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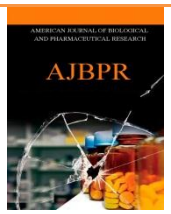

AN APPRAISAL OF SPATIO-TEMPORAL ASSOCIATION BETWEEN SAKER FALCON MIGRATION AND ENVIRONMENTAL CORRELATES AT JORBEER CONSERVATION RESERVE, BIKANER, RAJASTHAN (INDIA)

A.K. Kataria[1*], N.Kataria[2] and R.N.Kumawat[3]

[1]Principal Investigator, Centre for excellence for use of space-based technology in animal science, Rajasthan University of Veterinary and Animal Sciences, Bikaner-334001, Rajasthan, India.
[2]Department of Veterinary Physiology, College of Veterinary and Animal Science, Rajasthan University of Veterinary and Animal Sciences, Bikaner-334001, Rajasthan, India.
[3]Deputy Forest Officer (Wildlife), Bikaner, Rajasthan, India.

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ABSTRACT

The present endeavor appraised the spatiotemporal relationships between saker falcon migration and environmental correlates at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India during period from April 2015 to July 2016. Saker falcon (*Falco cherrug*) was observed only from November to March. Saker falcons were not evidenced during summer months (April, May, June and July) of years 2015 and 2016. The bird stayed at reserve during various months of the study when the temperature-humidity index (THI) values remained between 56.64 and 72.5. It was observed that maximum THI value threshold of saker falcon was 72.5. During the residential period of saker falcon, maximum environmental temperature varied between 21 and 35^0C. The date-wise observation of falcons including array and metric of comparisons i.e. per cent as well as the concurrent recording of environmental correlates can be used for monitoring falcon traffic in the conservation reserve that may have dramatic impacts to estimate migrant population. It can be deduced that falcons arrived and stayed when THI values were either 72.5 or less making the environment most suitable. The result of present endeavor exhibited precedent of wintering for saker falcons at the Jorbeer. It can be figured out that migratory raptors have *savoir fare* to toggle on various feeding strategies to façade threats of food dearth during months of year throughout migration. The endeavor will assist in comprehending the intricacies of environment and bird interactions during migratory drives.

INTRODUCTION

The adaptive evolution between behavioural tactics can bring a swing in migratoriness bothering the researchers associated with evolutionary ecology. Density dependent variations can further be affected by the environmental factors and human interference. Underlying mechanism in the behaviour of falcons producing variations in the migratory routes is a poorly comprehended issue. It is imperative to understand the highly specialized tactic of falcons during migration. Observational studies are beneficial to be familiar with migratory strategies of falcons

Corresponding Author

A.K.Kataria
Email:- akkataria1@rediffmail.com

without disturbing their psychosomatic system. Researchers are of the opinion that ecological specialization to unpredictable resources averts long-distance migratory raptors from becoming sedentary on reserves [1]. The saker falcon (*Falco cherrug*) is a large species of falcon of the family Falconidae [2]. This species has been uplisted to endangered because a revised population trend analysis indicates that it may be. This negative trend is a result of unsustainable capture for the falconry trade, as well as habitat degradation and the impacts of agrochemicals, and the rate of decline appears to be particularly severe in the species's central Asian breeding grounds [3]. It is a raptor of open grasslands preferably with some trees or cliffs. It is migratory and execution of conservation plans across all reserves is imperative to make sure a constructive conservation status [4].

Pre-migration and post-migration factors may influence the pattern of migration. Temporal studies can help in maintaining spatiotemporal database for assessing growth in numbers or reduction in numbers for making future strategies regarding conservation centres. Temporal dynamic and ecological processes together are important tools of contemporary research in the field to assess migratory behaviour. Upshot of these studies can help in preparing index of species in a given geographical region and to clarify the extent of the threat from trapping and its effect on population trends is vital. Saker falcon is physically adapted to hunting close to the ground in open terrain, combining rapid acceleration with highly manipulated strategies. It uses copses or cliffs for nest sites occupying the old nests of other birds [5]. Field observations offer orderly information about the migrant at journey halts. Scientists have evaluated the association of environment with the migrants pouring in rates [6]. Utilization of space-based technology in perspective of migration typicality and ecological information analysis can offer new tools to develop understanding on the distribution and movement of birds and their concern to human intermission and environmental changes [7]. Temperature and humidity are critical constituents of environmental *milieu* which can thump upon migratory efficiency of falcons covering larger distances. Field observations are required to bring into record more individuals to scrutinize members of the species. Because of dearth of research on spatiotemporal information in a reserve, the present investigation was planned with the goal to follow migration pattern contemplating environmental temperature and humidity at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India (JCRBRI).

MATERIALS AND METHODS

The investigation was carried out for an appraisal of spatiotemporal relationships between saker falcon (*Falco cherrug*) migration and environmental correlates at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India. The area of reserve comprised of 56.46 km^2 situated south east to Bikaner at distance of 12 Km with a geographical position of 20'3° north latitude and 73'5° east longitudes at height of 234.84m mean sea level. Bikaner, a district in the dry *Thar* desert, is located in the northwest of the state of Rajasthan in north India.

To determine spatiotemporal relationships between saker falcon migration and environmental correlates, data collected over a period of 16 months from April 2015 to July 2016 were analysed. The population influx/outflux was recorded visually along with environmental correlates (temperature and relative humidity) on 1^{st} and 15^{th} day of each month. The environmental correlates were recorded by using portable instrument (Atmospheric Data Centre Pro, Brunton, USA) and THI was determined as described by Gantner *et al.* [8].

RESULTS AND DISCUSSION

Population of saker falcon in numbers at JCRBRI from April 2015 to July 2016 is depicted in fig.1. The birds started marking their presence from the month of November 2015 and disappeared from the site in the month of April 2016. From April to October, 2015 and from April to July, 2016, Saker falcons were not observed at the reserve. From November 2015 to 1^{st} January 2016, only one Saker falcon was present, then number became 2, 5, 4, 5 and 5 on subsequent days of observation till march 2016. Again from April to July, 2016, no falcon was observed. Saker falcon population (%) with average temperature-humidity index values (THI) from April 2015 to July 2016 is depicted in fig.2. From April to October, 2015 the THI values dangled between 75.5 and 82 at which no saker falcon was seen. The period from November 2015 to March 2016 illustrated THI values as 72.5 and lower, and population per cent of saker falcon varied between 20-100%. From April to July, 2016, THI varied between 79 and 85, at which again no saker falcon was observed. Fig.3 shows the comparison of saker falcon population (%) with maximum environmental temperatures (^{0}C) at the reserve. During residential period of falcons, maximum environmental temperature varied between 21 and 35^{0}C. When population per cent varied between 80 and 100, maximum temperature varied between 24-35^{0}C. On April 1, 2016 maximum temperature of area became 41^{o}C resulting in disappearance of falcons from JCRBRI.

Figure 4 shows variations in minimum environmental temperature values and total saker population (%) at JCRBRI from November 2015 to March 2016. It was observed that falcons stayed at the area when minimum environmental temperature varied between 6 and 19^{0}C. Eighty per cent and above population was observed when minimum environmental temperature varied between 10 and 19^{0}C. In order to illustrate the figure clearly, polynomial trend lines have been used for each case. The R^2 value for saker falcon population is 0.831 (83.1%) which

is a good fit of the line to the data. A polynomial trend line is used to find out the relationship of falcon population with temperature of year. The R^2 value for minimum environmental temperature is 0.804 (80.4%).Falcons showed a winter migratory pattern at JCRBRI. Fig.5. depicts meteogram versus saker falcons' residential period at reserve. It can be deduced that saker falcon cannot live in higher temperatures and selected moderate periods for their residence.

Anguish about the refuge of migratory falcons from the probable impact of environmental challenges has accentuated the need for up keeping of reserves. To accomplish the mission, falcons proficiently shove lots of encumbrances of environment. However, trapping of falcons during their journeys is an important issue to tackle with [4]. The genus Falco is virtually worldwide in distribution and occupies a wide range of thermal habitats. Being endothermic, they must have adaptive mechanisms for maintaining a stable internal body temperature. They require to eat a lot to fuel higher metabolism. Researchers have observed panting at higher temperatures in falcons. Tarsal thermoregulatory mechanism is probably universal among Falconiforme [9]. Changes in yearly pattern of bird migration are regulated by peripheral and inner pressures. Diverse migrants have their dissimilar inbuilt responses governing practices like migration, breeding, molting, residential time, reflying etc. Temporal facet of migration is important for the breeding aspect of birds so that new generation come up to enhance population density of a species. However, hostile environment puts a threat over existence issues of a species. Therefore, great variations are observed in the migratory pattern in relation to time and migratory epoch of one species cannot be applied to another as migratory periods are adjusted according to scrupulous needs of species or individual. Peripheral pressures are generally acquired from the environmental correlates, availability of food supply, safety of alcove, human intrusion, load from other species of migrants, prowlers etc. Appropriate handling of the information about the residential period, population density and variation in environmental elements can be beneficial in formulating strategies regarding scientific management of the reserves. Sixteen months data of the migratory falcons reaching to this conservation reserve were used to test for their arrival, residential and re-flying periods in response to environmental correlates of arid tracts. The data obtained can be useful in devising comfort level of falcons in terms of residential period and THI values obtained. Loads of details obtained in the study suggest that environmental correlates can creep the migration of falcons. The THI value of 72.5 or less can be considered comfortable for the residence of saker falcon in the reserve. Environmental hurdles cover important angst over survival and future breeding accomplishments and growth in numbers.

Fig 4. Meteogram versus saker falcons' residential period at Jorbeer Conservation Reserve, Bikaner (Rajasthan, India)

Months	Maximum Environmental Temperature ^{0}C	Minimum Environmental Temperature ^{0}C	THI	Saker falcon population per cent
APR-1 2015	37	22	75.5	
APR-15 2015	35	24	76.5	
MAY-1 2015	38	23	76.5	
MAY-15 2015	41	25	79	
JUNE-1 2015	43	23	79	
JUNE-15 2015	35	22	80	
JULY-1 2015	38	26	81	
JULY-15 2015	39	27	82	
AUG-1 2015	31	24	79.5	
AUG-15 2015	32	24	80	
SEP-1 2015	36	26	80	
SEP-15 2015	41	26	81.5	
OCT-1 2015	39	23	78.2	
OCT-15 2015	39	23	79	
NOV-1 2015	31	19	72	20
NOV-15 2015	32	19	72	20
DEC-1 2015	28	10	64.76	20
DEC-15 2015	25	6	57.06	20
JAN-1 2016	26	11	62.07	20
JAN-15 2016	21	6	56.64	40
FEB-1 2016	24	10	58.55	100
FEB-15 2016	24	10	58.13	80

MAR-1 2016	35	18	72.5	100
MAR-15 2016	33	19	72	100
APR-1 2016	41	27	79	
APR-152016	42	28	79.5	
MAY-1 2016	45	28	79	
MAY-15 2016	44	27	82.5	
JUNE-1 2016	44	28	82.5	
JUNE-15 2016	40	26	82	
JULY-1 2016	40	27	84.2	
JULY-15 2016	40	28	85	

Fig 1. Saker falcon population at Jorbeer Conservation Reserve, Bikaner (Rajasthan, India)

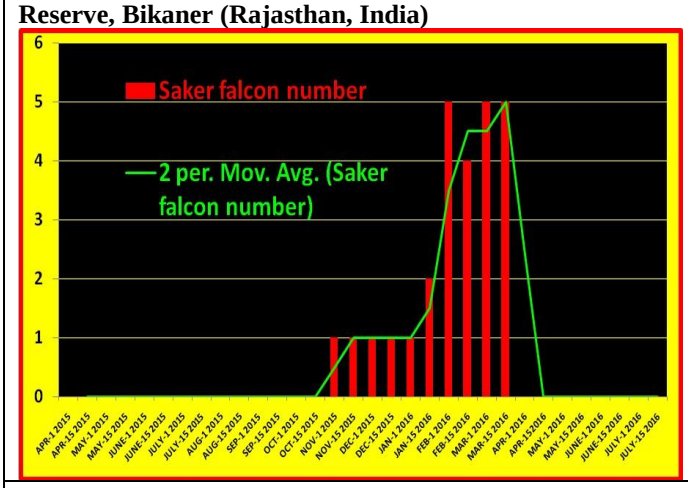


Fig 2. Saker falcon population (%) versus temperature humidity index values (THI) at Jorbeer Conservation Reserve, Bikaner (Rajasthan, India)

Fig 3. Comparison of saker falcon population (%) with maximum environmental temperatures (^{0}C) at Jorbeer Conservation Reserve, Bikaner (Rajasthan, India)

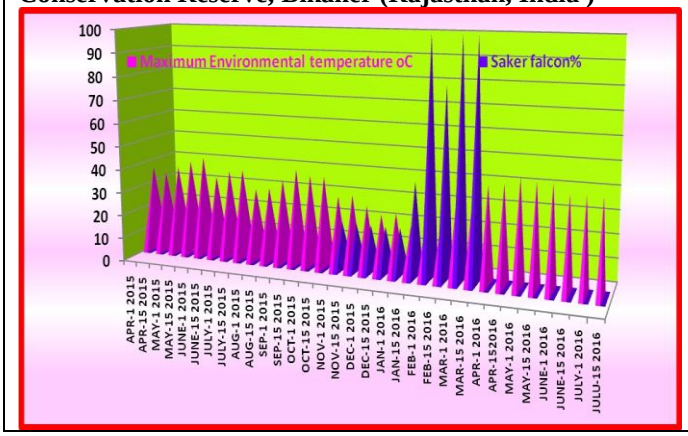
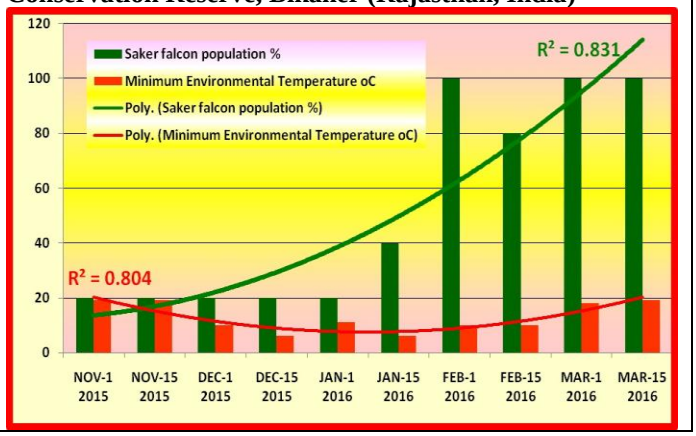


Fig 4. Variations in minimum environmental temperature values and total saker population (%) at Jorbeer Conservation Reserve, Bikaner (Rajasthan, India)



CONCLUSION

The date wise observation of falcons including array and metric of comparisons i.e. per cent as well as the concurrent recording of environmental correlates can be used for monitoring falcon traffic in the conservation reserve that may have dramatic impacts to estimate migrant population. It can be deduced that falcons arrived and stayed when THI values were either 72.5 or less making the environment most suitable. The result of present endeavor exhibited precedent of wintering for saker falcons at the Jorbeer reserve. It can be figured out that migratory raptors have *savoir fare* to toggle on various feeding strategies to façade threats of food dearth during months of year throughout migration. The endeavor will assist in comprehending the intricacies of environment and bird interactions during migratory drives.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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