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TEMPERATURE HUMIDITY INDEX *VIS-À-VIS* BLACK KITE (*Milvus migrans*) POPULATION AND MIGRATION PATTERN IN ARID TRACTS IN INDIA

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ABSTRACT

The purpose of this investigation was to appraise the migration drift of black kite (*Milvus migrans*) at Jorbeer Conservation Reserve, Bikaner, Rajasthan (India) over the period from April 2015 to July 2016. The birds' population was recorded along with environmental temperature and humidity on 1st and15th day of every month. A maximum of 1100 black kites were evidenced in the mid of January 2016 followed by a gradual decline. Minimum number was observed around mid April to beginning of May 2016. Population of black kite was less than 20% in the months from April to September, 2015 and April to July, 2016. April, May and June months of both the years showed extremely high environmental temperatures. From April 2015 to September 2015, THI values swung between 75.5 and 82 with population per cent of below 20%. In October 2015, THI varied from 78.2 to 79 and population per cent varied between 45 and 55%. November to February illustrated THI values as 72 and lower with bird population per cent fluctuating between 63 and 100%. Period from March 2016 to July 2016 showed a marked rise in THI values with concomitant decrement in bird population. Residential population in summer months was lower in year 2016 in comparison to that in 2015 because of comparatively higher THI in year 2016. From October 2015 to March 2016, the presence of birds was above 45%. During December 2015 and January 2016, the bird population was above 80% and October, November and February months showed variation in population between 45 and 78%. It was noted that bird population was affected by environmental temperature and not by humidity. It can be concluded that in the arid area of Rajasthan (Jorbeer Conservation Reserve), black Kite population was higher during extreme cold months when minimum temperature was very low whereas extreme hot environmental temperature period showed minimum concentration of birds. Highest concentration of birds was observed when temperature humidity index (THI) was 72 or low. The upshot of study showed pattern of wintering in this area, however, summer months were not deserted. It can be deduced that migrant species know how to switch on adaptive foraging tactics to visage challenges of food scarcity in both cold and hot periods of year during migration. The investigation will help in understanding how weather influences processes that drive bird population dynamics and in predicting the effects of climate change on threatened ecosystems and bird species.

Keywords: Bikaner, Black kite, population, temperature-humidity index, weather.

INTRODUCTION

"Mass migrations are among the most striking examples of animal movement in the natural world. Such migrations are major drivers of ecosystem processes and strongly influence the survival and fecundity of individuals. For migratory animals, a formidable challenge is to find their way over long distances and through complex, dynamic environments. However, recent theoretical and empirical work suggests that by traveling in groups, individuals are able to overcome these challenges and increase their ability to navigate**"**[1]. Climate variation is evolving in the way impinging on the biological system negatively by contributing towards ecological imbalances. Migration of birds is the customary seasonal event alongside a definite flyway amid reproductive and cold environment factors. Birds migrate from areas of low or lessening reserves and supplies to regions of increasing resources. Chief resources of concern are food and nesting locations. Predation and mortality are crucial factors associated with the event of migration. Although most mortalities in long-distance migrant birds is thought to occur during migration, evidence of conditions on migration affecting breeding population sizes has been completely lacking [2].

Worldwide environmental variation is a chief peril to biodiversity. Sweeping evaluations have in general spotlighted the brunt of environmental changes of the geographic ranges of species and on phenology [3]. Contemporary research have shown that many bird populations in recent times have altered their migratory behaviour in retort to alterations of the environment [4]. Extreme changes in the environment correlates can affect migratory capabilities of the birds. Birds migrating larger distances are encountered with assorted spatial information. Remoteness of destination necessitates travelling of larger migration distances which can be correlated with the recruitment of new neurons into the brain regions involved with migratory navigation. Therefore a multidisciplinary attitude imparts new insights into the capability of the brain of birds to adapt to different migration threats [5] . There are several approaches in which the environment can manipulate migration of birds. Correlates of the environment i.e. temperature, humidity, wind condition etc. can apply individual or combined impact on migratory efficiency.

Black kites (*Milvus migrans*) are birds of prey residing in virtually the entire habitats varying from deserts to riverside and forests covering Asia, Africa, Australia and Europe [6]. They are opportunistic seekers belonging to family Accipitridae. Distribution of this kite is wider in temperate and tropical parts. January and February months are marked as breeding season of black kites in India [7]. Knowledge on the migration and wintering behaviour of the black kite is based on visual observation of migrating and wintering birds. Migration of birds is an inadequately implicit vibrant course of action in which biologists crave to model how birds manage when to migrate, how far to fly each night, where to stop over and when to resume flying. The collected data in general are discrete with lack of comprehension by volunteer bird viewers. Thermal comfort indices such as the temperature-humidity index (THI) integrate the effects of temperature and humidity and may offer a means to predict the effects of thermal conditions on performance. Hence, the present study was initiated with the aim to follow birds' migration pattern in view of various environmental correlates in Jorbeer Conservation Reserve, Bikaner, Rajasthan, India. These composite indices will help in calculating the climate impact indicators reflecting the divergent facets of species favoured or disadvantaged by climate change. Further, the data collected will help in synthesizing effects of future climate change with relevance to a specific arid area. Using an indicator will ease climate impact assessments and adaptation plans. Since climate, in contrast to weather, is more evident from long term statistics, hence parameters determined will show how the climate changes between different time periods can influence migration. Knowledge of variability in migratory behaviour and performance linked to robust population change data may therefore be necessary to understand population declines of migratory species and efficiently target conservation resources.

MATERIALS AND METHODS

The investigation was carried out to find out migration pattern *vis-à-vis* temperature humidity index (THI) values of black kite in arid tract of India. The area selected for the investigation was Jorbeer Conservation Reserve, Bikaner, Rajasthan, India (JCRBRI) which comprised of 56.46 km^2 situated south east to Bikaner at distance of 12 Km with a geographical position of 20'30 north latitude and 73'50 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. The reserve is unique in the sense that every day around 30-35 cattle carcasses are dumped in its area attracting a variety of raptors in this reserve.

The period of investigation was of 16 months from April 2015 to July 2016. Black Kite population was recorded visually along with environmental correlates (temperature and relative humidity) on 1^{st} and 15^{th} day of each month. In order to compare environmental correlates of summer months of two years, data were also recorded on other dates of months to get monthly average environmental temperature, mean maximum environmental temperature and average THI of months from April to July of year 2015 and 2016.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 black kite (in numbers) at JCRBRI from April 2015 to July 2016 is depicted in Fig.1. There was an increase in number of the birds during October 2015 and March 2016. Bird count on 1st October showed a five time rise from the preceding 15th September 2015 counts. Simultaneously the bird count on 1st April 2016 showed a 100 times decrease than previous value on 15th March 2016. Peak value was observed on January 15, 2016.

Figure 2 exhibits per cent decrease in black kite numbers as compared to peak value from April 2015 to July 2016. Black bars show decrease in number greater than 80% and red bars less than 30%. Mid February 2016 to March 2016 showed a decrease from 36% to 55%. April 2016 onwards, decrease was 98%. This showed the migration of birds from Jorbeer Conservation Reserve to other places. April 2015 to September 2015 showed decrease between 81 and 99.54%. This graph also helped in assessing the residential period of migratory birds.

Black kites population (%) with average temperature-humidity index values (THI) from April 2015 to July 2016 are depicted in Fig.3. From April 2015 to September 2015, THI values swung between 75.5 and 82 and per cent population was below 20%. Though in October 2015, THI varied from 78.2 to 79 but still population was higher (45-55%). November to February illustrated THI values as 72 and lower and bird population per cent increased from 63 to 100%. Period from March 2016 to July 2016 showed a marked rise in THI values with concomitant decrement in per cent population. Black kites population (%) in year 2015 and 2016 from April to July is depicted in Fig.4. This graph clearly depicts a comparative aspect of residential population of birds during summer months of two consecutive years. Residential population was consistently lower in year 2016 than 2015 for the summer months. The average per cent value of April to July in 2015 was 8.23±1.53 and in 2016 it was 1.58±0.56 showing a significant difference ($p \leq 0.05$).

Temperature humidity index values (THI) at JCRBRI between year 2015 and 2016 from April to July are shown in Fig.5. This graph shows that THI values were consistently higher during summer months of 2016 than of 2015.This graph helped out in finding the reason that why black kite population was significantly ($p \leq 0.05$) lower in year 2016 during summer months as compared to summer months of 2015. Maximum environmental temperature values and black kite population (%) from April 2015 to July 2016 are revealed in Fig. 6. When maximum environmental temperature was higher, black kite population per cent decreased consequently and *vice versa*. Whilst maximum environmental temperature ranged between 31 and 43°C from April to September, 2015, bird population reduced to less than 20%. Bird population became fewer than 5% in 2016 from April to July as temperature varied from 40 to 45°C during data collection period. Maximum per cent of bird population (63-100%) was witnessed from November 2015 to February 2016 when maximum environmental temperature ranged from 21 to 32°C.

Comparison of THI values with black kite population (%) at JCRBRI from April 2015 to July 2016 is illustrated in graph 7 exhibiting lucid particulars about the utmost residential epoch of black kites in cold months trailed by a lessening number during transition periods and summer months, respectively. Scaffolding of this graph can be used to divide months of the year into three categories as April to September, March and October and November to February according to bird population. In this investigation the percent of black kites were less than 20%, 45 to 55 and 60 to 100 %, respectively in above mentioned categories. THI value from 80-85 were tolerated by the birds harbouring the area during summer months. Representations in Fig. 8 are supported by the monthly average environmental correlates between year 2015 and 2016 in April to July months. This figure states the dependence of residential bird population number on the environmental correlates. This comparative aspects provided in the graph tried to help in finding out the reasons of low concentration of birds in summer months. High heat index is correlated with lower concentration of birds. Depictions in Fig. 9 are based on the minimum environmental temperature values and black kite population (%) from Nov 2015 to Feb 2016.Decreasing trend of minimum environmental temperature was well associated with the increasing trend of black kite population. This showed that in arid tracts majority of birds preferred winter months for their residence.

Maximum count of black kite recorded was 1100 around mid of January. Peak of species migration was observed in the month of January around mid length. Then a gradual decline was observed in the numbers. Minimum number was observed around mid April to beginning of May. Then again gradually number started increasing till mid July. Then till mid August a slight decrease was recorded and then onwards an increase was there till January. Population of black kite was less than 20% in the months from April to September. In arid tracts, April, May and June months show extremely high environmental temperatures. During extreme hot periods, environmental temperature may reach up to 48 to 49°C in arid tracts with humidities as low as 8%. Though black kites survive in deserts but in present study it was noticed that these months were not liked by majority of the black kites. From October to March, the presence of birds was above 45%, highest being in the month of January. December and January are the months having extreme cold environmental temperature period in this region. During this period the presence of birds was above 80%. February, October and November months are considered as moderate periods. In present study, these months showed variation in population from 45 to 78%. In the first fortnight of October, per cent of bird population was lower than 50%. Probably it showed the effect of warmth carried from the month of September to early October. Month of March again showed a decline probably due to increasing effect of higher environmental temperature. It was noted that bird population was affected by environmental temperature than humidity because bird population was lower both in the periods of high humidity and low humidity. However, during low temperature period, bird density was found higher.

It is a point of concern regarding the protection of migratory birds from the possible impact of climate change by accentuating the need for more conservation. To accomplish these journeys, birds must effectively navigate many impediments including a dynamic environment. To make proper use of this ever-fluctuating situation necessitates not only an eerie wisdom of timing but an intuitive sense of the environment and its proclivities. Loads of evidence suggests that environmental variations provoke the migration of birds from around the world in many ways. Immediate reactions that impel the decisive bangs of climate variation on birds may produce important transformations to ranges that could be calamitous for many species. Therefore, migratory birds necessitate synchronized safeguard [9]. Heat stress indices combine the effects of both temperature and relative humidity and are classified into alert, danger and emergency zones. Because different animal species and humans have different sensitivities to temperature and relative humidity, the heat stress calculations are thus unique of that particular species. Scientists have classified THI values to denote stress conditions. In one type of classification, bird comfort zone is considered when THI is less than 70. From 70 to 75, alert condition is considered where heat stress reduction measures like increase in ventilation rate can be observed. Danger condition is from 76–81 [10]. Birds encounter ecological barriers during migration. Unwelcoming environmental attributes can avert movement due to peril of mortality from starvation, predation, collision and harsh weather [11]. Environmental impediments can have significant concern over survival issues and prospective reproductive success. Therefore, birds have evolved physiological strategies to combat barriers coming in the way of migrations. Pattern of upshot of the present study showed that weather has great impact on the migratory behaviour of birds. However, birds stayed in the environmental periods which were not so friendly. This reserve is a dumping site for cattle carcass. It is well suited for the stay of black kites due to availability of ample food during residential period.

We used sixteen months data of the migratory birds reaching to this conservation reserve to test for their arrival, residential and reflying periods in response to environmental correlates of arid tracts. Our findings suggest that variations in environmental correlates induced changes in migration pattern of birds. Scientists [12] have suggested that immigrant birds have to manage with environmental challenges in dissimilar regions along with incessant restraints impressed by human provoked transformations in the course of geographical conversions and bumpiness of reserves. Conjectural studies insinuate that variations in food allocation can encourage alterations in the social haggle of entities lacking obvious adjustable worth. Pragmatic work on this issue has only been completed at trimmed geographical areas for single species. Conversely, the virtual input of food scarcity and reliability can fluctuate among bird species, relying on their magnitude of plasticity. Regardless of the ecological importance and allure of black kite as bird of prey, several facets of physiology and biology are stay put and inadequately established. Further studies in the field of migration of the black kite can provide power to make clear the deviations in the migratory behaviour year per year.

Fig. 1. Black kite population at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India

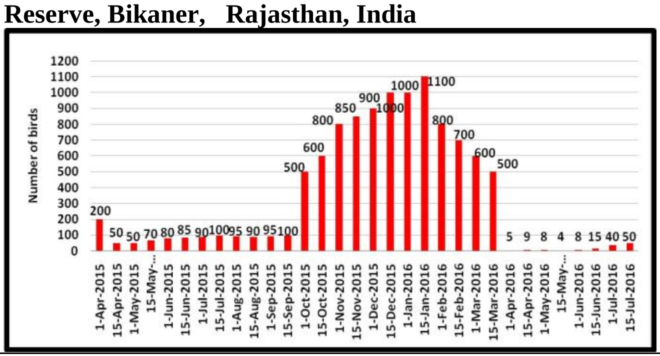


Fig. 2. Per cent decrease from peak value in black kite population at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India

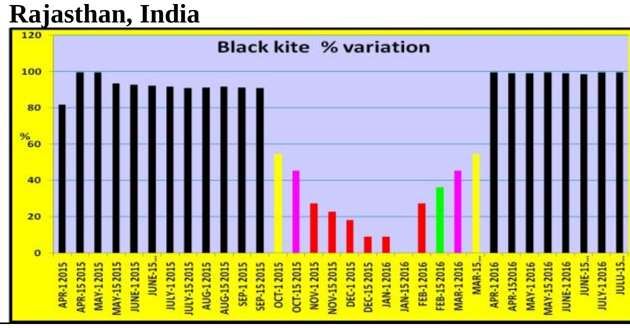


Fig. 3. Black kites population (%) versus temperature humidity index values (THI) at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India

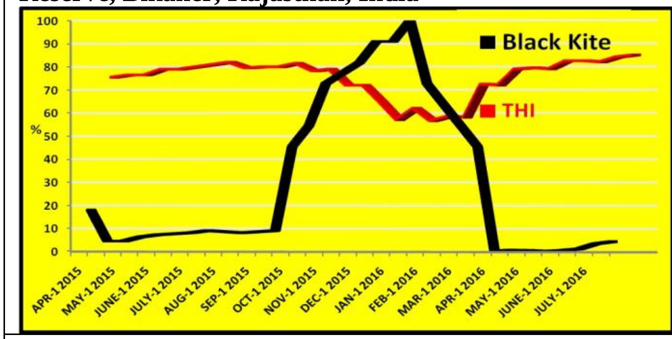


Fig. 4. Black kites population (%) in summer months at Jorbeer Conservation Reserve, Bikaner , Rajasthan, India

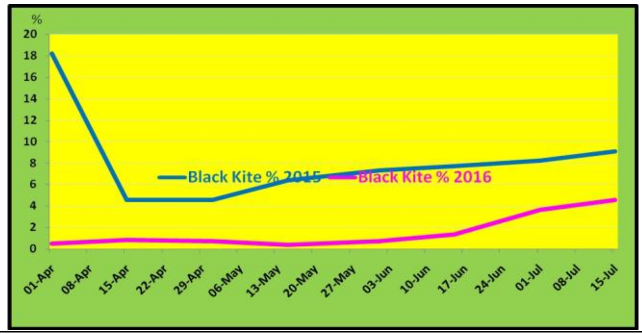


Fig. 5. Temperature humidity index values (THI) of summer months at Jorbeer Conservation Reserve, Bikaner , Rajasthan, India.

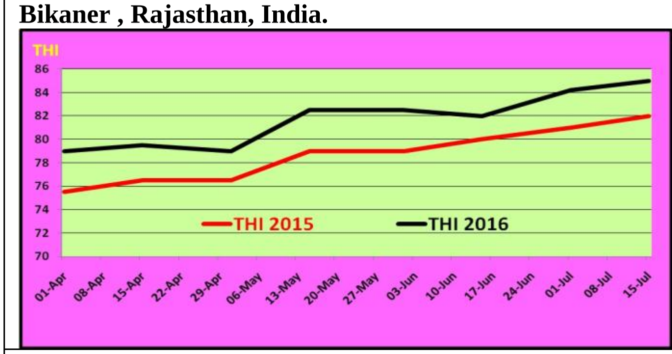


Fig. 6. Maximum environmental temperatures (^{o}C) and black kite population (%) at Jorbeer Conservation Reserve, Bikaner , Rajasthan, India.

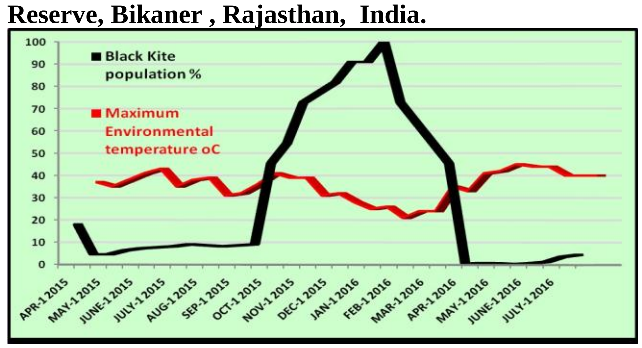


Fig. 7. Association of THI values with black kite population (%) in different months at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India.

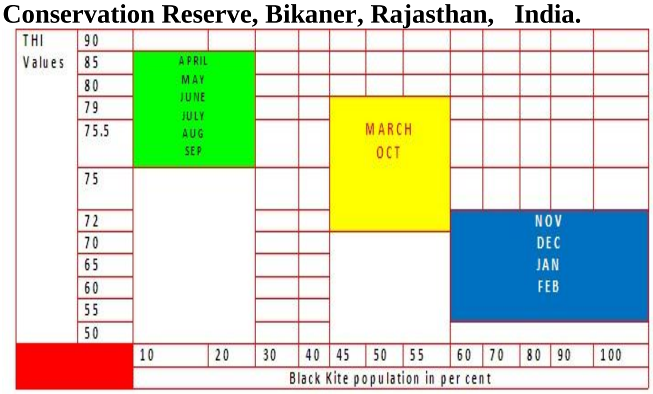


Fig. 8. Comparisons of environmental correlates of summer months of year 2015 and 2016 at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India.

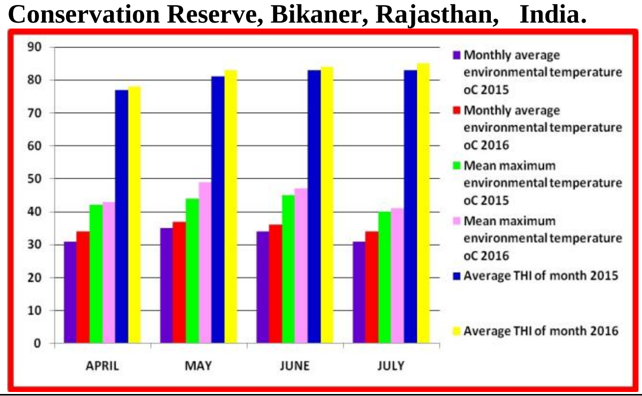
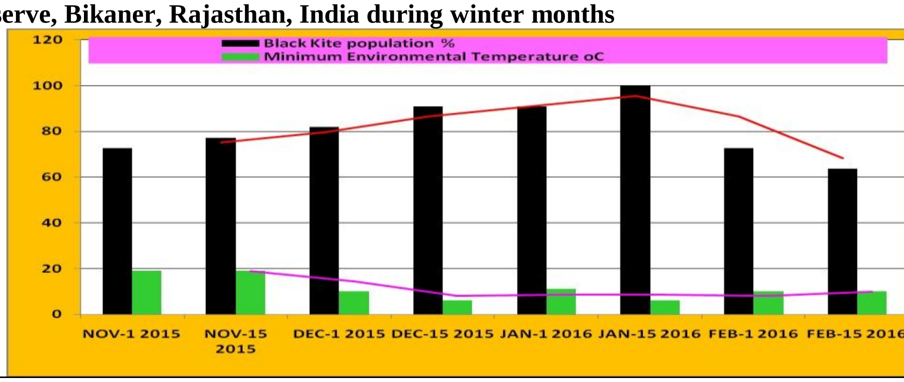


Fig. 9. Comparisons of minimum environmental temperature values and black kite population (%) at Jorbeer Conservation Reserve, Bikaner, Rajasthan, India during winter months



CONCLUSIONS

It can be concluded that in the arid area of Rajasthan (Jorbeer Conservation Reserve), black Kite population was higher during extreme cold months when minimum temperature was very low. Extreme hot environmental temperature period showed minimum concentration of birds. Maximum concentration of birds was observed when THI was 72 or low. The upshot of study showed pattern of wintering in this area, however, summer months were not deserted. It can be deduced that migrant species know how to switch on adaptive foraging tactics to visage challenges of food scarcity in both cold and hot periods of year during migration. The investigation will help in understanding how weather influences processes that drive bird population dynamics and in predicting the effects of climate change on threatened ecosystems and bird species.

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