STATUS, ECOLOGY, BEHAVIOUR AND CONSERVATION OF HARRIERS IN THE THAR DESERT OF RAJASTHAN, INDIA – A REPORT

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Content Page

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Front Cover Photo: A male of Pallid Harrier (Circus macrourus) in flight – a globally Near-threatened species.

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I dedicate this report to my dear father Late Shri Shyam Lal and my mother Rammo devi who are real source of inspiration to me for taking up such field research and they are always with me to support and encourage.

Chapter 1

INTRODUCTION

Raptors or Birds of Prey are one of the least studied groups of birds (Newton 1979). Harriers – the migratory raptors to India are the only diurnal group of raptors nesting and roosting on the ground (Cramp and Simmons 1980, Simmons 2000). No other group of raptors has so superbly adapted their lifestyles in open habitats like grasslands and wetlands. Therefore, they are reliable indicator of the health of the plains including grasslands and wetlands (Verma, 2007). Of sixteen species of harriers occurring in the world, six are known to occur in India representing greatest diversity of harriers post breeding in the world (Simmons, 2000). Of six species of harriers in India, four i.e. Eurasian Marsh Harrier *Circus aeruginosus*, Montagu's Harrier *C. pygargus*, Hen Harrier *C. cyaneus* and Pallid Harrier *C. macrourus* have been recorded in the Thar Desert of Rajasthan (Sharma, 1988, Personal observation). Of these, the Pallid Harrier is classified as 'Near Threatened' at global level (BirdLife International 2003).

They are palearctic migrants to the country (Ali and Ripley 1983). Recently, a satellite telemetry study was conducted on the Pallid Harrier in the Velavadar Black Buck National Park in Gujarat (India) which confirmed this and recorded their origin in Kazakhstan (personal observation, Natural Research Limited, UK, 2008).

Knowledge concerning non-breeding period of the life cycle is central to an understanding of migrant biology and conservation (Rappole 1995). Any information on their distribution, abundance and ecology is urgently required to plan conservation measures. The grasslands are one of the most threatened ecosystems found in India (The Biological Diversity Act, 2002). It becomes more important to investigate ecological requirements of harriers, which roost communally in grasslands and are more prone to threats like conversion of grasslands into agricultural lands, grazing, grass cutting and plantations. Harriers are mainly known to roost in grasslands in their wintering ground in

India (Rahmani 1986, Clarke 1996, Verma 2002, 2002a, 2007). Numbers (up to over 2000 individuals at Velavadar Blackbuck National Park, Gujarat) and distance travelled (20-40 km) up to roost site are evidences about how important such sites are for harrier survival (Verma 2002, Verma and Prakash 2007). Roosts can be an important source of collecting information on population status of harriers (International Action Plan for the Pallid harrier 2003), because consistent and repeatable roost counts may allow monitoring population trends.

The Thar Desert holds vast extent of grasslands however no attempts so far have been made locating harrier roost sites and studying their ecological requirements in the region. Very little information is available on the status, ecology and behaviour of harriers from the Thar Desert. Except Tal Chhapar no communal roost sites are known form vast stretches of grasslands of Thar Desert. The present study aims to provide information on the status of harriers in Thar Desert, communal roost sites, stopovers, and behaviour.

Chapter 2

STUDY AREA

The state of Rajasthan with an area of 3, 42,274 km^2 constitutes the largest state of India. It extends between 23°3' N and 30°12' N latitudes, and 69°30' E and 78°17' E longitudes. The Aravali range, running from Sirohi in the southwest to Khetari in northeast bisects the state into two unequal parts. The northwestern region constitutes the major part of the Indian desert while the southeastern region is a combination of semiarid and fertile regions. In the northwestern region the average annual rainfall ranges from 20 to 40 cm. Low and irregular rainfall is responsible for a general dearth of vegetation. Vegetation is xerophytic and thorny bushes type **(Plate 1.)**. Dry violent winds, strong dust storms, wide diurnal and seasonal variations in temperature, paucity of food and usable water are the common features of the area.

The potential roost habitats of harriers were surveyed in the Thar Desert in Jaisalmer, Jodhpur, Badmer, Bikaner (December 2008 and January 2009) and detail study on the roost ecology was made at the Tal Chhapar Wildlife Sanctuary (Tal Chhapar WLS), Churu during 2008 –2009 **(Plate 2)**.

Plate 1. *A typical landscape of Thar Desert (Rajasthan) with xerophytic and thorny vegetation.*

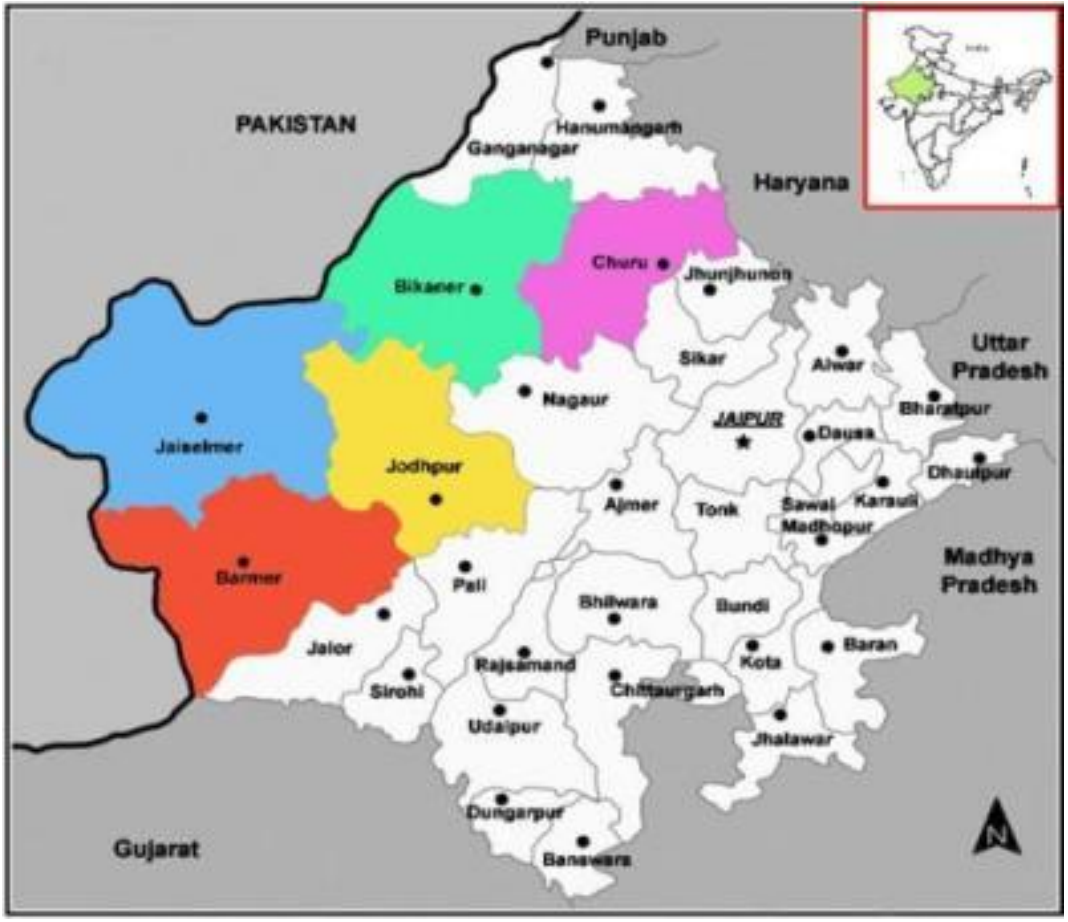


Plate 2. *Map showing Study Area i.e. Barmer, Jaiselmer, Jodhpur, Bikaner and Churu.*

A detailed study on the roost population dynamics was conducted in the Tal Chhapar WLS during 2008 – 2009 **(Plate 3)**. Tal Chhapar WLS is located in the tropical arid zone of the Great Indian Thar Desert (27º 47' N and 74º 25 E, msl 326m). It is located 215 km from Jaipur and 12 km away from Sujangarh in Churu district in northwestern Rajasthan, India and is on the extreme fringe of the Thar Desert.

The 7.19 Km^2 area of the sanctuary comprises largely of grassland (about 70%) (*Aristida* spp., *Cenchrus ciliaris, C. setigerus, Lasiurus sindicus, Chloris virgata, Brachiaria ramosa, Cynodon dactylon, Dactyloctenium aegyptium, Desmostachya bipinnata, Dichanthium annulatum, Digitaria pennata, Eleusine compressa, Eragrostis ciliaris, Sporobolus coromandelianus*) with scattered trees (mainly *Prosopis cineraria, Acacia nilotica, Salvadora persica*), bushes (*Capparis decidua, Zizyphus nummularia, Calotropis procera*), halophytes (mainly *Sueda fructicosa*) and sedges (mainly *Cyperus rotundus*).

The dominant fauna in the sanctuary included Blackbuck *Antilope cervicapra*, an antelope, Indian Fox *Vulpes bengalensis*, Desert Fox *Vulpes vulpes pusilla*, Demoiselle crane *Grus virgo*, and Harriers. The Spiny-tailed Lizard *Uromastyx Hardwickii* is the most abundant reptile. The sanctuary experiences dry climate. The rainy season (July-September) is characterized by very low precipitation (c 300 mm). The summer (March-June) is very hot with dry violent winds and strong dust storms and maximum temperature reaches 48 º C. The winter (October-February) is severe with temperature as low as 0.5 º C in January.

Chapter 3

METHODOLOGY

Road transect method was followed to collect information on harrier species composition and relative abundance. During Road Transect Survey, attempts were also made to locate communal roost sites of harriers. About half an hour prior to sunset, the area was scanned from vantage points for roosting harriers. The GPS position was noted of the area where harrier or roost was found. The survey was conducted in December 2009 and January 2010.

Harrier Survey using camel

A transect of about 250 km passing through the Desert National Park (Jaiselmer and Badmer) was surveyed for harriers on both camel alone and camel cart **(Plate 4)**. The transect route comprised Jaiselmer – Phulia (85 km), Phulia – Miyajlar (15 km), Miyajlar – Bandhera (30km), Bandhera – Girab (20km), Girab – Bhu ka par (10km), Girab – Harsani (18km), Khuri – Phulia (38km), Khuri – Sudasari (20km) and Sudasari – Sam (15km). The survey was conducted in fine weather between 007 – 1200 and 1500 – 1800.

Harrier Survey using vehicle

Of total 700 km transect covered using fourwheel vehicle, about 300 km transect was covered in Jaiselmer; Jaiselmr – Mokla Centre (50km), Mokla – Sultana (40 km), Sultana – Ramgarh (45 km) (Indira Gandhi Canal, Ramgarh), Ramgarh – Mohangarh via Asutar road, Tanot (180 km), about 100 km in Jodhpur; Kheenchan and Bap grassland and 100 km in Bikaner; Jodbeed and Gajner Wildlife Sanctuary were surveyed. The speed of the vehicle was kept at 30 km/hr during the survey **(Plate 5)**.

Plate 4. *The camel and camel with cart were also used to survey the desert areas for locating harriers and their roosts.*

Plate 5. *Four wheelvehicle was also used for harrier survey in the desert.*

Roost study

Data on the species composition, population dynamics, roosting behavior and diet was collected from the communal roost located at the Tal Chhapar WLS, Churu **(Plate 3)**. Harrier populations can be estimated from counts at communal roosts (Weller et al. 1955, Bildstein 1979). Roost counts were made from vantage points in the evenings about 2 hours of sunset and till all harriers had roosted. Harriers arriving at roost were counted in flight. Other information collected included sex and age, habitat types, roost associates, potential predators and other anthropogenic threats. Pellets were collected from the roost in the morning after harriers had left. The post roost observations were taken half an hour of sunrise upto half an hour after sunrise when generally all roosting harriers had left for their foraging grounds. The roost site was searched for pellets thoroughly.

Plate 3. *The Blackbuck are the dominant faunal species at Tal Chhapar WLS, Churu.*

Chapter 4

RESULTS

1. Harrier abundance

Two individuals, one each of Hen Harrier and Eurasian Marsh Harrier was observed foraging in the evening (1635 – 1715 hrs) during the Road Transect Survey along Indira Gandhi Canal in Jaiselmer. An adult male of Hen Harrier was foraging in the harvested agricultural land surrounded by *Prosopis juliflora*, barren land, *Capparis decidua*, Sewan grass clumps, and *Prosopis spicigera* (27°21'55.2 N and 70°50'40.7 E, MSL 162 m). Further, about 5 km ahead an immature male of Eurasian Marsh Harrier was recorded. It was also foraging over mustard fields and along the canal and was also observed stooping over Green Sandpiper *Tringa ochropus* (27°23'24.2 N and 70°51'50.0 E, MSL 146 m) **(Plate 6)**. It also flew in the same direction in which the Hen harrier moved towards Nehdei village.

Plate 6. *An immature Eurasian Marsh Harrier was recorded foraging along the tributary of IG Canal near Sultana.*

2. Communal Roost Location

A communal roost comprising two individuals of Pallid Harrier (both males) was located in the grasslands of Sudasari in Desert National Park, Jaiselmer (Enclosure – A) (26º43'54.6 N and 70º37'39.2 E, MSL 227 m) (Plate 6). The roost was located by following one of the Pallid Harrier individuals continuously for four days. They arrived after sunset from outside the park boundary. Before roosting, they spent time pre-roosting **(Plate 7)**. They perched on stump and spent time on preening and resting. Before settling finally they took around quarter to half an hour scanning their roost. It became quite dark when they finally settled for roosting. The roost habitat was an open area having clumped grass patches dotted with bushes (*Capparis decidua*) and thorny trees (mainly *Prosopis spicigera*).

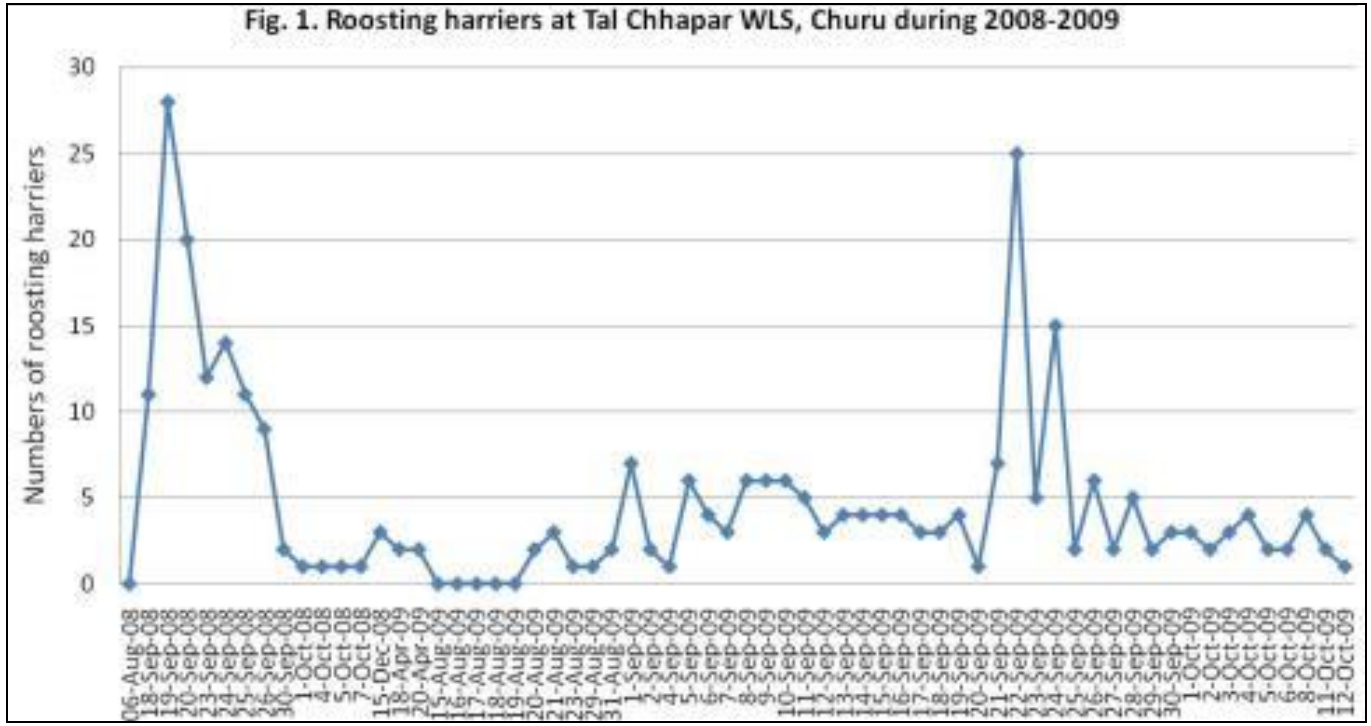
Plate 7. *The Pallid Harrier male perched on a stump near its roost in Sudasari – a pre-roost site.*

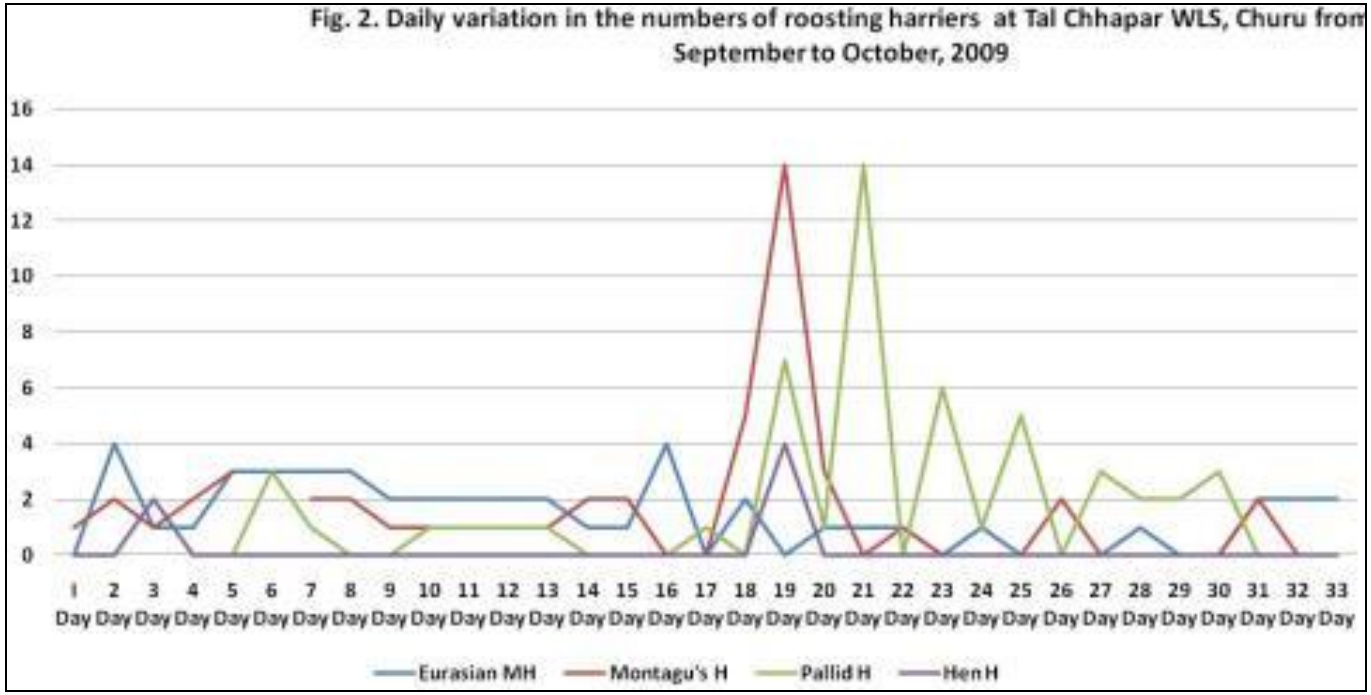
There were potential harrier roost habitats at Mokla Centre (26°59'29.7 N and 70°51'01.8 E, MSL 184 m) and grasslands on the way to Sultana, Ramgarh, and Chandan CAZRI Centre (26°59'48.6 N and 71°20'00.6 E, MSL 196 m) in Jaiselmer, Bap grasslands near Kheechan at Phalodi in Jodhpur (27°22'20.9 N and 72°21'19.0 E, MSL 210 m), and Gajner Wildlife Sanctuary (27°56'42.7 N and 73°03'05.8 E, MSL 213 m) in Bikaner however no harrier roost sites were found at any of these sites during the survey conducted in January 2010.

3. Movement pattern of harriers at Tal Chhapar WLS

The Harriers generally arrived in the Tal Chhapar WLS by August and their numbers increased in the month of September reaching a peak by third week of the same month and thereafter numbers decrease sharply in October. During 2008 and 2009, the maximum numbers of roosting harriers was recorded to be 28 and 25 individuals respectively **(Fig. 1)**. A small roosting population of about 2-3 individuals used the sanctuary after October till April. This was probably the wintering population which used to forage in and around the sanctuary and also roosted interchangeably both inside and outside the sanctuary. They mostly arrived from west direction (over Chadwas village) and were observed leaving towards Dewani and also to Gopalpura in south east and south west direction. A frequent change in the roost composition and structure confirmed that the sanctuary was being used as a staging ground by migratory harriers **(Fig. 2)**. The harriers used the sanctuary as a stopover mostly for spending nights and moved further up the next day by early morning much before sunrise. It happened most of the times that large numbers of harriers counted in the previous evening were found absent from the roost when counted the following morning. The individual roost sites were searched for pellets intensively however we got very little success in finding pellets. Fifteen pellets were collected from the communal roost of harriers at Tal Chhapar WLS in six days search for 18 hours in September, 2008. The encounter rate was 0.8 pellets/hour. These pellets were collected out of 96 harriers which were observed roosting in the six evenings

however the numbers reduced to 21 in the mornings – the post roosts. There was a 98% decline in the numbers of harriers when recounted at post roost in the mornings.





The data taken for thirty three consecutive days on roosting harriers from 4th September to 6th October, 2009 indicated a marked change in both species composition and their numbers. The population of Eurasian Marsh Harrier fluctuated between 0 – 4 individuals, Montagu's Harrier between 0 – 14, Pallid Harrier between 0 – 14 and Hen Harrier between 0 – 4 **(Fig. 2)**.

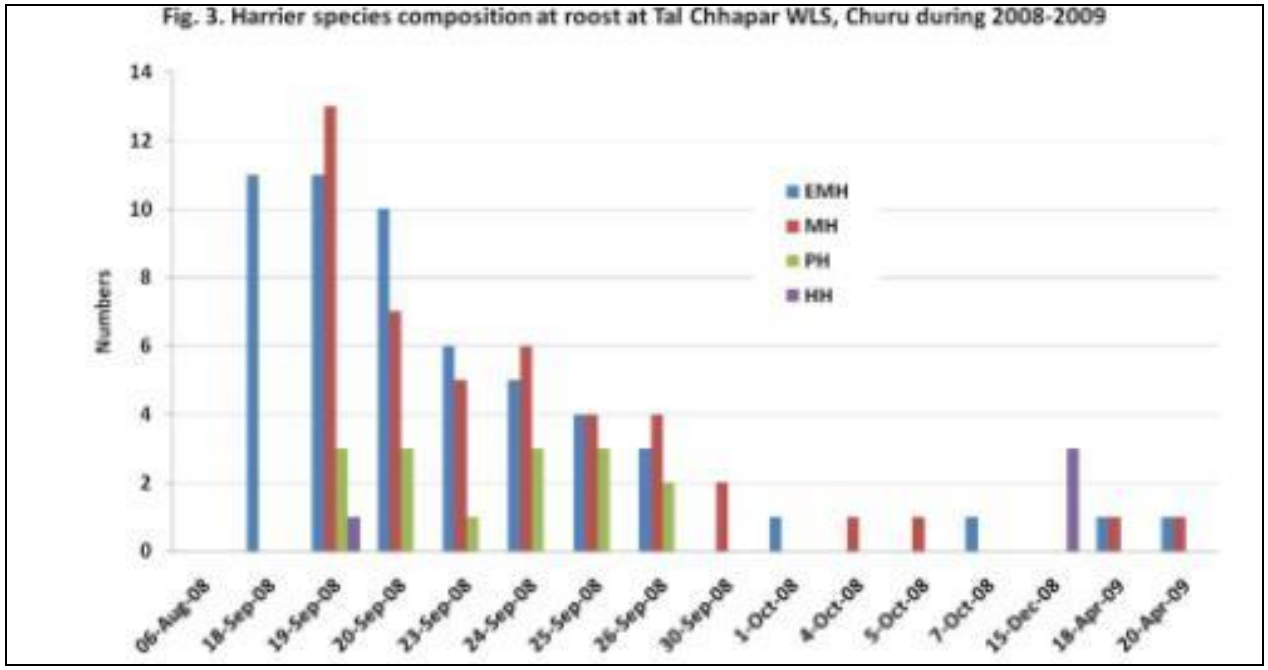
4. Species composition

Four species of harriers i.e. Eurasian Marsh Harrier (EMH), Montagu's Harrier (MH), Pallid Harrier (PH) and Hen Harrier (HH) were observed roosting at Tal Chhapar WLS during the winter of 2008. Of total 118 sightings, the Eurasian Marsh Harrier accounted for 46%, Montagu's Harrier 38%, Pallid Harrier 13% and Hen Harrier 3%. Similarly, four species of harriers were observed roosting in the

sanctuary during the winter of 2009 however there was a drop in EMH and an increase in Pallid Harriers. Of total 180 sightings, the Eurasian Marsh Harrier accounted for 28%, Montagu's Harrier 37%, Pallid Harrier 32% and Hen Harrier 4%.

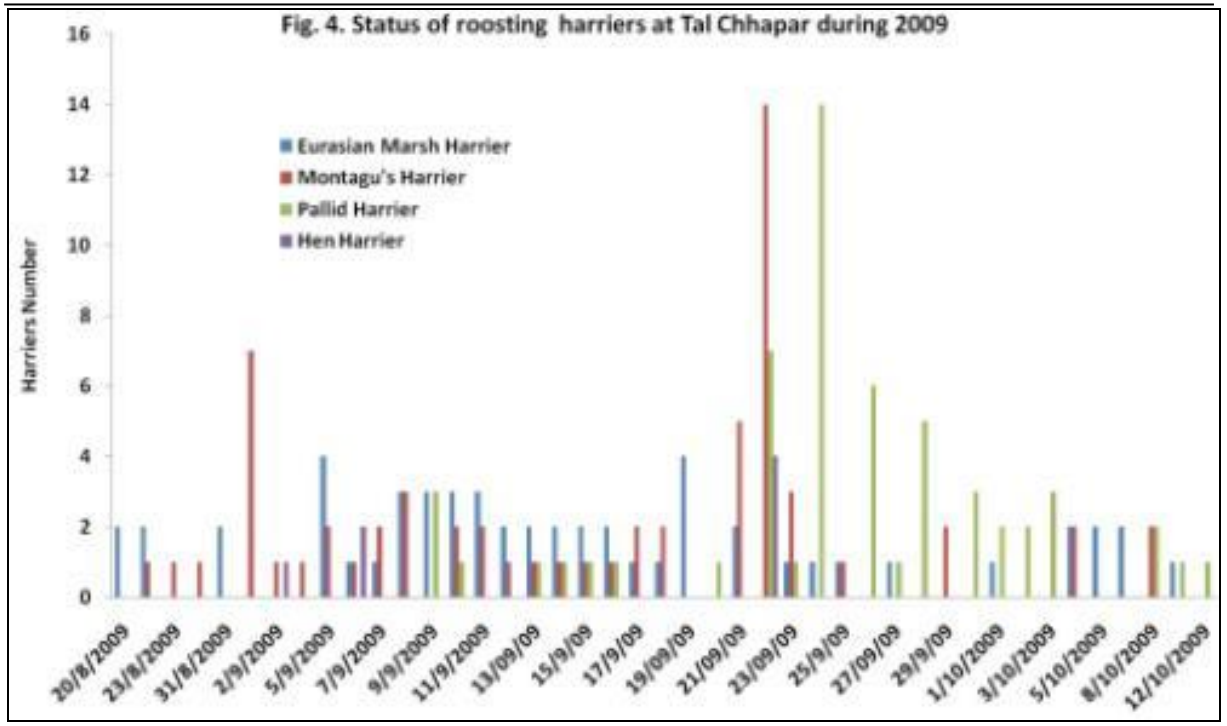
5. Population fluctuation in the year 2008

The Eurasian Marsh Harrier was not sighted in early August. A maximum population of 11 individuals was recorded in the month of September and the population declined by the end September itself. About 1-2 individuals roosted in the sanctuary from October to April. The Montagu's Harrier also showed the similar trend as Eurasian Marsh Harrier. The Pallid Harrier was present in September only. The Hen Harrier was sighted in September and then later appeared in December **(Fig.3)**.



6. Population fluctuation of harriers in the year 2009

The Eurasian Marsh Harrier was sighted in all the months from August to October. The 4 individuals formed the highest population in September. From one individual in August the population of Montagu's Harrier increased suddenly to 7 individuals in the first week of September and for the whole next week it fluctuated between 1-2 individuals. A sharp increase was again noted in the third week with 14 harriers however it again declined sharply the next day and thereafter the population was found very low fluctuating between 1-2 individuals till October. The Pallid Harrier arrived in the sanctuary by second week of September and the population kept fluctuating between 1-2 individuals and the population suddenly increased to 14 by third week and a gradual decline was followed thereafter till the end of the month. In October, the population of Pallid Harrier remained low between 1-3 individuals. The Hen Harrier arrived in the sanctuary by first week of September. The population reached a peak in the third week when 4 individuals were recorded and thereafter no Hen Harrier could be observed at the roost in the sanctuary **(Fig. 4)**.



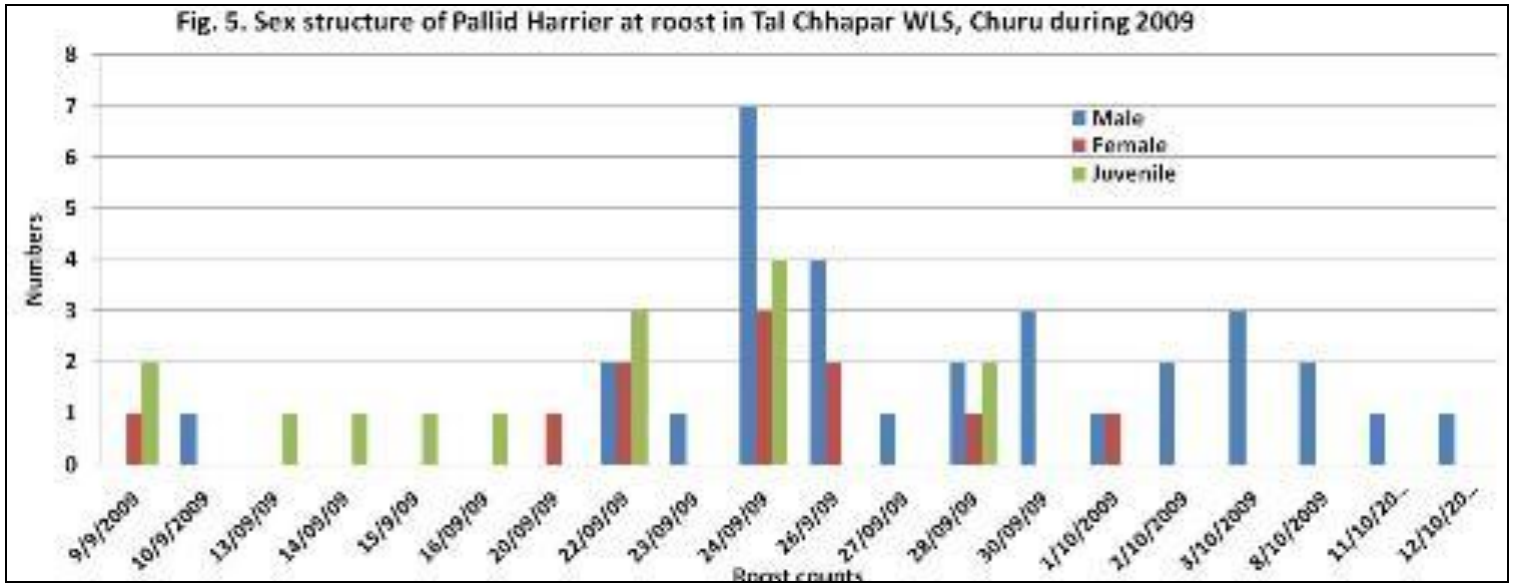
7. Sex Structure of Harriers at Roost

During 2008, of 118 total sightings on all harriers, there were 53% juveniles, 31% females and 15% males. During 2009, of 180 sightings on all harriers there were 41% juveniles, 37% females and 22% males.

Of 54 individuals of Eurasian Marsh Harrier during 2008, the juveniles accounted for 44%, females 44%, and males 11% while in 2009 the juveniles accounted for 16%, female 58% and males 26% (N=50). Of 45 individuals of Montagu's Harrier during 2008, the juveniles accounted for 71%, females 22%, and males 7% while in 2009 the juveniles accounted for 26%, females 32% and males 42% (N=66). Of 15

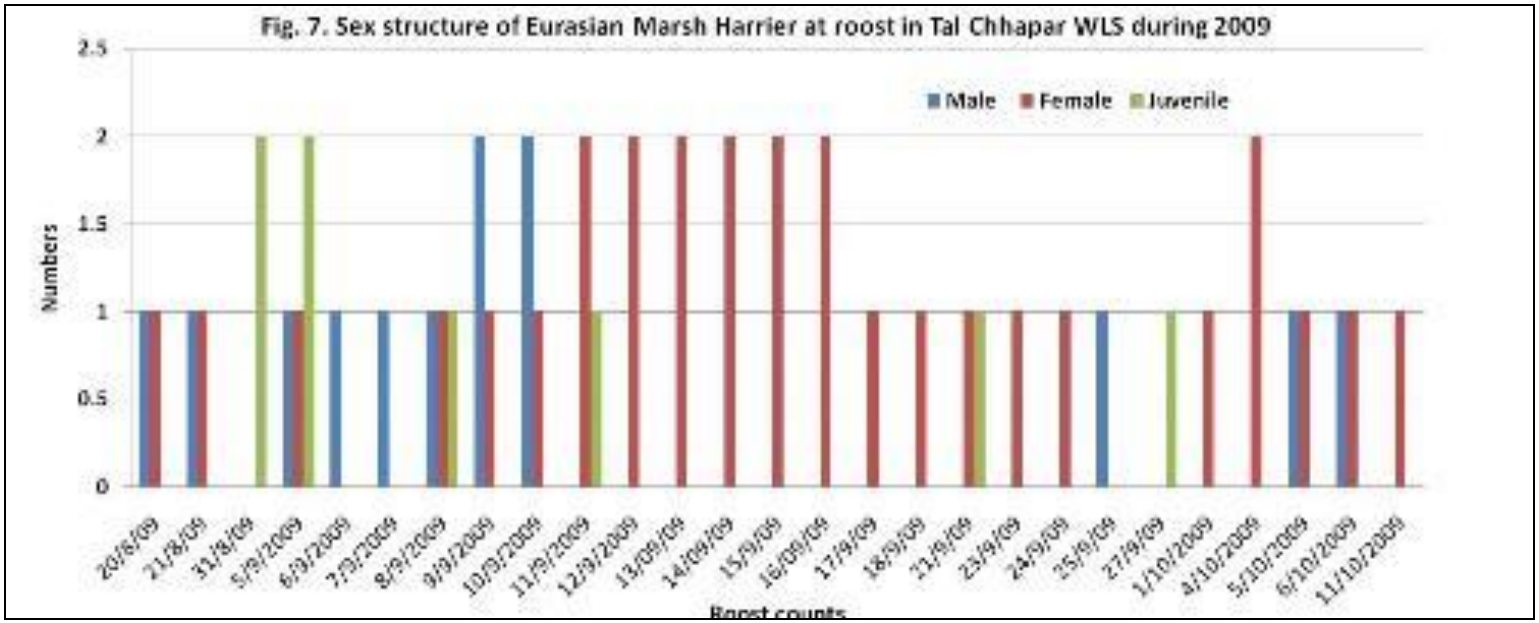
individuals of Pallid Harrier during 2008, the juveniles accounted for 47%, females 0%, and males 53% while in 2009 the juveniles accounted for 26%, females 35% and males 54% (N=57). Of 4 individuals of Hen Harrier during 2008, the juveniles accounted for 0%, females 75%, and males 25% while in 2009 the juveniles accounted for 0%, females 71% and males 29% (N=7).

The juveniles of Pallid Harrier arrived at roost in the sanctuary by second week of September, attained a maximum population by the fourth week (4 individuals) and also left the area by the end of the month. They were not observed in the month of October. The females followed the similar pattern as juveniles however its highest population was recorded to be 3 individuals. Males of Pallid Harrier arrived little later than females and juveniles in the second week reaching a peak at 7 individuals in the third week of September and continued arriving till second week of October **(Fig. 5)**.



The juveniles of Montagu's Harrier arrived by first week of September when four individuals were recorded. They showed second peak during third week of the same month. They were present in October also. Arrival pattern of females was also erratic as juveniles however a continuous flow was observed during third week of September when they attained a peak population also (5 individuals). The males of

Montagu's harrier arrived earlier than juveniles and females in the third week of August. They attained a peak in population during third week of September (5 individuals) and were found absent during October. The females probably formed the wintering population of the sanctuary **(Fig. 6)**.



The EMH juveniles arrived later than adults in August remained absent for whole of the second week of September and left the sanctuary by end of September whereas males and females were recorded till October. Males remained absent in the second and third week of September however they appeared again in the fourth week of the same month and were also present in October. The females were more regular than juveniles and males and probably formed the wintering population of the sanctuary **(Fig. 7)**.

8. Roost habitat of harriers at Tal Chhapar WLS

Roosting habitat was categorised into pre-roost, roost (for spending night) and post roost. Harriers arrived from outside the sanctuary from Chadwas in north, Dewani in south and Tal Chhapar in north and Rampura in west. However they mostly arrived from Chadwas side. They pre-roosted before settling for night roost for about an hour or so (Plate 8). During pre-roosting, they took rest silently, preened their body and were observed vocalizing at conspecifics which passed closed to them. The pre roost habitats comprised of bare grounds, mounds, open areas in grasslands and *Sueda* herbs. At sunset, they started leaving pre-roosts moving to their night roost. Before settling down for night roost the harriers scanned flying low and high over roost habitat number of times. Vocalization was also heard. Considerable amount of time was spent before final roosting took place. The scanning activity took 15 – 30 minutes. They roosted in grassland (< 0.5m), herb dominated vegetation patches and also on all bare grounds (Plate 9). They were also found roosting on patches of mixed vegetation i.e. Grass, *Scirpus rotandus* and *Sueda fructicoas*.

Plate 8. *Harriers' pre-roosting site at Tal Chhapar WLS.*

Plate 9. *Harriers' night roost sites at Tal Chhapar WLS.*

In the morning, the harriers left the roost about 15 minutes before sunrise except few which flew after sunrise. Maximum harriers took direct flight probably heading towards their respective foraging grounds. However, they also post roosted close to their night roost mostly

in bare grounds (Plate 10). These were the harriers which were sighted foraging around the roost. At post roost they spent time resting, preening, excreting and sometime casting pellet.

Plate 10. *A female Montagu's Harrier at post roost in Tal Chhapar WLS during April, 2009.*

9. Predators of harriers at Tal Chhapar WLS

The potential predators of harriers at the sanctuary could be the Indian Fox, the Desert Fox and the Jungle Cat (*Felis chaus*). A kill of Montagu's Harrier was found with its feathers and bones scattered at the roost during 2005 (personal observation). There were fox dens located near roost sites of harriers.

10. Pellet Analysis of Harriers roosting at Tal Chhapar WLS

In all, 15 pellets could be collected from the communal roost of harriers at Tal Chhapar WLS in six days' search for 18 hours in the month of September, 2008 **(Plate 11)**. The encounter rate was 0.8 pellets per hour. These pellets were collected out of 96 harriers which were observed roosting in the six evenings however the numbers reduced to 21 in the mornings – the post roosts. There was 98% decline in the numbers of harriers when recounted at post roost in the mornings. All the pellets analysed contained mandibles in them indicating the prey consumed by harriers to be grasshoppers **(Plate 12)**. The numbers of mandibles ranged between 31 – 62 mandibles/pellet. This indicates the diet of an individual harrier to be ranging between 16 – 32 grasshoppers. In the year 2009, no pellets were found at the roost even after long hours were spent searching them.

Plate 11. *An individual roost site with egested pellet.*

Plate 12. *Ggrasshopper – major prey of harriers at Tal Chhapar WLS.*

Chapter 5

CONCLUSION AND RECOMMENDATIONS

Plate 13. *Sudasari grassland in Desert National Park, Jaiselmer*

1. The Sudasari grassland in the Desert National Park, Jaiselmer was identified to be supporting a harrier roost in January, 2010 **(Plate 13)**. Two individuals of Pallid Harrier roosted here. A thorough search is required to be made here between July to November for locating more harriers and their roosts. Long term study on harriers should be targeted here on priority basis to collect data on their movement pattern and other aspects of ecology which will form basis for harrier conservation in the region.

2. The 1400 hectare grassland of Mokala centre, Sultana road side grasslands, and Gajner WLS in Bikaner could support harrier roosts in winter. It is recommended that harrier survey should be targeted here again from July to November.

3. There should be initiated a detailed and long term monitoring programme for harriers (at least for five years initially) at Tal Chhapar WLS which acts as an important stopover for these long distance palearctic migrants. Areas upto 50 km towards west and north of the sanctuary should be surveyed during July to October to collect information on population and distribution of harriers and whether there exist any roosting habitats for harriers.

4. A satellite- telemetry study should be initiated on harriers at Tal Chhapar WLS especially Pallid Harriers which are globally Near-threatened species so as to collect more information on their distribution in India. Information on whether harriers from here converge to Velavadar roost (Gujarat) – the largest roost in India (over 2000 individuals, Clarke et. al. 1998) or spread to some other parts of the country. Many small and large communal roosts can be located easily by conducing such studies.

5. A study about the impact of over population of Blackbucks especially on roosting harriers in the Tal Chhapar WLS should also be taken up. Roosting harriers have been observed shifting their roosts quite a number of times during nights as they get disturbed by running blackbucks.

REFERENCES CITED

1. Ali, S., and Ripley, S.D. (1983). Handbook of the Birds of India and Pakistan Compact Edition. Oxford University Press, New Delhi.
2. Bildstein, K.L. (1979): Fluctuations in the numbers of Northern Harriers at communal roosts in south central Ohio. *Raptor Res.* 13: 40-46.
3. BirdLife International (2003): International Action Plan for the Pallid harrier (*Circus macrourus*). Document prepared by BirdLife International on behalf of the European Commission. Strasbourg, 1-4 December 2003.
4. Clarke, R (1996): Preliminary observations on the importance of a large communal roost of wintering Harriers in Gujarat (NW India) and, comparison with a roost in Senegal (W. Africa). . *J. Bombay nat. His. Soc.* Vol. 93: 44-50.
5. Clarke, R., Prakash, V., Clark, W.S., Ramesh, N. and Scott, D. (1998): World record count of roosting harriers *Circus* in Blackbuck National Park, Velavadar, Gujarat, north-west India. *Forktail* 14: 70-71.
6. Cramp, S, and Simmons, K.E.L. (1980). Handbook of the birds of Europe, the Middle East and North Africa. The birds of western Palearctic Vol.2. Oxford University Press, London.
7. Newton, I. (1979). Population ecology of raptors. T & A D Poyser Ltd., England.
8. Rahmani, A.R. and Manakadan, R. (1986): A large roost of Harriers in Andhra Pradesh, India. *J. Bombay nat. His. Soc.* 83: 203-204.
9. Rappole, J. H. 1995. The ecology of migrant birds: a neotropical perspective. Smithsonian institution press, Washington.
10. Sharma, A. (1988). Harriers at Tal Chhapar Blackbuck Sanctuary, Rajasthan. *Newsletter for Birdwatchers*, Vol. 28 (11 & 12): 5-6.
11. Simmons R.E. (2000): Harriers of the World: Their behaviour and ecology. Oxford Ornithology Series. Edited by C.M. Perrins. Oxford.

12. The Biological Diversity Act, 2002 (2005): The Biological Diversity Act, 2002 No. 18 of 2003 with up to date rules including Convention on Biological Diversity. Natraj Publication, Dehradun.
13. Verma, A. (2002): A large roost of Eurasian Marsh Harriers *Circus aeruginosus* at Keoladeo National Park, Bharatpur, India. *Forktail* 18: 150-151.
14. Verma, A. (2002a). Wintering ecology of Marsh Harrier. Ph.D. thesis submitted to Mumbai University, Mumbai (India).
15. Verma, A. 2007. Harriers in India: A Field Guide. *Wildlife Institute of India*, Dehradun, India.
16. Verma, A., and Prakash, V. (2007): Winter roost habitat use by Eurasian Marsh Harrier *Circus aeruginosus* in Keoladeo National Park and its environs, Bharatpur, Rajasthan, India. *Forktail* 23: 17-21.
17. Weller, M. W., and I.C.Adams Jr., and B.J. Rose. 1955: Winter roosts of Marsh hawks and Shorteared Owls in Central Missouri. *Wilson Bull*. 67:189-193.