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Wildlife Collisions to Aircraft in India - A Comparative Analysis of Hazardous Species Involved in Different Time Periods

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ABSTRACT

Wildlife strikes (mainly birds, but also includes bats and other mammals on the ground) with aircraft is a serious economic and safety concern in the aviation industry. The solution to the problem can be evolved by identifying the species involved in the incidents/ accidents. In the Indian context, such an attempt was started in 1980. In the recent past, Indian Air Force adopted the DNA Bar-coding technology to identify the species involved. The extent of the problems faced by the country and involvement of different species in various time blocks has been compared with an objective of analysing changes over different periods to gauge the changes and assess the future requirements. The data indicates that over the years, the number of strikes has increased manifold in the civil aviation sector. The number of species involved in strikes has almost doubled. The serious strikes due to Vultures have nearly disappeared and their place has been mainly taken over by Black Kites. In the recent past, Black Kites are the cause of highest damages and also have the highest probability of causing damages (61.17%) when struck. Adoption of DNA Barcoding technology has helped to identify the species in incidents where minimal bird remnants were found. Although the numbers of accidents have decreased, the economical losses continue to rise due to high cost of modern aircraft.

Keywords: Wildlife strike; Bird strike; DNA Barcoding; Aircraft; Aviation; Damage; Economy; Vultures, Black Kite; Bats; Lapwing; ecology

1. INTRODUCTION

The civil and military aviation communities widely recognise that the threat to safety from aircraft collisions with wildlife (wildlife strikes) is increasing[1]. Aircraft collisions with birds and other wildlife have become an increasing concern for aviation safety in recent years[2]. The number of WS reported to International Civil Aviation Organisation (ICAO) has increased significantly from 42,508 (for the period 2001-2007)[3] to 97,751 (for the period 2008-2015)[4]. In USA, the numbers increased from 7,632 in 2008 to 16,020 in 2018. It indicates that the WS have become more than double in ten years. In the last three years, the numbers have grown from 13,454 (in 2016) to 14,664 (in 2017) and reaching 16,020 in the year 2018[2]. This indicates that the numbers grew by 8 and 9 percent in the last two years indicating the seriousness of the problem.

The numbers of WS indicate that they happen on regular basis. However, it was not there in the common man's appreciation. The accident on 15 Jan 2009 in which the pilot successfully ditched the aircraft on to Hudson river[5] caught the attention of the whole world. However, such successful landings after aircraft looses complete power do not happen very often. In March 2008, a Cessna 500 aircraft crashed due to a BS killing all the five personnel on board[5]. The Australian BS Statistics report indicates that there were 12 cases in Australia in which both engines of aircraft got ingested with birds[5]. The 185 passengers (and nine crew) on board the Indian Airlines passenger flight had a great escape in 1986 when the aircraft crashed at Madras (Chennai)[6]. More numbers of abort takeoffs due to WS have been reported in the recent past as well[7, 8]. In 2019, Indian military forces lost two aircraft due to BS[9,10]. IAF has lost another two aircraft [11,12] since 2014.

The military aviation suffers more losses due to inherent way in which they fly. Considering this, military airfields study the problem more intensely and institute more precautions to prevent the hazard. The long term study conducted by Israeli Air Force has led to an interesting book 'Flying with Birds'[13]. The German Air Force and Royal Netherlands Air Forces have regularly shared their bird ecological study results and experiences in International Bird Strike Committee proceedings[14,15].

In India, the pioneering airfield bird ecological studies were started under the leadership of Dr Salim Ali and Dr RB Grubh of Bombay Natural History Society (BNHS) in 1980. The research team consolidated their study report[16] for 22 airports

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during the period 1980-1988. Further, a PhD thesis[17] in 1990 has contributed by synthesising/ compiling the information. These studies provide a basis for a comparison of numbers of WS and species involved in the Indian context.

While periodic studies have been published in various regions on different aspects of BS, very few attempts have been made to compare BS in different time periods. An attempt has been made partly by ICAO's Wildlife Strike Analyses report in 2017 in which it compared the BS data of two periods 2000-2007 and 2007-2015. However, the study was restricted to comparison of number of states which reported the incidents and number of incidents in each month. Searing[18] compared the numbers of BS before making the BS reporting mandatory (2000-2007) and after making it compulsory (2007-2009) in Canada. But, no species comparison was made. In the latest study (published in March 2020)[19],conducted at Netherlands, the BS rates, ratios of damage, altitude, months, parts struck, effect on flight and magnitude of damage for different regions namely USA, Europe, Australia and Canada have been carried out. A comparison of involvement of species in WS over three different periods to record the changes and to assess the future challenges is a novel attempt made by this study.

2. MATERIALS AND METHODS

2.1 Collection of Wildlife Strike Information

Information used in this article was sourced from both published literature and the official records of IAF. Past information from 1966 to 1989 was taken primarily from in a PhD thesis[17]. Published literature such as the journals and papers were also referred. This includes the data from both civil and Air Force airfields. Information on the WS from 1993 to 2018 used in this analysis was mainly from IAF airfields.

In the past, Bombay Natural History Society used to collect the data based on a proforma which was sent by airline operator/ military airbase along with feather sample. The sample was identified for species involved and database was maintained. The PhD thesis mentioned above used this methodology.

As IAF is a part of the study, the data has been taken directly from their database. The species data is based on carcass identification, feather identification and as well as DNA bar coding data built up by IAF.

Total number of WS in a year for IAF is a 'Confidential' data and the same is not shared here. Only the data of the WS in which species has been identified is used in this study. Information on WS of civil aerodromes for the period from 2012 to 2016 was collected from the grey literature such as newspapers and reliable internet sources. They have been cross-checked with DGCA reports/ answers given in the Parliament by Minister of Civil Aviation to the highest possible extent. The term 'incident' is used when strike results in NIL/ negligible damage. The term 'accident' is used when the repair cost of the damage exceeds the 10% of the original cost of the aircraft.

2.2 Comparison and Analysis

Various studies that are carried out on the WS data analyse on different parameters. Though, there is no standard protocol to make such studies, it is generally observed that after comparing the total numbers, the data is analysed for time of day, month of the year, phase of flight, part of the aircraft struck and effect on flight. Some studies have specifically focused on damage caused by birds and their relation to mass of the birds[15]. The current article was intended to analyse changes in bird ecology. Hence, focus has been given to number and type of species as well as damage caused by each species.

Analyses have been carried out for three periods. The periods were identified based on the sources of data. The data for first period from 1966 to 1988 has come from a PhD thesis from Bombay University and other published literature. The next period from 1993 to 2009 draws its data from IAF records. Species identification was done through carcass identification by airfield staff and feather identification by BNHS during this period. The last period is considered from 2010 to 2018. This period also draws its data from IAF records. But, Species identification was done through carcass identification by airfield staff. In addition, blood sample identification was done through DNA Barcoding technology with the help of various labs.

The following analyses have been carried out for the understanding of the growing nature of the problem, extent of damage and changes in the species involved in various periods:

a. General comparison of WS, fatalities and number of species involved in three periods
b. Number of incidents involving major species and changes in their percentage of contribution in different periods.
c. Comparison of the number of species involved in damage causing incidents and fatalities.
d. Analysis of location of wildlife strike. The locations are classified in to three categories namely 'Within Sanitised zone' (area where dedicated personnel are deployed for observing, reporting and scaring away the birds- mainly constituting the runway area), 'Outside the sanitised zone' and at 'unknown location' and the records were analysed.
e. A general analysis of the economic effects of increasing WS and the amount of damages they are causing.

3. RESULTS

3.1 Trend of Wildlife Strikes over Different Years in Civil Aviation Sector.

Table 1 gives recent information (from 2012 to 2016) of the WS (mainly birds) from civil aerodromes of India with percent of damage per year for the five years.

From the table, it can be inferred that the numbers are steadily rising. The number of WS which leads to damage is generally around 10 percent of the total strikes. Both the incident numbers and damaging incidents show a steady increase in these years. An exponential growth of the civil aviation sector witnessed in the recent past is one of the reasons. But, concerns raise high due to exorbitant costs of damage, indirect costs and operational restrictions caused by these incidents.

Table 1. Data of reported wildlife strikes in Indian civil aerodromes (2012-2016)

Year	Incidents leading to damage	Total incidents[20-22]	Percent of damage to total
2012	67	607	11.04
2013	67	736+	9.10
2014	81	719+	11.27
2015	66	764+	8.64
2016	103	839+	12.28
Total	384	3665*	10.47

* The data includes mostly bird strikes.
\+ Number confirmed through DGCA Annual Safety Report-2016 (calculating daily report of WS X 365).

3.2 Damages Caused and the Species Involved over Different Periods

The data of indicating the numbers of WS in which species was identified; number of species involved and other associated data in the three time periods is shown in Table 2.

The table indicates that the average number of crashes per year due to WS in India have reduced from 2.21 to 0.33 in recent times. It has also seen reduction in fatal injuries. On the other hand, species identification has progressed well and there is a marked increase in number of species identified.

3.3 Damage Causing Species and Extent of Damage

The list of critical species identified in Wildlife Strikes with their contribution to the overall BS (in which species is identified) is given in the Table 3.

Damage to Aircraft: Table 4 gives details of the types of damage to the aircraft by different species of problematic birds for the period 2005-2018 within IAF. The species have been arranged in the descending order of number of incidents resulting in damage. Black Kites, Bats (various species) and Lapwings top the list.

3.4 Bird Strikes Analysis by Zones

The data with regard to the BS as per their location (for IAF, for the period 2010-2018) is given in the Table 5.

Table 2. Wildlife Strikes and associated data for different time periods between 1970 and 2018

	1970-1988 (Civil & Military)	1993-2009 (IAF)	2010-2018+ (IAF)
Number of WS reported	1228*		
Average annual number of WS reported	53.39		
Crashes / complete destruction of aircraft	50 (IAF)+ 1(Civil)	17	3
Annual average of Cat I accidents (crashes)	2.21	1	0.33
Crashes with fatal injuries (All IAF)$	7	5	1
Number of WS incidents considered/samples in which species identified (n)	360** (1966-1989)	192	489
Average number of incidents# in which species was identified per year for the time period	15.65	11.76	55.77
Number of species identified (Birds + Bats)	67 Birds + 03 Bats	76 Bird +05 Ground mammals	115 birds+ 12 Bat + 03 insect + 06 ground mammals

*Minimum numbers. Compiled from different literatures[23 and 24]. ** Species identification data has been taken from a PhD thesis[17]
\+ Financial years from 2010-11 to 2018-19 data is taken. $ In addition, at least eleven people died on ground in 1990 when an IAF aircraft crashed.

Table 3. Critical species involved in WS in different time periods with their percentage of contribution to overall wildlife strikes.

Species	Period 1966-1989 (n_1=360)[17]		Period- 1993-2009 (n_2=192)		Period- 2010-18 (n_3=489)	
	Number	Percentage	Number	Percentage	Number	Percentage
Black Kite	73	20.28	16	8.33	77	15.74
Vultures (03 species)	78	21.67	3	1.56	04	0.8
Bat (03 Species)	5	1.78	10	5.20	62	12.67
Cattle Egret	4	1.11	8	4.16	20	4.09
Swallows	1	0.28	08	4.16	54	11.04
Swifts	24	6.7	06	3.12	69	14.11
Lapwing Sp.	10	2.85	44	22.91	44	8.99
Eurasian Thick-knee	7	1.97	01	0.5	22	4.49
Pigeon	28	7.78	10	5.2	32	6.54
Larks	3	0.84	04	2.08	50	10.22

Table 4. Number of damage causing incidents involving various critical species for the period from 2005 to 2018.

Species	Incidents with damage	Incidents with No damage	Total incidents	Percentage of damage	Accidents (Crashes)	Remarks
Black Kite	52	33	85	61.17	3	02 Fatal accidents
Bats	32	36	68	47.05		12 types of species
Lapwings	27	46	82	32.92		Group of 03 species
Swifts	16	59	75	21.33		Group of 04 species
Rock Pigeons	13	27	40	32.50		
Lark	13	39	52	25.00		Group of 08 species
Thick-knee	11	11	23	52.17	1	Night crash
Sparrow	11	11	22	50.00		
Swallows	10	50	60	16.66		Group of 06 species
Dove	7	13	20	35.00		Group of 03 species
Cattle Egrets	7	20	27	25.92		
Small birds#	6	2	8	75.00#		
Indian Roller	4	14	18	22.22		
Others	89	149	238	37.39	3*	86 different species.
Total	307	-	535	-	7**	-

* Crashes involved a Marsh Harrier, Honey Buzzard and Plovers (in one accident each)..
** Species could not be identified in one crash which is not included in this data
# Species identification has not been reasonable for this group. It is expected to include Larks, Swallows, Swifts, Sparrows and other birds. Hence, this group is excluded for comparison of percentage of damage causing incidents. But, information is provided here for an overall appreciation.

Table 5. Number of wildlife strikes in various zones/ locations

Zone	Number	Percentage
Sanitised zone*	336	25.46
Outside sanitised zone	186	13.97
Unknown location	806	60.55

* Explained in materials and methods.

3.5 Species Identified in WS in IAF

Species identified in WS with IAF aircraft during the period between 2005 and 2018 are listed in the Appendix A. This list gives a general idea of the species which exists in airfield area as well as in the areas where aircraft flies.

4. DISCUSSIONS

4.1 Species Diversity

The number of species identified as involved in the WS in each time period has increased considerably from 67 in the first period of 23 years to 76 in the second time period of 17 years. Number of species indentified nearly doubled to 136 (115 birds, 12 Bats, 06 ground mammals and 03 insects) in third period of nine years. This may be attributed to two reasons, namely the actual increase in diversity of airfield birds and due to adoption of advanced identification techniques such as DNA Barcoding.

The former probable reason of increased bird diversity in the airfields cannot be fully validated. But, there are few indicators available. In Agra, 75 bird species were listed in the check list[16] prepared by BNHS during their comprehensive study. As per the internal study conducted by IAF in May 2009 (conducted for ten days), 92 species were recorded. Similarly, 115 species were recorded by BNHS at the Gwalior airfield in 1989[16]. An internal study of IAF in 2007 recorded 110 species. (Observations by a Bird watcher from 2004-07 showed a total of 145 including 110 of previous reference). However, the list didn't include 21 species which were there in the 1989 BNHS list indicating that there were species which have left the airfield area and there are more species which have occupied the void created by those species which left the area. These can only be used as general indicators and not as precise scientific conclusions as only the spotting of species were recorded over different observation periods. The numbers of individuals and their frequency of each species have not been recorded in a systematic way.

The other probable reason of better identification techniques such as DNA Barcoding has certainly contributed to the increase in number of species identified for WS. A huge number of samples were identified for Swallows (60 samples involving 05 species of Swallows) and Swifts (75 samples involving four species). Within the category of Bats, 68 samples were identified involving 10 species. Most of these have been achieved with minute blood stain samples. This is a clear indication of the contribution of the DNA Barcoding technology. In fact, the current success rate of sample identification is around 36.62 %. There is a scope to identify more species if the success rate increases.

4.2 Damage Caused by Various Species

Of the cases in which species is identified (for the period 2005-2018), 196 of 535 cases resulted in damage to the aircraft. This amounts to around 36%. As per the ICAO report for the period 2008-2015, the civil aviation suffered damage in 34% of the wildlife strikes[3]. Although, the percentage shows only marginal difference, it may be noted that the IAF data is being considered only for the incidents in which species has been identified. Considering the same, it is imperative that IAF is reporting larger percentage of WS without damage. This may be due to higher vulnerability that exists in the Indian sub-continent or due to systematic reporting culture in IAF. It also points to the probability of involving small and less damage causing birds (such as Swallows and Swifts) in WS while carrying out military maneuvers at low heights.

The results show that 55 percent of incidents (with damage) involve just three species namely Black Kites, Bats and Lapwings. These are required to be considered as ‘Most hazardous species’ for the management purpose. Another 34.85% is contributed by Swift, Swallows, Thick-knee, Sparrow, Doves, Egrets, Rollers and few unidentified small birds (must have been Larks, Pipits, Munias, Swallows or Swifts). These may be considered as ‘Moderately hazardous birds’ for management purpose. Considering the variety of 86 species which contribute to 28% of damage, all other birds may be considered as ‘Least hazardous species’. This categorisation will enable the wildlife hazard managers to prioritise their activity and optimise their time and resources. Similar categorisation of species has been proposed by other researchers[15].

4.3 WS in Different Zones

The percentage of WS among the three categories namely within the Sanitised zone (area where dedicated personnel are deployed for observing, reporting and scaring away the birds- mainly constituting the runway area and approach paths), Outside the sanitised zone and at unknown location were analysed. They were observed to be 336 (25.46%), 186 (13.97%) and 806 (60.55%) respectively.

For a cursory look, the first two figures seem to contradict the concept of sanitisation. It is expected that less number of BS should take place in sanitised zone. However, there is a large number of BS in the category of BS at unknown location. This may be due to occurrence of BS outside the sanitised zone, but the impact not felt by pilot. On the other hand, BS in a sanitised zone is observed by many people on ground who keep vigilant eyes on the aircraft. BS is accounted in sanitised zone, even if the pilot does not perceive the strike, but is observed by the Bird Watchers.

Although ICAO does not use the same terms, a report[4] indicates 4% strikes in En-route phase and 5% at unknown locations. On the other hand, IAF has nearly 14% of WS at locations outside the sanitised zone (corresponds to location away from aerodrome). IAF data indicates nearly 60% of the incidents to be taking place at unknown locations whereas the civil data indicates a small quantum of 5%. There is a huge variation in this regard. The probable reasons can be involvement of smaller birds which do not give an indication when they strike, huge noise of the aircraft and deeper engagement of pilots in the cockpit towards mission.

While much of the literature on WS makes a statement that strikes takes place during the landing and takeoff, the actual reality may be much different as the location of strike is not known in more than 60% of the strikes, especially in the military flying. Situation of Civil aircraft and Military aircraft may be different in this case; military aircrafts have to do more low level flights compared to civil flights. Civil aircrafts generally come in conflict with avian flying zones mostly during the landing and takeoffs only.

4.4 Need for Scientific Reporting

Proper identification of the species is critical in planning and managing the wildlife hazards to aircrafts. Most of the time identity of the species will be difficult due to the extensive damage of the specimen or mostly even lacking the actual specimen except some blood stains or a couple of feather samples. There is a need for proper collection of appropriate samples for the right identification of the species. Currently, success of identification of species stands at around 36% (internal study). As of now, the modules/ measures designed and implemented caters only for 40% of the strikes and continues to fail the remaining 60% of the strikes. Hence, a scientific way of reporting is the first step towards designing any scientific module for mitigation of the hazard. This aspect has been acknowledged by FAA (of USA) and has instituted an award for qualitative reporting by aerodromes[25].

4.5 Analysis of WS Numbers

In addition to the data available in the Table 1, data available from another source[26] gives the number of WS for the year 2017 and 2018 as 1,125 and 1,244 respectively. This data was not included in the table as the number of strikes involving damage was not available. But, the data is very pertinent as it shows doubling of the number of incidents from 607 (in 2012) to 1244 (in 2018) in a span of seven years. On the contrary, USA took twelve years to double their incidents from 7,046 in 2005 to 14,503 in 2017. While all the measures instituted by USA may not be applicable or practical in India, a balanced review of policy will certainly help in reducing the pace WS growth. The first step to be initiated is to establish a dedicated body to monitor the issue and publicise the data after necessary analysis.

The number of crashes (or Hull loss accidents) and fatalities have reduced drastically within IAF. The crashes have reduced from 2.08 per year in the first block to 01 per year in the second block of period. This has further reduced to one per three year in the last block which is considered as a great improvement. The fatalities have also reduced from 17 to 5, and then to 01 in three successive time periods. (In fact, the one fatality in the last period was due to an attempt made by the pilot to maneuver the aircraft away from the civil population area during which he lost the height). Some of the probable causes for the reduction are listed below:

- Change in the bird environment due to reduction of Vultures in the sky.
- Increased awareness and initiation of bird ecological studies.
- Creation of dedicated organisational structure with Safety

Officers and Bird Hazard Combat Teams.

- Extensive use of acoustic scaring devices.
- Environmental modifications within the airfield such as vegetation management.
- Establishment of modern slaughter houses at different cities and Solid Waste Management plants at different cities.
- Constant study of bird environment and implementation of Red and Green periods (Restricted and open periods for operations) within IAF.
- Establishment of an in-house Ornithology Cell to constantly monitor the bird environment changes and implementation of anti-WS strategies.
- Adoption of latest forensic technology such as DNA Bar coding for identification of species involved.

While the numbers are increasing leading to damages and financial losses from the perspective of the operators, the service providers in civil sector (Airport authorities) look at the problem from a different perspective. They measure the rate of WS (Number of WS per 10,000 movements) which is fairly consistent over the years. As per DGCA's Annual safety report-2017, the target given to airports was to achieve was 4.44 BS per 10,000 movements and the airports achieved 3.75. Nevertheless, the rising numbers are a serious concern for the operators due to high costs of damage and indirect costs. Operational restrictions such as blocking of runway and returning of aircraft are also acknowledged by service providers and they also intend to bring down the problem.

4.6 Economic Considerations

While the numbers of crashes are coming down, in the records of IAF it does not really correlate to reduction in economic losses. It is pertinent to note that the economic loss for the IAF due to last BS accident is approximately Rs. 08 crores. However, with the induction of modern aircraft with superior technologies, even moderate damage can cause considerable financial loss. For example, specific damage to certain blades of SU-30 MKI will cost us approximately Rs. 07.50 crores. On similar lines, a bird strike to an F-35B stealth bomber of US Marines on 07 May 2019 in Japan costed more than $2 million, though did not result in a crash[27]. Hence, as far as economic losses are considered, we are almost at the same level or even more deteriorated, though the reduction in mere numbers of damaged incidents may seem satisfactory.

5. CONCLUSION

As the number of flights increase in the airspace, the problem of their collision with birds (and wildlife in general) will also increase. WS is a peculiar problem which demands constant assessment and novel methods to tackle the hazard. In the civil aviation sector, the wildlife strikes recorded every year is increasing. In IAF, the crashes due to WS are becoming less but total strikes and the economical losses continue to rise. The number of species involved in WS is increasing making the analysis and implementation of prevention measures difficult. This study has analysed the species and damage data intensively and ranked the hazardous species. Black Kites, Bats and Lapwings top the list indicating that the measures against these animals should be given due priority. The analysis indicates that there is scope for enhancing the quality of reports and species identification success rates. The study also highlights the advantages of adopting latest technology like DNA Bar-coding to help in comprehending the problem in a detailed manner. Continued studies in this field will help aviation sector to find solutions which are economically viable and ecologically sustaining. It will also help in keeping the anti-bird measures up to date as the bird environment is highly dynamic and vulnerability of each species keeps changing over a period of time. Organisational developments would include establishing a dedicated national body for collating the data in a standard manner, monitor the problems, analyse the data and develop ecological/ administrative tools for reduction of the problem. The body can also be a central agency for coordinating with international organisations.

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Dr Yamini Singh has received her PhD in Biotechnology from Jiwaji University Gwalior. Presently working as a Scientist 'E' in DRDO-Defence Institute of Physiology & Allied Sciences, Delhi. She has 15 research publications in her credit. She has 03 patents in her contribution. Her current research include genetic studies on enhancement of human performance at high altitude, High altitude genetic adaptability and high altitude susceptibility such as high altitude pulmonary edema (HAPE). She is involved in mitochondrial DNA sequence variation analysis, DNA barcoding for identification of avian species striking, bioinformatic analysis.
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Appendix A

Species Identified in Wildlife Strikes with IAF Aircraft (2005-2018)

Note:

(i) The nomenclature followed is as per 'A field guide to the birds of India, Sri Lanka, Pakistan, Nepal, Bhutan, Bangladesh and Maldives' by Krys Kazmierczak and Ber van Perlo (2006)[28].

(ii) The initial results of species identification from blood samples through DNA Bar coding were from different labs such as NCCS, LaCONES and DIPAS. Ornithology Cell sought clarifications on some of the species which were not existent in India. In such cases, the species for which next highest base pair matching was available was considered. However, the data is built up over almost a decade. Same process has not been done for all samples and some assumptions have been made to match the species which have distribution in India.

Birds

Common Name	*Scientific Name*
Asian Koel	*Eudynamys scolopaceus*
Asian Openbill	*Anastomus oscitans*
Black Kite	*Milvus migrans*
Black-shouldered Kite	*Elanus axillaris*
Brahminy Kite	*Haliastur Indus*
Oriental Honey-buzzard	*Pernis ptilorhynchus*
Long-legged Buzzard	*Buteo rufinus*
White-eyed Buzzard	*Butasturteesa*
Cattle Egret	*Bubulcus ibis*
Intermediate Egret	*Ardea intermedia*
Common Hoopoe	*Upupa epops*
Common kestrel	*Falco tinnunculus*
Common Moorhen	*Gallinula chloropus*

Common Name	*Scientific Name*
Great Cormorant	*Phalacrocorax carbo*
Indian Courser	*Cursorius coromandelicus*
Temminck's Courser	*Cursorius temminckii*
House Crow	*Corvus splendens*
Large-billedCrow	*Corvus macrorbynchos*
Common Hawk Cuckoo	*Hierococcyx varius*
Eurasian Collared Dove	*Streptopelia decaocto*
Laughing Dove	*Spilopelia senegalensis*
Spotted Dove	*Spilopelia chinensis*
Black Drongo	*Dicrurus macrocercus*
Common Shelduck	*Tadorna tadorna*
Tufted Duck	*Aythya fuligula*
Short-toed Snake Eagle	*Circaetus gallicus*
Steppe Eagle	*Aquila nipalensis*

Common Name	*Scientific Name*
Tawny Eagle	*Aquila rapax*
White-bellied Sea Eagle	*Haliaeetusleucogaster*
Eurasian Hobby	*Falco subbuteo*
Eurasian Skylark	*Alauda arvensis*
Amur Falcon	*Falcoamurensis*
Common Rosefinch	*Carpodacus erythrinus*
Lesser Flamingo	*Phoeniconaias minor*
Black Francolin	*Francolinus francolinus*
Grey Francolin	*Francolinus pondicerianus*
Green Bee-eater	*Merops orientalis*
Eurasian Marsh Harrier	*Circus aeruginosus*
Pallid Harrier	*Circus macrourus*
Eurasian Sparrowhawk	*Accipiter nisus*
Eurasian Sparrowhawk	*Accipiter nisus*
Black-crowned Night Heron	*Nycticorax nycticorax*
House Sparrow	*Passer domesticus*
Red-naped Ibis	*Pseudibis papillosa*
Indian Peafowl	*Pavo cristatus*
Indian Pond Heron	*Ardeola grayii*
Red-headed Vulture	*Sarcoramphus calvus*
Common Kingfisher	*Alcedo atthis*
Northern Lapwing	*Vanellus vanellus*
Red-wattled Lapwing	*Vanellus indicus*
Yellow-wattled Lapwing	*Vanellus malabaricus*
Ashy-crowned SparrowLark	*Eremopterix griseus*
Crested Lark	*Galerida cristata*
Desert Lark	*Ammomanes deserti*
Oriental Skylark	*Alauda gulgula*
Greater Short-toed Lark	*Calandrella brachydactyla*
Sykes's Lark	*Galerida deva*
Common House Martin	*Delichon urbicum*
Pale Martin	*Riparia diluta*
Sand Martin	*Riparia riparia*
Bank Myna	*Acridotheres ginginianus*
Common Myna	*Acridotheres tristis*
Indian Nightjar	*Caprimulgus asiaticus*
Nightjar Sp.	*Caprimulgus Sp.*
Savanna Nightjar	*Caprimulgus affinis*
Barn Owl	*Tyto alba*
Eurasian Eagle Owl	*Bubo bubo*
Eagle Owl	*Bubo Sp*
Alexandrine Parakeet	*Psittacula eupatria*
Rose-ringed Parakeet	*Psittacula krameri*
Spot-billed Pelican	*Pelecanus philippensis*

Common Name	*Scientific Name*
Rock Pigeon	*Columba livia*
Richard's Pipit	*Anthus richardi*
Tawny Pipit	*Anthus campestris*
Greater Sand Plover	*Charadrius leschenaultia*
Kentish Plover	*Charadrius alexandrines*
Little Ringed plover	*Charadrius dubius*
Long-billed plover	*Charadrius placidus*
Common Quail	*Coturnix coturnix*
Common Redshank	*Tringa tetanus*
European Roller	*Coracias garrulous*
Indian Roller	*Coracias benghalensis*
Chestnut-bellied Sandgrouse	*Pterocles exustus*
Shikra	*Accipiter badius*
Bay-backed Shrike	*Lanius vittatus*
Great Grey Shrike	*Lanius excubitor*
Siberian Stonechat	*Saxicola maurus*
Pintail Snipe	*Gallinago stenura*
Little Stint	*Calidris minuta*
Painted Stork	*Mycteria leucocephala*
Barn Swallow	*Hirundo rustica*
Red-rumped Swallow	*Cecropis daurica*
Striated Swallow	*Cecropis striolata*
Wire-tailed Swallow	*Hirundo smithii*
Swallow Sp.	
Alpine Swift	*Tachymarptis melba*
House Swift	*Apus nipalensis*
Little Swift	*Apus affinis*
Eurasian Teal	*Anas crecca*
Cotton Teal	*Nettapus coromandelianus*
Gull-billed Tern	*Gelochelidon nilotica*
Roseate Tern	*Sterna dougallii*
Eurasian Thick-knee	*Burhinus oedicnemus*
Tree Pipit	*Anthus trivialis*
Egyptian Vulture	*Neophron percnopterus*
Slender-billed Vulture	*Gyps tenuirostris*
White-rumped vulture	*Gyps bengalensis*
White Wagtail	*Motacilla alba*
Blyth's Reed warbler	*Acrocephalus dumetorum*
Grasshopper warbler	*Locustella naevia*
Hume's Leaf Warbler	*Phylloscopus humei*
Paddyfield Warbler	*Acrocephalus Agricola*
Western Crowned Warbler	*Phylloscopus occipitalis*
Isabelline Wheatear	*Oenanthe isabellina*
Zitting Cisticola	*Cisticola juncidis*

Mammals -Bats (Flying Mammals)

Common Name	*Scientific Name*
Indian Flying Fox	*Pteropus medius*
Japanese House Bat	*Pipistrellus abramus*
Greater Asiatic Yellow Bat	*Scotophilus heathii*
Cadorna's Pipistrelle	*Hypsugo cadornae*
Chinese Noctule	*Nyctalus plancyi*
Egyptian Free-tailed Bat	*Tadarida aegyptiaca*
Lesser Asiatic Yellow Bat	*Scotophilus kuhlii*
Long-winged Tomb Bat	*Taphozouslongimanus*
Naked-rumped Tomb Bat	*Taphozous nudiventris*
Tickell's Bat	*Hesperoptenus tickelli*
Egyptian Tomb Bat	*Taphozous perforates*
Wrinkle-lipped Free-tailed Bat	*Chaerephon plicatus*

Mammals – (Ground Mammals)

Common Name	*Scientific Name*
Dog	*Canis lupus familiaris*
Wild Boar	*Sus scrofa*
Rhesus macaque	*Macaca mulatta*
Blue bull (Nilgai)	*Boselaphus tragocamelus*
Jackal	*Canis aureus*
Porcupine	*Erethizon dorsatum*

Insects

Common Name	*Scientific Name*
Dragonfly	*Anisoptera Sp.*
Beetle	*Coleoptera Sp.*
Brown planthopper	*Nilaparvata lugens*