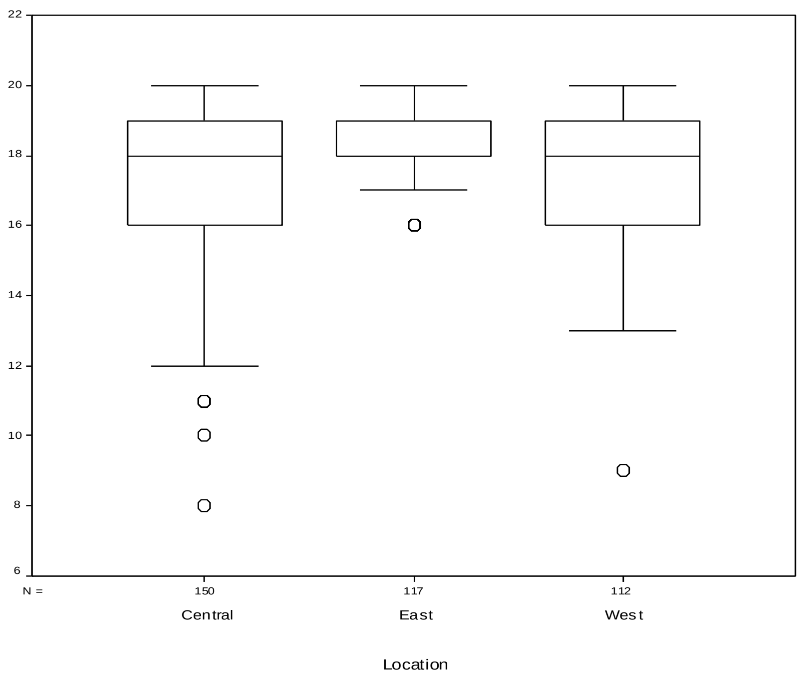






Analysis of variance and Kruskal-Wallis test showed significant ($p < .001$) differences between the condition of chital from East Gir to West and Central Gir populations. The condition of the chital population in East Gir was much better that the condition of chital in the National Park and West Gir (Tukeys Multiple Range Test, $P < 0.05$) (Fig 11.   )

Figure 11 . Box and whisker plot for the total condition score (TCS) of chital from East, West and Central Gir.



This suggests that competition with livestock was not an important factor determining the nutritional status of chital since the population sampled in East Gir was sharing its habitat with a large livestock population. It was surprising that the National Park population had the lowest condition scores in comparison to the east and west Gir population. This is likely an effect of habitat and in turn forage availability and not presence of livestock.

CHAPTER - 5

MONITORING OF BIRDS

K.Sankar, Q.Qureshi, Nita Shah, S.Mukherjee, C.Dave

5.1 INTRODUCTION

Birds as a community are excellent environmental indicators for the ecosystem due to their diversity at various trophic levels in the system. Monitoring the various guilds of birds (eg. Insectivores, frugivores, carnivores, omnivores) would ensure that most of the aspects of the eco-system are monitored. It may also be relevant to identify particular species that are either endangered or habitat specialists and then develop protocols for monitoring them. These indicator species or groups selected for monitoring should be relatively amenable to easy data collection procedures. Any program to estimate and monitor the abundance of bird communities in Gir would involve diverse methods, some of which can be used by forest staff and others only by trained wildlife biologists. The Gir field staff can be trained to gather information on presence/absence data and information on abundance of different bird species (e.g. less, common, abundant) and the biologists, besides the above details, on density of some important bird communities. A protocol for monitoring of important bird species of Gir prepared in this report also envisages scope for future monitoring of important bird species of Gir, appropriate methodology for monitoring different bird species, important areas for monitoring and recommend who should do such monitoring.

5.2. APPROACH, METHODS AND RESULTS

We identified Peafowl (*Pavo cistatus*), Raptors**,** Land birds, and Waterfowls as the major groups of birds for monitoring in Gir. Identification of intensive study areas and selection of appropriate methodologies for the monitoring of important bird species and or communities was decided upon during the reconnaissance of Gir in month of April/May 2001.

5.2.1. Peafowl are found in great abundance in Gir (Trivedi 1993, Singh & Kamboj 1996). They form a major prey for small carnivores, leopards and some raptors (Chellam 1993). Surrounded by an agricultural landscape where pesticides use is rampant, cases of mass mortality of peafowl amongst these farmlands is not uncommon. It is likely that although now peafowl are found throughout the agro-pastoral landscape, the Protected Areas (PA’s) would ultimately serve as refugia for the species in the future. In such a situation it would be important to monitor the population of peafowl.

All the eight permanent line transects in different habitat types (Fig. 3) for the estimation of large ungulate population are being used to collect information on density, distribution and population structure of peafowl. These transects cover all major habitat types across Gir forest. These transects were walked during summer and winter during the study period. Number of peafowl encountered on each sighting during the transect walk, sighting angle and angular sighting distance was recorded. The line transect data was analysed using "DISTANCE" software version 3.5 (Lakke *et al*. 1999). The formula for density estimation of peafowl using Distance programme is given below:

$$D = \frac{\text{Number of peafowl detected X Probability density function}}{\text{2 X Total transect length}}$$

D = Density

2 = For both sides of the transect

Table 23 shows the density of peafowl in different habitat types in summer and winter, the overall density, encounter rate, effective strip width, total survey effort (km), coefficient of variation and confidence intervals on densities and effective strip width and the best fitted model for the density of peafowl. The estimated overall peafowl density in Gir was 16.80 per km². The overall estimated encounter rate for peafowl was 0.588 peafowl per km². The Hazard Rate Key was the best-fitted model (Table 23). Of the three major habitat types, the hill forest had the highest peafowl density in summer (50.7 per km sq), winter (37.6 per sq km) and as well as the combined data for winter and summer (42.6 per sq km).

Table 23. Peafowl densities in Gir in different habitat types

Habitat & Season	Thorn Forest Pooled	Thorn Forest Summer	Thorn Forest Winter	Hill Forest Pooled	Hill Forest Summer	Hill Forest Winter	Teak Mix Pooled	Teak Mix Sum mer	Teak Mix Winter	All habitats Pooled
Effort	111	66	45	75	39	36	53.7	36	17.7	239.7
Sample	37	22	15	25	13	12	18	12	6	80
OBS	85	74	10	37	20	15	21	15	6	141
ESW	33.56	33.63	47.92 4	14.881	9.604	19.219	54.064	47.27 1	61.287	29.47
ESW CV	0.168	0.129	0.00	0.392	0.487	0.652	0.00	0.00	0.00	0.11
Density	24.82	29.73	12.05 6	42.560	50.727	37.587	6.372	7.345	6.914	16.8
DCV	0.262	0.224	0.409	0.475	0.602	0.777	0.281	0.306	0.624	0.19
D UCI	41.28	46.19	27.25 4	104.740	156.600	155.16	11.296	13.78 9	28.140	24.36
D LCI	14.9	19.14	5.333	17.294	16.432	9.101	3.595	3.910	1.699	11.59
CS	2.176	1.784	5.2	2.568	1.900	3.467	1.762	1.667	2.500	2.199
DS	11.4	16.6	2.319	16.576	26.698	10.840	3.617	4.407	2.766	7.64
DS CV	0.239	0.201	0.349	0.438	0.553	0.723	0.262	0.272	0.609	0.17
ER	0.766	1.121	0.222	0.493	0.5.3	0.417	0.391	0.417	0.339	0.588
Model	Hazard rate key	Half normal Cosine	Uni-form Key	Hazard Rate key	Hazard Rate key	Hazard Rate key	Uni-form Key	Uni-form Key	Uni-form Key	Hazard rate key

ESW - Effective strip width.
ESW CV - Effective strip width coefficient of variation.
DLCI - Density of individuals analytic lower confidence limit.
DUCI - Density of individuals analytic upper confidence limit.
DCV - Density of individuals analytic coefficient of variation.
Effort - Total survey effort (km).
CS - Mean cluster size.
ER - Encounter rate.
DS - Density of clusters.
DSCV - Density of clusters analytic coefficient of variation.
OBS - Observations (No. groups seen)

For estimating the peafowl density in case of less than 40 sightings per transect walk it is suggested that the data should be analysed using `King's formula' as mentioned below:

$$D = \frac{\text{Number of peafowl seen}}{\text{Total length of the transect X 2 X PSD}}$$

D = Density
2 = For both the sides
PSD = Perpendicular sighting distance

It is suggested that all 9 line transects as mentioned above, should be walked in all seasons by either the field staff or trained biologists to study the seasonal difference (monsoon, summer, winter) in the use of habitats by peafowl in Gir. While walking the transects, number of peafowl sighted, perpendicular distance and sighting angle should be recorded for each sighting.

5.2.2. Land bird species diversity in different habitat types would serve as a good tool for monitoring ecological changes. It may not be possible to enumerate and identify all bird species encountered in field but with trained biologists it is possible to achieve the objective of such monitoring.

Of the nine line transects selected for the ungulate population estimation, six were selected for collecting information on land bird communities (Table 24). Transect walks were carried out during the month of October – November 2001. Using `Point Count technique' (Buckland *et al.* 1993) at every 200 mts along the transect line, land bird species encountered, their total number, and perch height were recorded.

In total 49 species of land birds were recorded. T3 (Teak mixed forest in moderately undulating terrain) had the highest bird species richness (H'=2.636) and abundance (n=21). T4 (Teak mixed forest in highly undulating terrain) had the lowest bird species richness (H'=1.387) and abundance (n=3) (Table 24).

Table 24. Land bird species diversity and richness in Gir (October –November 2001)

Transect No.	Total length (km)	Total # of Points/Transect	Bird Species Richness	Bird Species Diversity (H')	Vegetation type	Terrain category
T1*	3	7	9	2.148	Thorn-*Boswellia* mixed forest	Highly undulating
T2*	3	22	17	2.375	Acacia-*Anogeissus*-*Boswellia*	Moderately undulating
T3*	3	21	21	2.636	Teak mixed forest	Moderately undulating
T4**	3	5	3	1.387	Teak mixed forest	Highly undulating
T7*	3	10	12	2.608	*Boswellia*-*Lannea* mixed forest	Slightly undulating to flat
T8*	3	13	11	2.525	*Boswellia*-*Lannea* mixed forest	Highly undulating
Gir (Total)	18	78	49	2.280		

*** - Transect in Gir Sanctuary**

**** - Transect in Gir National Park**

It is suggested that these 6 line transects as mentioned above, should be walked in all seasons by trained biologists to study the seasonal difference (monsoon, summer, winter) in the use of habitats by different land bird communities (Appendix 7). The following important land bird species are identified for regular monitoring in Gir:

Peafowl *Pavo cristatus*, Lesser florican *(Sypheotides indica)*, Yellow-legged green pigeon *(Treron phoenicoptera)*, Pied crested cuckoo *(Clamator jacobinus)*, Indian pitta (*Pitta brachyura)*, Painted sand grouse (*Pterocles indicus indicus*), Stork-billed kingfisher *(Pelargopsis capensis)*, Golden oriole *(Oriolus oriolus)*, Blacknaped oriole (*O.chinensis*, Forest wagtail (*Motacilla indica,)*, White-bellied minivet (Pericrocotus erythropygius), Spotted flycatcher *(Muscicapa striata)*, Brown flycatcher *(Muscicapa latirostris)*, Moustached sedge Warbler *Acrocephalus melanopogo* and Rufous fronted wren warbler (*Prinia buchanani).*

In addition, based on opportunistic sampling throughout the Gir forest, birds (any species) seen should be identified and recorded along with habitat types by trained biologists. On the basis of frequency of sighting, the bird species can be assigned abundance values (common, occasional, uncommon and rare). Based on this information collected over a period of time, it is possible to have an inventory of birds of Gir giving details of their distribution pattern, status (resident, winter, visitor, summer visitor, monsoon visitor, local migrants, vagrant/straggler) and abundance (rare, common, abundant) information. Singh and Khamboj (1996) had listed 289 bird species in Gir. Of which the following bird species records need further confirmation:

Ringed plover (Charadrius hiaticula), Grey woodpecker (*Picoides nanus*), Red backed shrike (*Lanius colurio*), Black headed oriole (*Oriolus xanthornus*), White bellied minivet (*Pericrocotus erythropygius*), Blue chat (*Erithacus brunneus*), and Red start (*Phoenicurus phoenicurus*). The blue chat and red start should be `vagrants' in Gir.

We suggest collecting information of breeding status of Grey drongo (*Dicrurus leucophaeus*) in Gir. Contrary to published literature, this species is breeding in central Indian highlands (Jayapal Pers.com.). If it is found breeding in Gir, it will be very useful information.

The Black headed oriole (*Oriolus xanthornus*) sighting in Gir needs further confirmation. If it is recorded again this should be the first record from the Kathiawar region. The Black headed cuckoo shrike (*Coracina melanoptera*) population in Kathiawar Penninsula is an isolated one and hence collecting information on its status, distribution, and breeding in Gir will be necessary. The current status of spotted flycatcher (*Muscicapa striata*) is unknown in its existing ranges and the Brown flycatcher (*M.latirostris*), which is a passage migrant, has been listed as a `near threatened' by the Bird Life International. These two species have been reported from Gir and their status needs to be monitored.

The wintering population of Moustached sedge warbler (*Acrocephalus melanopogon*) requires constant monitoring, as it is a `wetland-special' species. Similarly the Rufous fronted wren warbler (*Prinia buchanani*), which is found in semi arid thorn forest is a good ecological indicator species. This species needs constant monitoring.

5.2.3. Raptors (hawks, eagle, kites, osprey, falcons, kestrels and vultures) are diurnal flesh eating birds belong to the order Falconiformes**.** As they are positioned on top of the food chain while being restricted to specialized habitats (e.g. riverine forests, matured forests, open forests, woodlands), monitoring their population will be very important. These habitats are critical for several other species including lions. Five species of vultures viz. Griffon vulture (*Gyps fulvus*), Indian long-billed vulture (*G. indicus*), Indian white-backed vulture (*G.bengalensis*), king vulture (*Sarcogyps calvus*) and Egyptian vulture (*Neophron percnopterus*) are found in Gir

(Grubh 1980). Recently due to the dramatic decline in vulture numbers throughout the sub-continent it would be relevant to develop a protocol for monitoring them.

As an exemplary case information on population structure (adults, sub adults and young) and habitat use of five species of vultures viz. Indian long-billed vulture, Indian white-backed vulture, king vulture, cinereous and Egyptian vulture were collected as and when they were encountered in field (Figure 12). The stage based age structure of Egyptian vulture and king vultures suggested that the species are doing well since there was good recruitment stages seen (Figure13). However, almost all sightings of white backed and long billed vultures were of adult birds suggesting lack of recruitment to these birds population. Cinereous vultures were rare in Gir and we had only 2 sightings.

Figure 12. Number of different vulture species sighted in and around Gir PA between September 01 and February 02.

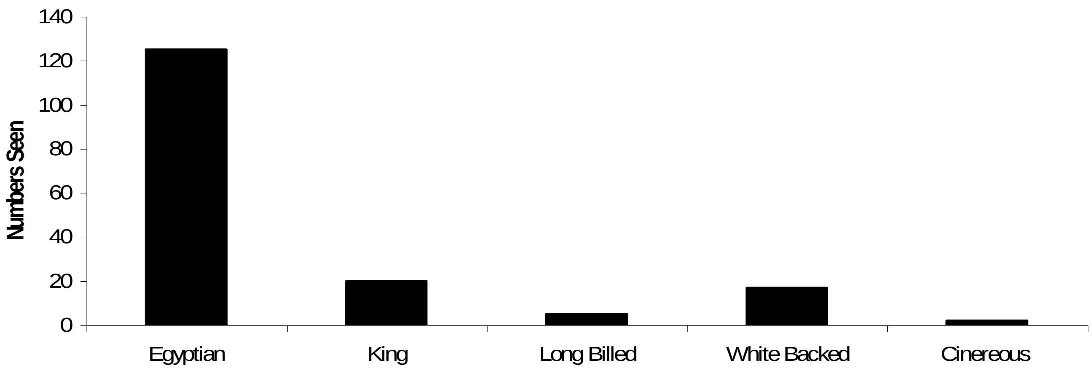
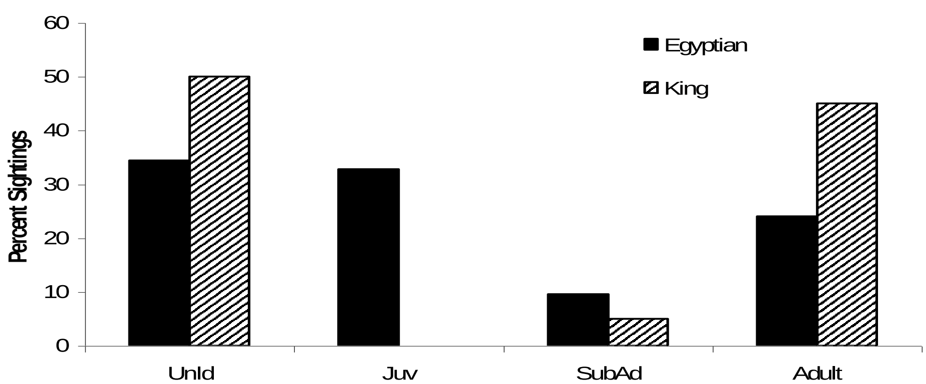


Figure 13. Age composition of *Neophron percnopterus* and *Sarcogyps calvus* in Gir



The following important raptor species are identified for regular monitoring in Gir:

Aquila heliaca Imperial eagle, *Spilornis cheela* Crested serpent eagle, *Spizaetus cirrhatus* Crested hawk eagle, *Butastur teesa* White-eyed buzzard eagle, Haliaeetus leucoryphus Pallas fishing eagle, *Bubo zeylonensis* Brown fish owl, *Strix ocellata* Mottled wood owl, *Circus cyaneus* Marsh harrier, *Falco tinnunculus* Kestral, *Falco peregrinus japonensis* Peregrine falcon, *Falco biarmicus cherrug* Saker/chirag falcon, *Falco biarmicus cherrug* Red headed merlin, *Pandion haliatus* Osprey, *Gyps fulvus* Griffon vulture, *G. indicus* Indian long-billed vulture, *G.bengalensis* Indian white backed vulture, Sarcogyps calvus King vulture, *Neophron percnopterus* Egyptian vulture, and *Gyps fulvus* Griffon vulture.

As per the available literature, the Mottled wood owl (*Strix ocellata*) population in Kathiawar peninsula is isolated. Hence the current status of this species in Gir needs to be assessed as it is an indicator of matured forest. The Besra sparrow hawk (*Accipiter virgatus besra*) occurrence in Gir needs to be confirmed. The Imperial eagle (*Aquilla heliaca*) needs to be monitored to find out whether they breed in Gir. This species breeds in northwestern India including Rajasthan. The Saker or chirag falcon (*Falco biamicus cherrug*) is supposed to be the winter visitor in Gir and their presence needs to be reconfirmed. There is no recent record of this species reported from this region. The Bird Life International has categorized redheaded merlin (*Falco chicqera*) as a `near threatened' species. As this species is reported from Gir, their status and distribution needs to be reconfirmed.

5.2.4. Waterfowl (resident & migratory) would form an important component of the avifauna given the large water bodies present in the PA and the role of the Gir ecosystem as a catchment area for the *Sorath* region of Gujarat. Also most waterfowl are migrants and are of international conservation importance.

It is suggested that `Total Count' method (Buckland *et al.* 1993) should be employed to count the waterfowls in all major water bodies of Gir during winter months. Seven large water bodies in Gir were identified for collecting information on waterfowl population. They were: Rawal dam, Jamri dam (East Gir), Kamleshwar, (West Gir), Singoda and Machundari (Central).

The following important waterfowl species and water birds are identified for regular monitoring in Gir: *Anhinga rufa* Darter, *Dendrocygna javanica* Lesser whistling teal, *Nettapus coromandelianus Cotton* teal, *Anas crecca* Common teal, *Anas poecilorhyncha* Spotbill duck, *Sarkidiornis melanotos* Comb duck, *Anser anser* Greylag goose, *Anser indicus* Bar-headed goose, *Anas acuta* Pintail, *Anas crecca* Common teal, *Anas poecilorhyncha* Mallard, *Anas strepera* Gadwal, *Anas Penelope* Wigeon, A*nas querquedula* Gargany,
Anas clypeata Shoveller, *Pelecanus onocrotalus* Rosy pelican, *Mycteria leucocephala* Painted stork, *Anastomus oscitans* Open billed stork, *Ciconia episcopus* White necked stork,

Ephippiorynchus asiaticus Black necked stork, *Cicona nigra* Black stork, *Threskiornis aethiopica* White ibis, *Platalea leucorodia* Spoonbill, *Sterna aurantia* Indian river tern, *Phoenicopterus minor* Lesser flamingo, *Athya farina* Common poachard and *Grus antigon* Sarus crane.

5.3. DISCUSSION

The suggested methods for monitoring populations of important bird species in Gir, methodology, personal and habitat/areas to be monitored are given in Table 2.

Table 24. Suggested methods for monitoring populations of Bird species/groups in Gir

Species/group	Common name	Method	Personal	Habitat/Areas
		RAPTORS		
Aquila heliaca	Imperial eagle	LT/TCS/ER	Biologist	Wooded forest
Spilornis cheela	Crested serpent eagle	LT/TCS/ER	Biologist	Wooded forest
Spizaetus cirrhatus	Crested hawk eagle	LT/TCS/ER	Biologist	Wooded forest
Butastur teesa	White-eyed buzzard eagle	LT/TCS/ER	Biologist	Wooded forest
Haliaeetus leucoryphus	Pallas fishing eagle	TC	Biologist	Wooded forest
Bubo zeylonensis	Brown fish owl	TCS	Biologist	Riverine forest
Strix ocellata	Mottled wood owl	TCS	Biologist	Wooded forest
Circus cyaneus	Marsh harrier	TC	Biologist	Aquatic areas
Falco tinnunculus	Kestral	LT/TCS/ER	Biologist	Open forest, Grassland
Falco peregrinus japonensis	Peregrine falcon	LT/TCS/ER	Biologist	Open forest, Grassland
Falco biarmicus cherrug	Saker/chirag falcon	LT/TCS/ER	Biologist	Open forest, Grassland
Falco biarmicus cherrug	Red headed merlin	LT/TCS/ER	Biologist	Open forest, Grassland
Pandion haliatus	Osprey	TC	Biologist	Aquatic areas
Gyps fulvus	Griffon vulture	LT/TCS/ER	Biologist	All forest types
G. indicus	Indian long-billed vulture	LT/TCS/ER	Biologist	All forest types

G.bengalensis	Indian white-backed vulture	LT/TCS/ER	Biologist	All forest types
Sarcogyps calvus	King vulture	LT/TCS/ER	Field staff, Biologist	All forest types
Neophron percnopterus	Egyptian vulture	LT/TCS/ER	Field staff, Biologist	All forest types
Gyps fulvus	Griffon vulture	LT/TCS/ER	Field staff, Biologist	All forest types

<u>WATER FOWL</u>

		Total count	Field staff, Biologist	Kamleshwar, Rawal, Jamri, Singoda, Machundari
Anhinga rufa	Darter			
Dendrocygna javanica	Lesser whistling teal			
Nettapus coromandelianus	Cotton teal			
Anas crecca	Common teal			
Anas poecilorhyncha	Spotbill duck			
Sarkidiornis melanotos	Comb duck			
Anser anser	Greylag goose			
Anser indicus	Bar-headed goose			
Anas acuta	Pintail			
Anas crecca	Common teal			
Anas poecilorhyncha	Mallard			
Anas strepera	Gadwal			
Anas Penelope	Wigeon			
Anas querquedula	Gargany			
Anas clypeata	Shoveller			

<u>OTHER WATER BIRDS</u>

		Total count	Field staff, Biologist	Kamleshwar, Rawal, Jamri, Singoda, Machundari
Pelecanus onocrotalus	Rosy pelican			
Mycteria leucocephala	Painted stork			
Anastomus oscitans	Open billed stork			
Ciconia episcopus	White necked stork			
Ephippiorynchus asiaticus	Black necked stork			
Cicona nigra	Black stork			
Threskiornis aethiopica	White ibis			

Platalea leucorodia	Spoonbill			
Sterna aurantia	Indian river tern			
Phoenicopterus minor	Lesser flamingo			
Athya farina	Common poachard			
Grus antigon	Sarus crane			

LAND BIRDS

Pavo cristatus	Peafowl	LT/ER	Field staff, Biologist	All forest types
Sypheotides indica	Lesser florican	ER/TCS	Field staff, Biologist	Grasslands
Treron phoenicoptera	Yellow-legged green pigeon	LT/ER/PC	Field staff, Biologist	All forest types
Clamator jacobinus	Pied crested cuckoo	LT/ER/PC	Field staff, Biologist	All forest types
Pitta brachyura	Indian pitta	LT/ER/PC	Field staff, Biologist	All forest types
Pterocles indicus indicus	painted sandgrouse	LT/ER/PC	Field staff, Biologist	All forest types
Pelargopsis capensis	Stork-billed kingfisher	TSC	Field staff, biologist	Riverine forest
Oriolus oriolu	Golden oriole	LT/ER/PC	Field staff, Biologist	All forest types
O.chinensis	Blacknaped oriole	LT/ER/PC	Field staff, Biologist	All forest types
Motacilla indica	Forest wagtail,	LT/ER/PC	Biologist	All forest types
Pericrocotus erythropygius	White-bellied Minivet	LT/ER/PC	Biologist	All forest types
Muscicapa striata	Spotted flycatcher	LT/ER/PC	Biologist	All forest types
Muscicapa latirostris	Brown flycatcher	LT/ER/PC	Biologist	All forest types
Acrocephalus melanopogon	Moustached sedge Warbler	LT/ER/PC	Biologist	Wetlands
Prinia buchanani	Rufous fronted wren warbler	LT/ER/PC	Biologist	Thorn forest

PC – Point Count, **ER** – Encounter Rate, **LT** – Line Transect, **TCS** – Time Constrained Searches, **TC** – Total Count

CHAPTER - 6

MONITORING LIONS

Yadvendradev Jhala, Shomen Mukherjee, Nita Shah, Kartikeya Singh Chauhan, Chitranjan Dave And Yogendra Sinh Jhala

6.1. INTRODUCTION

Gir forest is the home of the last free ranging population of the Asiatic lions (*Panthera leo persica*). It is primarily this attribute that has generated interest since historic times from both National as well as International communities and has been responsible to a greater extent for the creation of the Gir protected area. In addition to being charismatic, lions are also the top carnivores in Gir and rightly bear the flagship title for the biodiversity of the region. Conservation of the lions is synonymous to conservation of Gir. Unlike many other protected areas in the country and elsewhere in the world, Gir forests do not boast of being hot-spots for endemism or biodiversity. It would not be wrong to say that the lions are the prime attraction for conservation of this area in terms of public interest, legislation, funding, and protection.

The importance of lions to Gir and *vice versa* cannot be over emphasized. The Gir lions are highly valued locally and worldwide, thus making it imperative for a well designed long-term population monitoring scheme to be implemented. A census using baits was regularly conducted every five years from 1968 to 1995 (Jhala et al. 1999, Singh 1995, 1997). This long-interval monitoring met with social and ethical opposition and thus even this exercise could not be conducted in since 1995. The only form of monitoring, besides the one being conducted as a part of this project, has been in the form of number counts done by the Gir P.A. management through intensive search of the forest.

Since there are no baits being offered it is difficult to attract lions and keep them stationary for any length of time even when detected. Therefore, the method has no way of ensuring total counts or avoiding double counts. This method of intensive search could be used to formulate a good index for lion numbers, provided it was calibrated either against area searched or against search effort. Currently no such records are being kept making the data non comparable between years for any kind of trend estimation.

The best method to keep the pulse of the lion population would be by an annual evaluation of their numbers and demographic parameters through scientifically designed protocols with the assistance of modern technological tools like radio-telemetry. Data on survival, mortality, natality, fecundity, dispersion and ranging patterns would be readily obtained by this monitoring scheme. Any signs of decline or unusual deaths would be detected immediately, causes identified quickly and remedies applied.

Pennycuik and Rudnai (1970) suggested the use of vibrissae patterns for individual identification of African lions; this technique is now a regular tool for identifying lions in the Serengeti (C. Packer pers. comm.). Jhala et al. (1999) refined and tested the sighting-re-sighting population estimation method based on unique vibrissae pattern on Gir lions. This technique coupled with a good experimental design and data-collection protocol developed herein should become a long-term population monitoring tool.

6.1.1. Approach and scope of the task

The objective of this component of the project was to develop :

1) A population monitoring protocol for the lion population in and around Gir PA.

2) Use this protocol to estimate and monitor the lion population on an annual basis so as to demonstrate its efficacy and also to identify and rectify any short falls in the experimental design that may become obvious only after data collation and analysis.

3) To establish a regular demographic monitoring program for lions with the assistance of radio-telemetry.

6.1.2. Lion population monitoring

Based on Pennycuik and Rudnai (1970) and Jhala et al. (1999) whisker patterns of individual lions were calibrated on a graph paper using a spotting scope (Fig 14). It would be of relevance to describe the method here with the modifications introduced in this study in some detail.

On observing a lions face with a spotting scope it would be seen that there are several rows on its upper lip from which vibrissae (whiskers) emerge. It is important that the observer views the lion’s whisker patterns at a right angle (90°) to the face of the lion. The whisker rows that are used for individual identification are the top 3 rows; A, B and C. It is only the row B that has a continuous row of spots with whiskers emerging from some of these spots. This row can have anywhere between 5 to 9 spots. Row A consists of spots above row B. The spots in row A are defined in relation to their position to spots in row B (see Fig 14). Thus there are potentially 17 positions for spots to occur in row A. However, we have not found more than 4 spots in row A in Gir lions.

Similarly, row C also has a potential of 17 positions below row B, but the number of spots were relatively few (0-5). Rows A and C are not complete rows but consist of sporadic occurrence of spots. There are several complete rows of spots below row C (downwards towards the upper lip), but these are not used for identification.

In the present study the data on the spots was recorded as shown in Fig 14 and in the data sheets (Fig 15 and Appendix 8). All other permanent marks that would assist in individual identification were recorded (see Appendix 8 for data sheet format). The information content from the rows A and B from both sides of the lions face along with the information on the gender of the lion is sufficient for individual identification. According to Jhala et al. (1999) the average probability of confusing 2 lions with this information is one in ten thousand amongst a population of 300 lions. Combining information from row C, other body markings, and age group of the lion the reliability of individual identification would be enhanced. Notches on ears are another identifying feature that are quantifiable. Notches on ears (both left and right) are quantified with the lion looking directly at the observer. Notches on the ear are recorded as to the hour hand position on the dial of a clock and in accordance to their size (eg. large and deep, small and deep or shallow) (see Fig15. for details). Another quantifiable character are the presence and number of nasal spots (see Fig 15). We also recorded major permanent scars on the face and body of lions. Data were also recorded on the condition and ware on the teeth so as to assist in ageing the lions. Photographic records were obtained of all these characteristics whenever possible so as to have unambiguous records for future references (Fig 15).

Figure 14 : Calibration of vibrissae patterns of lions for individual identification.

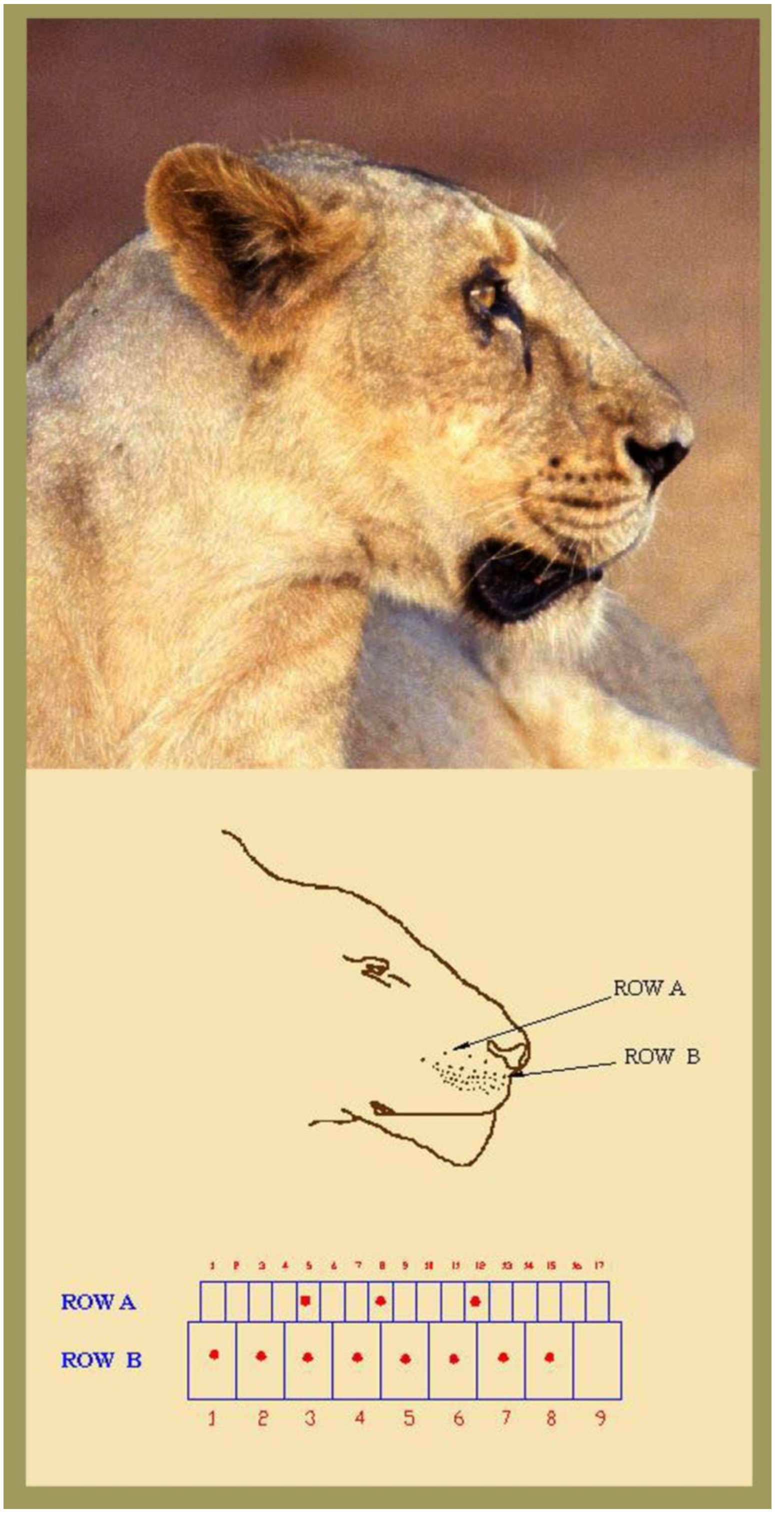
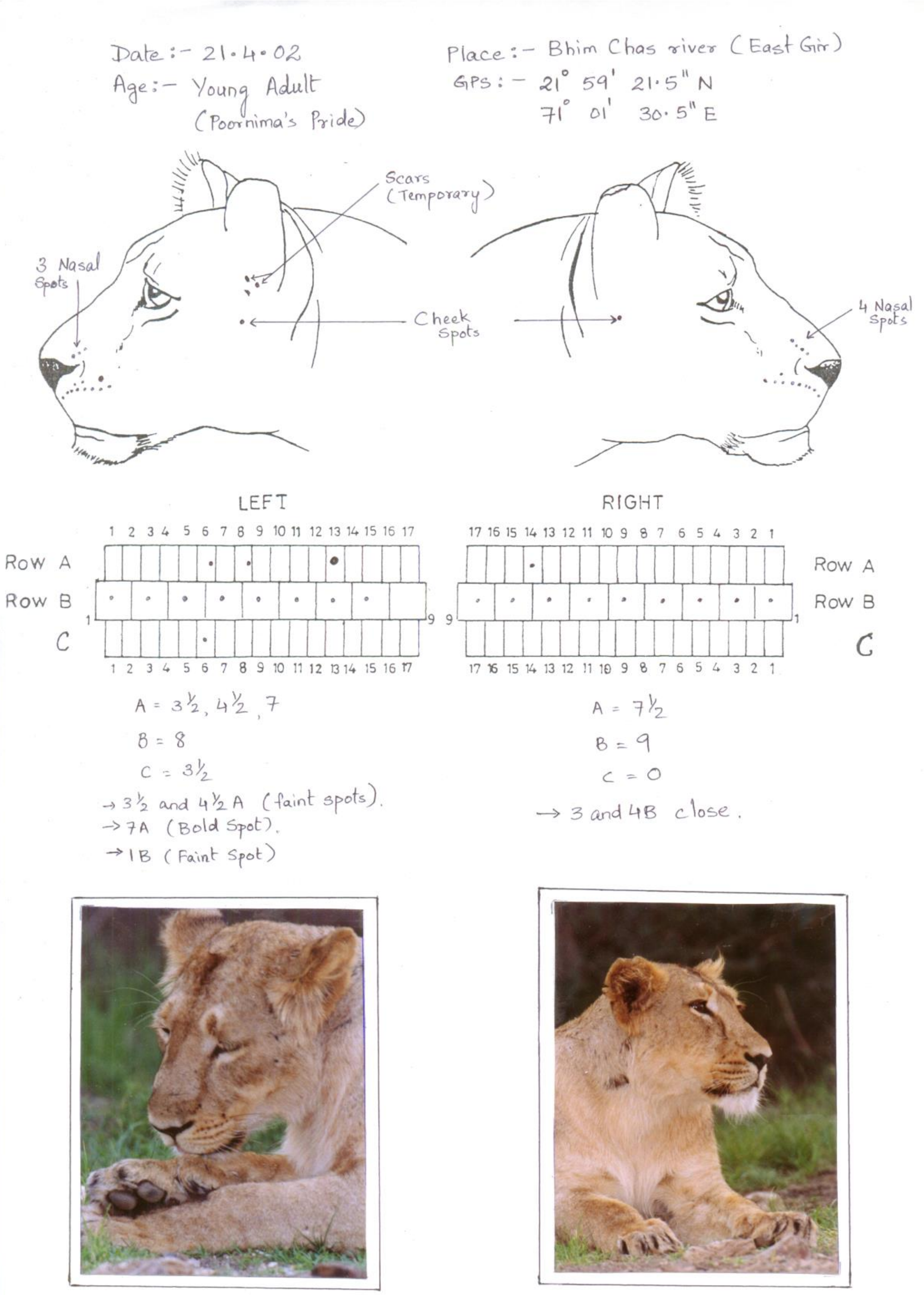
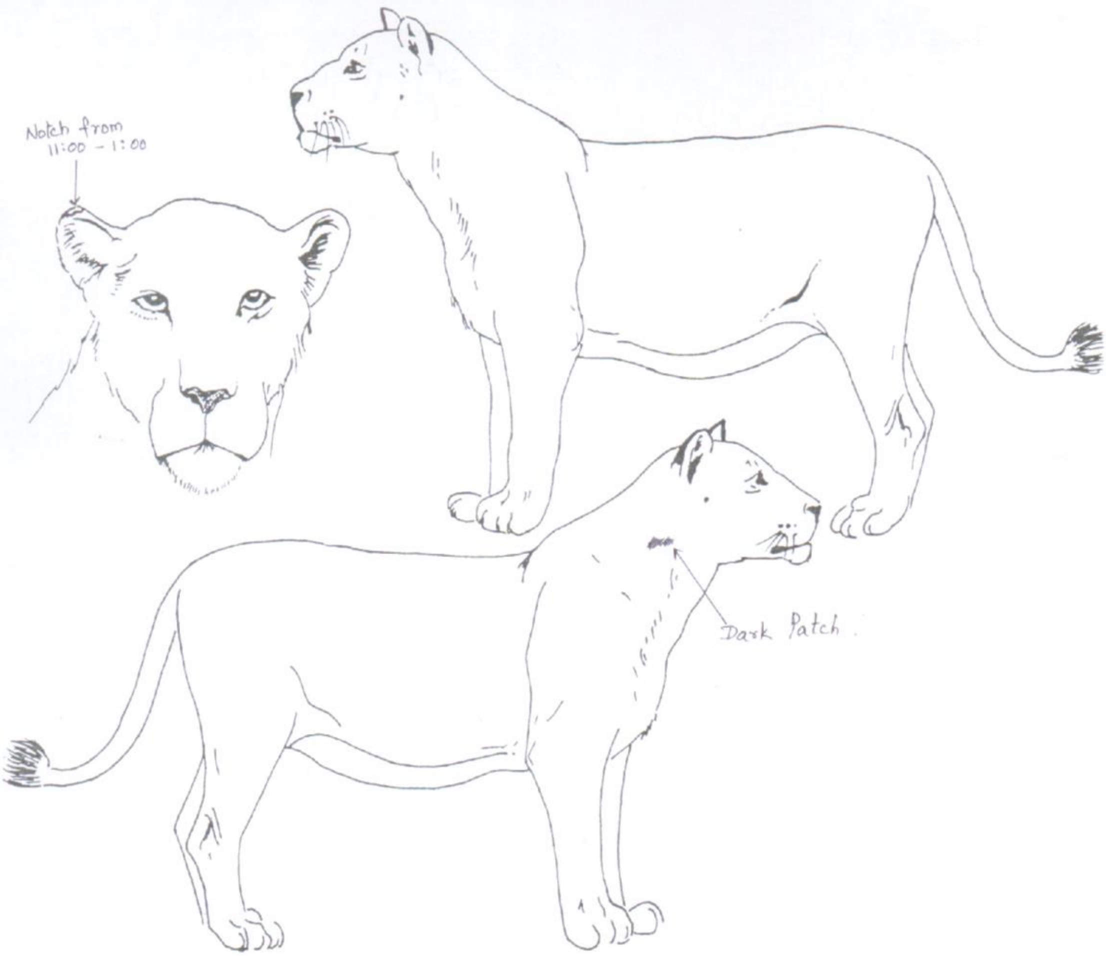


Figure 15. Entries on data-sheet for individual identification of lions for monitoring.





→ Resting on river bed. (Bhim Chas river)
→ Associated with 11 other animals.
→ Body clear.

Tooth (Age) → 3½ - 4 years
↓

6.2. SAMPLING STRATEGY

A sampling strategy consisting of three sampling periods each lasting from 3-4 months was used to collect data. Gir PA. was stratified into three strata; west Gir, central Gir, and East Gir. Attempt was made to invest similar efforts for locating lions and collect data and record locations (with a G.P.S.) in each stratum. A minimum number of lions (10) sampled was considered essential from each strata for each session. Attempt was made to record data on all lions older than 1.5 years. Though we collected data on younger lions, these were not used in the analysis, since the statistical models used for estimating population size assumes a closed population. Mortality over the short duration of the project was most likely to occur in younger age groups and therefore, these were excluded from the analysis.

This design was developed to minimize over sampling areas near the base camps and under sampling areas further away. However, this bias was not totally removed since all lions encountered were sampled and included in the analysis (Figure 16). Such a sampling strategy would bias results when sample sizes are small in comparison to the population size and would result in under estimates of the actual population size. In this study sample sizes were quite large (193 samples of 159 individual lions in a population of about 270 lions, 59% of the total population), and the resultant estimates of population size were larger than the official records (see later this section). The distribution of sampled lions (Fig16) to a large extent reflects the density of lions in the Protected Area and to a lesser extent our sampling bias. The average diameter of a lioness seasonal range is about 8 km (see later this study and Ravi Chellam 1993). The spatial distribution of sampled lions (Fig 16) suggests that most lions residing in Gir Protected Area would have had a chance of being sampled by us since no area with a radius of 8 km has remained un-sampled.

We propose that in each year 2 sampling sessions, one in winter and one in summer each of a three month duration be conducted. Obtaining an adequate number of samples of lions in the monsoon is difficult and therefore, not recommended. It would therefore be possible to obtain a Lincoln-Peterson estimate of the population size each year and a population estimate using the heterogeneity model (Pollock et al. 1990) every 2 years.

6.3 ANALYSIS

The data obtained herein are conducive for analysis using Pollock's robust design (Pollock et al. 1990) and statistical estimates of population size were obtained within the duration of the project. Sampling and monitoring if continued beyond the duration of this project (which is the ultimate objective for doing this exercise) then the data thus collected will provide estimates of lion survival and annual population size. Though for the current exercise data on younger age groups (< 1.5 years) was not used for analysis, these could easily be incorporated in the current experimental design for future analysis.

The models would provide stage specific mortality and dispersal rates. There would be no need to assume population closure over the long term monitoring (Pollock et al. 1990).

Three sampling sessions were possible during the tenure of the project. Data were analyzed using Lincoln-Peterson estimator and the various mark-recapture models described in Pollock et al. (1990), and Norris & Pollock (1996) using the computer software program MARK (White 2002). The model selection procedure of MARK selected the null model (N_o) which assumes that there is equal "catchability" (i.e. equal probability of working on the whisker patterns) of all lions. This model is biologically unrealistic since lions differed in their probability of being "captured". Some were shy and difficult to work with while others were quite complacent. On several occasions lions did not permit us to work with them.

The second best model selected by program MARK was the Heterogeneity Model (M_h) (see Appendix 9 for Program MARK results). This model assumes that each lion has its own unique capture probability. We did not expect lions to have a "trap" (M_b) or "time" (M_t) response i.e. lions would not become habituated or shy to our method of data collection.In the case of sighting-resighting population estimate of lions Heterogeneity model (M_h) would be the most biologically realistic model. In the given time frame of this study we lacked the replicates required to perform powerful tests to select between different models (Pollock et al.1990).

Consistent population estimates were obtained from the robust Lincoln-Peterson estimates (Table 25). The coefficient of variation (CV) of the population estimates were reasonably small (ranging between 4-12%). Jhala et al. (1999) recommend CV values less than 10% for reasonably precise population estimates. However, CV values lower than 3% are recommended if the goal of the monitoring was to detect population changes of less than 10% magnitude with sufficient statistical power (Plumptre 2000, Taylor and Gerodette 1993). This would surely be desirable and could be achieved through more sampling sessions (4-6 sessions).

The current estimates provided (table 25) are fairly good in comparison to similar estimates obtained for tigers using Mark-Recapture techniques (Karanth 1995, Karanth and Nicholes 1998).

After 2-3 sessions of "mark recapture" the data that needs to be compared becomes enormous for manual handling and visual interpretation. We are in the process of developing an individual identification photo documentation software program that would be linked to a database. This would permit us to handle large amount of information accumulated through several capture sessions of lions efficiently on a computer. It would allow us to compare between sessions and identify recaptures through an automated process. Also since the program would be linked to a database, it would be possible to look up individual histories of each lion encountered, thereby permitting long-term monitoring of individual animals.

6.4 OUTCOME OF THIS WORK

The proposed protocol would ensure a regular continuous monitoring of the lion population in Gir Protected Area. An annual and bi-annual reliable population estimates would be obtained. Accuracy and precision of these estimates to detect any change (bi annually) in the population that would be of biological significance would be achieved if a minimum of 50 lions were sampled in each session. The protocol should be extended to the satellite populations also for their monitoring. Information on survival and dispersal would be obtained between every 2 year period within the Protected Area and also for the satellite populations and movements between them detected.

The photo-documentation software program linked to the database that we intend to prepare would ensure that exhaustive data collected through the lion “capture” sessions could be efficiently handled, rather than the laborious manual handling and visual interpretation. It would assist in long-term monitoring of individual lion life histories with short term monitoring intervals essential for managing such an endangered population of a large carnivore.

Table 25: Details of sample sizes and population estimates of lions (> 1.5 years), in 2001-2002 within the Gir Protected Area, with Lincoln-Peterson and Heterogeneity models obtained from program MARK.

	Sample 1	Sample 2	Sample 3	L-P I Ses 1&2	L-P II Ses 2&3	L-P III Ses1&3	Average L-P estimate (Sd, CV%)	Pop Estimate Heterogeneity model (SE)	95 % Confidence Interval
Males	29	35	37	179	194	189	187 (8, 4.2)	157 (12)	137-184
Females	21	36	35	101	101	112	105 (6, 5.7)	114 (9.7)	99-137
Total	**50**	**71**	**72**	**280**	**295**	**301**	**292 (11, 3.8)**	**271**	**236-321**

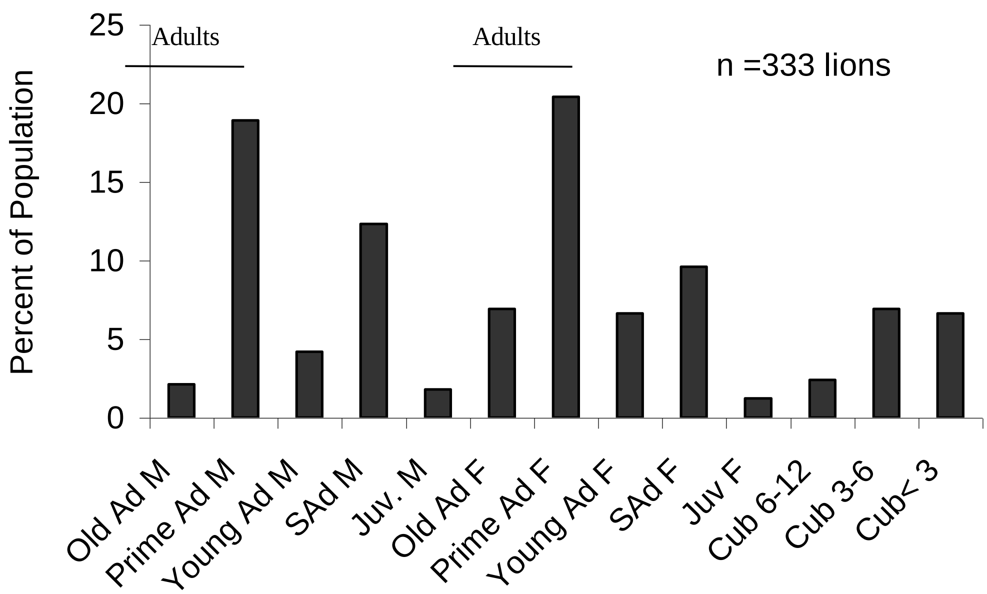
L-P – Lincoln Peterson Estimate

6.5 LION DEMOGRAPHY

Size, body markings, tooth eruption and ware, and development of secondary sexual characteristics in case of males, were the primary criteria used to age the lions (Schaller 1972). Data where age category was uncertain was discarded from this analysis. Project personnel were trained and tested in identifying the various age categories

In all 333 lion sightings (ad libitum and individuals form population estimates) throughout Gir P.A. were used to classify them into eight age classes which provided finer demographic parameters thereby avoiding biases creeping in while trying to age the lions into exact age categories (years and months). Adult lions were classified into 3 age categories; young adult (3-5 years), prime adult (5-9 years), and old adults (older than 9 years). Lions between the age of 2-3 years were classified as sub-adults, 1-2 years as juveniles and younger than 1 year as cubs. Cubs were further distinguished into very young cubs (0-3 months), young cubs (3-6 months) and older cubs (6 -12 months).

Figure 17 . Age and sex composition of the lion population in Gir National Park and Sanctuary (2001-2002), based on adlibitum sighting and visual estimation of age (stage) categories.



Cubs (less than 1 year olds) comprised 15.3 % of the population while lionesses in the reproductive age group comprised 32.7% of the population (Figure 17). The ratio of cubs to reproductive females was 0.47 and quite low in comparison to that reported by Pati and Vijayan (2001). Schaller (1972) reports cub to female (including sub-adults) ratios between 0.4 to 0.66 in the Serengeti. Adult sex ratio of males : females was 1:2.57, sex ratio for sub adults and juvenile lions was 1:0.78 and 1:066. Sex ratios obtained from this study were similar to those computed from the population estimation done by the Gujarat Forest Department in May 2001 (Pathak et al. 2002), and to that reported in the Serengeti (Schaller 1972).

6.5.1. Radio-telemetry and demographic monitoring

Radio-telemetry is an indispensable technological tool that enables collecting data that are either extremely difficult or otherwise resource intensive to obtain. It is extremely important to obtain information from individually known animals at precise predetermined time dictated by an experimental design to answer many ecological questions. Radio-telemetry is a tool that assists in collecting this information which would otherwise not be possible to obtain. It is often argued that lions in Gir are easy to locate and radio-collaring is not essential. These arguments are baseless when it comes to collecting data over several years or even tracking a lion through the night.

Radio-telemetry would be an extremely valuable not only for collecting scientific data but also as a monitoring tool. We propose that lions from a minimum of 10 prides are perpetually equipped with radio-collars. If appropriately monitored, as per the protocol proposed, data extremely relevant to the management of the species and its ecosystem would be obtained. These prides would serve as indicators for any unusual events like epidemics, large scale movements, poaching episodes etc.

6.5.2 Radio-Collaring, Ranging, and Demographic Data

We had hoped to achieve a target of 10-12 radio collared lionesses during the tenure of this project. We could radio-collar seven lionesses from different prides spaced through out Gir (Table 26). All the capture and radio-collaring operations went conducted extremely smoothly. The use of Meditomedine in combination with Ketamine (Jalanka and Roeken 1990, Kreeger 1996) improved the safety margin and provided more versatility for anesthetizing free ranging Indian lions. The high potency of the drug enabled ease of delivery through a gas powered projectile dart (Teleinject) of small volume (3 ml). The almost soundless and low impact mode of delivery coupled with quick induction time (2-5 min) guaranteed that lions did not go far after being darted. The maximum distance a lioness moved after being darted was 40 m, all other lionesses were anesthetized within 15 m of the darting spot. The extremely specific antidote Atipamezole resulted in total recovery of anesthetized lions within a very short duration (details of drug doses and data on collared lionesses is provided in Appendix 10).

Ranges of lionesses were quite consistent in sizes (Table 26, Figure 16). In the beginning of the study Female 99 had 5-7 month old cubs and her range was restricted. Female 93 had 2-3 month old cubs and initially had a small range. She lost her cubs to lion predation (infanticide) (Table 27) and subsequently her range expanded. Female 95 delivered 2 cubs during the course of this study and the family is currently doing well. Female 52 had 2 cubs prior to radio-collaring, she lost one of her cubs at about 2-3 months of age. When radio-collared she had got inside the Devalia Safari park with her cub probably for the supplemental food and security from male lions offered by the enclosure. She was released outside with her remaining 5 month old cub. Within a few weeks this cub was killed most probably by a male lion outside the safari park. The lioness 52 reentered the Devalia Safari park through gaps in the enclosure and delivered cubs within 55 days of the loss of her previous litter. This is most unusual since lioness normally do not conceive when they have cubs less than 1.5 years of age (Schaller 1972). Currently she resides within the safety of the safari park with her cubs, and therefore has a very small range. Her home range estimate has not been used for computing the averages range sizes of lionesses (Table 26).

Table 26: Ranges of radio-collared lioness in Gir Protected Area calculated using Minimum convex polygon with CALHOME software.

Ch# No	General Location	Maximum Convex Polygon (100%, km^2)	Number of Locations
52	Devalia (W.Gir)	4.85	50
99	Timbarva (E.Gir)	37.51	150
17	Kankai (C.Gir)	32.88	70
98	Tulsishyam (E.Gir)	65.99	205
95	Kherambha (W.Gir)	48.46	115
15	Jambudi (E. Gir)	49.6	80
93	Shirvan (W.Gir)	58.57	154
	Average (n=6)	48.8 (SE 5)	

Table27: Summary Table of major events for demographic data collection from radio-collared lionesses and their associated group members.

AdF= Adult Female, SAF= Sub-Adult Female, YAdF = Young Adult Female, SAM = Sub Adult Male YADM =Young Adult Male

Female ID	Date	Estimated Age (Years)	Location Area	Important event	Associated animals	Remarks
98	5-7-01	2.5	Tulsishyam	Radio Collared.	3 AdF, 2 SAM, 2 SAF	Total group of 8 animals
	30-6-02	3.5			1 AdF, 2-3 SAM, 2 SAF	Pride Fluid with as many as 18 different lions seen associating temporarily
99	11-7-01	7-8	Timbarva	Radio Collared.	2 M cubs, 1 F cub	6-7 month old
	30-6-02				2 M cubs, 1 F cub	1.5 year olds – sometimes other females seen associating, also this group joins up with Tulsishyam group on kills (three occasions)
95	27-12-01	8	Kherambha	Radio Collared.	YADF	
	28-2-02				Single	Young female left, collared lioness single
	24-3-02			Pregnant	None	
	31-3-02			Delivered 2 cubs	None	Place: Kheramba (mated Dec 20-25 with Tagged Male of 3 Male Coalition)
	30-6-02				Three cubs 3 month old	Lioness and cubs doing well
93	28-12-01	7-8	Sirvan	Radio Collared.	1 YAdF, 2 Cubs	2-3 month old cubs
	5-3-02			1 cub missing.	1 YAdF, 1 Cub	Likely killed by male lion.
	26-4-02			Cub killed	1 YAdF	2 nd Female cub killed by a lion and fed on. Mother with a limp.
	6-6-02			Mating	Coalition male	
	8-6-02			Mating	1 YAdF	
	24-6-02			Mating.	1 YAdF	
	30-6-02				1 YAdF	Both lionesses in close association, has probably conceived.
15	10-1-02	6-7	Jambudi	Radio Collared.	1 PAdF, 2M cubs, 2F cubs	M cubs 5-6 months old F cubs 3-4 months old
	30-6-02				1 PAdF, 2 M cubs, 2 F cubs	Collar malfunctioned since March, sporadic data collected. All cubs surviving and same female in association
52	4-10-01	8-9	Devalia	Radio collared.	1 Cub	Cub 4-5 month old
	16-10-01			Cub missing		A scat with claws was found. Most likely killed by a male lion.
	7-12-01			Delivered 3 cubs.		Inside safari, Carissa thickets
	30-6-02				3 Cubs six month old	Doing well due to protection of safari park and extra food.
17	29-4-02	> 12	Kankai	Radio collared.	None	Collared in Kankai
	11-5-02			Mating	YAdM	Male left after 5 hrs.
	4-6-02			Mating	YAdM	Kankai
	30-7-02			Captured		Maggot infestation, Treated in Sasan
	Sep 02			Released		Doing well and hunting in C. Gir

(Table 27) summarizes that data recorded towards collecting demographic information from the radio-collared lionesses. A proper format for recording data from radio-collared lions is given in Appendix 11. The schedule for recording data from the collared lionesses would depend on the objectives of the study. For collecting demographic data a radio-location followed by visual sighting and visual monitoring of the lioness and its associated animals for 8-10 hrs every 3 days would suffice. This time interval would ensure that group members that are temporarily separated or cubs that are hidden for short durations would not be missed. This schedule would then guarantee that demographic events like births, dispersal, mortality, matings, and social data on pride/group dynamics would be recorded with a good temporal resolution. However, if cause specific mortality is the objective of the study then a continuous vigil would need to be kept especially during the vulnerable time frame (eg. when cubs are less than 3 months old). Regular visual confirmation is needed (5-6 hr interval) to record causes of death of young cubs.

6.6 PRECAUTIONS

It is important that the persons collecting this kind of data are trained not only in using telemetry equipment but also in animal behavior. Observers should be extremely careful not to disturb the lions whilst they are tracking. Most lions habituate well to this kind of data collection provided experienced observers take care during the initial phases of data collection. It is extremely important not to interfere or disturb the lions when they are hunting.

6.7 PROPOSED WORK

Demographic data takes several years to accumulate even when collected from a large number of individuals. In this case, there are only seven females from different groups that are radio collared, the battery life of the radio-collars already deployed is of an average duration of 3 years. This is a minimum timeframe for all females to conceive, bear and raise at least a single litter. It would be prudent to re-collar the same individual females once the current radio collar batteries are exhausted and continue with data collection for a minimum of 3-5 litter cycles for each female (as is currently being done for tigers in Panna for obtaining life time demographic data (Raghunandan Singh Chundawat Pers. Comm.)). The other alternative would be to put out more transmitters on females from other social groups (another 5 lionesses, as proposed in the technical proposal). This approach would provide a sufficiently large sample for good scientific inference on demographic parameters.

Currently telemetry equipment is loaned to the Gir P.A. management staff and a protocol for data collection suggested (see above and Appendix 11). It is important that the above schedule for collecting data in the formats provided are recorded systematically, without gaps, so as to make the above efforts of time and resources investment meaningful.

Monitoring through telemetry and by the individual identification through mark recapture models will ensure that the Park management would always be abreast with processes and changes that are likely to affect the Gir lions. Important information on annual population estimates, population structure, dispersal, survival rates, litter sizes, infant mortality, inter birth intervals, epidemics, and poaching; – critical information for managing any endangered species population, will be available from this monitoring scheme. Further once the photo-documentation library coupled with a database becomes functional it will be possible to trace individual life histories of lions as well.

CHAPTER - 7

MONITORING LEOPARDS

Yadvendradev Jhala, Nita Shah & K. S. Chauhan

The Gir management believes that the leopard population in Gir has increased significantly over the past years (Bharat Pathak pers. comm.). This has raised concerns regarding possible competition between lions and leopard and predation of lion cubs by leopards. Such ecological aspects are beyond the scope of the current consultancy project and could potentially be answered by an in-depth study using telemetry. Intensive research on leopards using telemetry has commenced (J. Khan pers. comm.). Since Gir is a major strong hold for leopards it would be essential for the P.A. management to have a good handle on the population trends of this large cat. Indices of population density and leopard numbers would be relatively easy to develop once leopards are radio collared. In the absence of this technological tool, a simple yet robust monitoring scheme has been proposed.

There are potentially two aspects of the leopard population that are of interest to the Gir PA management; a) Population Trend and b) Population Numbers. Estimating and monitoring leopard population numbers is by far a more formidable task as compared to monitoring leopard population trend. For achieving the basic biological objective of monitoring, it would suffice to monitor population trends (Caughley 1977). Actual numbers would be needed for political reasons and for answering complex questions like ecological interactions between carnivores, their prey base, and on human-leopard conflicts. Such questions would need information on actual densities and which cannot be answered by relative densities (obtained for trend monitoring). Whereas, if information on numbers and densities are obtained they would also provide information on population trends.

7.1. LEOPARD POPULATION TRENDS

Most wildlife staff is trained and quite capable in recognizing pugmarks of leopards and differentiating them from lion and hyena pugmarks. It would be important to test the ability of the staff deputed to conduct this exercise in identifying leopard pugmarks. This is the only pre-requisite for this monitoring protocol. Staff does not need to be trained in pugmark tracing techniques.

The proposed sampling scheme is designed based on the current knowledge of leopard pugmark encounter rates and their ecology. The index that surrogates leopard numbers is the number of leopard pugmark track sets encountered along pre-determined roads. The pugmark set encounter rate as proposed in the following protocol is likely to meet the criteria of a good index of population size (Gibbs 2002).

7.2. PROTOCOL

1) A pugmark set is defined as a series of individual pugmarks (of a single leopard) seen on a jungle road. The pugmark set may be composed of one to several pugmarks (if the leopard had been walking along the road). It is likely that the same leopard leaves the road (being sampled) and returns to walk back on the road. To avoid inflation of the index by data from single leopards walking along roads and also to avoid the subjective bias in deciding if two pugmark sets belong to the same leopard or to two different leopards, only pugmark sets separated by a minimum distance of 100 m would be recorded. Therefore, say if a leopard walking along a road leaves the road and returns back after 50 m then the second pugmark set would not be recorded. However, even if the same leopard were to return back to the road after 100 m, then the pugmark set would be recorded as a second set.

2) Fifteen km stretches of forest (unpaved) roads have been selected for sampling. Each 15 km road would be further divided into 1 km stretches. The 15 km road would be the primary sampling unit while the 1 km stretches on this road would be the secondary sampling unit. Five such primary sampling units have been chosen each in West, Central and Eastern Gir. The best season to conduct this sampling would be February-March. Since by this time road network within Gir is in fairly good condition and sufficient vehicles have already moved on these roads so as to make the road surface suitable to record pugmarks. Also there is sufficient moisture during early mornings to retain good track sets without distortion.

3) Each sampling unit would need to be sampled five times on subsequent mornings (prior to any vehicular movement on these road stretches). The day prior to beginning the sampling, all selected road stretches would need to be searched and all pugmarks encountered obliterated. Thus, the proposed protocol would require a six day investment per year with a well supervised systematic data collection schedule. It is not essential that only one team consisting of two trackers searches each sampling unit, it may be more time efficient if three teams are

deployed to each primary sampling unit and made responsible to cover a predetermined segment of 5 secondary sampling units (5 kms). This distance on the average can be effectively covered in two hours without the team getting fatigued. The sampling team should be instructed to erase all tracks once they have recorded them on the data sheet to avoid recounting the next morning.

4) The primary sampling units suggested (based on their location, distribution and substrate) are:

West Gir :

a) Devalia Range
b) Kherambha to Kutni Board via Khada
c) Visavadar/Kamleshwar Naka Road to Kadeli Ness to Bhambhapole Naka
d) Kamleshwar Naka to Kamleshwar Temple Via Mindholi
e) Talala Road (Khokhra Naka) to Sirvan Village Road

Central Gir :

a) Kaleshwar Road-Kankai Junction towards Kankai
b) Chodavdi to Banej
c) Dhabara to Chovadi Road
d) Janwadla to Jamvala to Gola board
e) Kiyakata to Devkanya

Eastern Gir :

a) Timbarva to Loki to Sikal Kuba
b) Bhimchas to Hadala
c) Jasadhar to Ghodavdi to Machundari
d) Leriya to Hadala
e) Banej to Vanka Jambu to Hadala

It is possible that some of the roads mentioned above may not be 15 km in length. In that case, an appropriate length of road segment in the same area should be sampled to complete the 15 kms of the primary sampling unit.

5) This exercise needs to be undertaken once each year. It is important to sample the same road stretches each year so that the same set of confounding factors would likely influence the recording of pugmarks. This would ensure that the data set is conducive for comparison

between years for obtaining trends. A Sample data format for recording is provided (Appendix 12).

6) Analysis would be done by computing either the average pugmark sets recorded over the five morning samples within the primary unit or the presence or absence of pugmarks within secondary sampling units, and their standard deviations and standard errors. Grand averages or region wise averages would provide analysis for the entire protected area or for trends region wise. The best way to estimate trends would be by regressing the pugmark set index against years (Sokal and Rohlf, 1981). If the regression is significant then the leopard population is either increasing or decreasing. A significant positive slope indicates an increase in the population and a significant negative slope indicates a decrease in the leopard population. If the regression is not significant (slope is not different from zero) then the leopard population is stable.

7) A 15 km length of linear road is likely to traverse about 2-5 leopard ranges in good leopard habitat. In poor leopard habitats or in the case of leopard population declines it may be possible that no pugmarks are encountered on the sampling units. This would be rare on all five sampling occasions, but in case it happens then the index would suffer with low precision. In that case the sampling intensity would need to be increased from 5 to 8 or 10 replicates of the same sampling units.

8) The same protocol can be used simultaneously for population trend monitoring of hyaena, jackal, and porcupine. By recording tracks of these species along with the leopard pugmarks population indices for these animals could also be developed without much extra effort.

7.3 ESTIMATING AND MONITORING LEOPARD NUMBERS

Estimating actual numbers of any carnivore population is a laborious and resource intensive exercise. The ecological attributes of territoriality, low density occurrence and secretive-nocturnal behavior of carnivores makes it difficult to use traditional techniques of enumeration like line transects, block counts, and total counts. A relatively successful technique that has been applied for population/density estimation of large carnivores are the various models using the broad framework of the mark-recapture statistical theory (Jhala et al. 1999, Karanth and Nicholes 1998, Maddock and Mills 1994, Pollock et al. 1990).

A pre-requisite for a mark-recapture population estimate is that the identity of some individual animals in the population is known with certainty. In the case of tigers (*Panthera tigris*), their stripe patterns are unique to individuals and photographs taken by remote cameras within an experimental design framework provide data for population or density estimation (Karanth 1999, Karanth and Nichols 1998). Lions are uniquely identified by their whisker patterns (Pennycuick & Rudnai 1970, Jhala et al. 1999 & this vol.). Leopards, jaguars (*Panthera onca*) and cheetahs (*Acinonyx jubatus*) too can be individually identified from the spot pattern on their bodies. It would be possible to identify individual leopards in Gir through camera traps and then estimate their numbers through mark-recapture models. A detailed protocol for such an experimental design and data collection is given in Karanth and Nichols (2002).

Like all field methods there are advantages and disadvantages in using the camera trap technique for leopard enumeration in Gir. It is likely that the camera trap technique may work well in Gir. However, keeping in mind a) the high probability of camera thefts, b) large number of camera traps required for an adequate sample size and c) the costs in terms of money and skilled labor involved, we are proposing a modification of the existing pug-mark technique for leopard population estimation at this juncture. The Protected Area staff is well trained in identifying pugmarks, the climate and soil conditions in most areas of Gir are conducive to recording animal tracks. We propose that quantitative measurements obtained from pugmark sets of leopards be used for individual identification.

Recent research at the Wildlife Institute of India has resulted in developing statistical models for discriminating individual tigers (*Panthers tigris*) from their pugmarks (Sharma 2001, Sharma et al. in Review). The methodology of obtaining the pugmarks are similar to that proposed by Choudhury (1970, 1971) and Panwar (1979). However, our data on pugmark tracings of leopards in Gir suggests substantial variation between tracers.

7.3.1. Pugmark Photography

To avoid this source of variability that is likely to affect model accuracy in identifying individual leopards we recommend the use of pug-mark photography to replace pugmark tracings. A photographic stand has been devised to facilitate pug mark photography (Figure 18). This stand ensures that the camera is at a fixed distance from the pugmark and the lens is parallel to the pug mark surface. Data on location, date, pugmark number and pugmark set are recorded on the photograph itself.

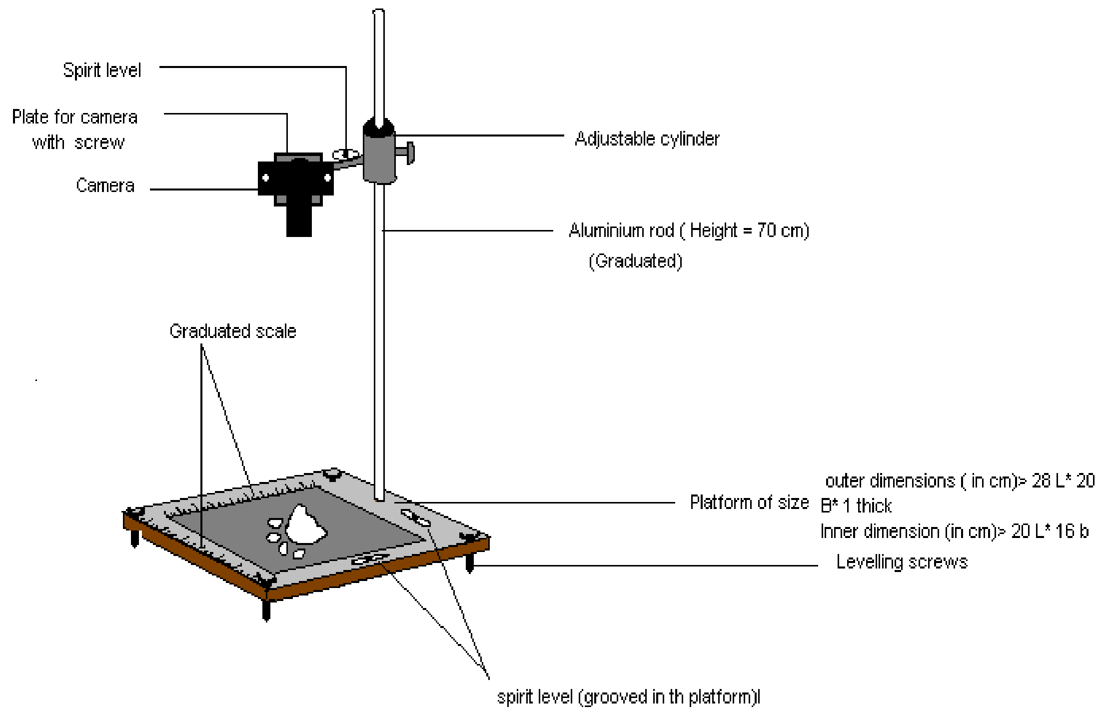
7.3.2. Procedure

It is important that a minimum of 8 to a maximum of 20 pugmarks of the hind foot from a pugmark set are photographed. A pugmark set is defined as a series of pugmarks made by a single leopard walking at a normal gait. Both left and right hind pugmarks should be photographed (not necessarily in equal numbers). Besides photographing pugmarks two other measurements need to be recorded in the field. These are stride and straddle (Figure 19). It is important that stride is measured parallel to the line of walk while straddle is measured perpendicular to the line of walk of the leopard. A minimum of 8 measurements and a maximum of 20 measurements of stride and straddle need to be recorded for each pugmark set. The photographs are then transformed into digital images by scanning. These images are then subjected to measurement of the following 9 variables on the computer.

These data matrix are then subjected to multivariate analysis to identify individual leopards. It would not be possible to transfer this entire technology to the Gir P. A. Management at this stage since it is still in the formulative stage and involves a rather cumbersome process of using several software for measurements and analysis. We are in the process of developing a customized software to conduct the measurements and analysis in the same package. Meanwhile if appropriate data are collected in according to the protocol mentioned above. We would help conduct digital processing and analysis at the WII laboratory.

Once individual leopards are identified it would be possible to conduct a mark-recapture population estimate based on pugmarks. Total enumeration of the leopard population may not be possible or desired for monitoring or for ecological understanding. It may be possible to estimate densities in different habitats and then with sufficient replicates extrapolate these to the entire P.A and surrounding landscape to arrive at population estimates.

Figure 18 . Photographic stand devised for photographing pugmarks



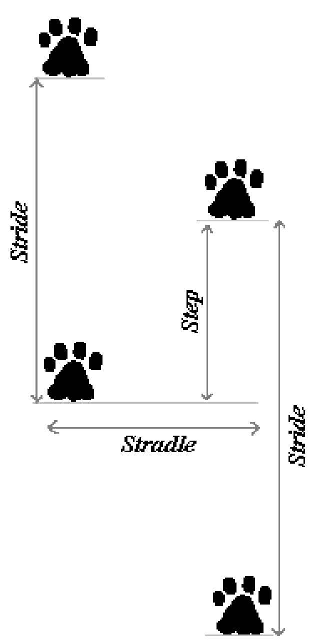
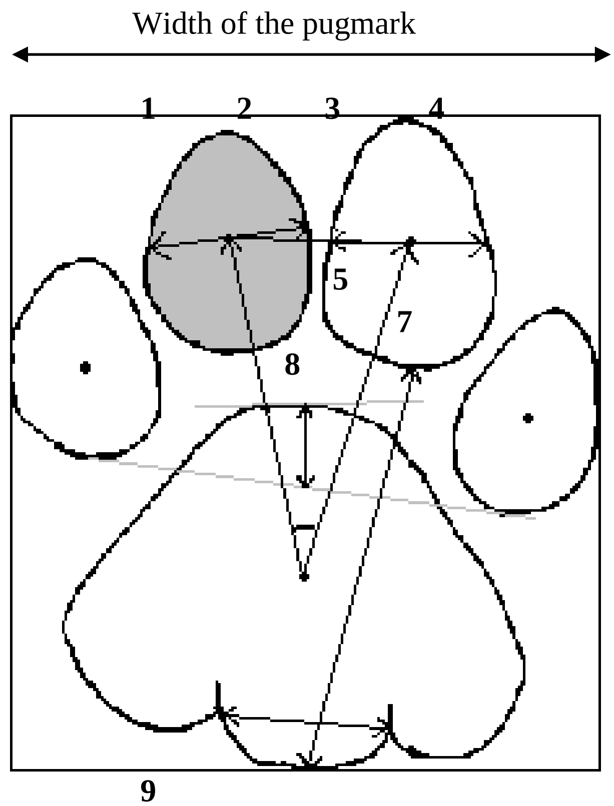


Figure 19a. Gait parameters: stride and straddle measurements from a pugmark set.

Figure 19 b: Nine pugmark variables measured from pugmark.



1. Area of toe no.3
2. Length of minor axis of toe no. 3
3. Distance between toe no. 2 and toe no. 3
4. Length of minor axis of toe no. 2
5. Distance between main pad top to toe base-line
6. Angle between PT2 to PT3
7. Heel to lead toe length
8. Distance between N1 and N2
9. Width of the pugmark

It would be logical to use the road network identified for monitoring trends (primary sampling units) also for photographing pugmarks. Pugmark photography and gait measurements could be taken simultaneously with the trend monitoring exercise so as to save time and effort. For density or population estimation it may be necessary to have4-5 pugmark "capture" sessions (similar to those of lions). With each capture session consisting of a minimum of a 8-10 day effort across the entire area (range/habitat type or PA over which population estimate is desired) spaced at least a month apart. Thus population estimation would require a minimum of a five month period (November to March) with 2 months required to process and analyze data.

CHAPTER – 8

SMALL CARNIVORES

A.J.T. Johnsingh

Gir protected area, falling in the semi-arid zone of Gujarat, has diverse habitats such as dry deciduous forests, thorn scrub, grasslands, riverine forests, pockets of cultivation, rivers and reservoirs with a varied invertebrate and vertebrate prey. As a result it has a diverse small carnivore community represented by Ethiopian, native and Indo-Malayan species. The carnivore community likely to be found in Gir is represented by two cat species (rusty spotted cat *Felis rubiginosa* and jungle cat *F. chaus)*; two civets (the small Indian civet, *Viverricula indica* and the palm civet *Paradoxurus hermaphroditus*); two species of mongoose (the common Indian mongoose *Herpestes edwardsi* and the ruddy mongoose *H. smithi*); two species of canids (jackal, *Canis aureus* and the Indian fox *Vulpes bengalensis)* and ratel or honey badger (*Mellivora capensis*). There are unconfirmed reports of the occurrence of smooth Indian otter (*Lutra perspicillata*). The small Indian mongoose (*H. auropunctatus*) may occur in the cultivated areas and Gir may be too dry to support leopard cat (*F. bengalensis*).

The behaviour and the habitat preference of these carnivores vary and therefore the methods to assess and monitor their abundance should also vary. The nocturnal species are the rusty spotted cat, the small Indian civet, the common palm civet and the ratel. Of these the common palm civet may occur largely along the riverine tract. The jungle cat, the ruddy mongoose, the common Indian mongoose, the jackal and the Indian fox can be diurnal, when the weather conditions are cooler, as well as crepuscular. The smooth Indian otter should be confined only to the reservoirs and the streams adjacent to them.

Most of these small carnivores (with exception of the jackal) would occur at low densitites, therefore requiring a large effort to quantify their abundance. Monitoring protocols would have to rely on encounter rates over a quantified search effort. The methods suggested for the project "Impact of monitoring India ecodevelopment project on gir National Park and Sanctuary" to develop a monitoring protocol for these small carnivores were:

To use the four broad vegetation categories identified in Gir P.A for small carnivore encounters restrict searches to specific prime habitats like riverine tracts that would be identified and demarked on a map.

- Selection of stretches of road in these vegetation types, the road length selected will be in proportion to the availability of the habitat and or depend on the encounter rate of the target species.

- A search effort of six night drives using searchlight along the forest road network would provide the preliminary encounter rates of small carnivores necessary to develop a monitoring protocol.
- Daytime surveys of the reservoirs and the streams to quantify otter sightings and their indirect evidences.

During the project period (1st March 2001 to June 2002) *ad libitum* observations were made whenever small carnivores were seen and 67 km road transects were run. These transects were run between 2100 and 2400 hrs from November 2001 to May 2002. There were four sightings of jackal (once a mother with three pups and other sightings were of solitary animals) and two of solitary jungle cats.

Ad libitum observations, from November 2001 to May 2002, yielded

10 sightings of common mongoose, all adults and once a pair. These sightings were between 05 03 2002 and 31 05 2002 and all were in day time.

Four sightings of jackal, a total of seven animals. Six were in pairs and one was solitary. These sightings were between 20 04 2002 and 06 06 2002.

Four sightings of ruddy mongoose from 05 03 2002 to 30 05 2002. Three sightings were in day time and one late in the evening at 1850.

One sighting of small Indian mongoose on 06 05 2002 at 2105 hrs.

One unidentified small cat on 06 04 2002.

So a meagre sighting of a total of 14 jackals, 11 of common Indian mongoose, four of ruddy mongoose, two of jungle cat, one of small Indian civet and one of a small unidentified cat. This is largely because of the lack of effort to look for small carnivores. The study by Pati *et al* (year) indicates that if there is effort even a rare species like ratel could be seen 13 times during a period of 24 months. Basically we recommend the following two methods to monitor small carnivores in Gir protected area.

One is *ad libitum* sampling. This is to record the sightings of small carnivores whenever and wherever they are seen. But the staff need to be trained to look for and identify the small carnivores.

The other is run 20-30 km road transects at night in summer in western, central and eastern Gir to record the sighting of small carnivores. The road should be marked into km segments. Summer is selected because the day time heat would force the animals to seek water at night. An open Gypsy should be used and two observers besides the driver with search light should look for small carnivores. The transect should begin around 2000 hrs and each transect should be run 6-8 times.

Data sheets for recording *ad libitum* and road count sightings are provided in Appendix 13.

CHAPTER - 9

MONITORING CONFLICT : LARGE CARNIVORES AND WILD UNGULATES

Ravi Chellam

9.1. INTRODUCTION

When dense populations of large carnivores (lions and leopards), live in close proximity of human settlements conflict between the carnivores and people is inevitable. The main kinds of conflict that have occurred in and around Gir are lions and leopards attacking and killing livestock (livestock depredation), injuring or killing people (human attacks) and the fear felt by the people due to the presence of wild large carnivores close to their settlements.

When crops are cultivated adjacent or close to wildlife habitats herbivores do tend to raid the crops as they find the crops highly palatable and much more nutritious than naturally occurring forage. Herbivores have also been raiding crops around Gir and the main species involved are nilgai and wild pigs (Sinha 2002).

9.2 APPROACH AND SCOPE OF THE TASK

Sub Task : Consultant Dr. Ravi Chellam was an invitee and WII representative for the Census from 12th to 19th May 2001. He assessed the field situation in order to initiate the conflict component. He also visited the Gir PA from 17th to 22nd January, 2002.

Discussions with the park management and review of ongoing consultancy reports indicated that the above components were covered in-depth under another consultancy (Man and Animal Conflict in and Around Gir Protected Area – S. P. Sinha 2002). It would be a waste of resources and time to duplicate the effort and collect primary information on the above task. Instead the best strategy would be to study the report and data already generated, identify if any further parameters need to be collected in the field and then develop protocols for recording and monitoring conflicts between wildlife and humans.

Review of literature and P.A. management records suggests that there are 505 cases of large felid attacks on people from 1988 to 2000. Of these 55% were by lions and the remaining 45% by leopards. Lion attacks occurred primarily in mango orchards and open areas while leopard attacks were largely restricted to sugarcane plantations (Sinha 2002).

In 1980's the proportion of livestock killed was greater within the protected area (61%) compared to outside the PA (39%) (Joslin 1984), however, the scenario is now reversed with 73% of the livestock being killed outside of the PA while only 26% were killed inside the PA (Johnsingh et al. 1998). The average number of livestock killed per year between 1985-95 was 1563 (Johnsingh et al. 1998) while in 1999 to 2000 the number of livestock killed by large felids was 1631 (Sinha 2002). Such analysis of existing records suggests that conflicts concerning livestock depredation are largely outside of the PA and have probably stabilized in their magnitude.

Sinha (2002) reports that the maximum damage to crops is caused by wild pigs (*Sus scrofa*). Other wildlife that cause crop damage are nilgai (*Boselaphus tragocamelus*), chital (*Axis axis*), chinkara (*Gazella benneti*), langur (*Presbytes entellus*), porcupine (*Hysterix indica*) and hare (*Lepus nigricollis*).

A protocol has been developed to record conflicts (human attacks, live-stock kills and crop depredations). (Appendix 14a & 14b). If data is collected according to this protocol it will enable long term monitoring and analysis, which will provide information of direct and immediate relevance to the management. This will also enable the initiation of action for mitigating the conflict and simultaneously add to the database for long-term trend analysis.

CHAPTER –10

MONITORING IMPACT OF MANAGEMENT ACTIVITIES IN GIR CONSERVATION AREA (GCA)

P.K. Mathur & V.B. Mathur

10.1 INTRODUCTION

The significance of monitoring in strengthening PA management and improved decision making cannot be overemphasized. Protection of a single endangered species or the whole complexity of the dynamic ecosystem requires management interventions in order to restore impaired habitats, ensure ecosystem integrity and maintain optimal environmental conditions. To manage dynamic PA with a degree of efficiency and safety, the manager needs to know and understand a great deal more about the way in which the various ecological processes operate and also to monitor the responses subsequent to various management interventions.

The Gir Conservation Area (GCA) or Gir forest comprising Gir NP, Gir WLS and adjoining peripheral Reserved, Protected and Unclassified Forests lies in the semi-arid Saurashtra peninsula. The conservation values of a protected area help in determining the management goals and objectives. The conservation values of GCA have been well-documented (Singh and Kamboj, 1996). The GCA forms the largest compact patch of natural dry-deciduous teak (*Tectona grandis*) and thorn forests. The GCA is the last wild abode for the Asiatic lion (*Panthera leo persica*). Rugged and hilly terrain of GCA forms the catchment of seven principal perennial rivers flowing in the region. The four major reservoirs located inside GCA immensely contribute in the charging of the aquifers and also support intense agricultural development in the PA surrounds. Grasslands locally called as `Vidis', the pastoralist community (`Maldharis') and their livestock form an integral part of the Gir ecosystem. The Gir ecosystem or entire landscape is maintained by a complex interaction of the physical, biological and socio-economic sub-environments, which in turn are influenced by various forms of management interventions. It is an established fact that in semi-arid and arid landscapes the physical environment, (which itself is regulated by the complex interaction of precipitation-evapotranspiration) plays an overwhelmingly significant role and influences the biological diversity, productivity and socio-economic profiles in the area. Based on the above conservation values, the following objectives of the management have been set for the GCA:

- ❖ Protect and conserve the Gir forest in a manner that is consistent with the ultimate and perpetual conservation of the Asiatic lion and all other life forms and systems that together constitute this unique ecosystem,
- ❖ Improve health of the forests, their ecological functions (e.g. catchment protection) and productivity including fodder, firewood, small timber and other forest produce, to their optimum level in consonance and consistent with the above objective,
- ❖ Enlist peoples' participation in biodiversity conservation through imparting nature education and promoting wildlife tourism,
- ❖ Reduce negative impacts on the biodiversity through appropriate ecodevelopment programmes,
- ❖ Promote ecological studies, and ecological research in pursuance of the above objectives,

10.2. MANAGEMENT STRATEGIES

In order to accomplish the objectives of management, wide-ranging and inter-related strategies have been adopted in the GCA. The GCA has been under 'active' management for over three decades and is one of the few PAs in the country that has had well conceived management plan(s) supported by findings from long term multi-disciplinary research (Joshi, 1976; Singh and Kamboj, 1996). The outcomes of the management approach and conservation strategies adopted in GCA have been recently reviewed (Pathak *et al*., 2002) and it has revealed that the desired objectives of the management have been achieved to a very large extent. The stable/increasing populations of the 'flagship' and other featured wildlife species and improvement in their habitats are indicators of successful management strategies and actions implemented in the GCA so far.

10.3. THREATS TO GCA

Despite active and appropriate management interventions certain threats have persisted all along. Moreover, with the rapid development and urbanization in the PA surrounds; increase human and livestock populations and consequent decline in livelihood options for the resource dependent communities, new threats have also emerged that need to be effectively addressed by the PA management. These threats *inter alia* include encroachment, livestock grazing, fuelwood extraction, poaching, man-wildlife conflict, collection of NTFPs, forest fires, pilgrimage, tourism, and industrial development. These threats are further compounded by natural calamities *viz.*, recurrent cycles of drought and water scarcity and occasional cyclones. These natural calamities have a direct bearing on the livelihood options due to the loss of agriculture, employment opportunities and marketing of agricultural and horticultural produce during the natural calamity period.

10.4. MANAGEMENT INTERVENTIONS

Based on the conservation values, management objectives and keeping in view the existing and emerging threats, the following management interventions have been adopted in the Biodiversity Conservation Plan for Gir (Vol. III – Supplemental Management Plan, 2003-2007) by Pathak *et al*., 2002).

- Settlement, Survey and Demarcation
- Protection
- Habitat Restoration, Improvement and Management
- Development and Management of Peripheral Forests
- Wildlife Population Management
- Wildlife Health Management
- Awareness, Education and Training
- Research and Monitoring
- Tourism and Interpretation
- Ecodevelopment and Maldhari Rehabilitation

Since a range of management activities as indicated above are to implemented by the PA management, it is critical to develop a framework to monitor the outcomes of the above management interventions.

10.5. MONITORING FRAMEWORK – THE KEY QUESTIONS

The basis of any monitoring framework is a set of 'key questions' which the management has to respond. Monitoring is not just 'blind data gathering' process under which voluminous data is generated and perhaps never subjected to rigorous scientific analysis and interpretation. Instead, monitoring is a focussed activity with stated goals to address basic questions pertaining to the complexity and dynamics of the physical, biological and social attributes. Some of the 'key questions' often deliberated by the scientific community and management authorities in the context of GCA are:

- What are the site specific, seasonal, annual and long-term patterns and trends in rainfall? How do these patterns influence the availability of water, grass, forage , and agricultural production?
- What is the effect of changes in land use on the movement and dispersal of lion and other wildlife and on the corridor function?

- ❖ What changes are being brought about in the structure and composition of vegetation due to (a) protection, (b) biotic pressure (e.g. grazing, fire, collection of NTFPs, etc.), and what is their influence on the distribution and status of lion and its prey species?
- ❖ What is the effect of various management practices and biotic pressure on the population structure and dynamics of the flagship and other featured species?
- ❖ How effective have been the management interventions with respect to (a) encroachment, (b) illicit grazing, (c) man made forest fires and (d) other offences?
- ❖ What has been the pattern in habitat recovery/restoration as a result of Maldhari relocation?
- ❖ What is the outcome of the management interventions undertaken in the peripheral forests and grasslands?
- ❖ How successful have been the interventions targeted to reduce the adverse effect of (a) people on PA, and (b) PA on people?
- ❖ Is there any influence on wildlife and its habitat due to (a) road network, (b) pilgrimage, and (c) tourism?
- ❖ How effective have been the management efforts in raising conservation awareness and eliciting public support for the conservation and management?

Certainly, the above is not a comprehensive listing of key ecological and management questions, but only an indication of the type of issues and challenges to which the PA management has to respond. This response cannot come from any adhoc measures but only through a systematic and structured process of data collection, collation and analysis, that is operated through staff and participatory involvement of the local communities. Scientific institutions including Universities have to play a major role in the design and development of a monitoring framework as well as in its implementation, to the extent possible.

10.6 APPROACH

The overall approach adopted for dealing this component of the consultancy assignment can be summarized as follows:

i) Review of published/ unpublished literature.

ii) Developing an understanding of key monitoring issues.

iii) Evolving criteria to evaluate present management practices and existing monitoring activities.

iv) Developing an ecological monitoring framework/format for data collection.

v) Organizing training programmes for senior management and frontline staff on monitoring framework implementation.

10.7 SCOPE OF THE TASK

Considering the significance of management interventions being made in GCA and based on the consensus arrived at during the discussion with senior PA management staff, the scope of this sub-task of the assignment was limited to focusing on the monitoring of the following management activities/ interventions:

- ❖ Monitoring of water resources.
- ❖ Monitoring of grasslands.
- ❖ Monitoring of vegetation, habitat conditions following Maldhari `ness' evacuation.
- ❖ Monitoring of weeds.
- ❖ Monitoring of intense land use changes occurring in PA surrounds.

10.7.1. Monitoring of Water Resources

The entire Saurashtra region of which GCA is a prominent part is characterized by scanty and erratic rainfall. Undoubtedly, the extent and pattern of rainfall determine the primary productivity of grasslands, forests and agricultural ecosystems. Within GCA itself, the extent and pattern of precipitation are highly variable with an increase in aridity as one moves from west to east. An analysis of the rainfall trend in GCA based on the data collected between 1960 and 1984 reveals that the total annual rainfall has fluctuated from a minimum of 189 mm (Kamleshwar – 1987) to maximum of 1,889 mm (Kamleshwar – 1983) with the mean annual of 980 mm. Even in one of the best rainfall year (1983), 678mm rain was recorded in Shingoda (Central Gir) while 3,176 mm rain was recorded in Visavador (north-western Gir). Similarly, there is a wide fluctuation in the total number of rainy days e.g., at Kamleshwar the maximum number of rainy days have been 78 in 1975, while the minimum number of rainy days i.e., 21 were recorded in 1972 and 1986 (Singh and Kamboj, 1996). These wide fluctuations in rainfall as well as in rainy days have led to severe and recurrent droughts resulting in acute scarcity of water for wildlife, livestock and people besides causing drastic reduction in grassland and agricultural productivity. Thus, there is a direct link between annual precipitation and fodder availability or scarcity, loss of agricultural production as well as labour employment, livestock mortality and enhanced PA-people conflict.

The overall strategy to ensure effective management of water resources for multiple objectives has been to harness precipitation by creating reservoirs and other water harvesting structures e.g., small and large check dams.

Realizing the importance of monitoring rainfall pattern, the Gir PA management has established several meteorological stations. In addition to this, the Irrigation and Agriculture departments have also set-up meteorological stations at select locations. The PA management has established a system of obtaining rainfall data from 27 stations located in various parts of GCA. Apparently, there is a variability in the recording of rainfall data from these stations mainly due to inadequate staff and proper motivation. On the contrary, a meticulous system of collection and maintenance of rainfall data was observed at the reservoir sites by the Irrigation Department.

Realizing the manpower constraint in GCA it would be desirable to collect rainfall data from 5 representative locations spread across GCA by the GFD itself.

Beside the rainfall data, it is also important to collect information on water flow to the reservoir and resultant reservoir recharge during the post-monsoon season. Such information can be appropriately used for quantifying the catchment values in ecological as well as economic terms. Several interesting and useful correlation can be made between the extent of precipitation, reservoir level, post-monsoon recharge, water discharge and overall catchment capability measured through grass and agriculture production.

10.7.2. Monitoring of Physical Parameters

Physical parameters notably rainfall, temperature, humidity, wind velocity have a very important role to play in influencing the dynamics of GCA. The extent and pattern of rainfall determines the primary productivity of grasslands, forests and agriculture ecosystems. Similarly, the temperature, humidity and wind velocity have varying influences on the habitat condition and animal behaviour. The following parameters need to be monitored by the Gir PA management:

Table 28

S.N.	Parameter	Sub-Parameter	Periodicity	Remarks
1.	Rainfall	• Quantum	Daily at 0800h	Select 5 locations in North, South, East, West and Central Gir for monitoring the parameters
		• Local Variability	-do-	
		• Trends ▪ Total precipitation ▪ No. of rainy days	Monthly & Annually	
2	Temperature	▪ Minimum Temp. ▪ Maximum Temp	Daily at 0800h with monthly and annual trends	-do-
3.	Relative Humidity	-	Daily at 0800h with monthly and annual trends	-do-
4.	Wind Velocity	-	Daily at 0800h	-do-

It is suggested that modern equipment for automatic recording of the above parameters may be procured and installed by the Gir PA management before the onset of monsoon in 2003. The formats for data collection and collation are given in Appendix 15 to Appendix 18.

1.7.1. 2 Monitoring of Catchment Capability and Stability

Monitoring of the catchment capability and stability is an important requisite as the reservoirs in GCA are an integral part of the life support system. Presently the Irrigation Department monitors the rainfall data and water releases from the dams and it would be pragmatic for the Gir PA management to coordinate efforts with them and get the compiled data on a monthly basis from the five dam sites.

Table 29

Sl. No.	Parameter	Sub-Parameter	Periodicity	Remarks
1.	Catchment Capability and Stability	• Change in water level at dam sites during monsoon season	Monthly	Coordinate with Irrigation Deptt.
		• Change in water level at dam sites during post-monsoon season, as a measure of re-charge capability	Monthly	-do-
		• Release of water from dams for irrigation and other purposes	Monthly	-do-
		• Silt loads at all dam sites	Monthly basis during monsoon and post-monsoon season	Coordinate with Gujarat Agriculture University (GAU), Junagadh or GSWRDC

The format for data collection and collation are given in Appendix 19 and 20.

10.7.3 Monitoring of Ground Water Exploitation

People in the surrounds of GCA exploit ground water for agriculture, horticulture, drinking, animal husbandry and industrial purposes. A large number of open and bore wells have been dug in the area for exploiting the ground water resources and it is essential to monitor their numbers along with the change in water table by recording the following parameters.

Table 30

Sl.No.	Parameter	Sub-Parameter	Periodicity	Remarks
1.	Exploitation of Ground Water Resources	• No. of open wells in select villages	Monthly and Annually	*The selection of villages should be done judiciously covering the areas from the PA boundary to the coast and also from West to East. Water table should also be monitored in select locations inside Gir PA including settlement villages. The proposed forest settlement villages are Shirvan, Bhayadhar, and Ghodavadi. Nine (9) villages should be selected in the Gir west and East Divisions lying within (a) 2 km, (b)2-10km, and (c) >10km distance from the PA boundary.*
		• No. of bore wells in select villages	Monthly and Annually	
		• Depth of water table in open and bore wells in select villages	Monthly and Annually	

The format for data collection and collation is given in Appendix 21.

10.7.4. Monitoring of Availability/ Retention and the Use of Waterholes by Wild Animals

The Gir PA management has established a number of waterholes of different types for use by wild animals. It is important to monitor their use by different wild animals by making systematic observations. It is also important to monitor the evidence of habitat degradation around these waterholes by measuring soil erosion, forage availability, regeneration status and weed proliferation. Similarly, the maintenance of the artificial waterholes including functioning of pumps etc. should be routinely monitored.

10.7.5. Monitoring of Ingress of Salinity

With the rapidly changing land use around Gir PA especially near the coast line and excessive amount of ground water being harvested in the region, it is important to monitor the ingress of salinity. It can be done by measuring water quality in terms of `Total Dissolved Solids (TDS)' in select water bodies/ bore wells. Analysis of water samples collected from each water body/bore well can be got done through GAU, Junagadh or GSWRDC. The format for data collection and collation is given in Appendix 21.

10.7.8. Monitoring of Grasslands

The grasslands, locally known as `Vidis' (*ca*. 8% of GCA) are an integral feature of the GCA. The grassland in GCA are characterized by prominent graminoid species *viz., Sehima nervosum, Themeda quadrivalvis* and *Apluda mutica*. In many places these three species form pure patches and where grasslands have been degraded due to heavy livestock grazing and fire, poor quality grass *viz., Aristida spp.* and *Hetropogon contortus* occur. A large number of forb species also occur in these grasslands. *Indigofera indica* and *Heylandia latebrosa* are two important leguminous plants occurring in these grasslands, which are usually preferred by both domestic and wild herbivores. In such vidis, weeds *viz, Lantana camara, Cassia tora and Prosopis julifora* are also present. Prominent shrubs species in these grasslands are *Zizyphus, Capparis aphylla* and *Carissa congesta.* On account of sustained protection some of these grasslands have interspersed dense tree patches dominated by tree species *viz., Acacia senegal, Acacia nilotica, Acacia leucophleoa, Butea monosperma, Terminalia crenulata* and *Diospyros melanoxylon*. Many faunal species specially Chinkara, Chousinga, Nilgai and Cheetal utilize these grasslands.

There are two types of Vidis *viz.,* (i) Reserved and (ii) Non-Reserved. The basic differences between the two are that in the former (i) greater level of protection is provided; (ii) no grass harvest/ livestock grazing is allowed during the growing season; (iii) systematic grass harvest, bailing and storage is carried out in the post-monsoon and winter season (mid October – February). There are 31 Reserved Vidis and 48 Non-Reserved Vidis covering 84.8 km^2 and 65.4 km^2 area, respectively. The Gir (West) Division and Gir (East) Division manage 79 Vidis. Some of the Non-Reserved Vidis are given to various institutions such as Gaushala, Panjarapole, Panchayat, etc on short to long-term basis and some are sold out to public by auction.

The annual grass production in vidis fluctuates widely depending upon total rainfall, number of rainy days and level of protection provided during the active growth period or the rainy season. Since these grasslands have been traditionally managed for `hay production' for a very long time, systematic records of grass collected from each of the Reserved Vidis are available with the Gujarat Forest Department. The management of the vidis mainly includes (i) protection by erecting fences (stonewall, trenches etc); (ii) grazing regulation; (iii) fire control; (iv) soil and moisture conservation works and (v) systematic grass harvest. In recent years an attempt has been made by the Gir (West) and Gir (East) Forest Divisions to document the structure, composition and status of each of the vidi.

The major management issue with respect to Reserved vidis is to maintain the diversity and productivity on a sustainable basis. These vidis are affected by successional changes. Woody species *viz.*, *Terminalia crenulata*, *Acaecia senegal*, *Acacia leucophleoa* and *Butea monosperma* are increasingly getting established and therefore, area under grass cover is gradually reduced. To counter this trend, the PA management undertakes manual uprooting of such woody species during the rainy season. Presently, such operations are on a small scale, mainly as experimental trials in select vidis and should to be continued with proper documentation. However, the following points need to be taken into consideration during such woody species removal:

a) No woody species should be removed on the boundaries/ periphery of those vidis that are in proximity to villages, as the woody layer can serve as additional boundary demarcation.
b) As woody species coverage upto 30-40% of the total area of grassland (vidis) in mosaic patches is desirable it should be ensured that a proper mix of grass-woody species cover as required by various faunal species.
c) Monitoring of areas subjected to removal of woody species needs to be done in order to ensure the recovery of palatable grass species instead of undesirable herbaceous weed plants.

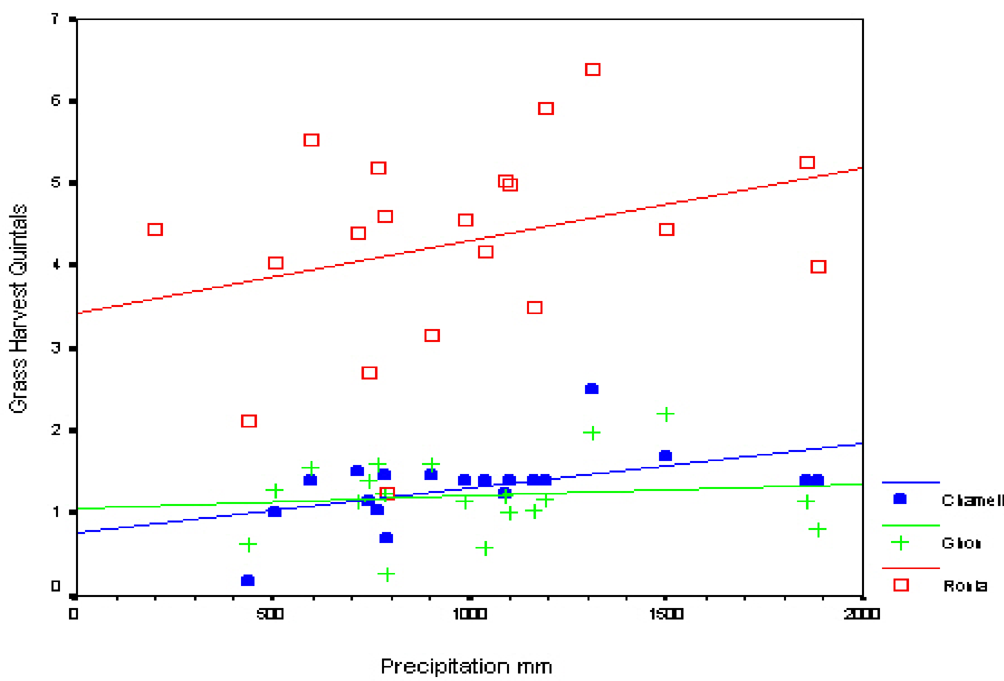
In many Non-Reserved vidis, habitat degradation is apparent due to uncontrolled and excessive grazing by livestock. Perennial and palatable grass species are thus, being replaced by annual and non-palatable grass or weed species e.g., *Aristida spp.*, *Lantana camara*, *Cassia tora*. Besides this, the diversity of herbs, particularly leguminous species has also declined in such excessively grazed vidis. Degradation of non-reserved vidis needs to controlled/checked/reduced by providing enhanced protection, especially during the grass growth period.

Following important parameters need to be monitored in all vidis so as to assess their overall status:

a) Proportion of annual Vs. perennial grass species, their cover and proportion of leguminous herbs – number of perennial grass tussocks/m^2, tussock vigour and diversity of desirable forb species.
b) Relative proportion of grass, shrubs and tree layers in vidis.
c) Overall grass production.

A long-term data set exists on the production from the Vidis in and around the Gir PA (Singh, and Kamboj. 1996) (Appendix 15). In a semi-arid region aboveground production in grasslands is highly correlated with precipitation. In theory it would be possible to model and monitor grassland productivity based on rainfall data. Keeping in mind the good record keeping of rainfall data at several stations within and outside of Gir P.A. we attempted to model grassland production based on rainfall. Such an attempt has been successful in the Bhal region of Gujarat (Jhala 1991) where a 2 year rainfall sequence accounted for over 90 % variability in above grassland production in Velavadar National Park. Such models would not only permit better management in knowing a priori the likely production for the year but also serve as a monitoring tool. We attempted simple linear regression and multiple regression models with subsequent year's rainfall as the independent variable and grass harvest as the dependent variable. Examples of a graphical representation are presented below for some vidis as an illustration.

Figure20: Relationship between rainfall and grass harvest from Ronia, Ghon, and Chameli Vidis.



Though the figure suggests a linear relationship between rainfall and grass harvest as expected, the data were extremely variable and were not conducive to modelling. The relationships were not statistically significant (p values between 0.6 to 0.03 with R^2 values ranging between 0.04 to 0.2). This suggests that data would need to be collected on grassland production in a prescribed format using a good experimental and sampling design which would ensure reducing extraneous sources of variation.

A user-friendly sampling technique is recommended for monitoring of grassland. It is recommended to select eight (8) representative vidis across GCA covering 4 in Gir WLS and 4 in peripheral forests. In the peripheral forests category, 2 vidis should be 'Reserved' and 2 should be of 'Non-Reserved' type. Selected vidis should be a mix of 'good' as well as 'degraded' ones. Ten random quadrats (1mX1m) and 'toe-point intercept method along the longest diagonal are recommended for assessing the structure, composition, cover, and use of each grassland. The format for data collection and collation is given in Appendix 22 and 23.

10.7.8.1. Grassland Composition, Cover, Height and Production

It is recommended to lay ten (10) random 1mX1m quadrats so as to cover the representative hill-tops, slopes and low-lying areas in the entire vidis. These quadrats are to be used to assess the grass/forb composition, grass cover, contribution of annual vs. perennial (tussock) grass species, grass height and grass production at the end of growing period.

10.7.8.2. Grassland (vidis) Status and Use

It is recommended that the longest diagonal of the vidi be selected and used as a transect line for the 'toe-point intercept' method. It is proposed to walk this transect and assess status of grassland after every 50 standard steps and measure presence/absence of grass, shrub, tree and bare ground at the location of every 50th step. Indirect animal use evidences such as pellet/dung are also to be recorded.

10.8. Monitoring of Vegetation Changes

Vegetation has a direct bearing on wildlife conservation and management on the account of its role as a primary producer of organic matter on which all organisms depend, directly or indirectly. The vegetation is also subject to changes on account of several factors viz., succession, micro-climatic variation, selective consumption by herbivores, catastrophic events such as cyclones, fires, droughts, and by human interferences. Thus, in vegetation monitoring it is important to select a series of parameters that can be adequately described and can also be precisely re-measured at an interval in order to detect the discernible change.

The vegetation of GCA is characterized by teak (*Tectona grandis*) bearing forests in the western Gir and thorn forests dominated by *Acacia* sp.and Ziziphus sp. in the eastern Gir. The vegetation types of GCA have been described by Khan *et al*. (1990), Chellam (1993), Chavan (1993), Diwakar (1995). Broadly, the following are the major vegetation types:

1. Moist Mixed Forest
2. Mixed Forest
3. Teak - Acacia - Zizyphus
4. Acacia (Teak) - Anogeissus
5. Acacia - Lannea - Boswelia
6. Thorn Forest
7. Scrublands
8. Savanna

Besides the above, there is a considerable area under the grasslands (vidis) or savannah. Each vegetation type has a unique ecological value for wildlife species.

Several framework for vegetation monitoring exist in the scientific literature. However, the most pragmatic and tested framework has been of J.M. Sykes and A. D. Horrill (1976) which has been prescribed for Tiger Reserves in India. Two prominent PAs and Tiger Reserves *viz*., Kanha TR and Melghat TR have been using vegetation monitoring scheme as described by Sykes and Horrill (1976) for the more than two decades. The complete rationale, methodology, sampling scheme, data processing and analysis has been described in the "Vegetation monitoring in Indian Tiger Reserves' by Sykes and Horrill, 1976.

Essentially, the above vegetation monitoring framework comprises of establishing permanent vegetation plots (100mX100m = 1ha). These 1ha plots are used for the assessment of tree layer. The scheme further describes the use of nested nine 10mX10m plots for shrub layer and nine 2mX2m plots for herb/ground layer (**Fig. 21**).
In the case of GCA, it is proposed to lay thirty (30) 1ha plots in the following seven described vegetation types:

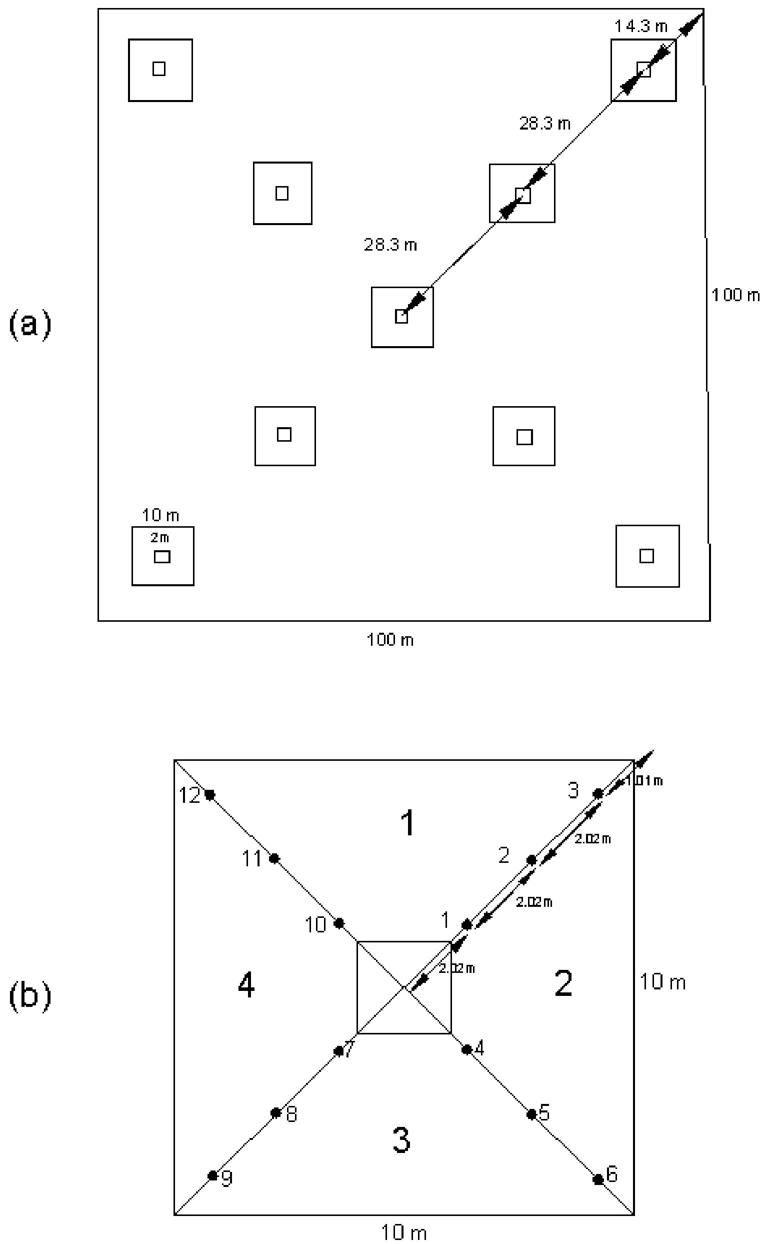
	Vegetation Type	Plots
1	Moist Mixed Forest	5
2	Mixed Forest	5
3	Teak - Acacia - Zizyphus	5
4	Acacia (Teak) - Anogeissus	5
5	Acacia - Lannea - Boswelia	5
6	Thorn Forest	5
7	Scrublands	5
8	Savanna	5
Total Plots		**- 40 Plots**

The location of above proposed permanent plots is shown in **Fig 1., Chapter 2)** and described in **Table 31**.

Table –31: Locations of vegetation monitoring plots in Gir Protected Area.

Vegetation Type	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Moist Mixed	70.68332 21.19934,	70.61801 21.19706	70.78056 21.0399	70.92178 21.02871	71.05261 21.0694
Mixed	70.63966 21.18007	70.68432 21.20687	70.74163 21.12622	70.93367 21.03661	71.1555 21.10019
Acacia-Teak-zizyphus	70.60041 21.18251	70.72761 21.17245	70.76339 21.08393	70.87737 21.08804	71.10194 21.0366
Acacia-Teak-Anogeissus	70.65898 21.23852	70.83442 21.09854	70.8535 21.00104	71.06226 21.09017	70.85352 21.06203
Acacia-Lannea-Boswellia	70.58647 21.22296	70.69299 21.22812	70.82693 21.04757	70.97582 21.10017	71.12791 21.08296
Thorn	70.53472 21.27648	70.67356 21.08537	70.83415 21.1855	71.00898 21.10701	71.13006 21.01241
Scrubland/Savanna	70.65528 21.25185	70.98773 20.94969	71.18867 21.07666	71.0479 21.22522	70.51927 21.14929

Fig. 21. Suggested layout for (a) One hectare permanent sample plot and (b) 10m X 10m plot



Under the above scheme, six plots are to be established every year and the baseline information is to be collected. This way, it will take 5 years for all the 30 plots and a 5-year periodicity of repeated data collection will also be established. Since the establishment of plots, baseline data collection and analysis require certain level of technical knowledge and skill, it may be carried out in collaboration with scientific institutions or neighboring universities. Since the vegetation changes in the teak bearing forests are of utmost relevance to the management of GCA, it is proposed that the first six plots may be established in Teak dominated forests. Further, considering the active plant growth period and short life of herbaceous flora, it is recommended that the field assessment in the permanent plots be undertaken preferably in the month of September every year. However, the vegetation quantification work should not prolong beyond the first fortnight of October by which time most of grasses, forbs will start senescence and would be difficult to identify.

10.8.1. DATA RECORDING

Measurement of vegetation in the permanent sample plots will be done as soon as possible after the growth season so that density estimation can be done with a fair degree of accuracy. It is proposed that four vertical layers will be identified as under:

1.	Woodland level	-	Over 5 m height
2.	Scrub level	-	Over 2 m to 5 m height
3.	Field level	-	Over 0.5 m to 2 m height
4.	Ground level	-	Less than 0.5 m height

The format for data collection are as given in Appendices 24 to 27. All trees above 30 cm GBH will be enumerated and classified species-wise in 30 cm girth classes.

(a) Measurement in one-hectare plots

The crown density for the entire one-hectare plot will be assessed in the following density classes:

1. Dense (over 0.7)
2. Medium (over 0.4 to 0.7)
3. Sparse (over 0.1 to 0.4)
4. Open (0.1 or less)

(b) Measurement in 10m x 10m plots

In these plots measurements will be recorded in the field and scrub levels as follows, in the vertical layers between 0.5 m – 2 m and 2 m – 5 m heights.

(i) Density measurements will be in the same standard as in one-hectare plot, *viz.*, dense, medium, sparse and open

(ii) Species composition in the scrub level (2 m – 5m) will be done by total enumeration as in woodland measurement.

(iii) Species composition in field level (0.5 – 2m) will be done by point sampling.

(c) Measurement in 2m x 2m plots

Measurements in these plots will be recorded as follows:

(i) Density measurement will be in the same standard as in all the three other vertical layers stated above.

(ii) Species composition will be ascertained and recorded with reference to the check-list of common species of woody plants, forbs, and grasses occurring within the plots.

(iii) Estimate of the proportion of woody plants, forbs and grasses will be made by point sampling on the diagonals at 20 cm intervals from the center of the plot.

10.8.2. MONITORING OF HABITAT CONDITIONS FOLLOWING MALDHARI `NESS' EVACUATION

At present, 253 families of maldharis inhabiting 54 `nesses' and 566 households in 14 forest settlement villages constitute the integral component of Gir Wildlife Sanctuary. 592 families of Maldharis were relocated between 1973 and 1987. Presently, the Gir NP (258.71 km^2) does not have any human settlements inside. However, there are 97 villages within a 6 km periphery of Gir WLS with about 1.5 lakh human population. About 15,000 livestock of maldharis and forest settlers graze in the sanctuary. In addition, nearly 1 lakh livestock belonging to villages adjoining GCA also grazing illegally in the sanctuary during the monsoon. The impact of maldharis on the Gir ecosystem has been a subject on intense discussion and has been studied by many workers. The negative impacts on the habitat in and around `nesses' have been fairly well documented. The habitat conditions in the evacuated ness sites in Gir NP have improved over a period of time, supplemented by various habitat improvement activities undertaken by the PA management.

From the ecological standpoint, the maldhari evacuation has been beneficial. However, from socio economic and human dimension point of view the relocation process can be made more humane and equitable. It is proposed to lay four permanent 1ha plots as per the methodology described by Sykes and Horrill (1976) in representative evacuated sites to serve as `ecological benchmarks' for monitoring success ional changes in the habitat.

10.9. MONITORING OF WEEDS

Biotic pressures mainly in form of livestock grazing and fire have led to soil erosion and proliferation of weeds *viz., Lantana, Cassia, Prosopis* etc. The PA management undertakes operation to remove/reduce *Lantana* by manual uprooting in select sites across two Forest Divisions. Experimental trials for *Lantana* removal have given `mixed' results. Since livestock grazing cannot be fully checked/ controlled in areas of *Lantana* removal, they always remain susceptible to weed invasion. Thus, such sites require effective protection from grazing and fire and continuous monitoring. For monitoring the weed proliferation data would be collected through twenty-five 1ha permanent plots which will be laid in the representative areas of GCA. In areas where management has made efforts to remove weeds through manual operations, it would be simpler to re-visit these areas in the subsequent years to visually estimate the success of the operation.

10.10. MONITORING OF LAND USE CHANGES AROUND GIR

The enterprising human community living in the surrounds of GCA has been instrumental in effecting rapid and extensive land use changes in the last 4-5 decades. The agriculture pattern has seen a sea change. From the initial rainfed agriculture supporting millets (maize, sorghum) to single `kharif' crop of groundnut followed by taking of 2-3 crops including that of sugarcane have been prominent feature of the transformation in agriculture. In the last decade, sugarcane cultivation has also been gradually replaced by planting of horticulture crop mainly the `kesar' variety of mango. Large scale conversion of forest and grassland areas into agriculture fields along with intensification of agriculture has thus taken place in the GCA surrounds. This has brought about major landuse changes. Intensification of agriculture has also led to creation of extensive `bela stone walls' on one hand and excessive withdrawal of ground water through bore wells on the other. In addition to this, the industrial expansion has also led to significant changes in land use.The Gir PA and its surrounds are a rich repository of limestone. There is an increasing pressure to mine these deposits for the cement industry.

Unfortunately, limestone deposits fall in the existing as well as potential corridors for the movement of lions. Thus, it is essential to monitor the development of mining as well as the cement industry. Infrastructure development in the coastal zone has also added to these changes. The growth in tourism in the region has also influenced the economy and pace of infrastructure development. Since these landuse changes have taken place in areas traditionally used by lions and its prey, man-wildlife conflicts are on the rise. There is a need to monitor these changes and their impacts in order to develop a strategy for harmonizing conservation with development.

Broadly, land use outside the Gir PA includes the following:

- ❖ Small, scattered patches of forests and grasslands (vidis) including linear riparian forests linking Gir PA with the coast
- ❖ Agriculture
- ❖ Horticulture – Orchards
- ❖ Habitations and other built up areas

The best technique to monitor changes in the above land use patterns is the 'change detection' through satellite data of two time periods. As per the satellite image interpretation carried out as a part of the present assignment the land use patterns in a representative area are as follows (Fig. 22 and Table 32):

Table 32. Percent vegetation and land use types in representative area (Sirvan Village).

Vegetation/Land use type	*Percent Area*
Wetland	0.21
Moist Mixed Forest	9.27
Mixed Forest	15.52
Teak-Acacia- Zizyphus	16.30
Acacia-(Teak)-Anogeissus	3.30
Acacia-Lannea-Boswellia	2.10
Thorn	3.17
Scrubland	0.44
Savanna	1.37
Agriculture	7.91
Orchards / Scrub	21.87
Orchards / Agriculture	17.01
Barren / Built up area / Scrub	1.52
Total Classified Area (sq.km)	15.40

Since relatively speaking rapid land use changes are occurring on the southern boundary of Gir PA and taking into consideration the satellite data cost and interpretation effort, it is proposed to carry out change detection using satellite data at the periodic interval of 3 years for areas lying between the southern boundary of PA and the coast.

CHAPTER – 11

TRAINING

Initially we had proposed to conduct training for Gir PA in data collection and need for monitoring. However, due to lack of funds this component had to be dropped. The need for training cannot be over emphasized for conducting any kind of monitoring. In October and November 2001 we were to conduct the wildlife research techniques course in Gir for our Masters students. Since we did not have resources for a formal training for the staff we informed CF Junagadh to depute selected staff from the GFD for the training along with the MSc students. The following staff of east and west Gir P.A. were identified by the Park Authorities for participating in the techniques course.

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Shri B.A Dave, Forester
Shri L.N. Rathod , Forester
Shri M.G Somarh ,Forester
Shri D.P.Dave, Forester.
Shri J.B. Bhatti, Guard
Shri K.P. Gajera, Guard

Exercises conducted during the training period were,

1. **Use of Field Equipments**
   Compass (see through, forward & reverse bearing, map reading)
   Densiometer (spherical and GRS) for canopy cover estimation
   Global Positioning System (GPS) its functions and importance.
   Laser Range Finder for animal distance estimation
   Clinometer and Height Meter for angle and slope,
   Altimeter (Altitude estimation),
   Paedometer , Hip Chain
2. **Identification of tracks and signs/ indirect evidence of animals and**.
   birds
3. **Use of track plots for the study of carnivore species monitoring**.
4. **Practical demonstration**
   Immobilization Equipment and Drugs
   Radio-Telemetric equipment
5. **Practical exercises**
   Training was provided in

- Walking line transects, collecting data on ungulate and bird abundance and distance estimation for animals sighted.
- Vehicle based road transects for the estimation of peafowl and large ungulate abundance.
- Vegetation quantification techniques for tree, shrub and ground layers.
- Lion Whisker (Vibrissae) pattern, for lion identification

We have been continuously interacting with and using the services of the PA management staff in conducting and demonstrating monitoring exercises. Many GFD staff have accompanied our team on radio tracking lions and are quite familiar with the equipment.

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Appendix – 1a

Appendix – 1b

a. Sample of Tree Data from Permanent Vegetation Plots

Date	Tr. No.	Pt NO.	Vegitation Plot GPS Location						Vegetation Association													Remarks
			N-D	N'	N"	E-D	E'	E"	Sps	No. of	Av.Ht.	GBH	Lopping/	cutt.	Brows	Reg.	Phenology				% Can.	
									Name	indiv.	(mt)	(cm)		Ht (cm)			Leaf	Col	Flr	Fruit	Con.	
12-Dec-01	2	2.20	21	16	19.20	70	34	48.70	A. catechu A. catechu A. catechu A. catechu	4	3.687	53.8	A A A A	-			Mostly dry	Brown	-	-	28.5	Nearly all barm others with very dry and very few leaves
12-Dec-01	2	2.20	21	16	19.20	70	34	48.70	Z. xylopyros	1	2.5	40	A	-			dry		-	-	28.5	
12-Dec-01	2	2.20	21	16	19.20	70	34	48.70	Mathij	1	3.76	32	A				dry	Brown	-	-	28.5	
12-Dec-01	2	2.20	21	16	19.20	70	34	48.70	Roan	1	3	47	A						-	-	28.5	
12-Dec-01	2	2.40	21	16	19.10	70	34	41.90	Moldi Moldi	2	6.625	89.8	A				very few dry green				17.06	
12-Dec-01	2	2.40	21	16	19.10	70	34	41.90	A. catechu A. catechu A. catechu A. catechu A. catechu A. catechu A. catechu	7	3.557	49.9	P	1.99			Dry Dry fre green lvs green lvs	Dry Dry+green on top green lvs			17.06	One tree copisced as 2 branches
12-Dec-01	2	2.40	21	16	19.10	70	34	41.90	Mathij	1	2.75	43					very few dry lvs					
12-Dec-01	2	2.40	21	16	19.10	70	34	41.90	Roan	1		40					no leaves					
12-Dec-01	2	2.60	21	16	15.90	70	34	35.70	Diospyros melanoxylon	5	5.55	47.1	A				green leaves				30.06	1 tree copisced as 2 branches
									"				A				green leaves					
									"				Lopped	40			green leaves					
									"				-				green leaves					
									"				-				v.few green lvs					
12-Dec-01	2	2.60	21	16	15.90	70	34	35.70	Mindhori Mindhori	2	5	37.5	-	-			sparse GL lots a GL				30.06	one copisced as 2 branches
12-Dec-01	2	2.60	21	16	15.90	70	34	35.70	Sajar " " "	4	5.77	76.3	lopped lopped lopped lopped	166 218	106	257	green leav green leav green leav green leav		ripe		30.06	1 tree copisced as 4 branches

b. Sample of Shrub Vegetation Data Permanent Plot for Monitoring

Date	Obs	Locality	T.N.	Pt.N.	Dir.	Transect Point GPS Location						Vegitation Plot GPS Location						Vegetation Association													Remarks
						N-D	N'	N"	E-D	E'	E"	N-D	N'	N"	E-D	E'	E"	Shrub-	N.of	Avg.	Lop/	Bro	Regen.	Reg.	Phenology				Animal	Dung	
																		name	ind.	Ht.cm	cut			No.	Lf	Cl	Flr	Frt	spe.	Piles	
12-Dec-01	Bindu Priya	Dedakhari	2	2.20	L	21	16	19.90	70	34.00	48.60	21	16	19.20	70	34.00	48.70	Abelmoscus manihot	2	59	-		-	-	-	-	-	-	-	-	The entire area had been burnt as fire line by the department.
12-Dec-01	Bindu Priya	Dedakhari	2	2.20	L	21	16	19.90	70	34.00	48.60	21	16	19.20	70	34.00	48.70	Kubdo	15	67	-		-	-	-	-			-	-	-
12-Dec-01	Bindu Priya	Dedakhari	2	2.40	R	21	16	18.40	70	34.00	42.00	21	16	19.10	70	34.00	41.90	Crenulate					Terminalia crenulata	1	-	-	-	-	-	-	Most of the area was burnt for fire line by the department.
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	Kubdo	35	65	-	-	Terminalia crenulata	2	-	-	-	-	-	-	
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	S-Z	6	65	-	-	Diospyros melanxylon	2							
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	Ekal Kantho	5	90	-	-	Emlica officinalis	1							
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	Helicterus isora	10	197	-	-	Madhis	2							
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	Carissa congesta	2	160	-	-	Discrostarhys cineria	2							
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	Z.xylopyros	2	135	-	-	-								
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	Z.enoplea	1	120	-	-	-								
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	Boidi	1	50	-	-	-								
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.60	70	34.00	35.50	21	16	15.90	70	34.00	35.70	Capparis separia	1	150	-	-	-								

c. Sample of Herb Vegetation Data Permanent Plot for Monitoring

Date	Obsr	Locality	T.No.	Pt N.	Dir.	Transect Point GPS Locaton						Vegitation Plot GPS Location									%	%	%					Remarks
						N-D	N'	N"	E-D	E'	E"	N-D	N'	N"	E-D	E'	E"	Grass name	Avg. Ht.	% cvr	Grass cvr	Weed cvr	Litter cvr	TI cvr	Weed spec.	Aug. Ht.	% cvr	
12-Dec-01	Bindu Priya	Dedakhari	2	2.20	L	21	16	19.90	70	34	48.60	21	16	19.20	70	34	48.70	Sehima sulcatum (saniar)	96.5	5	-	-	-	-	-	-	-	Most of the area was burnt for fireline so no grasses left surrounding areas showed Apluda nutica as dominant after Saniar grass which was identified by its basal part (that had not been burnt).
12-Dec-01	Bindu Priya	Dedakhari	2	2.40	R	21	16	18.40	70	34	42.00	21	16	19.1	70	34	41.9	Apluda nutica	134	40	40	-	58	98	-	-	-	Most of the area was burnt. Most of the grasses had not been burnt but cut as fire guard line.
12-Dec-01	Bindu Priya	Dedakhari	2	2.60	L	21	16	16.6	70	34	35.5	21	16	15.9	70	34	35.7	Apluda nutica	47.5	35	35	-	30	65	-	-	-	Most grasses bent
12-Dec-01	Bindu Priya	Dedakhari	2	2.80	R	21	16	15	70	34	28.9	21	16	15.7	70	34	28.7	Apluda nutica	43	15	15	-	80	95	-	-	-	
12-Dec-01	Bindu Priya	Dedakhari	2	2.12	L	21	16	11.40	70	34	15.30	21	16	11.80	70	34	15.40	Apluda nutica		10	10	-	55	65	-	-	-	Grasses cut for guardline. Most areas burnt for fireline
12-Dec-01	Bindu Priya	Dedakhri	2	2.16	R	21	16	8.50	70	34	2.00	21	16	19.10	70	34	1.60	Apluda nutica and other grasses	47.5	15	15	-	70	85	-	-	-	most grasses bent
12-Dec-01	Bindu Priya	Dedakhri	2	2.20	L	21	16	4.50	70	34	48.80	21	16	5.10	70	34	48.50	Apluda nutica	40.5	10	10	-	65	75	-	-	-	Rocky area

Appendix - 3

Monitoring of abundance and density of ungulates in Gir

Determining Encounter Rate on Line Transects

Name:………………………………………… Time : Start : …………..

Transect No. ………………………………… End: ……………

Date: ………………………………………… Weather conditions:

Length of transect: ………………………….. Area: ……………………

S.No.	Time	Species	Numbers	Remarks

Appendix - 4

Monitoring of abundance and density of ungulates in Gir

Estimation of ungulate density by Line Transects

Name:………………………………………… Time : Start : …………..

Transect No. ………………………………… End: ……………

Date: ………………………………………… Weather conditions:

Length of transect: ………………………….. Transect bearing: ………..

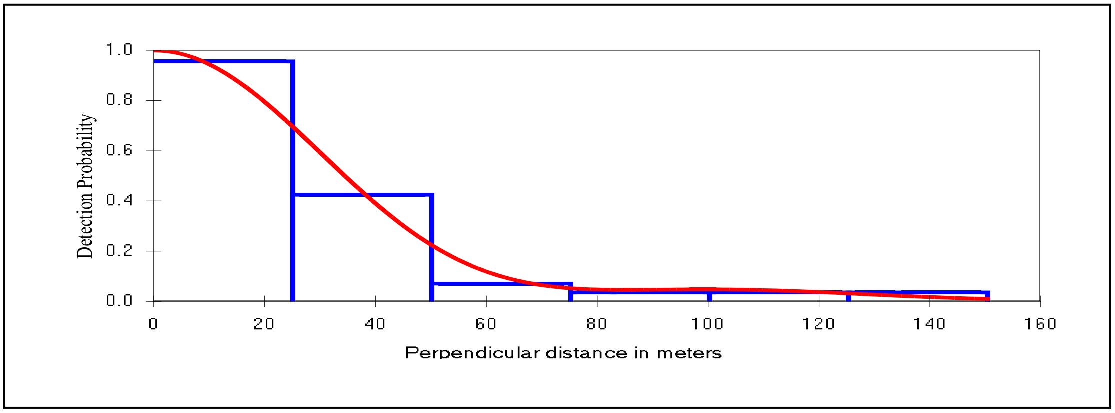
Area: …………………………………………

S.No.	Time	Species	Numbers	Bearing	Angular sighting distance, meter	Remarks

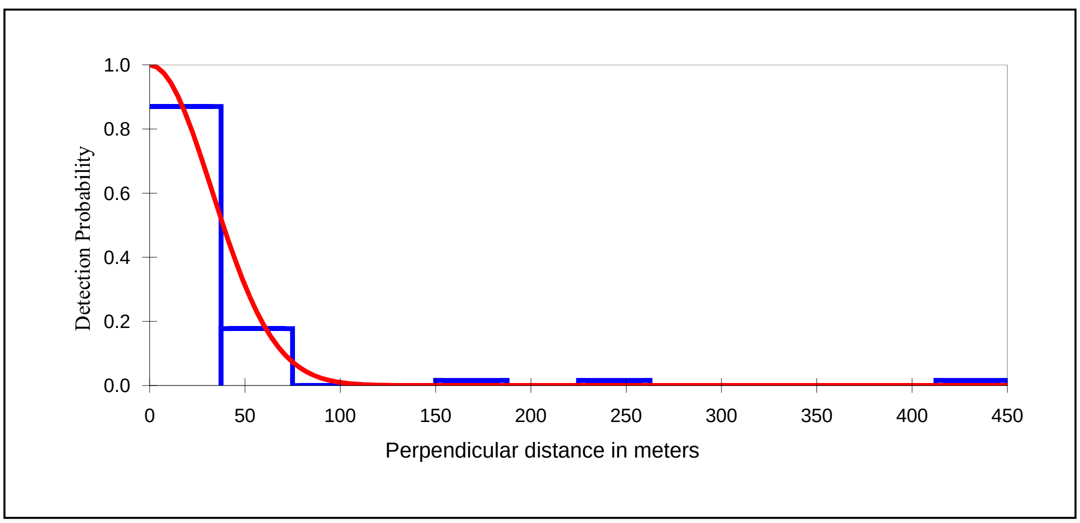
Appendix – 5

Half normal cosine model (default model) fitted on observed data for estimating effective width for chital in Gir

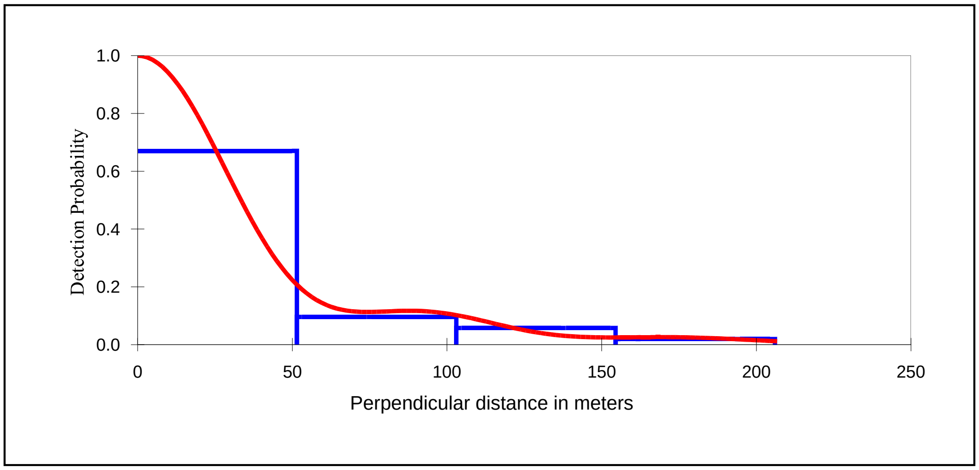
Summer-2



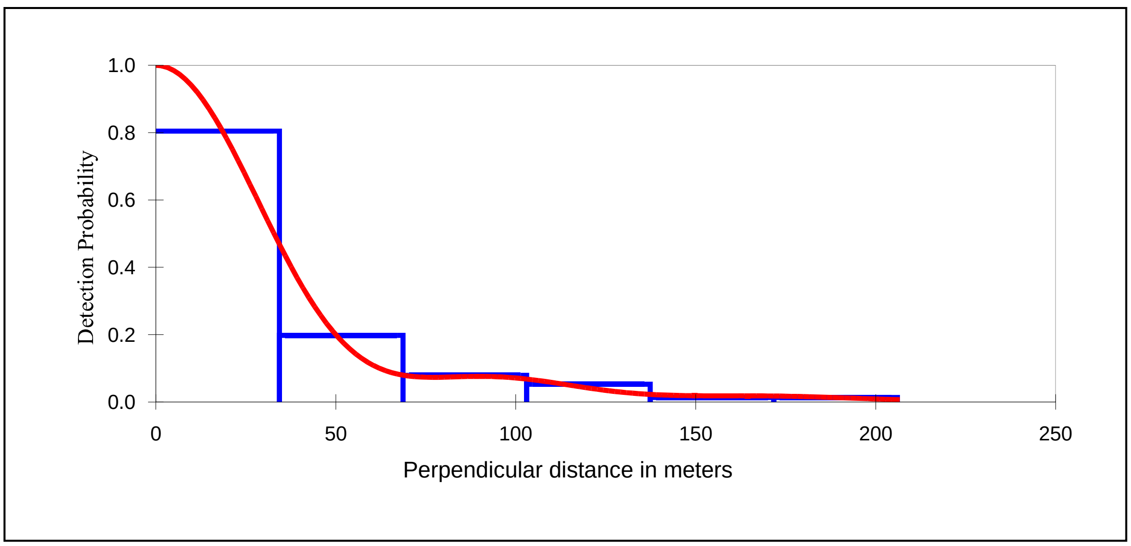
Winter



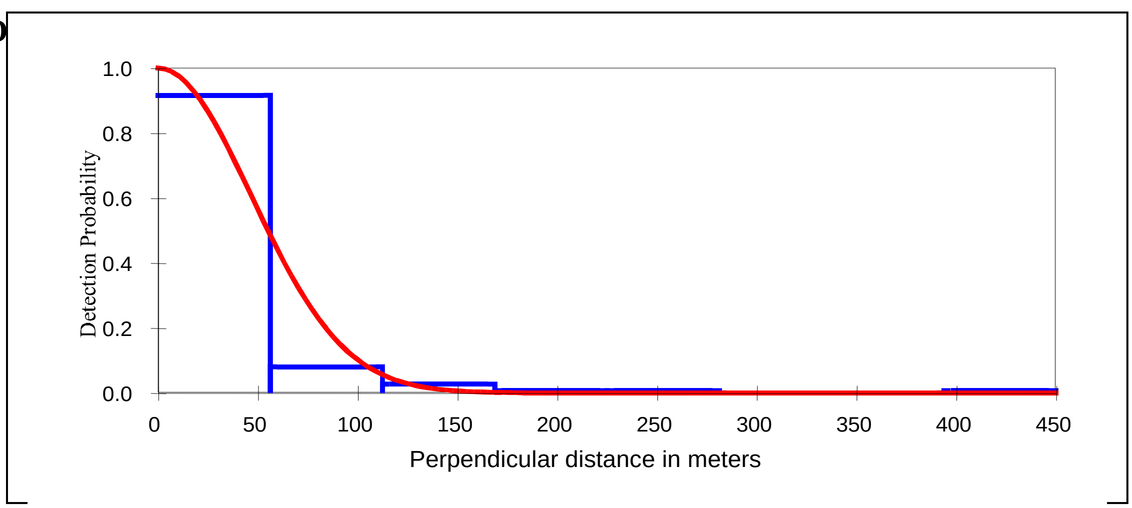
Summer-1



Summer 1 & 2



O



Condition score data sheet

Date______________________ General location______________________________

Observer____________________________

Condition to be scored on a scale of 1 to 5. 1=Bad condition, 5=Good condition

Serial No.	Specific location	Rump	Pelvic	Pectoral	Ribs	Age	Sex	Group size

Appendix – 7

LINE TRANSECT

Reference # : **Date :** **Time Start :** **Time End :**

Transect No. : **Transect Bearing :** **Weather :** **Locality :**

Observer : **GPS Location :**

Sl. No.	Segment No.	Time	Species	Total	Group Composition	Angular Distance	Animal Bearing	Vegetation Type	Remarks

DATA SHEET FOR POINT COUNT CENSUS OF BIRDS

Date : **Reference # :**

Locality : **Remarks on Weather :**

Habitat : **Point # :**

Transect No. / Count Station Nos. : **Transect Bearings :**

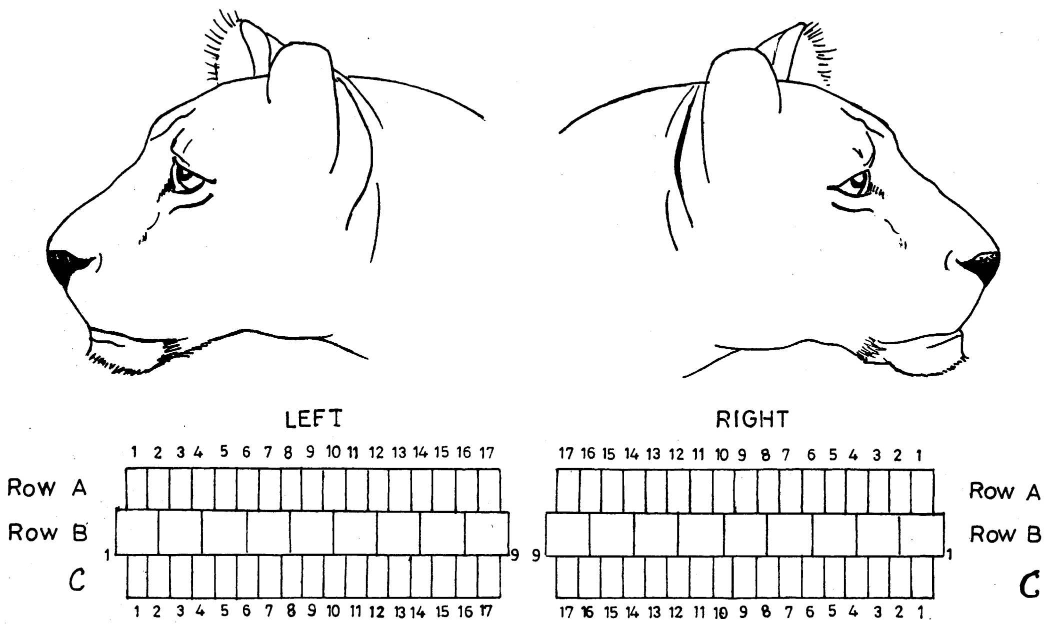
Start Time : **End Time :**

GPS Location :

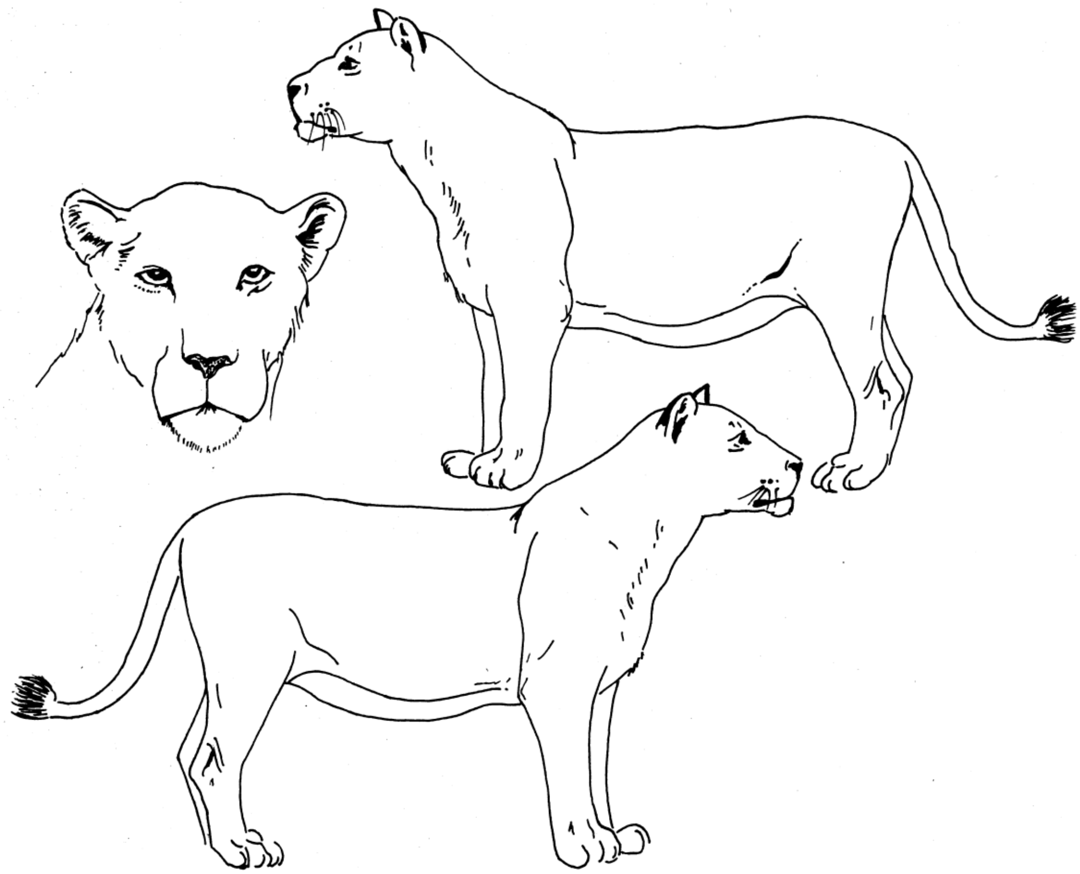
Sl. No.	Time	Bird Name	Total	No. of Individuals				Distance (m)	Perch Height (m)	Shrub/ Tree spp.	Remarks
				M	F	I	U/I				

Appendix – 8

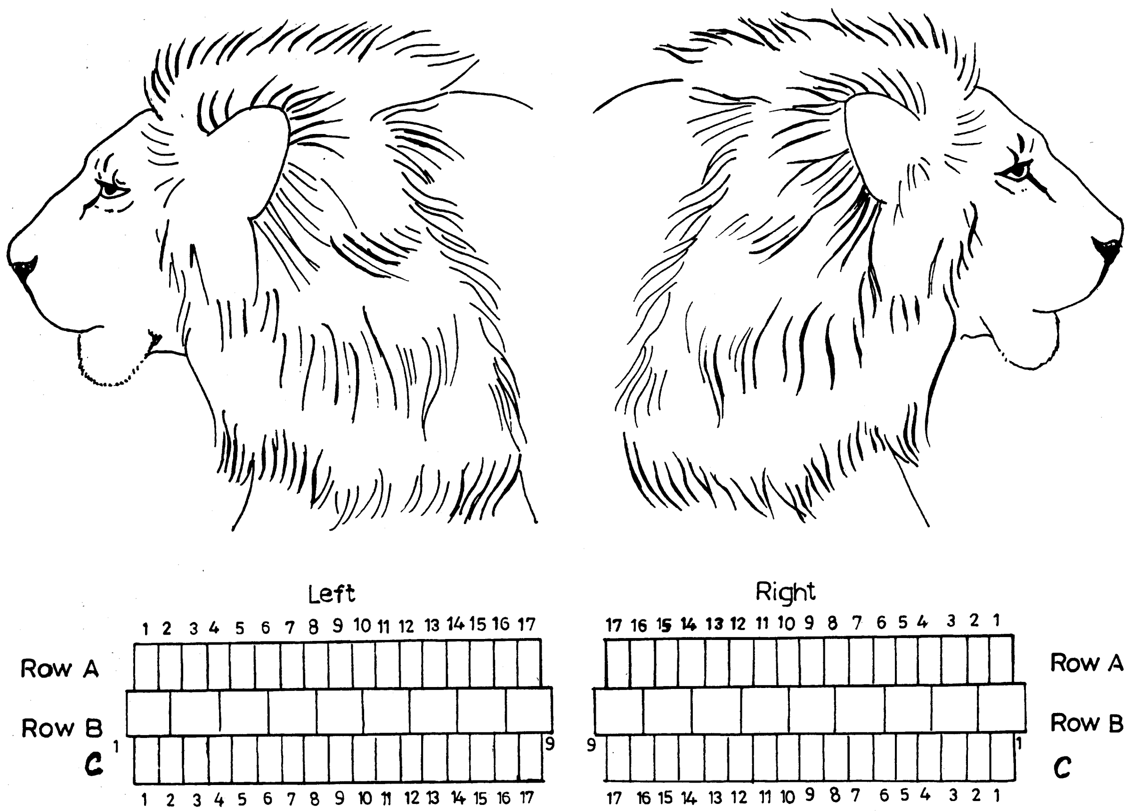
Lion Identification Data Sheets



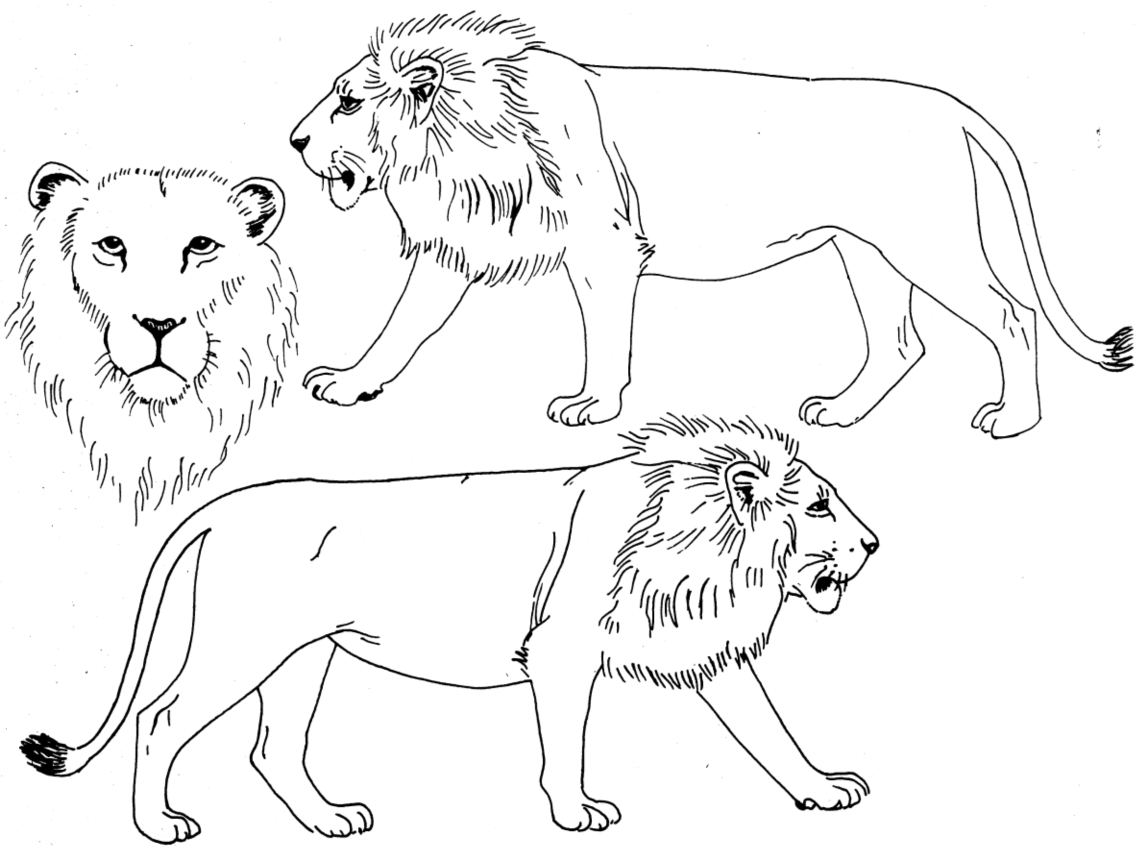
REMARKS



REMARKS


Left
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Row A
Row B
C
1
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Right
17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
Row A
Row B
C
9
1
17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

REMARKS



REMARKS

Relevant Results From Program MARK

Male Lions

Model selection criteria. Model selected has maximum value.

Model	M(o)	M(h)	M(b)	M(bh)	M(t)	M(th)	M(tb)	M(tbh)
Criteria	1.00	0.85	0.38	0.70	0.00	0.46	0.35	0.79

Population estimation with variable probability of capture by animal.
See model M(h) of the Monograph for details.

Number of trapping occasions was 3
Number of animals captured, M(t+1), was 86
Total number of captures, n., was 101

Frequencies of capture, f(i)

i=	1	2	3
f(i)=	73	11	2

Computed jackknife coefficients

	N(1)	N(2)	N(3)	N(4)	N(5)
1	1.667	2.000	2.000		
2	1.000	0.833	0.833		
3	1.000	1.000	1.000		

The results of the jackknife computations

i	N(i)	SE(i)	.95 Conf. Limits		Test of N(i+1) vs. N(i) Chi-square (1 d.f.)
0	86				
1	134.7	9.01	117.0	152.3	197.770
2	157.2	12.02	133.6	180.7	0.000
3	157.2	12.02	133.6	180.7	0.000

Average p-hat = 0.2144
Interpolated population estimate is 157 with standard error 12.0197
Approximate 95 percent confidence interval 137 to 184

Females

Model selection criteria. Model selected has maximum value.

Model	M(o)	M(h)	M(b)	M(bh)	M(t)	M(th)	M(tb)	M(tbh)
Criteria	1.00	0.93	0.00	0.34	0.01	0.49	0.24	0.80

Population estimation with variable probability of capture by animal.
See model M(h) of the Monograph for details.
Number of trapping occasions was 3
Number of animals captured, M(t+1), was 70
Total number of captures, n., was 95
Frequencies of capture, f(i)

i=	1	2	3
f(i)=	48	19	3

Computed jackknife coefficients

	N(1)	N(2)	N(3)	N(4)	N(5)
1	1.667	2.000	2.000		
2	1.000	0.833	0.833		
3	1.000	1.000	1.000		

The results of the jackknife computations

i	N(i)	SE(i)	.95 Conf. Limits		Test of N(i+1) vs. N(i)
0	70				Chi-square (1 d.f.)
1	102.0	7.30	87.7	116.3	46.273
2	114.8	9.66	95.9	133.8	0.000
3	114.8	9.66	95.9	133.8	0.000

Average p-hat = 0.2778
Interpolated population estimate is 114 with standard error 9.6624
Approximate 95 percent confidence interval 99 to 137

Appendix - 10

Lioness Capture Data

COLLARING PROTOCOL

Name: Poornima

Date: 5th July 2001

Sex: Female

Estimated Age: 2 – 2 1/2 years

Area: Tulsishyam

Drugs used for immobilization
Meditomedine (0.3 ml) + (2) Ketamine (2 ml) (Intramuscular by Remote dart)

Darting time: 16:41 hrs

Induction time: 16:43 hrs

Down time: 16:43:22 hrs

Antidote: 2.5 ml Atipamezole (Intravenous). Recovered in 2 minutes.

Body Parameters
Temperature: 101.9^{0}F
Respiration: 11 per minute
Heart rate: 72 per minute
Pulse rate: 72 per minute

Micro Chip # : 00-0125-C889

Radio collar frequency : Channel # 98

Body measurement
Shoulder height: 86 cm.
Nose tip – Tail tip: 265.5 cm.
Chest Girth: 90 cm.
Head Length: 31 cm.
Tail length: 82 cm
Body weight: 83.8 kg.

Other treatment: Ivomac Injection (sub cutaneous)

Remarks: Collected Blood samples and sent to Sakkarbaug Zoo, Junagad. Lioness belonged to a pride of 8 animals (3 adult females, 2 sub adult males and 2 subadult females) and was observed to join the pride after recovery. Lioness in excellent body condition.

Radio collaring Team
Shri K. S. Randhava, DCF Dhari
Dr. Bhuva
Dr. R. K. Hirpara
Dr. Y. V. Jhala & WII Team
Shri A. J. Makrani, RFO Hadala
& Forest staff of Hadala Range

COLLARING PROTOCOL

Name: Jhamri

Date: 11th July 2001

Sex: Female

Estimated Age: 7 –8 years

Area: Bhabhukia, Hadala range

Drugs used for immobilization

1. Meditomedine (0.42ml ≅ 8.4 mg) + (2) Ketamine 2.5 ml (250 mg) (Intramuscular by Remote dart)
2. Additional drug : 200 mg Ketamine

Darting time: 17:05 hrs

Induction time: 17:09 hrs
Down time: 17:11 hrs

Antidote: 3 ml Atipamezole I V. Recovery commenced after 10 min. and Lioness moved away after 30 min.

Body Parameters

Temperature: 102.7^{0}F
Respiration: 11 per minute
Heart rate: 65 per minute
Pulse rate: 78 per minute

Micro Chip # : 00-01E7-42A3

Radio collar frequency : Channel # 99

Body measurement

Shoulder height: 94 cm.
Nose tip – Tail tip: 326 cm.
Chest Girth: 105 cm.
Head Length: 36 cm.
Tail length: 77.5 cm
Body weight: 123 kg.

Other treatment: Injection Ivomac 4 ml (sub cutaneous)

Remarks: Collected Blood samples and sent to Sakkarbaug Zoo, Junagad. Lioness has 3 cubs aged 6-7 months, which were hiding and were observed to join the female after recovery. Lioness in excellent body condition.

Radio collaring Team

Shri K. S. Randhava, DCF Dhari
Dr. R. K. Hirpara
Dr. Y. V. Jhala & WII Team
Shri A. J. Makrani, RFO Hadala
& Forest staff of Hadala Range

COLLARING PROTOCOL

Name: Ramzana

Date: 27th December 2001

Sex: Female

Estimated Age: 9-10+ years

Area: Cabin wali Ati Dedakdi

Drugs used for immobilization
ketumine 300 mg + Meditomedine 5 mg

Darting time: 1:40 PM.

Induction time: 3:36 min.
Down time: 6:16 minutes

Antidote: Atipamezole 5 mg/ml.

Body Parameters
Temperature: 101.5^0 F
Respiration: 13 per minutes
Heart rate: 68
Pulse rate:

Micro Chip # : 00-01-CE-A9EA

Radio collar frequency : Channel # 95

Body measurement
Shoulder height: 98 cm.
Nose tip – Tail tip: 264 cm.
Chest Girth: 108.5 cm.
Head Length: 38 cm.
Tail length: 83 cm
Body weight: 135 kg.

Other treatment: Iuomac 4 ml (sub cutaneous)

Remarks: Good health accompanied by younger female.

Radio collaring Team
Shri B.P. Pati, DCF
Dr. R.K. Hirpara
Shri Y.V. Jhala & WII Team

COLLARING PROTOCOL

Name: Sonal

Date: 10th January 2002

Sex: Female

Estimated Age: 8 –9 years

Area: Jambudi, Jasandhar range

Drugs used for immobilization
3. ketumine 300 mg + Meditomedine 8 mg

Darting time: 5:57 P.M.

Induction time: 3 minutes
Down time: 5 minutes

Antidote: Atipamezole 10 ml. 54 min. after darting.

Body Parameters
Temperature: Rectal 102^0 F
Heart rate: 67
Respiration: 17 per minutes
Pulse rate:

Micro Chip # : 00-01E7-S164

Radio collar frequency : Channel # 15

Body measurement
Shoulder height: 97 cm.
Chest Girth: 106 cm.
Tail length: 70.5 cm
Nose tip – Tail tip: 231.7 cm.
Head Length: 30.4 cm.
Body weight: 119 kg.

Other treatment: Iuomac 3.5 ml (sub cutaneous)

Remarks: Healthy female.

Radio collaring Team
Shri Bharat Pathak, CF
Shri B.P. Pati, DCF
Dr. R.K. Hirpara
Shri Y.V. Jhala & WII Team
Shri B.J. Vadher, RFO Jasadhar

COLLARING PROTOCOL

Name: Sukhi

Date: 28th December 2001

Sex: Female

Estimated Age: 6-8 years

Area: Sukhnath Area Sasan

Drugs used for immobilization
ketumine 300 mg + Meditomedine 7 mg

Darting time: 3:58 PM.

Induction time: 3:30 min.
Down time: 5:30 minutes

Antidote: Atipamezole 125 mg. 53 min after darting.

Body Parameters
Temperature: 101.7^0 F
Heart rate: 62
Respiration: 12 per minutes
Pulse rate:

Micro Chip # : 00-ICE-CFF6

Radio collar frequency : Channel # 93

Body measurement
Shoulder height: 95 cm.
Chest Girth: 94 cm.
Tail length: 72.5 cm
Nose tip – Tail tip: 240.5 cm.
Head Length: 35 cm.
Body weight: 97 kg.

Other treatment: Iuomac 3.5 ml (sub cutaneous)

Remarks: Healthy female. Breeding status good accompanied by 2.5 - 4 Years female.

Radio collaring Team
Shri B.P. Pati, DCF
Dr. R.K. Hirpara
Dr. Y.V. Jhala & WII Team
Trackers of FD

Appendix - 11

Radio Location Data Sheet

Name: ________________ Date: ____________ Time: __________ Ch#: ___________
Drift: ________ Place: ____

GPS Loc:______________N _______________E _______________N _______________E
______________N_______________E _______________N _______________E
______________N_______________E _______________N _______________E

Habitat: ____
(overall) ____

MicroHabitat:____
____

Nearest Water Source: ____
(if known)
Nearest Ness/village & Approx. dist: ____
Nearest Known Place & Approx. dist: ____

No. of Animals Seen : _______ Activity of Animals: ________________

Identity of Animals: **(other than the collared one)**	**Age and Sex**	**Condition**
	______________	___________________
	______________	___________________
	______________	___________________

Whisker ID (if known): ____

TRIANGULATION DATA

	Place: _______________	_________________ **N**	___________________ **E**
Pt. #1	**Time: _______________**	_________________ **N**	___________________ **E**
	Bearing: _____________	_________________ **N**	___________________ **E**
	Place: _______________	_________________ **N**	___________________ **E**
Pt. #2	**Time: _______________**	_________________ **N**	___________________ **E**
	Bearing: _____________	_________________ **N**	___________________ **E**
	Place: _______________	_________________ **N**	___________________ **E**
Pt. #3	**Time: _______________**	_________________ **N**	___________________ **E**
	Bearing: _____________	_________________ **N**	___________________ **E**
	Place: _______________	_________________ **N**	___________________ **E**
Pt. #4	**Time: _______________**	_________________ **N**	___________________ **E**
	Bearing: _____________	_________________ **N**	___________________ **E**

Remarks: ____
____
____

Appendix – 12

Leopard Population Monitoring Datasheet

General location__________________ Date___________

Road Name__________________ Observer/Tracker Name
____
____

Start Time __________ End Time __________

Segment No. km.	Pugmark Sets Encountered	Type of Substrate (Sand, loan,Silt Moisture etc)	General Location (GPS if Possible)	Remarks (Size, Abnormalities, Photograph or Tracings Taken, etc.)
0-1				
1-2				
2-3				
3-4				
4-5				
5-6				
6-7				
7-8				
8-9				
9-10				
10-11				
11-12				
12-13				
13-14				
14-15				

Appendix – 13

Ad libitum sighting of small carnivores in Gir Protected Area

Date	Time	Weather	Location	Species	Number	Vegetation	Terrain	Distance to water	Distance to human habitation	Observer

Road counts of small carnivores in Gir Protected Area

Date W/C/E Gir B and E time Weather Observer

Time	Km segment on the transect	Species	Number	Perpendicular distance to the road	Behaviour

Appendix – 14(a.)

DATA SHEET FOR LARGE CARNIVORE (LION & LEOPARD) ATTACKS ON LIVESTOCK

1. Date of attack :

2. Time of attack (if the exact time cannot be determined, at least which part of the 24 hour day in which the attack occurred should be recorded):

3. Carnivore species (Lion or Leopard):
   (Provide details in Remarks as to how the identity of the predator was established-sightings, vocalization, pug marks).

4. Number of large carnivore(s) involved and their age & sex composition:

5. Any details on the individual identification of the carnivore(s):

6. Any details on the health status and injuries sustained by the carnivore(s):

7. Exact location of the attack:
   i. Inside or outside Protected Area?
   ii. Name of the attack site:
   iii. Distance from the nearest human settlement:
   iv. Distance from the Protected Area boundary:
   v. GPS coordinates (If coordinates can be collected for each attack site using a GPS it would be best as this data can then be easily and accurately mapped. Obviously this will depend on the availability of GPS and expertise of the staff in the field to use it):

8. Detailed description of the attack site (terrain, vegetation type, man-made structures, and other relevant details):

9. Vegetation cover at the attack site: Dense/Medium/Sparse

10. How many livestock were attacked and/or killed? The species, age/sex category of the attacked/killed animal(s).

11. Describe the exact circumstances of the attack by the large carnivore(s). (This narrative should be as detailed as possible. Often this will enable the construction of events, which lead to the attack. A large data base with such information if properly analysed can throw up a combination of circumstances under which more attacks take place and hence enable the framing and implementation of mitigating strategies).

12. What is the current size and composition of the attacked livestock herd?

13. Ownership details of the livestock:
    i. Name of owner:
    ii. Place of residence of the owner:
    iii. Is the owner a maldhari?
    iv. If not what is the owner's profession?

14. What is the manner in which the livestock are herded while grazing and moving and how are they protected during night? Details of the various animal husbandry practices.

15. For establishing broad patterns it is important to get data on the number of livestock lost to predation in the past 12 months and also the number lost due to other causes.

16. What is the economic impact of the livestock loss on the individual family?

17. Attitude of the local people towards lions and leopards and their conservation.

18. Remarks (including details of compensation claim):

19. Name of person collecting data:

20. Date of data collection:

21. Signature:

NOTE: It is important that data for fields 1, 2, 3, 4, 7, 8, 9, 10, 11, 13, 18, 19, 20, and 21 are filled in without fail. It will be very helpful if data for fields 5, 6, 12, 14, 15, 16, and 17 can also be obtained, as it will enable a more comprehensive analysis.

Appendix – 14(b.)

DATA SHEET FOR LARGE CARNIVORE (LION & LEOPARD) ATTACKS ON PEOPLE

1. Date of attack: 2. Time of attack:

3. Carnivore species (Lion or Leopard):
(Provide details in Remarks as to how the identity of the predator was established).

4. Number of large carnivore(s) involved and their age & sex composition:

5. Any details on the individual identification of the carnivore(s):

6. Any details on the health status and injuries sustained by the carnivore(s):

7. Exact location of the attack:

    i. Inside or outside Protected Area?
    ii. Name of the attack site:
    iii. Distance from the nearest human settlement:
    iv. Distance from the Protected Area boundary:
    v. GPS coordinates:

8. Detailed description of the attack site (terrain, vegetation type, man-made structures, and other relevant details):

9. Vegetation cover at the attack site: Dense/Medium/Sparse

10. How many people were attacked and/or killed? The age and sex of the attacked/killed person(s).

11. Describe the exact circumstances of the attack by the large carnivore(s).

12. What was the person doing when attacked?

13. Attitude of the local people towards lions and leopards and their conservation.

14. Remarks (including details of compensation claim):

15. Name of person collecting data:

16. Date of data collection:

17. Signature:

NOTE: It is important that data for fields 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 14, 15, 16, and 17 are filled in without fail. It will be very helpful if data for fields 5, 6, and 13 can also be obtained, as it will enable a more comprehensive analysis.

Appendix - 15

Form No. GCA/MON/PHY/01

Name of the Meteorological Station:
Station Code:
Range:
Division:
Month: **Year:**

Date	Rainfall (mm) at 0800 hrs	Remarks

- **Total Rainfall during the Month:**
- **Number of Rainy Days:**
- **Highest Rainfall (mm) in a day during the Month alongwith date:**

Date : **Signature:**
Name:

Appendix - 16

Form: GCA/MON/PHY/02
Meteorological Station:
Station Code:
Range : **Division:**
Month: **Year:**

Date	Temperature (^{0}C) at 0800 hrs		Remarks
	Minimum	Maximum	
Average for the month			

- **Minimum Temperature Recorded During the Month:**
- **Maximum Temperature Recorded During the Month:**

Date: **Signature:**
Name:

Appendix - 17

Form: GCA/MON/PHY/03

Meteorological Station:
Station Code:
Range: **Division:**
Month: **Year:**

Date	Relative Humidity (%)	Remarks
Total		

- **Average Relative Humidity During the Month:**
- **Lowest Relative Humidity Recorded During the Month:**
- **Highest Relative Humidity Recorded During the Month :**

Date: **Signature:**
Name:

Appendix – I8

Form: GCA/MON/PHY/04

Meteorological Station:
Station Code:
Range: **Division:**
Month: **Year:**

Date	Wind Speed (km/hr)	Wind Direction	Remarks

- **Average Wind Speed During the Month:**
- **Lowest Wind Speed Recorded During the Month:**
- **Highest Wind Speed Recorded During the Month:**

Date: **Signature:**
Name:

Appendix – I9

Form: GCA/MON/PHY/05

Name of the Reservoir:
Range:
Division:
Month:
Year:

Water Level at Reservoir Recorded at 0800 hrs					
Level on the First Day of the Month (A)	Level on the Last Day of the Month **(B)**	Net Difference **(B-A) = C**	**Total Discharge for Irrigation and other purposes D**	**Grand Total Water Level Gained During the Month C + D = E**	Remarks

Date:

Signature:
Name:

Appendix – 20

Form: GCA/MON/PHY/06

Name of the Reservoir:
Range: **Division:**
Month: **Year:**

Silt Load in Reservoir			Remarks
Level of Silt Load on the First Day of the Month (A)	Level of Silt Load on the Last Day of the Month (B)	Net Silt Load (B-A)	

Date: **Signature:**
Name:

Appendix – 21

Form: GCA/MON/PHY/07

Village Name:
Range: **Division:**
Taluka:
Month (May/September): **Year:**

No. of Open Wells in the Village:
No. of Open Wells in Use:
No. of Bore Wells in the Village:
No. of Bore Wells in Use:

Depth of Water Table (m) and Water Quality in Randomly Selected Any Five Open/Bore Wells

Well No.	Water Table		Total Dissolved Salts	Remarks
	Open Well (m)	Bore Well (m)	(ppm/ml)	
1				
2				
3				
4				
5				
Total				
Average Depth				

Total Dissolved Salts (TDS) will help in monitoring the 'ingress of salinity'. The water samples collected from each well can be analyzed at GAU, Junagadh or GSWRDC

Date : **Signature :**
Name :

Appendix – 22

Form: GCA/MON/ECO/01

Name of the Grassland (vidi):

Status (Reserved/Non-Reserved):
Range:
Division:
Size (ha):
Date of Measurement (First Fortnight of Oct):

A. Grassland Composition, Cover, Height and Production

Quadrat No.	Dominant Grass Species	Co-dominant Grass Species	% Grass Cover	% Forb Species	Average Grass Height (cm)	Grass Production			
						Fresh Weight (g/m^2) A	Air Dry Weight (g/m^2) B	Grass Production B x 10 = kg/ha	Remarks
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Total									
Average									

Date :

Signature :
Name :

Format: GCA/MON/ECO/01

B. Grassland (Vidi) Status and Use – Proportionate % Cover

Sl. No.	Step No.	Bare Ground	Grass	Shrub	Tree	Animal Pellet	Cattle Dung	Remarks
1	50		✓					
2	100		✓					
3	150			✓				
4	200				✓			
5	250				✓			
6	300		✓					
7	350					✓		
8	400					✓		
9	450						✓	
10	500						✓	
11	550						✓	
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								

28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48								
49								
50								
% of hits (No. of hits under each category/Total No. of Sample Points x 100)								

Appendix – 24

Form: GCA/MON/ECO/02

TREES IN HECTARE SAMPLE PLOT

Permanent Plot No.:

Compartment No.:

Range:

Division:

Month:

Year:

Forest Type:

Sl. No.	Local Name	Botanical Name	Species Code	Density of the Canopy					Remarks
				No. of trees in the plot (in 30 cm girth class)					
				30-<60	60-<90	90-<120	120-<150	150 & above	

Appendix – 25

Form: GCA/MON/ECO/03

SCRUB LEVEL MEASUREMENTS
(10m x 10m) plot

Permanent Plot No.:

Compartment No.:

Range:

Division:

Month:

Year:

Forest Type:

Scrub level (2m – 5m)				
Sl.No.	SPECIES			DENSITY
	Local Name	Botanical Name	Species Code	NUMBER

Appendix – 26

Form: GCA/MON/ECO/04

FIELD LEVEL MEASUREMENTS
(0.5 m – 2 m height) - (10m x 10m) Plots

Permanent Plot No.: 	**Compartment No.:**

Range: 	**Division:**

Month: 	**Year:**

Forest 	**Type:**

Sl.No.	Species		Species Code	Remarks
	Local Name	Botanical Name		
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				

Appendix – 27

Form: GCA/MON/ECO/05

GROUND LEVEL MEASUREMENT
(<0.5 m) - (2m x 2m) Plots

Permanent Plot No.: **Compartment No.:**

Range: **Division:**

Month: **Year:**

Forest Type:

Sl.No.	Species		Species Code			Remarks
	Local Name	Botanical Name	Woody	Forbs	Grass	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
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23						
24						