RESEARCH PRIORITIES OF THE WILDLIFE INSTITUTE OF INDIA

PRIORITY CRITERIA AND PRIORITY LIST

Recommendations of a joint meeting of the Research Advisory Committee and special invitees.

General

Wildlife Science is a developing science in India. It is essentially field based, multidisciplinary and applied in nature. The interspersion of human habitation through the forests all over the country and pressures of local demands on them add a new and important dimension to this science, both in relation to protected areas as well as wildlife outside the protected area system.

Organised wildlife research in the country has lagged behind except to some extent in the ornithological field, led by the Bombay Natural History Society. Likewise little attention has been paid to creating a systematic data base. Generally speaking, even universities have not been inclined to synecological studies of wildlife communities. Wildlife research in the country therefore, needs to be organised, with a prioritized utility oriented focus, in all its three aspects viz. Ecological, Biological and Socio Economic.

Wildlife Institute of India would understandably be called upon to play a nodal role in fostering the developing of this upcoming science, partly through its own research projects and partly by interacting with the universities and other research organisations. The meeting acknowledged the merit of in-house research projects of the Institute as a means of development of faculty and keeping the later abreast of field situations, so that their teaching remained contemporarily relevant at all times.

Priority Criteria

In the light of these general considerations, the task of the listing the research topics in an order of priority was made. Individual responses in the form of suggestions for research topics added upto a large list of all research subjects which appeared important. This was understandable because the great diversity of eco-system, the threats faced by them, the endangered status of a large number of species and the complex nature of dependence of local people upon forest, threw up an array of research problems from which shortlisting was not easy. Given this situation, the Committee felt that the following criteria could be used for shortlisting so that while the most endangered eco-system and species receive priority attention, the work leads to development of methodologies and techniques of a wider utility potential.

(i) Adoption of a multidisciplinary approach involving study of ecological, biological and socio-economic parameters related to ecosystems/species.

(ii) Preference to locate studies in potentially fragile ecosystems, specially those facing or in imminent threat of degradation.

(iii) Preference of 'indicator' and highly endangered species.

(iv) Studies to lead to standardisation of methodologies and techniques for research and management.

(v) Studies addressing people's needs and involvement, particularly in relation to those inhabiting protected areas or their surrounds, with a view to ensuring of compatibility.

(vi) Consultancies in fields like wildlife related impact assessment of development projects, eco- development, production of AV material and setting up of visitor centres in parks, leading to establishment of techniques for such tasks.

Priority List

It was recognised that resources and faculty time were limited and that these would themselves limit the size of in- house research effort. The touchstone of the aforementioned criteria should help in selection of problems, areas and spaces on realistic considerations. A short priority list developed appears in the following, but this has essentially to be indicative and not comprehensive.

1. <u>Eco-systems and Regions</u>

1.1 Baseline biogeographic information in relation to the protected areas system, so as to suggest new areas and revisions of boundaries of existing areas (Biogeography Project of WII is currently addressing this)

1.2 High altitude alpine areas and cold deserts.

1.3 Siwaliks, duars and Terai region.

1.4 Arid zones and hot deserts - Thar, Rann of Kutch.

1.5 Mangroves.

1.6 Tropical rain forests.

1.7 Grasslands.

1.8 Fresh water - rivers, lakes and swamps.

1.9 Corridor areas for seasonal movement of major mammals.

2. Species

2.1 Highly endangered species, addressing restoration of habitat and populations, including translocation, captive breeding and reintroduction. Type examples: Manipur sangai, lion, wild buffalo, elephant, dugong, Gangetic dolphin, pheasants, black-necked crane, lesser cats, malabar civet, pygmy hog, hispid hare, red panda, Phayre's leaf-monkey, takin, Tibetan gazelle, wild sheep and goats.

2.2 Indicator species e.g. snow leopard, tiger, gharial, clouded leopards.

2.3 Problems species e.g. wolf.

2.4 Species of economic importance e.g. fresh water frogs, butterflies.

3. Techniques and Methodologies

3.1 Cover mapping and habitat evaluation.

3.2 Status surveys.

3.3 Census and population trends.

3.4 Impact assessment of development and other projects on wildlife and habitats.

3.5 Habitat manipulation including water management.

3.6 Role of fire in habitat management.

3.7 Forestry practices and wildlife habitats.

3.8 Systems approach and use of biostatistics and computer in wildlife studies.

3.9 Capture and handling of animals.

3.10 Wildlife health and veterinary procedures.

4. People's needs and involvement

4.1 Interface conflicts and animal damage control.

4.2 Eco-development including land use readjustments, regulation of grazing and viable alternatives. Setting up pilot models under technical supervision of WII.

4.3 Production of AV material for extension and setting up visitor centres for parks.

Other functions of WII regarding wildlife research

In order to meet its responsibilities to foster the development of wildlife science in the country, the WII should undertake the following tasks:-

(i) Preparation and documentation of wildlife research in the country as a service programme.

(ii) Appraisal and assessment of the said wildlife research, and to ensure avoidance of duplication in such research.

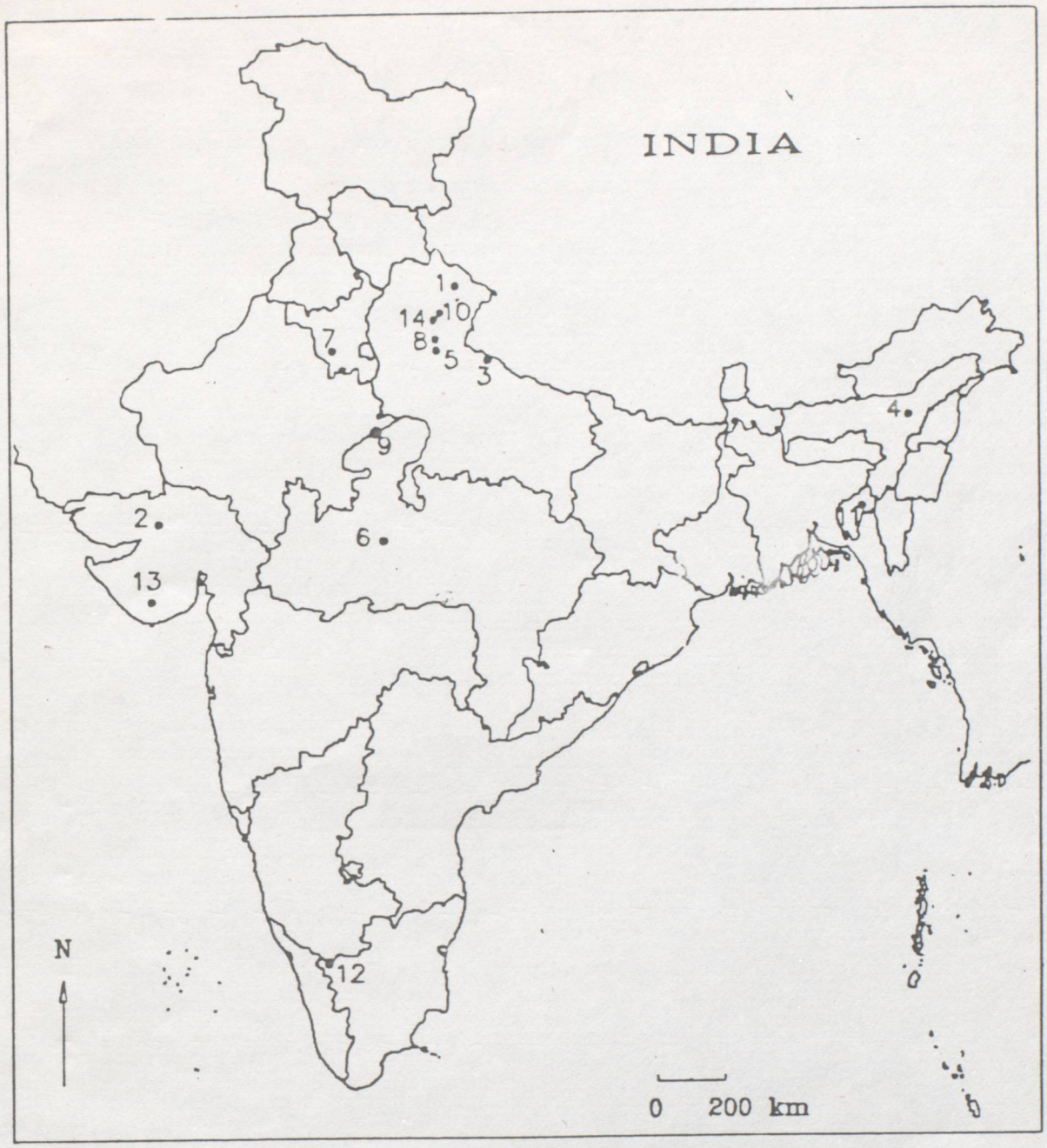
(iii) Publication of monographs on important studies. Use of journals like that of the BNHS and the Wildlife Preservation of Society of India (Cheetal) should be made by WII to publish its papers.

(iv) Linkages through field research in wildlife should be developed with universities and other research organisations.

(v) WII should act as the nodal agency and should be involved in appraising the wildlife research projects for which Government support is offered by Department of Environment, Forests and Wildlife and the Department of Science and Technology.

(vi) Providing guidance and assistance the extent possible and essential to the state wildlife wings in their research efforts.

Map Showing Locations of Ongoing Research Projects



1. Kedarnath Musk Deer Sanctuary–Habitat–ungulate ecology
2. Wild Ass Sanctuary–Ecology of Wild Ass and socio–economic study
3. Dudhwa NP–Ecology of Swamp Deer
4. Kaziranga NP–Ecology & genetics of Wild Buffaloes
5. Rajaji–Corbett NPs Corridor Forest–Habitat evaluation & socio–economic study
6. Narmada Sagar Project–EIA study
7. Haryana–Study on crop damage by Nilgai
8. Rajaji NP–Study on Elephants
9. National Chambal Sanctuary–Study on aquatic mammals (otter & dolphin)
10. WII, Dehra Dun –Strengthening of National Wildlife Database
11. Gumti WLS–Study on Phayre's leaf monkey
12. Mudumalai WLS–Study on Masinagudi village ecosystem for ecodevelopment planning
13. Gir NP & WLS–Study on impact of management practices on lion & ungulates habitat
14. WII, Dehra Dun–Laboratory study on carnivore diet

Map Showing Locations of Completed Research Projects

1. Hemis High Altitude NP–Snow leopard study
2. Sariska Tiger Reserve–Study on sympatric herbivores
3. Dudhwa NP–Monitoring of re-introduced rhinos
4. Pobitora WLS–Proposed introduction of Sangai
5. Manjira, Ethipothalia & Siwaram WLS–Monitoring of re-introduced Crocodiles
6. Gir NP & WLS – Ecology of Asiatic lion; Ungulate–habitat ecology
7A&7B Garhwal Himalayas & Arunachal Pradesh–Investigation on biogeographic pattern
8. Rajaji NP–Study on dependency of local people (Gujjars)
9. Rajaji NP–Study on habitat types & utilization by large mammals
10. Mundanthurai–Kalakad TR–Study on Nilgiri Langur
11. Srivilliputhur WLS–Ecology of Grizzled Giant Squirrel
12. Dehra Dun–Study on Flying Fox
13. National Chambal Sanctuary–Turtle ecology
14. North–Western Himalaya–Snow leopard survey

RESEARCH PRIORITIES OF THE WILDLIFE INSTITUTE OF INDIA

Field of research	PRIORITY ONE						PRIORITY TWO		PRIORITY THREE	
Ecosystems and regions	High Altitude	Siwaliks, Terai and Duars	Grasslands	Crucial Corridors	Hot arid		Tropical rain forests	Freshwater	Mangrove	Marine
Species and communities	Highly Endangered Species	Indicator Species	Problem Species				Species of economic importance		Orchids etc.	
Techniques and methodologies	Quantitative evaluation and monitoring of wildlife habitats	Impact assessment upon wildlife and their habitat	Fire management of wildlife habitats	Population assessment and monitoring	Wildlife habitat in managed forests	Habitat manipulation including water management	Capture and handling of wild animals		Status surveys	
People's needs and involvement	Interface conflicts and animal damage control	Ecodevelopment around protected areas (pilot models)	Conservation Education				Visitor centres for parks			
Other activities	Documentation and database	Publication of monographs and reports	Assist universities and Wildlife Wings in research	Management Planning			Appraisal and assessment of research projects		Nodal agency in coordinating wildlife research	

The Narcondam Hornbill - Conservation Measures
A preliminary report

Preface

Salim Ali Centre for Ornithology & Natural History, an autonomous centre of excellence of the Ministry of Environment & Forests, Government of India, has a long term project to study the status, conservation needs and ecology of endemic species of birds in the Andaman & Nicobar islands. The project has targeted three species, the Narcondam Hornbill, the Nicobar Megapode and the Andaman Teal for intensive studies. The project commenced in 1992 and is slated to end in 1998.. This report on the Narcondam Hornbill is based on an 95 day study between 26 February 1998 and 2 June 1998. Since some issues are of grave concern, this preliminary report is being submitted so that action may be initiated immediately. A detailed scientific report based on empirical analysis will follow.

Introduction

The Narcondam Hornbill *Rhyticeros narcondami* was described to science in the 1800s, by AO Hue, a founding member of the Indian National Congress and ornithologist par excellence. The Narcondam Hornbill is endemic to the less than 7 sq. km Narcondam island, and is perhaps amongst the most, if not the most restricted range species, in the world In the early 1900s B.B. Osmaston estimated a population of not less than 200 birds, and which S.A. Hussain, in about 1970, estimated to be about 400 birds. Both these numbers are open to debate as no replicable methodology was used to arrive at these figures. However, I am assuming that Hussain's figure is approximately correct as the duration of time spent on the island varies significantly (Osmaston less than 4 days; Hussain over a month).

The Narcondam Hornbill is amongst the most important and threatened avifauna species in the Andaman & Nicobar islands, and along with the flora and other fauna, many of which are unique to Narcondam, makes this island the single most important island in the Bay of Bengal.

Findings

The population of the Narcondam Hornbill is about 325 - 375 birds, and has apparently reduced since earlier times. The reasons are as follows.

1. Due to national security reasons a Look Out Post of the Special Armed Police, A & N islands, was established on Narcondam in 1968. The LOP consists of 17 men which include 1 Subinspector, 2 Head Constables, 10 Constables, 2 Radio Operators, 1 Medial Compounder , and 1 Bhandari.

2. The LOP camp now occupies about 15 acres of land which include the barracks of the personnel, coconut and arecanut (supari) groves, banana plantations, and vegetable plots.

3. Due to its extreme inaccessibility, and a misguided belief that there was an inadequacy in food resources, goats were introduced on Narcondam, so that the LOP personnel would have an adequate source of red meat.

4. The number of domestic goats that are maintained in the camp had at one time crossed over 400 animals, and there was a sizeable feral goat population. In the late 1980s/early 1990s the Ministry of Environment and Forests (MoEF) directed the A & N administration that the goats on Narcondam must be removed. This was based on a modern understanding of ecology which stipulates that the introduction of exotic species on islands is extremely detrimental to the flora and fauna, particularly endemic species of islands. Some of the goats were removed to satisfy the MoEF's directive.

5. Today there are over 135 - 150 goats being maintained in the camp, and over 200 feral goats. The goats on Narcondam have resulted in a total loss of regeneration; there is virtually no herb and shrub layer, and more importantly no saplings of trees. This is of particular significance as Narcondam, which is volcanic in origin, and largely composed of rocks, is held together by the roots of trees. The lack of regeneration because of grazing by goats seriously affects the survival of the island itself.

6. More importantly, goats graze on the saplings of the food plants of the Narcondam Hornbill, thereby seriously threatening the species.

7. Hunting of the Narcondam Hornbills, and pigeons, is a common occurrence. Discussions with SAP personnel and field evidence indicate that at least between 25 and 40 or more hornbills are shot every year by catapults. The variation largely depends on whether the sub inspector in charge of the camp is pro hunting or against hunting.

8. Green standing trees are cut for fire wood, simply because it is easier to split logs of green trees than that of dead trees. Three trees were felled during my study period thus indicating that about 12 trees are felled during a year. In addition about 400 poles (*ballis*), were cut during my study period to renovate fencing of the vegetable / horticulture crop plots to prevent the goats from grazing on them.

Conservation measures

1. All goats must be removed from Narcondam immediately. The removal must be supervised by a DCF / ACF of the A & N Forest Department, so that total complicity is assured. The presence of goats seriously threatens the survival of Narcondam island itself, and is the most critical ecological problem on Narcondam island.

2. Hunting of the Narcondam Hornbill cannot be stopped as it involves the ethics of the individuals involved. The hunting does not warrant the creation of a wildlife outpost as an increase in the human population on Narcondam is detrimental. Strict instructions however must be issues to ensure that the SAP personnel abide by the Wildlife Protection Act, and uphold the sanctity of the sanctuary.

3. Directives needs to be issued to the LOP personnel that green trees should not be cut, and that only dead and fallen wood should be used for cooking. Alternately, LPG must be provided to run the kitchen at the LOP camp on Narcondam.

Proposed Helipad

A proposal to construct a helipad on Narcondam island has been mooted, and a survey by the APWD has been done for the same in March 1998. As per the rules concerning the construction of helipads, all vegetation in about 150 m of coast will be cleared. The vegetation includes a few large and mature *Tetrameles insignis* (Teepok) and a couple of Ficus spp. trees, and some scrub forest bordering the hill and the coast.

It must be stressed at the outset that it is these trees which hold the essentially rocky beach together, thus preventing erosion from taking place. The beach is narrow, and the deforestation that has already taken place has resulted in erosion. Any further loss of vegetation can only accelerate erosion of the beach thereby threatening the LOP post itself. Thus it is strongly recommended that trees / vegetation should not be cut on the beach.

Helicopters are already landing on the beach where there exists a 90 m long and 40 m wide clear open space approachable from the sea. An operational helipad already exists, and has adequately served the purpose so far. It is therefore strongly recommended that a full scale helipad should not be constructed as this by definition would result in the clearing of vegetation that is of crucial importance to the well being of Narcondam island.

Other Construction

It was also learnt that there are proposals to construct an RCC guest house and further upgrade the existing facility on Narcondam with additional quarters etc. Any further construction and an increase in the human population on Narcondam can only be detrimental not only because of the inherent loss of vegetation, but also from an increased pressure on other resources on the island. Besides, any construction will be in violation of the CRZ and CZMP besides the Wildlife Protection Act. It is therefore strongly recommended that Narcondam island be allowed to exist as it is, as it is of immense biological importance, and extremely fragile.

GOVERNMENT OF RAJASTHAN

FOREST DEPARTMENT

A PROJECT FOR

AFFORESTATION AND PASTURE DEVELOPMENT

IN

INDIRA GANDHI CANAL AREA

STAGE - II

JAIPUR.

1987

Programme. About 1 lac hectares have been afforested under various schemes. Extensive work has been done in the field of tree plantations, pasture developments, fodder production, farm forestry, energy plantations etc. Thus in stage-I of the main canal upto 620 R.D. all the canal systems, almost all roads, fuelwood abadi plantations have been planted and about 80,000 hectares area has been treated under pasture development. The impact of this massive afforestation is being felt in the form of green belts providing protection to the canal system & Agricultural fields. The nature and extent of works carried out in stage-I are described below:-

S.No.	Nature of work.	Area(in Hect.)
1.	Canal side plantations.	10274
2.	Road side plantations.	2567
3.	Fuelwood Abadi plantations.	4069
4.	Sand Dune Stabilization and Pasture Development.	65859
	Total:-	82769 Hectares.
	Afforestation under D.P.A.P. in Stage-I & other schemes in Stage-II. ..	20000 Hectares.
	Total :-	102769 Hectares.

of protecting canal from the blowing sand. Keeping this in view, Rajasthan Government had launched a massive drive for afforestation and development of pasture land in Indira Gandhi Canal Project area in Stage-I. The proposals for afforestation and pasture development are based on the following concepts :-

1. Protection of canals, agricultural fields, railways, roads, habitations from the wind blown sand.
2. Meeting the requirement of fodder, fuelwood, & timber of the existing as well as projected population of the area.
3. Creating a surplus forest produce to meet the demands of neighbouring districts.
4. Creating employment opportunities for the land-less and poor villagers of the project area and the neighbouring districts.
5. To reduce the migration of livestock during drought years and to increase its productivity.
6. To improve eco-system in the region.

AFFORESTATION IN STAGE- I.

The afforestation in Indira Gandhi Canal Area right from Rajasthan feeder was started from the year 1962 and more intensively from the year 1974 under Command Area Development

7. ANNUAL FOOD PRODUCTION:	Lac tonnes.	14.50	22.50	37.00
8. DRINKING AND INDUSTRIAL USE.	Cusecs.	300	900	1200

Construction of Indira Gandhi Main Canal has been completed upto its tail end at 1458 R.D. near Mohangarh village and water from the tail has been discharged further to Sagar-Mal-Gopa branch on 1st January, 1987. The distribution system of Indira Gandhi Main Canal in Stage-I has been completed while in stage -II it has been partly completed. The Main Canal runs through Sriganganagar, Bikaner and Jaisalmer districts. The Main Canal and its systems pass through a vast sandy tract and are facing an alarming danger from blowing and drifting sand which causes massive siltation, thereby adversely affecting the flow of water in the canal. The problem is more acute in Stage-II area, mainly between Bhikampur (1058 R.D.) and Mohangarh (1458 R.D.) in case of main canal and in Dattor, Birsalpur and Charanwali Branch systems. Heavy amounts are being spent every year on clearing of deposited sand in the canals. The area on both sides of the main canal and its systems is widely open and there is practically no vegetation on the ground and trees are almost absent. High wind velocity during summer months and drifting of loose sand into canals is a recurring phenomenon. Sand Dune Stabilization and Pasture Development on massive scale is the only answer to the present problem

1955. According to the inter-state decision of December, 1981, Rajasthan has been allocated 8.6 million acre feet water. The Indira Gandhi Canal envisages use of 7.59 million acre feet.

The 649 kilometre long Indira Gandhi Canal with a capacity of 18,500 cusecs, takes off from Harika barrage in Punjab at the confluence of rivers Sutlaz and Beas. It traverses for a length of 204 kilometres as feeder not irrigating any land on the way with its first 150 kilometres length in Punjab and 19 kilometres in Haryana. The canal is 40.8 metres wide at a bottom and 6.4 metres deep. For administrative convenience the project works have been taken up in two stages- 1. Stage-I 2. Stage-II

The salient-features of the project are as under :-

TABLE - 1

S. No.	Particulars.	Unit.	Stage. I	Stage. II	Total.
1.	LENGTH OF MAIN CANAL :				
	i. Indira Gandhi Feeder.	Km.	204	-	204
	ii. Indira Gandhi Main Canal.	Km.	189	256	445
	Total :-		393	256	649
2.	LENGTH OF DISTRIBUTION SYSTEM:	"	2960	4800	7760
3.	CULTURABLE COMMAND AREA :				
	i. Under flow irrigation.	Lac Ha.	4.79	7.00	11.79
	ii. Under lift irrigation.	" "	0.46	3.12	3.58
	Total :-		5.25	10.12	15.37
4.	IRRIGATION POTENTIAL ON FUEL DEVELOPMENT:	" "	5.78	8.10	13.88
5.	COST.	Crore Rs.	246	1420	1666
6.	WATER REQUIREMENT.	Million Acre feet.	3.59	4.00	7.59

I N T R O D U C T I O N :-

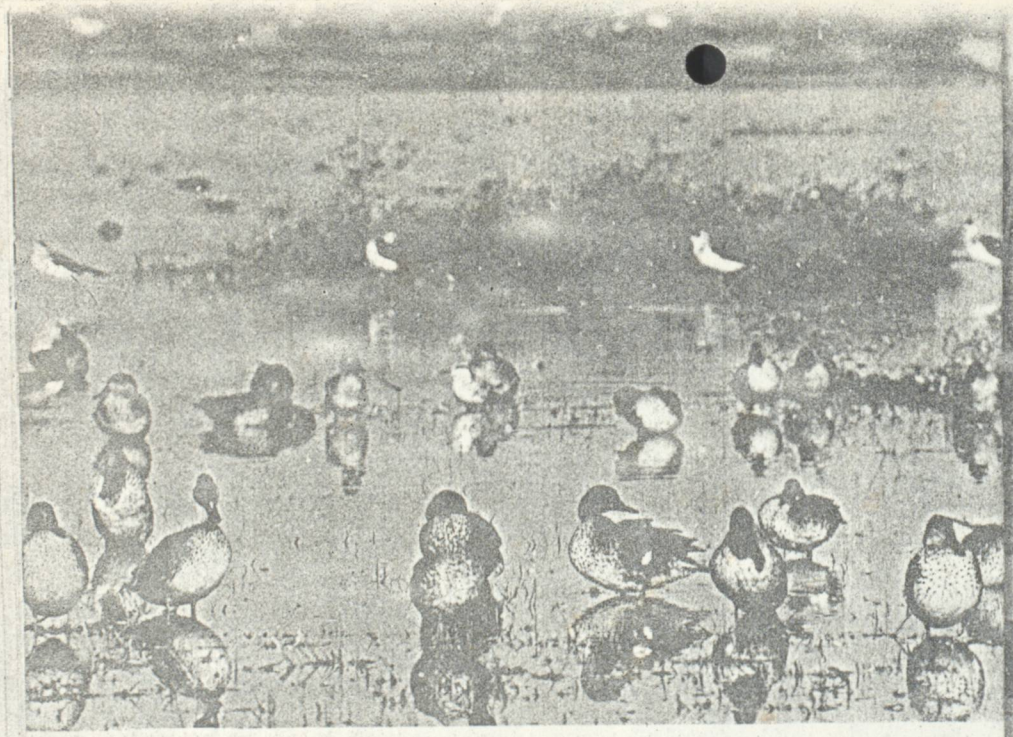
THE THAR DESERT :

The Thar desert is by far the most densely populated arid zone of the world. Whether man has created the desert or it is an out-come of the climatological and geological up-heavals is still not clear. However, the growing human and live-stock population in quest of development are adding to the desertification process. The situation is further aggravated by erratic, in-adequate and ill distributed rain-fall. The irrigation & afforestation are amongst the most important actions to reverse the process of desertification.

THE INDIRA GANDHI CANAL PROJECT :

The Indira Gandhi Canal Project is one of the largest canal systems of the world. It is a gigantic human effort to transform a part of the vast tracts lying desolate into a land of plenty and prosperity. The inhabitants of the great Indian Thar Desert have for generations accepted scarcity, drought and famine as part of their normal life. Almost every year is a drought year and practically nothing grows there as the rain-fall in the area is very scanty varying from 80mms. to 300 mms. In the project area the intensity of population varies from leas than 3 person per square kilometer to 39 per square kilometer.

Out of 15.85 million acre feet of surplus Ravi-Beas water, Rajasthan was allocated 8 million acre feet in January,



Common teals in Dihaila jheel

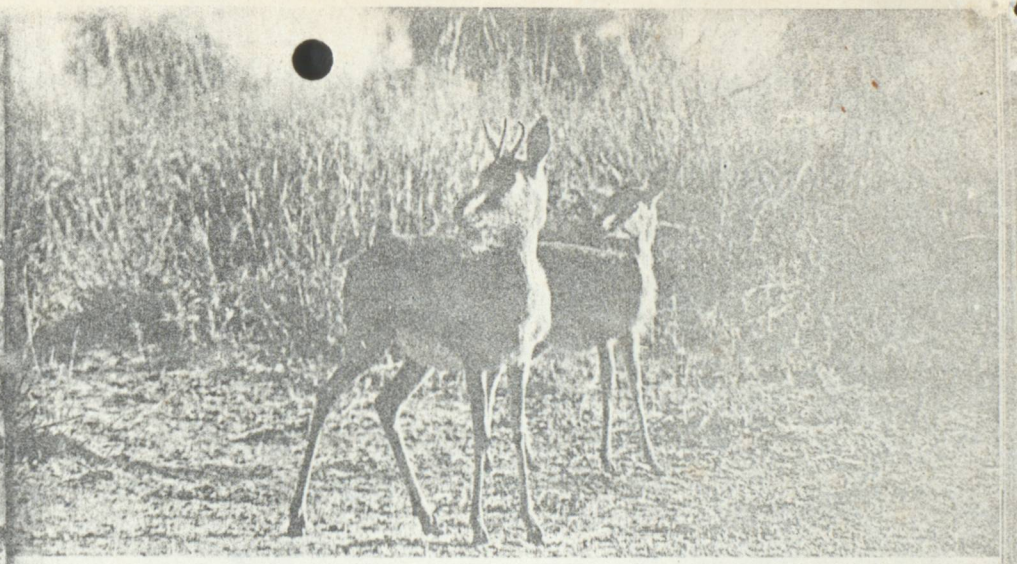
can be seen in winter with the diving ducks in more deeper parts of the jheel where the maximum depth can reach up to three metres.

Though it is difficult to estimate the number of birds at Dihaila, my conservative estimate is one lakh, with the common teal, pintail, ruff and reeve and stints contributing a major share. About a thousand to fifteen hundred barheaded and greylag geese and a few hundred spoonbills can also be seen at Dihaila.

At present, due to lack of trees, very few birds nest near the jheel. Once the trees are planted and protected, this jheel will certainly serve as a nursery for the chicks of spoonbill, egrets, storks and cormorants. This was amply proved to me by discovery of about 20 nests packed on two trees in a small pond, four kilometres from Dihaila. The birds of Dihaila need a few secluded trees to start a breeding colony.

The Bombay Natural History Society under the Avifauna Project started bird ringing at Dihaila in October 1985. It is hoped that this ringing will prove that the Dihaila jheel is one of the important water bodies in the country for the migratory birds. With the Central Government's recent concern to protect the wetlands, Dihaila jheel is a strong contender to be listed under the Ramser Convention.

ASAD R. RAHMANI



A Chinkara doe and fawn

Sitting by a desert waterhole

The fortress of Jaisalmer was behind us. Its medieval walls, perched on a hilly foundation, slowly grew smaller as we rattled away in a jeep that often seemed intent on killing us. We were headed for Sudasari, one of the numerous *chowkis* of the Desert National Park.

The winter of 1985-86 saw Dr Asad R. Rahmani and myself surveying Rajasthan, to assess the population of the Great Indian Bustard and locate an ideal field station from where these birds could be studied in a typical desert ecosystem.

Forty-five kilometres from Jaisalmer we turned off the metal road. A seemingly endless dirt-track stretched ahead of us. A *tibba,* in Marwari for shifting sand dune, had engulfed the road. In 1983 Dr Rahmani had been stuck on the very same dune until help arrived four hours later in the way of half a dozen robust villagers to push the jeep out of the sands. Eyeing my skinny body, he was rather reluctant to attempt crossing the dune but my optimism (no doubt from being a novice in these matters!) got to him too and we managed to inch our way across the dune. A couple of mini *tibbas* later we could see Sudasari ahead.

Sudasari is just a cluster of round mud huts manned by a few boisterous forest guards. The warmth and hospitality was characteristic of the people of the desert. A few plump chicken vigorously scratched the mud, a camel tethered to a post by its nose complacently chewed cud, some donkeys hung around a water

All photographs by the author

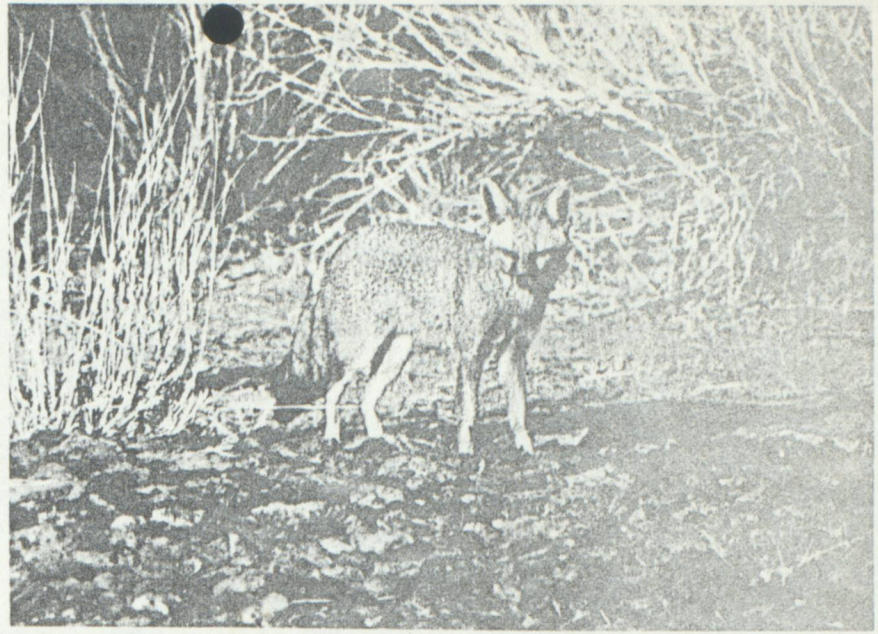
trough as if deep in their melancholic thoughts. As far as the eye could see there was no other sign of human habitation. Time seemed to have been arrested ages ago.

Water is the scarcest commodity in the desert. The Rajasthan Forest Department has made a small waterhole which the guards fondly call the *guzzler*. The denizens of the sands invariably made a bee-line to this surface water at some time of the day or the other. Overlooking the *guzzler* was a permanent hide from which one could watch or photograph animals and birds from close proximity.

Having always fancied myself as some sort of 'Lawrence of Arabia'. I got onto a camel at the earliest opportunity to scout around. I was fortunate enough to see some houbara. This endangered bustard preferred for sport by falconers and hunters is today completely protected in our country. Some hours later, somewhat richer in my knowledge of desert fauna, I returned. My back felt as though every vertebrae had been dislocated. The fact that the camel alternated between a terrifying gallop and a jarring trot had not made the ride any easier. Meanwhile Dr Rahmani made arrangements for our stay in Sudasari. He also went to check the hide from where three years ago he had taken some excellent photographs of the bustard drinking.

Next day I went to the hide as Dr Rahmani was busy in surveying the area for bustards. The afternoon was warm and sunny as I walked the odd kilometre to the *guzzler*. I settled down and after a long wait I heard the sounds of an approaching animal. Action at last! I quickly got my eye to the peephole but I was

The King Vulture



The Common Indian Fox

thoroughly disgusted to see that it was only a camel. I did not like the idea of taking photographs of a tame camel from a hide.

I resigned myself to another long wait when silently a king vulture dropped to the waterhole. This carrion feeder, unlike its commoner relatives is quite a handsome bird. Its bald, red head, black feathers and its ever watchful yellow eyes were a most impressive sight. Warily it drank, rapidly bringing up its head after every gulp. Thirst quenched, it was soon gone.

The warmth had made me drowsy when I made spot check on the waterhole. All traces of sleep were rolled out of me. Lapping thirstily at the *guzzler* was a desert fox. I clicked. At the sound of the shutter it was off. Weaving rapidly through the *sewan* grass clumps, it was soon lost to sight. In my excitement I had forgotten to adjust the speed and aperture of the camera as a result of which it was a poor shot. I guess it is something every budding wildlife photographer learns the hard way.

The wait between the 'arrivals' can be tedious. Within the confines of a small hide, one tends to fall into some kind of a trance. The anxious snort of a *chinkara* doe with her fawn broke my reverie. Nervously looking around, they froze at every rustle, real or imaginary. I clicked and they did not stop running until they were well away.

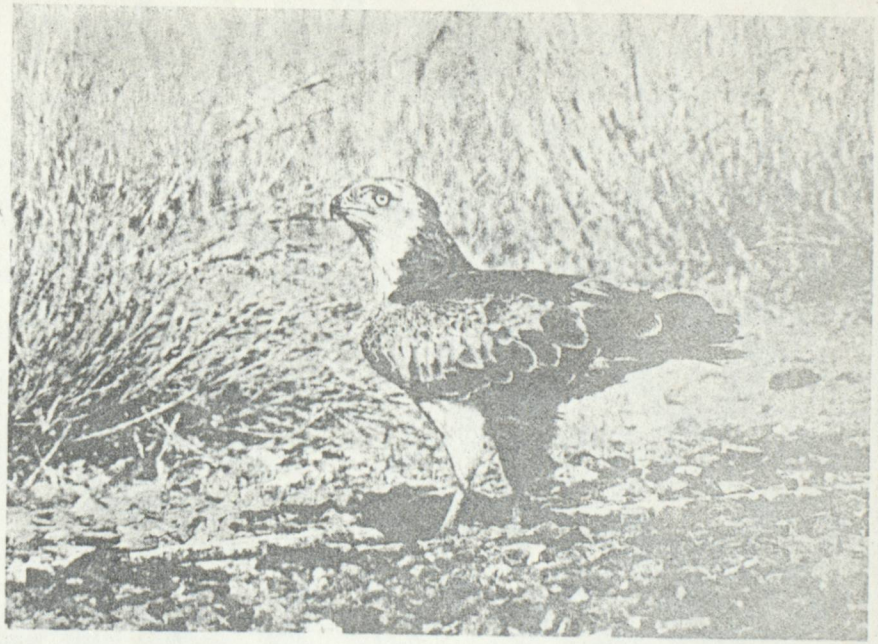
After another long wait, the star attraction of the Desert National Park arrived. Two male Great Indian Bustards were walking slowly and regally, carefully looking

A male of the Great Indian Bustard drinking

around in their haughty way towards the *guzzler*. Softly they *hook*-ed as they made sure all was safe. It was not long before they were thirstily drinking. Squatting on their tarsus, they used to bring their head up to ascertain whether all was still safe. Satiated, they walked away, stopping every now and then to peck at something that had caught their eye. It is truly a pity that this aristocratic bird has become so rare today to be listed in the RED DATA BOOK. The sight of the Great Indian Bustard at close quarters more than compensated all my troubles to come to this remote *chowki* all the way from Bombay.

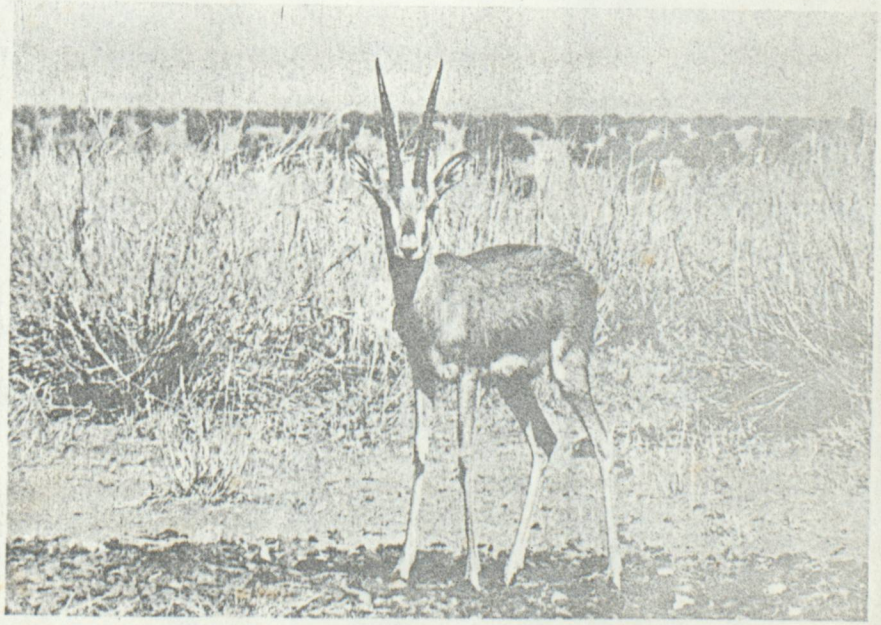
The following day both of us were eager to sit in the hide. Thankfully there was space in the hide for two people with all their photographic paraphernalia. It turned out to be a most exciting afternoon of my photographic career.

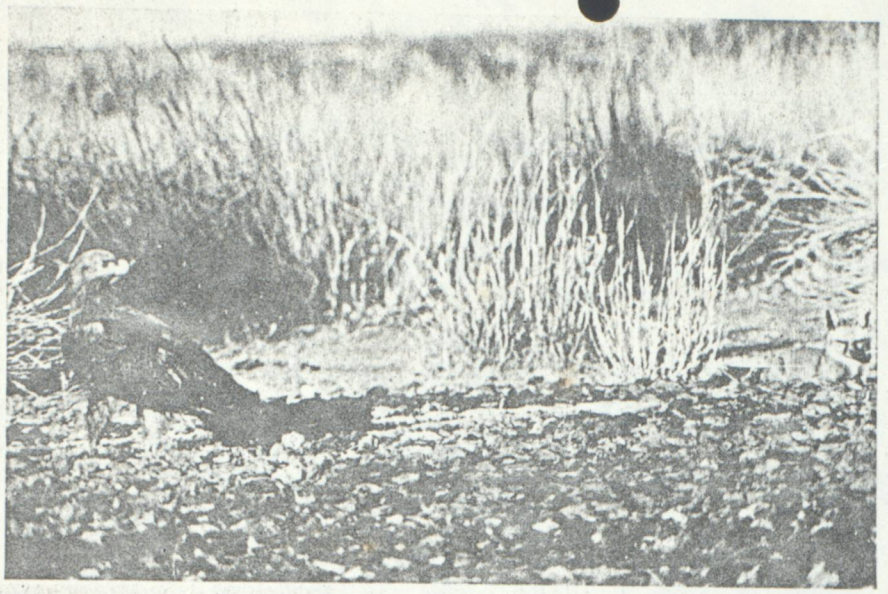
Not long after we had made ourselves comfortable there was a murmer of wing against the air. A raptor landed. Pale fierce eyes glared unafraid around. A wild power emanating from it held us spell-bound. Unafraid it drank again and again. When satiated it looked around for a while before leaving as silently as it had come. Awed, I could only ask 'What on earth was that ?'. Dr Rahmani said it was a buzzard, but which buzzard?. It turned out to be a longlegged buzzard when we identified it



The Longlegged Buzzard

A male Chinkara snorting





A Tawny (?) Eagle and a fox

from our slides and the specimens at the Society.

As the hour passed a *chinkara* came and went; a fox which did not care much about being photographed. Seemingly endless wait later, the bustards arrived. This time too there were two males and they seemed to enjoy being caught on film as they posed for us in every concievable posture.

We were contemplating leaving the hide when a most interesting thing occurred. Just as a common Indian fox reached the waterhole an eagle landed by the water. Promptly the fox changed course and trotted around to the other end of the trough. Settling down, for no imaginable practical purpose it went to sleep. The eagle seemed to expect such deference, for it paid no attention to the fox and drank its fill. The moment it took to wing, the fox was up and lapping water. A case of eagles first. And thanks to that; at last I had got a photograph of the shy fox.

Today Sudasari is just a memory and often when mundane living gets to me I wish I were back once more in the desert and going to that much-visited hide near the *guzzler* where the majestic Great Indian Bustard still strides confidently and where the wily fox makes way for the arrogant eagle.

RAVI SANKARAN

A forest — wet deciduous, semi-evergreen

Chuck-chuck, chuck-chuck-chuck, ... in quick succession. What's that?! was the query in a chorus by the birdwatchers. And Ganapati, the local Siddi guide, showed them the Giant Squirrel as it leapt from the high branches of a *Terminalia.*

The Society's members were camping at Magod, near Yellapur in Karnataka. The state government had planned a hydel project here some years ago. Fortunately, due to the opposition by the local people and on the advice of conservationists and naturalists the project was abandoned. Today, a small colony of Karnataka Power Corporation (KPC) is nestled on the periphery of this rich biotope. The roads constructed by the Power Corporation for the project have remained in good shape, thus making excellent nature trails for visitors. One such road leads to the waterfall, another to the abandoned dam site, and a third to the riverside where the hydroelectric power generator was to be located. A circular road connects all the three, thus making a complete, well-laid-out nature trail, through rich forestland, interspersed with cultivation.

River Bedthi flows full during the monsoons and rushes down into a rockpool, overflowing into a waterfall. A spectacular sight of a gorge can be had when seen from high above, where a visitors' gallery is built for the benefit of the tourists. This is Magod waterfall. We enjoyed every moment of it. Nature's bounty was abundant. Rich in flora and fauna, Magod forest offered us a pleasant week end.

My desk job does not permit frequent outings. When this trip was offered, I accepted with alacrity, and today I reminisce the pleasant week end I spent at Magod.

Walking through the green forest itself is relaxing. Besides, Magod offers a variety of birdlife. A list

All photographs by the author

WORK PLAN
JUNE 27 - NOVEMBER 1
R SANKARAN

SCHEDULE

June 27	:	Leave for Dudwa Tiger Reserve
June 28/29	:	Reach Dudwa Tiger Reserve
June 29 - July 1	:	Visit Grassland Ecology Project field Station at Dudwa. Check on progress/problems. Discuss study.
July 2-3	:	Leave for Bharatpur by jeep.
July 4-5	:	Proceed to Jaipur. Meet Chief Wildlife Warden for permission to work in Jaisalmer.
July 6- November 1	:	Field work at the Desert National Park

WORK PLAN

Objectives of the Project

1. To survey an evaluate the status of the subtropical grasslands of the Indian plains
2. To make an inventory of the major grasslands, both private and governmental, and to identify some for long-term conservation strategy.
3. To identify important grasslands from the view point of endangered biotic communities, both floral and faunal.
4. To make an inventory of the vertebrate fauna of major Indian grasslands.
5. To conduct detailed studies on ecology of indicator species such as blackbuck, chinkara, bustard, florican and quail.
6. To study the effects of stock grazing on the breeding success of indicator species.

Virtually all grassland habitat that exists in India maintain that status because they are protected from grazing and agriculture. The reasons for such protection are primarily for fodder produce and/or because the area is specially protected for its fauna and flora.

In atleast three regions, grassland habitats receive special protection; the protected areas are small (rarely exceeding 2500 ha.) and are islands amongst vast tracts of overgrazed revenue

land and agriculture. Such plots include those in the Desert National Park, the Drought Prone Areas Programme plots in the Deccan, and the fodder producing grasslands (reserved *vidis*) of western India.

Thus the basic fixed location research objective is to study the differences in the plant and animal communities within and outside the plots, and to answer such questions like 'What role does, for instance, the protected Desert National Park enclosures play in the wildlife conservation of the desert'. The studies will be so designed as to show the effects of overgrazing on plant communities and on animal use patterns. Subsequently, extensive surveys in the geographic area where each type of grassland occurs over which the results of the results of the intensive studies will extrapolated.

Eventually the thrust will be to increase the size and number of such protected grassland enclosures, the studies providing the base from which conservationists and environmentalists can draw their arguments.

The Desert National Park

The following studies will be initiated.

1) Densities of chinkara and bustards within and outside enclosures and the seasonal changes in use patterns.
2) Bird communities inside and outside enclosures.
3) Insect abundance inside and outside enclosures.
4) Differences in vegetation inside and outside the enclosures.
5) Grassland productivity.
6) Grazing pressures.
7) Surveys of all protected enclosures of the DNP - 10/12
8) Identification of potential areas for creating new enclosures.

Standard methods will be used. Once the study has commenced, and the first two-three months of field work is done, the finer details of the study programme will be done. The final working plan will be ready in October - November 1991.

SUMMARY

Based on observations on four year old plantations in command area of Stage II of Indira Gandhi Canal Project, the growth rate and forage production under different species of trees has been discussed. Eucalyptus camaldulensis attained maximum height and GBH of 12.85 m and 45 cms respectively. Whereas, minimum growth was observed in Prosopis cineraria which attained a height of 3.87 m and GBH 16 cms in 4 years. Growth of remaining species was in the order of Delbergia sisso, Acacia nilotica Ziziphus mauritiana and Tecomella undula

However, forage production under Prosopis cineraria was maximum (4.4 Tons/ha) an it was minimum under Eucalyptus camaldulensis plantations (0.4 Tons/ha). Under remaining species it was maximum in Acacia nilotica followed by Delbergia sisso, Tecomella undulata and Ziziphus mauritiana.

IRRIGATED FORESTRY IN I.G.N.P - STAGE II

A.K. UPADHYAYA,
Deputy conservator of forests
World food programme
Jaisalmer.

INTRODUCTION

The Stage II area of Indira Gandhi Nahar Project extends from 620 R.D. to 1458 R.D. of main canal and it's distribution systems in that reach. The area lies in north-west part of Rajasthan covering parts of Bikaner and Jaisalmer districts. The area is characterised by almost all adverse climatic conditions having low and erratic rainfall (annual average being 16 cms), extreme temperatures (maximum 48°C and minimum 0°C) pool frost in winter causing enormous damage to plant life and strong winds of the velocity as high as 40 KMPH often predominate in the area during summer months which causes sand movement of very high magnitude.

The irrigated agriculture and land settlement in the area has just begun. Due to irrigation, the agricultural and livestock productivity is bound to increase, as it has increased considerably in stage-I, after full devlopment. However, the natural grassland of sewan (Lasiurus sindicus) are unluckily concentrated in command area of Stage II and are bound to vanish after the irrigated agriculture starts at a full swing. Thus a resource which is being utilised by local cattle during recurring famine years is bound to be reduced. This will result in an additional burden on less extensive pastures which in turn will result into highest degree of land degradation outside the canal command area.

The desertification process in arid areas is a complex interaction of socio economic and natural process reducing the fertility and biological productivity of the soil. The main activities which are increasing the desertification in the area are

- Wood land clearance for cooking food, agricultural implements, house construction and for making charcoal.
- Overgrazing; more animals graze frequently on less extensive pastures and keep on migrating depending on rainfall distribution pattern.
- Inadequate land use practices and introduction of tractors for ploughing larger unirrigated areas in less time and thus accelarating sand movement of highest degree if rains fail.
- Extension of flood irrigation to those areas where soil depth is too less due to which waterlogging problem arises soon and land is lost for ever.

Eroded, overexploited, overgrazed and deforested lands become more vulnurable to droughts. The only means to combat desertification is to produce more from irrigated areas, therefore, reducing pressure on unirrigated areas.

Irrigated forestry in Shri Ganganagar district was started in early sixties using water from Bhakhra canal systems; Mathur (1961) and Singh (1963). Afforestation in stage I of Indira Gandhi canal project was stepped up considerably after 1973-74. Till now approximatly 1 lac ha area has been planted up in stage I under different types of activities. However, in stage II the afforestation is of a very recent origin and was started in the year 1987. In a short span of four years an area of 30,000 ha has been planted up.

Afforestation in stage II has twin objectives

- Protection of canals, roads, bridges, headworks and colonies from drifting sand.
- Production of fodder, fuelwood and timber to meet out the demand of local population on priority and others if surplus is produced.

the main activities of afforestation consists of canal side plantation, block plantation, sand-dune stabilisation, pasture development, road-side plantation, environmental plantation and canal bank stabilisation.

METHODS OF IRRIGATION.

Depending on relative level, of water in canal and of adjacent ground, different methods of irrigation are being adopted.

a) UNCOMMAND AREAS – where ground level is higher than the water level in canal – Previously for uncommand areas sprinkler irrigation was envisaged but the operation of sprinklers was not found suitable in the area due to high wind velocity causing drift of droplets, high evaporation losses and nozzle blockade due to sand particles. Presently lift irrigation is in practice. Depending on degree of lift and lead from water source, engines with different horse powers ranging between 5 HP to 25 HP are being used. Light Galvonised steel/Aluminium quick coupling pipes (LGS-QC pipes) with 75 mm and 100 mm diameter having riser outlets of 25 mm at suitable intervals are coupled to engines at to carry water. On these riser outlets PVC/rubber pipes of 25 mm diameter, having 15 to 30 m. length, are used. Six to fifteen outlets work at

a time depending on horse power of the engine, height of lift and lead from water source. This has proved an effective method of irrigation and quickly carries water to even 1 Km distance from water source without any problem. The system is easy to assemble and dismantle and there is no transportation loss of water.

(b) COMMAND AREA - where ground level is lower than water level in canal

(i) Terrain is either flat or can be levelled with very small efforts, then lined water courses are made and they are fed by permanent syphons from canals, basin irrigation is preferred. The plantation is divided into small plots each of which has a level surface. The basin is allowed filled with water which is allowed to infiltrate, basin size being 0.20 to 0.50 ha depending on degree of level and type of soil.

(ii) If the terrain is flat and furrows can be easily maintained for longer periods then 0.30 m deep furrows having bottom width of 0.30 m and top width of 0.40 m are made and plants are planted on lips of furrows. It requires some skill in diverting water from cemented channels to furrows and controlling its flow.

At most of the places basin irrigation is being preferred because of comparatively less requirement of labour inputs and better growth results.

(iii) If the terrain is undulating and operation of levelling is very costly then topography is retained and syphons are coupled to LGS QC pipes and spot irrigation is done.

In some road side / environmental plantations if lead from water source is too much then truck tankers/ tractor tankers or camel carts are used for irrigation of plantations.

AFFORESTATION ACTIVITIES

Different afforestation activities which have been undertaken in the area are described below.

(i) CANAL SIDE PLANTATION - A strip of 100 m width on either side of main canal and branches, 50 m on either side of distributories and 25 m on either side of minors and subminors was planted at 3m x 2 m spacing. Since, closure spacing requires an early thinning, the spacing has been changed to 3m x 3m in the later plantations. Irrigation frequency is 9, 9, 6, 6, 3, 3, 2 and 2 times from 1st to 8th year. In command areas Eucalyptus camaldulensis Delbergia sisso and Acacia nilotica have been planted, whereas, in uncommand areas Prosopis cineraria, Tecomella undulata and Ziziphus spp. and on naked dunes Acacia tortilis has been planted.

(ii) BLOCK PLANTATION - These are purely command area plantations done either on 12.5 ha abadit lands which are kept aside for afforestation in different chuks or large chunk of flat lands adjacent to main canal/ distribution systems in which flow irrigation is possible. As is the case in canal side plantations spacing has been changed to 3m x 3m. The frequency of irrigation is same as in canal side plantations. Main water course is lined and from main water course unlined channels off-take at suitable intervals, so that, whole area is covered. Species which have been used in this activity are mainly Delbergia sisso, Eucalyptus camaldulensis and Acacia nilotica with some mixing of Prosopis cineraria, Tecomella undulata and Ziziphus spp..

(iii) SAND-DUNE STABILISATION - Planting is done at a spacing of 3m x 3m. Active dunes are mulched, using local material. Mulch lines are perpendicular to prevailing south-west wind direction and spacing between two lines is 5 m. Seeds of Lasiurus sindicus (sewan)

and some local bushes are also sown in the area before monsoon. Irrigation frequency of 4, 6, 6, 3, 2, 2, 1 and 1 from 1st to 8th year is being adopted. The species in this activity are Acacia tortilis on high and shifting dunes and Tecomella undulata, Prosopis cineraria and Ziziphus spp on low semi stabilised dunes and in interdunal areas.

(iv) PASTURE DEVLOPMENT - Under this activity 1,000 Lasiurus sindicus grass slips raised in polythene bags in nurseries are being planted along with 200 plants of top feed species, like khejri and Ber, per ha. Irrigation frequency is same as in case of sand-dune stabilisation activity. Three irrigation to grass slips are given in 1st and 2nd year. No grazing is allowed for first five years, however, if needed the grass can be cut by local people on royalty basis. This has been tried successfully and grass is being made available at a rate of 30 Rs per quintal from these pastures.

(v) ROAD SIDE PLANTATION - seedlings are planted at 3m x 3m spacing except for shady and Ornamental trees which are being planted at a spacing of 5m x 5m. As roads in stage II are still under construction, this activity has not picked up desired speed. Irrigation shedule is similar to canal side plantation.

(vi) ENVIRONMENTAL PLANTATION - In order to protect irrigation colonies, headworks, and bridges and to create recreational avenues, ornamental and shady plants are planted at a spacing of 3m x 3m and 5m x 5m respectively, irrigation shedule being same as in canal side plantation. Irrigation is being done by truck tankers/ tractor tankers/ Camel carts or en[illegible]es and pipe lines depending on

distance of site from water source. One such plantation at 1458 R.D. has been converted to 'Deer Park' recently.

(Vii) CANAL BANK STABILISATION - Due to absence of vegetation on slopes of canal banks, the run-off of rain water makes gullies, if rains are heavy the lining of canal is also exposed sometimes. During summer months the sand movement along slopes, due to absence of vegetation, is very heavy which causes enormous deposition in canals in heavy filling reaches, therefore, stabilisation of these slopes is very essential. This activity has started this year only in heavy filling reaches. The slopes are mulched in a chess-board pattern and are planted with tufts of Saccharum munja at a spacing of 2 m x 2 m. Seeds of Calatropis procera (Aak) and Arand (caston) are also sown in the area. At the base of the slopes, shallow rooted plants like Parkinsonia are planted at 3 m spacing. The irrigation is done using sprinklers, because other methods can not be effectively applied.

MATERIAL AND METHODS.

Growth data for different species were collected from different types of plantation activities which were raised in year 1987-88 in world food programme division, Jaisalmer. The list of sites from where data were collected are given in table 1. Sample plot size was 0.15 ha and 250 plants were marked for observation of data. Plots were average representative of the whole site. For each species three replicates were taken at different sites and growth observations were recorded six monthly. For calculation of ground vegetation under all species, five replicates each of 5 x 10 m^2 was laid and all ground vegetation in that plot was cut from ground level and per ha air dried ground vegetation production in different species was calculated accordingly.

RESULTS AND DISCUSSIONS

Growth data and production of ground vegetation in different species in 4 year old plantations are shown in table 2. Maximum growth in height as well as girth was attained by Eucalyptus camaldulensis and minimum growth was attained by Prosopis cineraria. Due to this reason the component of Eucalyptus camaldulensis in canal side plantations should be more, since, it attains more height as compared to other species, hence, it forms an effective shelterbelt in checking sand deposition in canals. However, the performance of shisham and babul are also not bad as compared to Eucalyptus, if we compare total biomass. The branching in shisham and babul increases their biomass almost equal to Eucalyptus. Therefore, these two species should be given priority in block plantations.

Out of three indeginous species, which were planted in command area for the first time, the performance of Ziziphus mauritiana was found best and right from third year it has started producing fruits at a rate of 20 kg/plant. It was believed that Tecomella undulata and Prosopis cineraria have excessively slow growth rate. Kaul (1977) has reposted that under rainfed conditions Prosopis cineraria and Tecomella undulata attained a height of 2.8 m and 3.1 m respectively under Jodhpur conditions in 14 years. In extreme arid conditions of Jaisalmer the growth is bound to be lesser than at Jodhpur under rainfed conditions. However, in command areas Khejri and Rohida attained a height of 3.87 m and 4.56 m in 4 years, hence, they can not be called slow growing at all. Not only this

khejri started producing pods in three years at a rate of 5-6 kg (sangri) per plant and Rohida started flowering and fruiting from 3rd year.

So far as production of forage under different species ~~is concerned~~ in command area is concerned, it was found maximum in case of Prosopis cineraria followed by Acacia nilotica, Delbergia sisso, Tecomella undulata and Zizyphus mauritiana. Least production (almost negligible) was found under Eucalyptus camaldulensis. Roots of one plant of khejri and one plant of Eucalyptus was excavated and it was found that in case of Eucalyptus, 80% roots were concentrated in top 70 cms layer, in fact root hairs made a mesh along the surface which discouraged any ground vegetation. On the other hand, tap root of khejri was very strong and went beyond 3 m (we could'nt excavate beyond 3m). Due to coiling of roots at nursery stage a bulge in the roots was found almost at 30 cm depth (the size of polythene bag), from that bulge the roots trifurcated and three roots of almost equal thickness went down. Even the latral roots, which were four in number, after moving 1 to 2 m showed a tendency of moving down. This clearly revealed that roots of khejri were not concentrated along the surface, therefore, the plantation supported luxuriant growth of forage under khejri.

CONCLUSIONS AND SUGGESTIONS.

At present the land set ~~up~~ apart for afforestation activities in IGNP stage II is mostly unproductive land, either in form of high naked dunes or the areas which have high salinity and watter logging problems. Only small chunks of la here and there along the canals or Abadis in chuks

are suitable for production forestry. On the other hand if we effectively want to combat desertification process in arid region we should have

- Increased afforestation in command areas of IGNP stage II in order to meet out the fuelwood and timber demand of local people and ban on deforestation in uncommand arid areas.

- Land use should be in accordance with potentials and constraints of the soil. Agricultural activity should not extend to the areas where soil depths are too less and land is susceptible to waterlogging. Such lands, even if command, should be identified after a detailed soil survey of the area and should be reserved for afforestation activities.

- Increased and assured fodder supply from IGNP command areas, so that the cattle does not migrate from the area and accordingly the process of desertification does not spread to other areas.

- Suitable agroforestry practices for should be adopted for command areas with at least five to six rows of $\frac{1}{5}$ plants in south-west direction of all fields. Tractor ploughing for rainfed agriculture, exposing large areas for wind erosion, should be immediatly banned.

TABLE - 1

Details of locations from where data was collected

	Type of plantation	Location
1-	CANAL SIDE PLANTATION	(i) 1406-12 R.D., L.H.S., I.G.M.C. (ii) 1445-50 R.D., L.H.S., I.G.M.C. (iii) 1452-58 R.D., L.H.S., I.G.M.C (iv) 58 R.D., L.H.S., S.M.G.S.
2.	BLOCK PLANTATION	(i) 1325 R.D., L.H.S., I.G.M.C. (ii) 1406 R.D., L.H.S., I.G.M.C. (iii) 1410 R.D., L.H.S., I.G.M.C.
3-	ENVIRONMENTAL PLANTATION.	(i) 1458 R.D., I.G.M.C. (ii) Mohangarh colony.

L.H.S. = Left hand side

R.D = Relative distance (1 R.D. = 300 m)

I.G.M.C. = Indira Gandhi Main canal.

S.M.G.S. = Sagar Mal Gopa Shakha.

TABLE - 2

Growth and per ha ~~ground~~ production of ground vegetation in different species in command areas of IGNP- stage II.

AGE - 4 years.

S.NO.	SPECIES	HEIGHT in M.	COLLAR GIRTH (cms)	GIRTH AT BREAST HEIGHT (cms)	PER Ha PRODUCTION OF GROUND VEGETATION TONS.
1.	Eucalyptus camaldulensis	12.85	55	45	0.4
2.	Delbergia sissoo	9.90	40	33	2.1
3.	Acacia nilotica	7.65	37	29	2.4
4.	Ziziphus mauritiana	6.10	34	28	1.6
5.	Tecomella undulata	4.56	30	24	1.8
6.	Prosopis cineraria	3.87	22	16	4.4.

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AFFORESTATION ACTIVITIES

DIV:- W.F.P. JAISALMER

This division was created in 1987 March, with its headquarter at Bikaner. Jurisdiction extended from 930 R.D. of main canal to 1458 RD (tail at Mohangarh). In May 1988 division's headquarter was shifted from Bikaner to Jaisalmer and area under division now starts from 1300 R.D. of main canal and extends beyond 1458 RD to Sagarmal Gopa Shakha and Sahid Birbal Shakha alongwith their distribution system.

The area is characterised by all adverse climatic topographic and biotic conditions

1- barren land - with practically no vegetation
2- Undulating terrain - height of dunes varying from 10 to 40 M.
3- Sandy soil - with low moisture retention.
4- Low rainfall - Average annual being 15 cms
5- Wind velocity - very high during summer months, average being 20-30 KMPH occasionally touching 100 KMPH.
6- Average temperature - during summer months being 45°C. soil temperature 10-15° more. In winter mercury often drops to zero.
7- Cattle pressure is too much.

Only favourable condition for plantations is availability of water from Indira Gandhi Main canal and it's distribution system.

Various activities of afforestation have following objectives

1- Raising shelterbelt plantation along canals to check sand depositions in canal systems.
2- Planting on unstabilised dunes in order to stabilise them.
3- Production of fuelwood and timber in order to meetout district demand on priority and supply of these mat also to neighbouring districts if surplus is produced.

can be lopped in future years and fodder is obtained from them as well.

Fodder is being sold to local farmers, from these pastures at a nominal rate of Rs 30/ quintal in case of sewan grass. Approximatly 5,000 quintal fodder has been sold from these pastures till now. 1,050 Ha area has been treated under this activity and 4.20 lac seedlings have been planted.

[E] ENVIRONMENTAL PLANTATION :- In this activity plantation is done near heads and colonies. Mainly shady and ornamental plants are planted under this activity. An area of 34 Ha with 54,000 seedlings has been planted up till now.

[F] ROAD SIDE PLANTATION :- This activity has started in this year only and an area of 15 Ha (50 RKM) with 16,000 seedlings has been planted up.

As per details enclosed in annexure II, till now an area of 7,620 ha has been planted up in 4 years and in all 83.87 lac seedlings have been planted up.

[G] RESEARCH :- Besides plantation activities there are two research collaborations

- First with IAZFR (Indian Arid Zone Forestry Research Institute, Jodhpur) regarding ⓐ the performance of different species under different doses and different methods of irrigation and ⓑ Agroforestry practices.

- SECOND with WAPCOS (Water and Power consultancy service, New Delhi) on optimisation of sewan grass production under different Nitrogen and irrigation doses.

[H] WILD LIFE :- Because of plantations a shelter for wild life both for birds and animals has been provided near the water source, it has been observed that their population along the canal is increasing continuously. A Deer park in 2.5 Ha area near

tail of canal has been commissoned recently and has created an additional recreational avenue.

SPECIES COMPOSITION :- The composition of different species which have been planted till now are as under

Acacia nilotica	13.00 lacs.
Delbergia sisso	5.50 lacs.
Eucalyptus Camaldulensis	7.00 lacs.
Prosopis cineraria	11.00 lacs.
Tecomella undulata	11.00 lacs.
Ziziphus spp.	6.00 lacs.
Acacia tortilis	28.00 lacs.
others.	2.37 lacs.
TOTAL	83.87 lacs.

It is evident from the breakup that emphasis has been given to fodder species and indiginous plants. Prosopis cineraria and Tecomella undulata both have responded well to irrigation and fertiliser application and attribute that they are ~~slow~~ extremely slow growing plants have proved wrong.

EMPLOYMENT OPPERTUANITIES :- The ongoing afforestation activities have created enormous employment oppertuanities not only to local people residing in the viccinity of canal but also to the people residing in the remote villages of Jaisalmer district and other neighbouring districts of Barmer, Jodhpur and Nagaur. In all approximatly 7.00 lac mandays employment is generated every year.

SURVIVAL AND GROWTH :- WEIGHTED average of survival is 78%. In command areas it is more than 90%, whereas in uncommand areas it is > 60%. The growth of different species in 4 years is as under Eucalyptus 25-30 feet, Babul and Shisham 20-25 feet, Khejri Ber and Rohida 10-15 feet.

The plantations have clearly reduced the sand deposition in main canal and distribution systems. The results are quite prominent where width of planting is more than 500 M.

—:o:o:—

ANNEX II

PHYSICAL AND PLANTING TARGETS - WFP JAISALMER

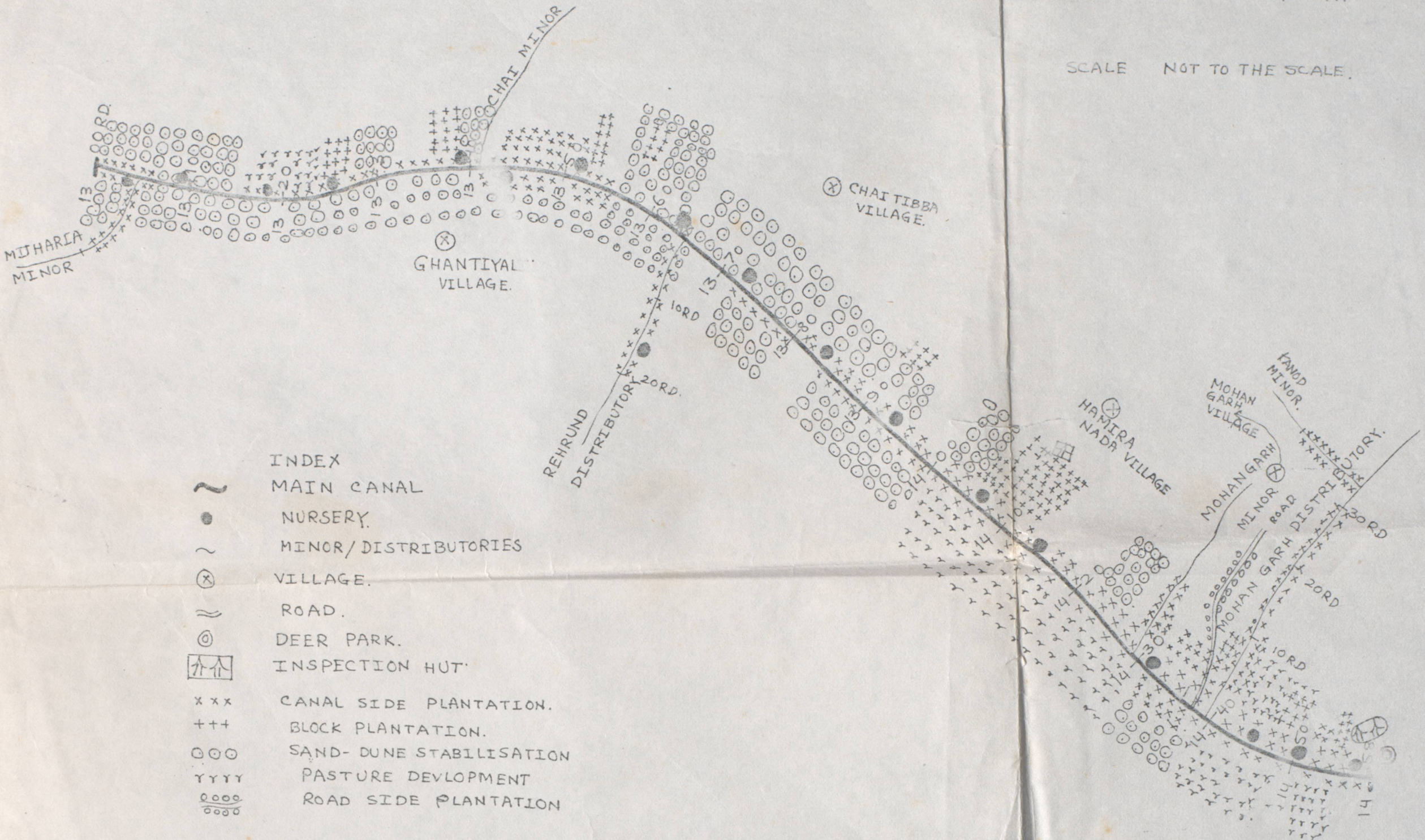
PLANTS IN LACS

		1987		1988		1989		1990		1991	
		PHYSICAL	PLANTS	PHYSICAL	PLANTS	PHYSICAL	PLANTS	PHYSICAL	PLANTS	PHYSICAL	PLANTS
CANAL SIDE PLANTATION (Command area dev., Overseas economic co-operation fund)	WFP→	80 Ha (400 RKM)	2.00	-	-	303 Ha (910 RKM)	4.55	7 Ha (20 RKM)	0.07	-	-
	DDP→	-	-	-	-	333 Ha (1000 RKM)	5.00	-	-	-	-
	CAD→	157 Ha (470 RKM)	2.35	1067 Ha (3200 RKM)	16.00	229 Ha (686 RKM)	3.43	-	-	-	-
	OECF→	-	-	-	-	-	-	576 Ha (1728 RKM)	5.75	270 Ha (900 RKM)	3.00
	TOTAL	237 Ha (870 RKM)	4.35	1067 Ha	16.00	865 Ha	12.98	583 Ha	5.82.	270 Ha	3.00
BLOCK PLANTATION	WFP→	-	-	10 Ha	0.16	71 Ha	1.18	100 Ha	1.10	-	-
	CAD→	25 Ha	0.41	150 Ha	2.50	70 Ha	1.16	-	-	-	-
	OECF→	-	-	-	-	-	-	70 Ha	0.77	28 Ha	0.31.
	TOTAL	25 Ha	0.41	160 Ha	2.66	141 Ha	2.34	170 Ha	1.87	28 Ha	0.31.
SAND DUNE STABILISATION	WFP→	500 Ha	2.00	-	-	-	-	200 Ha	2.20	-	-
	DDP→	-	-	800 Ha	8.80	700 Ha	7.70	-	-	-	-
	CAD→	-	-	200 Ha	2.20	-	-	-	-	-	-
	OECF→	-	-	-	-	-	-	200 Ha	2.20	375 Ha	4.13
	TOTAL	500 Ha	2.00	1,000 Ha	11.00	700 Ha	7.70	400 Ha	4.40	375 Ha	4.13
PASTURE DEVLOPMENT	DDP→	-	-	500 Ha	2.00	-	-	-	-	-	-
	CAD→	-	-	300 Ha	1.20	-	-	-	-	-	-
	OECF→	-	-	-	-	-	-	150 Ha	0.60	100 Ha	0.40.
	TOTAL	-	-	800 Ha	3.20	-	-	150 Ha	0.60	100 Ha	0.40
ENVIRONMENTAL PLANTATION	CAD→	12 Ha	0.20	12 Ha	0.20	-	-	-	-	-	-
	OECF→	-	-	-	-	-	-	5 Ha	0.08	5 Ha	0.06
	TOTAL	12 Ha	0.20	12 Ha	0.20	-	-	5 Ha	0.08	5 Ha	0.06
ROAD SIDE PLANTATION	OECF→	-	-	-	-	-	-	-	-	15 Ha	0.16
	TOTAL	-	-	-	-	-	-	-	-	15 Ha	0.16
GRAND TOTAL		774 Ha	6.96	3,039 Ha	33.06	1,706 Ha	23.02	1308 Ha	12.77	793 Ha	8.06

ANNEX I.

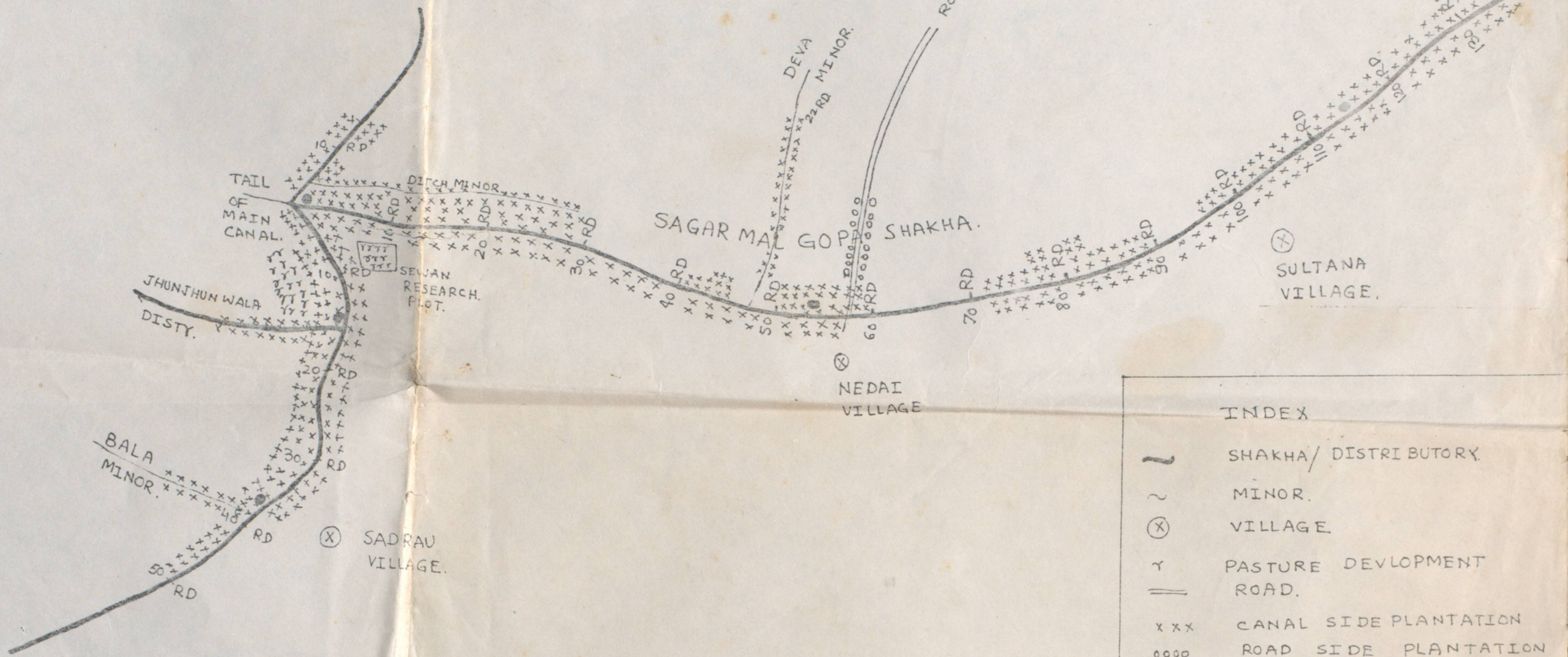
AFFORESTATION ALONG MAIN CANAL. (1300 - 1458 R.D.) AND IT'S DISTRIBUTION SYSTEM.

SCALE NOT TO THE SCALE.



AFFORESTATION BEYOND TAIL END OF MAIN CANAL

NOT TO THE SCALE.



INDEX

- SHAKHA/ DISTRIBUTORY.
- MINOR.
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- PASTURE DEVLOPMENT ROAD.
- x x x CANAL SIDE PLANTATION
- o o o o ROAD SIDE PLANTATION
- NURSERY.

INTERNATIONAL COUNCIL FOR BIRD PRESERVATION

WORLD WORKING GROUP ON BUSTARDS

A Programme for the Conservation of the Likh (Lesser Florican) Sypheotides indica in north-west India.

Abstract

Recent information has revealed that the Likh may be approaching a critically endangered status owing to extensive habitat loss and poaching. No studies have been carried out on it since 1950, and very few even before that.

A programme is outlined here for a full investigation of the Likh's status and distribution, its ecology and behaviour, and thus its conservation requirements. At least eight years will be needed to complete the work and present a comprehensive conservation plan.

The programme will be undertaken by a combination of international experts under the aegis of the ICBP Bustard Group, and Indian researchers on behalf of the Indian Bustard Group. The major part of the within-India expenditure will be underwritten by the Sir Peter Scott Trust of Jamnagar, but ICBP will have to raise the necessary funds for the travel of the international participants.

Background and Justification

The plight of India's two smaller bustard species, the Likh Sypheotides indica and the Bengal Florican Eupodotis bengalensis has only recently come to light. It seems that concern for their conservation has been diverted by the focus of attention on the Great Indian Bustard Ardeotis nigriceps. The latter species has now become relatively well catered-for, while a study of the Bengal Florican is planned for 1982 in a complementary ICBP project.

The Likh is the smallest of India's three endemic bustard species, weighing from 400g to 735g and wingspan 70cm to 91cm: females are somewhat larger than males. As a species, it is of some considerable scientific interest for it comprises a mono-specific genus within the Otididae, is semi-migratory within its range (confined to western and north-western India) having distinct breeding and wintering centres, and exhibits a spectacular but little-studied breeding system. Further, it is a highly representative example of a species adapted to savannah grasslands.

The latest, and probably best, account of the Likh is by Dharmakumarsinhji (1950). Broadly speaking, the Likh winters in the central Deccan plains (Maharashtra, Madhya Pradesh, and perhaps also Karnataka), moving to the north-western grasslands of Rajasthan and Gujarat (formerly also Sind, Pakistan) in mid-June, anticipating the monsoon rainfall. At this time, the cryptic mottled brown plumage of the males has been moulted out to a striking black, rust and white dress, complete with three or four long filiform-spatulate plumes projecting from the cheeks. The males tend to congregate in areas of high, early precipitation so that clumped populations arise which vary in density and distribution from year to year. During July, August and September the males hold fiercely-defended territories, which include one or more "jumping grounds" from which

they display by leaping vertically a metre or two, emitting a rattle-like call, throwing the head back and erecting the plumes at the apex of the jump, before parachuting down on outspread wings, prominently displaying the white patches on the primaries.

Females approach males for mating, then move out of the display grounds to lay 3 to 5 eggs in a bare-earth scrape. Why males should continue to display when most females are incubating or tending chicks, fundamentals such as diet (in quantitative terms), number of clutches, fledging success, the effects of human and grazing stock disturbance, and the entire gamut of winter behaviour and ecology are entirely unknown.

Due to the semi-migratory habits of the Likh, it has been recorded over a wide part of the Indian sub-continent, including Nepal and western Pakistan (Ali and Ripley 1969). However, the bird does not seem to have been recorded outside of its main range for many decades, and not even in Sind for some twenty years (T. J. Roberts, pers. comm.). Although early writers such as Blanford (1898), Finn (1915) and Baker (1935) agree that the Likh may appear super-abundant in good rainfall years, they also point out that hunting pressure was relentless, and particularly severe in the breeding season when males are easy to find: no flocks greater than 25 have been reported in the last thirty years.

Poaching remains a problem. Local trappers snare it as it forages around the grassy banks of dry rice-paddies in the winter, while during the breeding season, the conspicuous self-advertisement of the male gives an easy opportunity for both villagers (who secure it by arranging snares around the jumping ground, or a stuffed male which provokes a live male to come up and attack it), as well as hunters who could devastate an area's breeding potential by eliminating as many as twenty displaying males in one morning.

There has been no systematic record of the steep decline in the Likh population: its fate only became apparent when delegates gathered at the International Symposium on Bustards at Jaipur in November 1980 and compared notes. For example, there are no recent records from the whole of Rajasthan, yet the State Forest Secretary, A. M. Lal, can remember that in the early 1960's, desert roads would be difficult to drive on for the number of Likh crossing them.

As a result, a preliminary tour was carried out by P. D. Goriup and Z. J. Karpowicz from August to mid-October 1981, to enquire of the current Likh position (report in preparation). It transpired that a rapid and massive decline in Likh numbers occurred from at least the mid-1950's (i.e. shortly after Independence) till the present, when habitat loss, fragmentation and degradation exacerbated the effects of over-trapping.

For example, the Likh had been quoted in the 1966 minutes of the Southern Region of the Indian Board for Wildlife as one of the features of the proposed Tunghabhadra Sanctuary in Karnataka, but all its lowland grassy habitat had already been flooded out by a hydro-electric dam on the Tunghabhadra river constructed in 1952. At the same time, the plains of central India were becoming increasingly intensively cultivated, or converted to rice-paddy, with a concomitant and detrimental human impact on the last vestiges of grassland from over-grazing. Moreover, the grasslands in the breeding areas

have also been decimated: in the Kathiawar Peninsula alone (regarded for over a century as a Likh breeding stronghold, Dharmakumarsinhji, 1950) the vast grasslands in existence pre-Independence have now been reduced to a handful of private plots, and some 204 Forest Department "vidis". These latter include only 32 "reserved vidis" (i.e. grassland plots intended to produce hay) which total about 6,000 ha only, and in any case, 3,500 ha of that is shared between two adjacent sub-optimal sites. The agricultural pattern has also altered dramatically. In Jamnagar State in 1907, about 41.5% of the district was under arable (i.e. 3,742 km^2), of which 80.2% (3,002 km^2) was for cereal production; now, in 1980 71.8% of the land is under arable (i.e. 6,478 km^2) but only 22.9% (1486 km^2) is for cereals: 72.2% (1467 km^2) produces cash-crops, especially oilseeds (groundnuts and castor).

Gorup and Karpowicz visited over 50 individual sites purported to be grassland; actually, many had become invaded with thorny Prosopis juliflora, or converted to Eucalyptus or Acacia plantations, or were subject to illicit cutting or grazing or... eventually, eight sites yielded a total of 21 males and no females, nor did they find any evidence of nesting.

Clearly, a stage has been reached in which the Likh has or could become critically endangered. Immediate steps are needed to prevent any further demise. Although it is scheduled under the Indian Wildlife Protection Act (1972), on Appendix II of CITES and figures in the priorities of the ICBP Bustard Group conservation strategy, physical action in the field must be taken. It may be too late already: the extent of converted or over-grazed grassland, and the ever-increasing demands for access to the remaining areas poses a considerable threat. The programme presented below is designed to run for several years, in four parts, each dependant on the results of the previous work. However, each stage has an immediate application for the maintenance of the species, as well as its habitat which now represents the last examples of native grassland, complete with an herbaceous undercover, plus associated invertebrate fauna.

References

Ali, S and Ripley, D	1969	Handbook of the Birds of India and Pakistan Vol. 2. Bombay.
Baker, E.C.S.	1925	Nidification of Birds of the Indian Empire. London.
Blanford, W.T.	1898	Fauna of British India: Birds III. London.
Dharmakumarsinhji, K.S.	1950	Courtship display, behaviour and habits of the Lesser Florican. J. Bom. Nat. Hist. Soc. 49 201-216.
Finn, F	1915	Indian Sporting Birds. London.

Project Details

The strategy is to start work by concentrating in a relatively small area, but one which is recognised as of major importance, that is the Kathiawar Peninsula (see map). From here, the scope of survey and study will be expanded progressively as expertise improves, and participation increases. The flow chart below outlines the programme schematically:

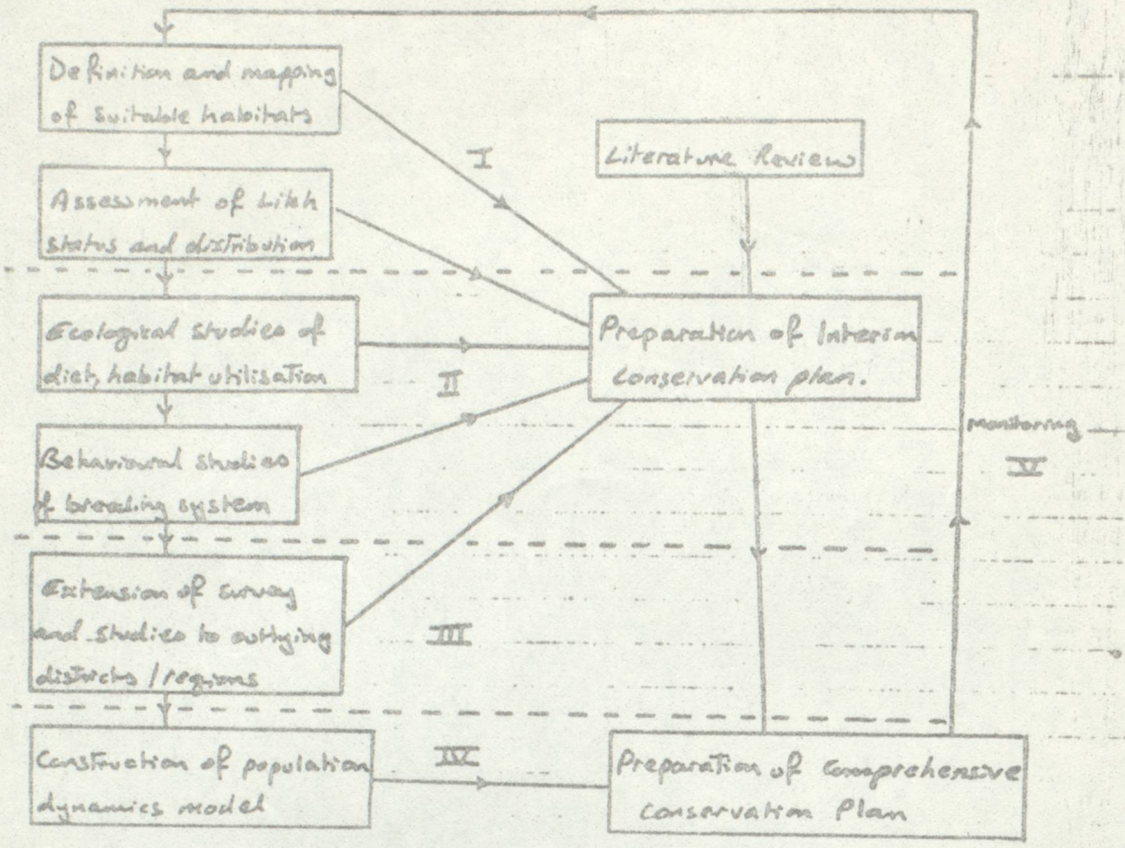


Figure: Flow chart of conservation programme for the Likh.

Phase I: The Kattiawar peninsula has been selected as the "target area" for instigating the Likh conservation programme, from which centre surveys will radiate out. There are several reasons for this, not least that the region is well known as a breeding centre for the Likh, that a base at Jamnagar will be provided by the Sir Peter Scott Trust, and that the area has already received some coverage from leading Indian ornithologists such as Dharmakumar Sinhji, Luvkumar Khacher and S.A. Jadeja, quite apart from the preliminary tour by Gurup and Karpowicz in August to October 1981, on behalf of ICBP.

For the mapping and status survey, it is proposed that a strong team of both Indian and international investigators should be put into the field, with at least two four-wheel-drive vehicles, drivers and guides at their disposal. Since no adequate maps exist, a major part of the work will involve interpreting aerial photographs of the region (if not actually flying over it themselves), to define which sites comprise ungrazed, open mature grassland. Each of these sites will then be visited with a sufficient number of people to ensure proper coverage to determine the presence or absence, and abundance/density of Likhs. These data will then be plotted to give an accurate distribution and density baseline for future reference. Almost as important, however, access routes, local contacts and administrative procedures will be established. Time required: 1 fieldwork season (15 weeks of monsoon).

Phase II: One or possibly two postgraduate students, perhaps registered for Ph.D(s) will be engaged to conduct in-depth ecological and behavioural research based on the

findings of Phase I. An important component of this work will be the development of a marking system for individual birds (e.g. colour rings, wing tags, dyes, radio-transmitters, or some combination), which expertise will be utilized in Phase III. The outcome of these studies will be accurate information on the minimum habitat tolerances of the Likh (for both males and females) derived from data on their diet, breeding behaviour and response to disturbance, plus preliminary estimate of sex ratio, nesting and fledging success. Of course, the conclusions of Phase I will be further extended and modified by this work.
Time required: 3 fieldwork seasons.

Phase III: By the time Phase I and II have been concluded, considerable information should have been collected on the presence of Likhs elsewhere in India. The aim of this Phase is to check on these, as well as pinpoint other sites, plotting their distribution and examining their conservation requirements. Probably one person with seasonal assistance would suffice.
Time required: 1 year.

Phase IV: A further postgraduate study will be commissioned to undertake a wide-ranging ~~ringing~~ marking of the known Likh population, to discover their migration routes, and determine population dynamics. This Phase should supply the final data required for the formulation of a realistically comprehensive conservation plan. Time required: 3 years.

Phase II: A constant monitoring of the Likh will be required to ensure that the objectives of the conservation plan are effective.

Each Phase will require considerable co-operation with, and assistance from, interested parties, particularly the Government of India (Forests and Wildlife), the Government of Gujarat (Chief Wildlife Warden), the Indian Bustard Group, universities, the Zoological and Botanical Surveys of India, and various individuals. These will assume a special significance for the monitoring in Phase II.

From each phase an interim conservation plan will be prepared, based on the latest information available, culminating in the comprehensive conservation plan.

Separate proposals will be made for each phase as the programme proceeds, since each must be prepared within the constraints of the results obtained, as well as personnel availability and financial resources.

Phase I Proposed

(A) Investigators (International)

Paul D. Goriup (Project coordinator): 1973-76 B.Sc. (Hons) Botany & Zoology, Reading U.K.; 1976-77 Diploma of Conservation and M.Sc. in Conservation Studies, University College London, U.K.; 1977-79 Vegetation mapping and reserve

management plan preparation for Nature Conservancy Council, Dept. Environment, U.K.; 1979 - present Secretary ICBP Bustard Group with survey experience in Canary Islands, Portugal, Turkey, Pakistan and India.

Kate Fitzherbert : 1975-79 B.Sc. (Hons) Zoology Monash, Australia (Hons. Thesis "observations on breeding and display in a colony of captive Australian Bustards, Ardeotis australis"); 1979 to present conducting Ph.D. research on breeding biology of Short-tailed Shearwater Puffinus tenuirostris, and course tutor for M.Sc. in Environmental Science, Monash.

David Baker-Gabb : 1972-74 B. Agric, Massey N.Z.; 1975 Dip. Sc., Massey; 1976-78 M.Sc. (Dist.) Massey : Aspects of the biology of the Australasian Harrier Circus aeruginosus approximans; 1979 Technician with Crop Research Division, DSIR, N.Z.; 1980 to present Ph.D. research into Australasian raptor behaviour; Member of ICBP Birds of Prey Group; Member Royal Australasian Ornithologists Union Conservation Committee; President Australasian Raptor Association.

One other participant with a geographic/cartographic background is to be selected.

N.B. Kate Fitzherbert and David Baker-Gabb are affianced and will have married by the time the expedition begins.

Investigators (Indian).

Dr. A. Rhamani : Principal Investigator of the Great Indian Bustard for the Endangered Species Project of the Bombay Natural History Society / Government of India.

Dharmakumarsinhji : Indian member of the ICBP Bustard Group; Author of prizewinning "Birds of Saurashtra".

Harsh Vardhan : General Secretary of the Tourism and Wildlife Society of India, which organised the International Symposium on Bustards (Jaipur, Nov. 1980) and editor of the proceedings; enthusiastic campaigner for bustards.

Others may also come forward.

(b) Timetable and Methods.

The Lekk display and breeding season in Kathiawar lasts for at least 15 weeks, from about mid-June to late September. It is proposed that ground preparations should begin at least two weeks earlier (i.e. June 1) and that the most profitable period (i.e. to mid-September) be utilised. Thus, the survey will run from June 1 to September 15 1982. However, owing to other commitments, not all of the participants can attend

for the full period, so a relay schedule has been devised, at least for the International participants, as follows:

Paul Goriup	June 1	to	September 17	15 weeks
other member	June 22	to	September 17	12 weeks
Kate Fitzherbert	June 22	to	August 27	9 weeks
David Baker-Gabb	August 3	to	September 17	7 weeks

Thus, the international participants will contribute 42 man-weeks to the field survey.

The effort will be directed mainly at discovering, visiting and assessing grassland sites for Likh. This will be done by studying aerial photographs and drawing maps. It is possible that the Sir Peter Scott Trust may be able to provide a light aircraft to facilitate this operation. Sites will be visited during the early morning or late afternoon, scanning for jumping males. At those sites where males are located, they will be counted, and a search for females undertaken.

(c) Budget.

The Sir Peter Scott Trust of Jamnagar has generously offered to accomodate the survey team, and to provide some transport. However, for some of the more distant sites, Government of Gujarat help will be sought.

Thus, the major appeal is for the international airline tickets for the foreign members, viz:

	U.S. $.*
Paul Goriup	1650
Kate Fitzherbert	2125
David Baker-Gabb	2125
One other	1650
	7550

* At 1981 rates, approx

+ an amount for the purchase of radio handsets to co-ordinate fieldwork

HABITAT, CENSUS, DISTRIBUTION AND THREATS WORKING GROUP

The working group focussed on the following issues:

1) What are the populations that we would consider?

2) What are the present census figures for each of these populations?

3) What is the estimated carrying capacity of each of these populations for the areas that they are located in?

4) The major catastrophes and their effect on the population i.e. the mortality caused by these catastrophes

5) The major threats and the mortality caused by these threats

6) Feasible management plans and strategies to maintain a stable/viable population in the present areas of distribution.

Estimates and figures were arrived at after consulting secondary literature and notes from the field managers and biologists.

MANAGEMENT SUGGESTIONS AND STRATEGIES

Management problems and feasible strategies for each of the populations was discussed. A general agreement for the necessary action for the populations was arrived at

UTTAR PRADESH

- Sathiana population has its breeding grounds outside the National park on private land (in Gola and Gajrala). The Sathiana population uses these breeding grounds for about five to six months every year. These breeding grounds cannot be physically duplicated inside the park. Land acquisition is near impossible as the area has been politically oversensitised. Protection to the Barasingha in Sathiana must not eclipse the management issues dogging other endangered species in the area viz. the Bengal Florican and the Hispid Hare. Management measures that were suggested for this population are as follows

  - Creation of "chowkis" (patrol areas) during the crucial 5-6 months so as to mitigate the problem of poaching. The added patrolling will give only a better chance for the survival of the population and will not be a solution to all the threats to the population.

  - If the population Sathiana population drops to numbers of 75 and below, it would have to be relocated to other areas within the protected area (not to a zoo).

  - There is the need to renovate the road connecting Bumnagar Chauraha, Sumer Nagar, Kema Gowdi and Gauri Phanta.

  - Other populations in Pilibhit and Katernighat need to be built up.

TABLE I : Census estimates & carrying capacity figures of the various populations of the Barasingha

NAME OF POPULATION	PRESENT POPULATION ESTIMATES	CARRYING CAPACITY
Sathiana	125	400
Kakraha	500	700
Bankital	125	200
Bhadhi & Nagraha	100	200
Kishanpur	400	600
Katerniaghat	50	1000
Pilibhit	200	400
Hastinapur	25	50
Suklaphanta	1750	1000
Karnali Bardia	50	100
Kanha	400	2000
Manas	50	100
Kaziranga	575	800

Carrying capacity has been estimated as the maximum no. of animals recorded in the area in its history or the best possible no that the area could support, based on the intuition of the field managers and researchers from these areas.

Table II : Factors contributing to mortality and their estimates (in %)

Name of population	Poaching	Flood	Predation
Sathiana	15%	20% (fawn)	10%
Kakraha	2%	1% (fawn)	10%
Bankital	2%	1% (fawn)	10%
Bhadhi & Nagraha	5%	1% (fawn)	10%
Kishanpur	5%	1% (fawn)	10%
Kataniaghat	15%	1% (fawn)	10%
Pilibhit	15%	1% (fawn)	10%
Hastinapur	20%	1% (fawn)	-
Suklaphanta	15%	1% (fawn)	10%
Karnali Bardia	15%	1% (fawn)	10%
Kanha	-	-	10%
Manas	-	-	-
Kaziranga	-	-	-

Catastrophe :

Since documentation of any catastrophe to the Barasingha population and related figures are not availible, the group decided to consider a disease that would wipe out half the numbers of the present populations (i.e mortality caused by the catastrophe would be 50% of the population).

TABLE III : RECRUITMENT FIGURES FOR VARIOUS CLASSES OF BARASINGHA

AREA	MALES:100 FEMALES	FAWNS:100 FEMALES
Satiana	54.8	44.30
Kakraha	54.8	44.30
Bankital	54.8	44.30
Bhadhi & Nagraha	54.8	44.30
Kishanpur	54.8	44.30
Katernighat	54.8	44.30
Pilibhit	54.8	44.30
Suklaphanta	45.71	46
Karnali Bardia	45.71	46
Hastinapur	-	
Kanha	59.45	36.29
Manas	-	-
Kaziranga	47.05	30

VARIABLES IN SYSTAT RECT FILE ARE:
SA SAO SUA SUB SUO

PAIRED SAMPLES T-TEST ON SA VS SAO WITH 6 CASES

MEAN DIFFERENCE = 178.908
SD DIFFERENCE = 675.025
T = .649 DF = 5 PROB = .545

PAIRED SAMPLES T-TEST ON SA VS SUA WITH 5 CASES

MEAN DIFFERENCE = -1142.204
SD DIFFERENCE = 1148.232
T = -2.224 DF = 4 PROB = .090

PAIRED SAMPLES T-TEST ON SAO VS SUA WITH 5 CASES

MEAN DIFFERENCE = -1463.244
SD DIFFERENCE = 633.205
T = -5.167 DF = 4 PROB = .007

PAIRED SAMPLES T-TEST ON SA VS SUB WITH 5 CASES

MEAN DIFFERENCE = 406.726
SD DIFFERENCE = 1135.102
T = .801 DF = 4 PROB = .468

PAIRED SAMPLES T-TEST ON SAO VS SUB WITH 5 CASES
MEAN DIFFERENCE = 85.687
SD DIFFERENCE = 545.533
T = .351 DF = 4 PROB = .743

PAIRED SAMPLES T-TEST ON SUA VS SUB WITH 5 CASES

MEAN DIFFERENCE = 1548.930
SD DIFFERENCE = 797.585
T = 4.343 DF = 4 PROB = .012

PAIRED SAMPLES T-TEST ON SA VS SUO WITH 5 CASES

MEAN DIFFERENCE = 585.874
SD DIFFERENCE = 1072.769
T = 1.221 DF = 4 PROB = .289

PAIRED SAMPLES T-TEST ON SAO VS SUO WITH 5 CASES

MEAN DIFFERENCE = 264.834
SD DIFFERENCE = 440.436
T = 1.345 DF = 4 PROB = .250

PAIRED SAMPLES T-TEST ON SUA VS SUO WITH 5 CASES

MEAN DIFFERENCE = 1728.078
SD DIFFERENCE = 549.809
T = 7.028 DF = 4 PROB = .002

SUDASARI A

SPECIES	COUNT	PDIST(M)	PDIST(KM)TOT	TOT/4	DENSITY
BBS	2	32.5	0.0325	1	0.25 1.923076
BCFL	74	22.29729	0.022297	67	16.75 187.8030
BHB	7	21.42857	0.021428	13	3.25 37.91666
BS	1	30	0.03	1	0.25 2.083333
BT	1	25	0.025	1	0.25 2.5
CB	20	23.5	0.0235	26	6.5 69.14893
D	1	10	0.01	1	0.25 6.25
GIB	2	250	0.25	1	0.25 0.25
GP	1	150	0.15	2	0.5 0.833333
H	1	10	0.01	1	0.25 6.25
HC	1	80	0.08	1	0.25 0.78125
IS	3	116.6666	0.116666	55	13.75 29.46428
KR	5	28	0.028	4	1 8.928571
LGB	1	15	0.015	1	0.25 4.166666
LGS	4	33.75	0.03375	2	0.5 3.703703
LSTL	3	4	0.004	8	2 125
LW	1	25	0.025	1	0.25 2.5
MH	1	75	0.075	1	0.25 0.833333
PBC	2	7.5	0.0075	1	0.25 8.333333
PW	1	40	0.04	1	0.25 1.5625
PWW	9	22.44444	0.022444	6	1.5 16.70792
RBS	4	25	0.025	3	0.75 7.5
RC	19	11.73684	0.011736	14	3.5 74.55156
RD	30	12.14285	0.012142	24	6 123.5294
RP	44	17.375	0.017375	416	104 1496.402
TE	1	250	0.25	1	0.25 0.25
UB	12	16.16666	0.016166	12	3 46.39175
WCB	3	13.33333	0.013333	2	0.5 9.375
WTM	14	9	0.009	57	14.25 395.8333
YTS	4	26.25	0.02625	5	1.25 11.90476

SUDASARI B

SPECIES	COUNT	PDIST(M)	PDIST(KM)SUM		SUM/4	DENSITY
BCB	1	75	0.075	1	0.25	1.111111
BCFL	27	33.81481	0.033814	21	5.25	51.75246
BHB	1	1	0.001	11	2.75	916.6666
CB	13	51.15384	0.051153	18	4.5	29.32330
CCC	2	25	0.025	5	1.25	16.66666
GB	1	75	0.075	1	0.25	1.111111
GIB	3	50.66666	0.050666	4	1	6.578947
GQ	1	1	0.001	1	0.25	83.33333
HC	2	62.5	0.0625	2	0.5	2.666666
IS	1	1	0.001	2	0.5	166.6666
IW	2	20	0.02	2	0.5	8.333333
LGS	9	56.66666	0.056666	5	1.25	7.352941
LSTL	5	21.4	0.0214	56	14	218.0685
MH	1	50	0.05	1	0.25	1.666666
PW	6	33.33333	0.033333	3	0.75	7.5
RC	3	31.66666	0.031666	1	0.25	2.631578
RD	19	54.47368	0.054473	21	5.25	32.12560
RP	20	39.4	0.0394	126	31.5	266.4974
RVB	1	75	0.075	1	0.25	1.111111
TE	4	143.75	0.14375	1	0.25	0.579710
UB	4	9.25	0.00925	11	2.75	99.09909
WCB	2	45	0.045	2	0.5	3.703703
WTM	2	10	0.01	3	0.75	25
YTS	5	36	0.036	3	0.75	6.944444

S4M-A

SPECIES	COUNT	PDIS(M)	PDIS(KM)	TOT	TOT/5	DENISTY
BCB	2	137.5	0.1375	1	0.2	0.559440
BCFL	73	24.94520	0.024945	49	9.8	151.1004
BRP	1	10	0.01	1	0.2	7.692307
CB	14	38.28571	0.038285	19	3.8	38.17451
CWS	1	5	0.005	1	0.2	15.38461
GCB	1	150	0.15	1	0.2	0.512820
GIB	1	5	0.005	1	0.2	15.38461
HS	1	5	0.005	1	0.2	15.38461
IS	10	61.7	0.0617	15	3	18.70091
IW	1	15	0.015	1	0.2	5.128205
LGS	4	77.5	0.0775	3	0.6	2.977667
LSTL	1	1	0.001	12	2.4	923.0769
LW	1	5	0.005	2	0.4	30.76923
PS	1	15	0.015	1	0.2	5.128205
PW	1	25	0.025	1	0.2	3.076923
RC	5	14	0.014	3	0.6	16.48351
RD	7	33.85714	0.033857	3	0.6	6.815968
RP	6	70.33333	0.070333	96	19.2	104.9945
RVB	3	96.66666	0.096666	4	0.8	3.183023
UB	4	30.5	0.0305	3	0.6	7.566204
WBV	1	200	0.2	3	0.6	1.153846
WCB	4	93.75	0.09375	4	0.8	3.282051
WTM	2	3	0.003	3	0.6	76.92307
YTS	1	1	0.001	1	0.2	76.92307

SHD - OUTSIDE

SPECIES	COUNT	TOT	TOT/4	PDIST(M)	PDIST(KM)	DENSITY
BCFL	22	27	6.75	30.72727	0.030727	78.45519
BHB	1	6	1.5	125	0.125	4.285714
CB	5	4	1	37.2	0.0372	9.600614
CL	1	1	0.25	5	0.005	17.85714
DW	2	2	0.5	25	0.025	7.142857
IS	2	6	1.5	75.5	0.0755	7.095553
IW	7	9	2.25	7.428571	0.007428	108.1730
KR	1	1	0.25	5	0.005	17.85714
LGS	6	3	0.75	49.16666	0.049166	5.447941
LSTL	4	9	2.25	9.25	0.00925	86.87258
LW	2	1	0.25	15	0.015	5.952380
MH	1	1	0.25	150	0.15	0.595238
PW	4	1	0.25	23.75	0.02375	3.759398
RC	8	3	0.75	22.75	0.02275	11.77394
RD	9	10	2.5	22.88888	0.022888	39.00832
RP	7	27	6.75	67.14285	0.067142	35.90425
UB	6	7	1.75	10.16666	0.010166	61.47540
WEB	1	1	0.25	25	0.025	3.571428
YTS	2	1	0.25	35	0.035	2.551020

AVIAN RICHNESS, DIVERSITY AND EQUITABILITY INDICES COMPUTED USING DIFFERENT FORMULAS FROM 5 LOCATIONS IN THE DESERT NATIONAL PARK

LOCATION	N0	R1	R2	LAMBDA	H'	N1	N2	E1	E2	E3	E4	E5
SUDASARI UP	19	4.450	2.514	0.154	2.229	9.292	6.492	0.757	0.489	0.461	0.699	0.662
SUDASARI B	24	4.770	2.154	0.248	1.927	6.867	4.034	0.606	0.286	0.255	0.587	0.517
SUDASARI A	28	4.897	1.778	0.474	1.388	4.009	2.110	0.417	0.143	0.111	0.526	0.369
SAM A	23	4.939	2.480	0.301	1.721	5.593	3.324	0.549	0.243	0.209	0.594	0.506
SAM UP	22	5.250	2.977	0.108	2.383	10.837	9.294	0.771	0.493	0.468	0.858	0.843

R1 = Margalef index (1958). R1 = S-1/LN(n)
R1 = Menhinick index (1964). R2 = S/√n
(where S = total no. of species, n = total nos. of individuals.

H' = Shanon Weiner's diversity index (1949). H'= E(PiLNPi), i = 1 to s.
(where Pi = Proportion of i^{th} species

LAMBDA = E ni(ni-1)/n(n-1)
(where n = total number of individuals in the sample)

N0, N1, N2 = Hill's diversity indices. (Hill 1973).
N0 = Total number of species
N1 = e^H'
(where H' is the Shannon Weiner's diversity index, e = exponential).
N2 = 1/Lambda

E1, E2, E3, E4 = Equitability (Evenness) indices
E1 (or J') = Pielou's index (1975, 1977). H'/LN(S)
E2 = Sheldon's index. (Sheldon 1969). e^H'/S
E3 = Heip's index. (Hiep 1974). (e^H'-1)/(S-1)
E4 = Hill's evenness index. (Hill 1973). (1/lambda)/(e^H')
E5 = Modified Hill's ratio. (Alatalo 1981). (1/lamda)-1/(e^H'-1).

UNPROTECTED LOCATION 2
OUTSIDE SUDASARI ENCLOSURES

COMMON NAME	SCIENTIFIC NAME	TOTAL SIGHTINGS	PDIS (m)	AVERAGE NUMBERS	DENSITY (km^2)
White-eyed buzzard-eagle	Butastur teesa	1	25.0	0.3	
Montagu's harrier	Circus pygarus	1	150.0	0.3	
Indian sandgrouse	Pterocles exustus	2	75.5	1.5	
Indian ring dove	Streptopelia decaocto	9	22.9	2.5	39.0
European roller	Coracias garrulus	1	5.0	0.3	
black crowned finch-lark	Eremopterix nigriceps	22	30.7	6.8	78.5
Lesser short-toed lark	Calandrella rufescens	4	9.3	2.3	86.9
Crested lark	Galerida cristata	1	5.0	0.3	
Grey shrike	Lanius excubitor	6	49.2	0.8	5.4
Rosy pastor	Sturnus roseus	7	67.1	6.8	35.9
Common babbler	Turdoides caudatus	5	37.2	1.0	9.6
Lesser whitethroat	Sylvia curruca	2	15.0	0.3	
Rufous chat	Erythropygia galactotes	8	22.8	0.8	11.8
Isabelline chat	Oenanthe isabellina	7	7.4	2.3	108.2
Desert wheatear	Oenanthe deserti	2	25.0	0.5	
Pied chat	Oenanthe picata	4	23.8	0.3	3.8
Yellowthroated sparrow	Petronia xanthocollis	2	35.0	0.3	
Blackheaded bunting	Emberiza leucocephalos	1	75.0	1.5	
Unidentified birds		6	10.2	1.8	61.5

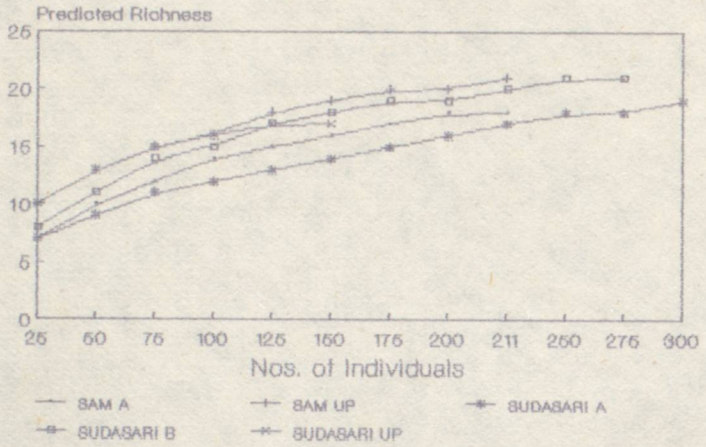
Note before

1) TOTAL SIGHTINGS : These are the sums of the number of times a species was seen on each transect count, a flock being considered one sighting.
2) PDIS (m) : The average of the perpendicular distances from the transect line that each species was seen.
3) AVERAGE NUMBERS : The total number of individuals of a species seen divided by the number of times that particular transect was traversed.
4) DENSITY : From the formula $D = n/(2lw)$, where n is the average number seen, l is the length and w the width of the transect. Values are given only for those species that were sighted a minimum of 4 times during the study.

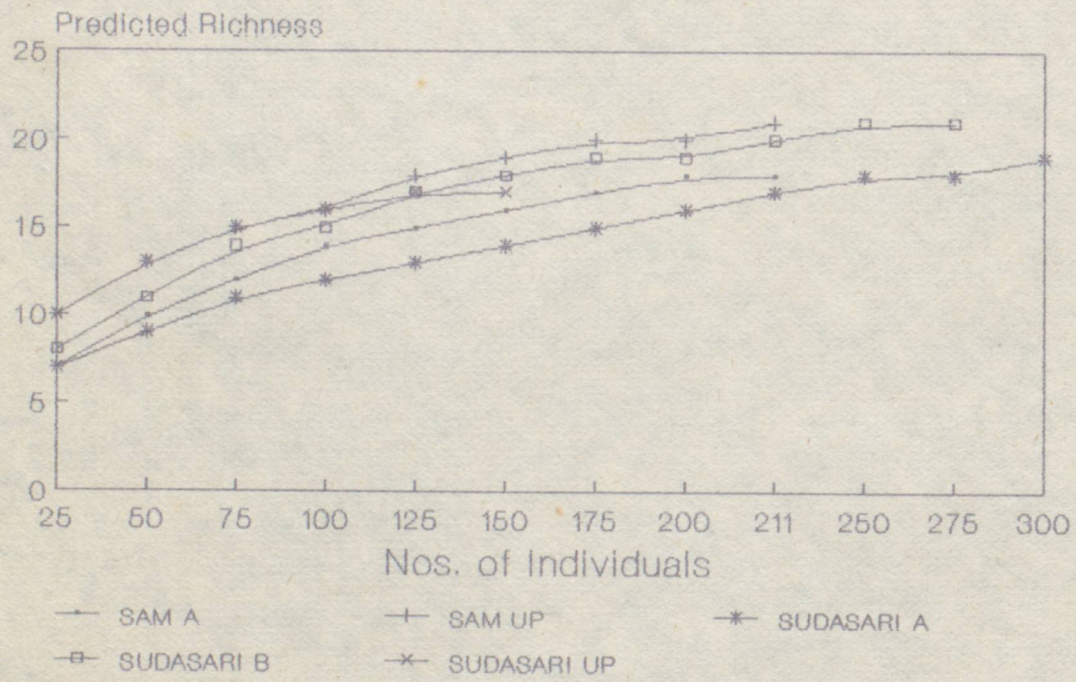
Method of calculating density :

1) The field data was collected using the open width line transect methods.
2) The density of each species was estimated by calculating the optimal width at which they were sighted. This was done by averaging the perpendiclar distances and then discarding records beyond the average distance. The density was then arrived at from the total number of individuals within the average sighting distance, the length of the transect and the width which was the average sighting distance for each species.

COMPARISON OF RICHNESS IN DIFFERENT LOCATIONS BY RARIFRACTION



COMPARISON OF RICHNESS IN DIFFERENT LOCATIONS BY RARIFRACTION



TOTAL AVIAN DENSITIES ON 5 TRANSECTS AT THE DESERT NATIONAL PARK

S.NO	TRANSECT	NOS	ST.TERM	DENSITY	SE D	AVG. NOS	DENSITY
1	saa1	42	8	0.0003640	0.000083	1.5	546.00
2	saa2	33	19	0.0005857	0.001097	1.181818	692.19
3	saa3	34	10	0.0003457	0.000091	7.676470	2653.76
4	saa4	21	6	0.0001749	0.000048	1.809523	316.49
5	saa5	16	9	0.0001856	0.000066	2	371.20
6	sao1	20	5	0.0001949	0.000059	2.2	428.78
7	sao2	22	14	0.0004486	0.001612	2.090909	937.98
8	sao3	30	8	0.0004448	0.000111	2.733333	1215.79
9	sao4	30	3	0.0001497	0.000043	1.333333	199.60
10	sao5	13	6	0.0001752	0.000059	5.153846	902.95
11	sua1	84	9	0.0004576	0.000080	5.523809	2527.69
12	sua2	80	8	0.0005120	0.000075	5.95	3046.40
13	sua3	65	17	0.0008329	0.000919	2.523076	2101.47
14	sua4	43	16	0.0004105	0.000968	2.418604	992.84
15	sub1	32	3	0.0001578	0.000038	2.4375	384.64
16	sub2	44	3	0.0001952	0.000042	5.022727	980.44
17	sub3	29	3	0.0001473	0.000036	2.034482	299.68
18	sub4	30	3	0.0001668	0.000039	4.866666	807.87
19	suo1	19	8	0.0002342	0.000075	1.947368	456.07
20	suo2	26	7	0.0002140	0.000065	4.192307	897.15
21	suo3	23	4	0.0001520	0.000043	1.304347	198.26
22	suo4	23	7	0.0003187	0.000084	2.434782	204.52

saa=Sam A, sao=Sam Up, sua=Sudasari A, sub=Sudasari B, suo=Sudasari UP (UP=unprotected)

Paired T-test for differences between avian densities on 5 transects in the Desert National Park

	SUDASARI A		SUDASARI B		SAM A		SAM UP	
	t	P	t	P	t	P	t	P
SUD UP	5.444	0.012	1.222	0.309	0.992	0.395	1.010	0.387
SAM UP	-4.027	0.028	0.246	0.822	0.530	0.624		
SAM A	-1.684	0.191	0.663	0.555				
SUD B	3.364	0.044						

COLUMN NO		R1	R2	LAMBDA	H'	N1	N2	E1	E2	E3	E4	E
BAR3KM	25	5.765	3.118	0.097	2.506	12.261	10.340	0.779	0.490	0.469	0.843	
BARMET	21	4.678	2.477	0.074	2.661	14.307	13.554	0.874	0.681	0.665	0.947	
BARSAN	22	4.984	2.676	0.070	2.698	14.848	14.307	0.873	0.675	0.659	0.964	
DESNKR	25	4.122	1.360	0.545	1.128	3.090	1.836	0.351	0.124	0.087	0.594	
DESVN	26	4.223	1.348	0.655	0.958	2.606	1.526	0.294	0.100	0.064	0.586	
GAJ1KM	29	5.257	2.022	0.087	2.721	15.196	11.554	0.808	0.524	0.507	0.760	
HUSAN	37	5.278	1.222	0.137	2.582	13.219	7.300	0.715	0.357	0.339	0.552	
JOR3KM	26	5.582	2.770	0.115	2.421	11.254	8.687	0.743	0.433	0.410	0.772	

PROTECTED ENCLOSURE 2
SUDASARI A

COMMON NAME	SCIENTIFIC NAME	TOTAL SIGHTINGS	PDIS (m)	AVERAGE NUMBERS	DENSITY (km^2)
Tawny eagle	Aquila rapax	1	250.0	0.3	
Montagu's harrier	Circus pygarus	1	75.0	0.3	
Grey partridge	Francolinus pondicerianus	1	150.0	0.5	
Great Indian bustard	Ardeotis nigriceps	2	250.0	0.3	
Indian sandgrouse	Pterocles exustus	3	116.7	13.8	
Indian ring dove	Streptopelia decaocto	30	12.1	6	123.6
Green bee-eater	Merops orientalis	1	15.0	0.3	
European roller	Coracias garrulus	5	28.0	1	8.9
Hoopoe	Upupa epops	1	10.0	0.3	
Black crowned finch-lark	Eremopterix nigriceps	74	22.3	16.8	187.8
Lesser short-toed lark	Calandrella rufescens	3	4.0	2.0	
Grey shrike	Lanius excubitor	4	33.8	0.5	3.7
Baybacked shrike	Lanius vittatus	2	32.5	0.3	
Redbacked shrike	Lanius collurio	4	25.0	0.8	7.5
Brown shrike	Lanius cristatus	1	30.0	0.3	
Black drongo	Dicrurus adsimilis	1	10.0	0.3	
Rosy pastor	Sturnus roseus	44	17.4	104.0	496.4
House crow	Corvus splendens	1	80.0	0.25	
Whitecheeked bulbul	Pycnonotus leucogenys	3	13.3	0.5	
Common babbler	Turdoides caudatus	20	23.5	6.5	69.2
Plain wren-warbler	Prinia subflava	9	22.4	1.5	16.7
Lesser whitethroat	Sylvia curruca	1	25.0	0.3	
Rufous chat	Erythropygia galactotes	19	11.7	3.5	74.6
Bluethroat	Erithacus svecicus	1	25.0	0.3	
Pied bush chat	Saxicola caprata	2	7.5	0.3	
Pied chat	Oenanthe picata	1	40.0	0.3	
Yellowthroated sparrow	Petronia xanthocollis	4	26.3	1.3	11.9
Whitethroated munia	Lonchura malabarica	14	9	14.3	35.8
Blackheaded bunting	Emberiza leucocephalos	7	21.4	3.3	37.9
Unidentified birds		12	16.1	3.0	46.4

PROTECTED ENCLOSURE 3
SUDASARI B

COMMON NAME	SCIENTIFIC NAME	TOTAL SIGHTINGS	PDIS (m)	AVERAGE NUMBERS	DENSITY (km^2)
Tawny eagle	Aquila rapax	4	143.8	0.3	0.6
Montagu's harrier	Circus pygarus	1	50.0	0.3	
Grey quail	Coturnix coturnix	1	1.0	0.3	
Great Indian bustard	Ardeotis nigriceps	3	50.7	1.0	
Creamcoloured courser	Cursorius cursor	2	25.0	1.3	
Indian sandgrouse	Pterocles exustus	1	1.0	0.5	
Indian ring dove	Streptopelia decaocto	19	54.5	5.3	32.1
Bluecheeked bee-eater	Merops superciliosus	1	75.0	0.3	
Green bee-eater	Merops orientalis	1	75.0	0.3	
Black crowned finch-lark	Eremopterix nigriceps	27	33.8	5.4	51.8
Lesser short-toed lark	Calandrella rufescens	5	21.4	14.0	218.1
Grey shrike	Lanius excubitor	9	56.7	1.3	7.4
Rosy pastor	Sturnus roseus	20	39.4	31.5	266.5
House crow	Corvus splendens	2	62.5	0.5	
Whitecheeked bulbul	Pycnonotus leucogenys	2	45.0	0.5	
Redvented bulbul	Pycnonotus cafer	1	75.0	0.3	
Common babbler	Turdoides caudatus	13	51.2	4.5	29.3
Rufous chat	Erythropygia galactotes	3	31.7	0.3	
Isabelline chat	Oenanthe isabellina	2	20.0	0.5	
Pied chat	Oenanthe picata	6	33.3	0.8	7.5
Yellowthroated sparrow	Petronia xanthocollis	5	36.0	0.8	6.9
Whitethroated munia	Lonchura malabarica	2	10.0	0.8	
Blackheaded bunting	Emberiza leucocephalos	1	1.0	2.8	
Unidentified birds		4	9.3	2.8	99.1