BEFORE THE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE, CHENNAI

Original Application No. 102 of 2021 (SZ)

With

Original Application No. 02 of 2020 (SZ)

IN THE MATTER OF:

S. Kumaradasan,
Vice President,
Velachery, Chennai …Applicant(s)

Versus

The Government of Tamil Nadu,
Chief Secretary, Chennai and Others …Respondent(s)

With

Tribunal on its own motion SUO MOTU based
On the News Item in Dinamalar Tamil newspaper,
"Velachery lake-full due to Monsoon" Plea for preventing
sewage waste get mixed in the lake.

And

The Government of Tamil Nadu,
Rep by its Chief Secretary and Others …Respondent(s)

TYPEDSET FILED BY THE 2ND RESPONDENT- WATER RESOURCES DEPARTMENT

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(**Note:** The page numbers are at the bottom of every page)

Through
Dr. D. Shanmuganathan
Standing Counsel For Government of Tamil Nadu
National Green Tribunal
Southern Zone
DATE: 16.02.2026

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ANNEXURE 1

IN THE HIGH COURT OF JUDICATURE AT MADRAS

DATED : 22.10.2025

CORAM

THE HONOURABLE MR. JUSTICE **S.M.SUBRAMANIAM**
AND
THE HONOURABLE MR. JUSTICE **MOHAMMED SHAFFIQ**

O.S.A. No.335 of 2025

1.The State of Tamil Nadu rep. By its
Principal Secretary to Government,
Revenue and Disaster Management
Department, Fort St. George,
Chennai – 600 009.

2.The District Collector,
Chennai District,
Collectorate of Chennai,
Singaravelar Maaligai,
62, Rajaji Salai, Chennai – 600 001. ... Appellants

Vs.

1.Madras Race Club,
A Company registered under the
Companies Act, 1913 rep. By
its Secretary S.Nirmal Prasad
having its office at Guindy,
Chennai – 600 032.

2.Tamil Nadu Race Horse Owners Association
rep. By its Secretary,
Madras Race Club, Owner's Lounge,
Guindy, Chennai – 600 032.

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3.Tamil Nadu Race Horse Trainers Welfare
Association rep. By its
General Secretary,
Madras Race Club,
Guindy, Chennai – 600 032.

4.Madras Race Club Staff Welfare
Association rep. By its Secretary,
No.12, Parasuramar Street,
Gandhi Salai, Velachery,
Chennai – 600 042. ... Respondents

For Appellants	:	Mr.P.Wilson, Senior Counsel for Mr.D.Ravichander, Special Government Pleader
For Respondents	:	Mr.P.H.Arvindh Pandian, Senior Counsel for Mr.Vaibhav R.Venkatesh for R1

ORDER

(Order of the Court was made by **S.M.Subramaniam J.**)

State of Tamil Nadu represented by its Principal Secretary to Government, Revenue and Disaster Management Department and the District Collector, Chennai are appellants in the present Original Side Appeal. The appeal is directed against the impugned order passed in O.A.No.401 of 2025 in C.S.No.81 of 2025. The suit has been instituted by the first respondent/Madras Race Club against the State of Tamil Nadu to declare G.O.(Ms.)No.343 Revenue and Disaster Management Department dated

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06.09.2024 terminating the lease and the consequential letter and notice issued by the Government of Tamil Nadu as null and void and consequential relief of permanent injunction was also sought for.

2. O.A. No.401 of 2025 has been filed not to dispossess the first respondent/plaintiff from the suit schedule property.

3. An interim order of *'status quo'* was granted by the learned single Judge of this Court. Counter Affidavit and Additional Counter Affidavit have been filed. It is submitted by the State that operation of order of status quo is impeding the works relating to development and strengthening of ponds, apart from the proposed Eco Park. The order of status quo would adversely impact public at large since all works have come to a stand still, moreso, with the onset of monsoon and heavy rains being forecast over the next few weeks. It was submitted that the application was heard and orders reserved by the learned Judge on 18.08.2025. Since orders are not pronounced State is compelled to file this appeal, else in view of the impending rains the order of status quo would adversely affect public interest.

4. C.M.P. No.25695 of 2025 has been filed to condone the delay of 74 days in filing the Original Side Appeal. The matter was taken up for hearing by this Bench on 17.10.2025. The State raised their apprehension that since the

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monsoon has arrived and heavy rain fall being forecast by the Meteorological Department throughout the State, order of status quo is impeding the State from initiating swift/necessary action to avoid flooding and preserve rain water in the public interest.

5. Learned counsel appearing on behalf of the first respondent, while arguing the condonation of delay petition, made a submission that the first respondent/Madras Race Club has no objection and they will not cause any obstruction to any work relating to strengthening or developing the ponds as it is in public interest. Considering the pleadings and arguments, delay of 74 days in filing the Original Side Appeal was condoned by this Court on 17.10.2025.

6. Subsequently, the Original Side Appeal was numbered by the Registry and listed for admission before this Bench today (22.10.2025). The first respondent filed an affidavit seeking for the recusal of one of us (S.M.Subramaniam, J.) from hearing the present case. Since the affidavit has been filed by the first respondent, it necessitated this Court to decide the said issue as a preliminary issue before proceeding any further with the admission of the Original Side Appeal.

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7. Reasons stated in the affidavit are that one of us (S.M.Subramaniam, J.) passed final orders in W.P.Nos.29644 to 29646 of 2017 on 29.03.2023 filed by the first respondent/Madras Race Club. In the said writ order, certain observations were made, which in the view of the first respondent, are adverse findings which are conclusive. It was thus submitted, there is likelihood of bias inasmuch as observations also touch upon validity of the lease entered into between the State of Tamil Nadu and the Madras Race Club several decades back. Second reason being one of us (S.M.Subramaniam, J.) appeared on behalf of one Mr.Jayapoorna Chandra Rao and his family members in a suit filed by the first respondent in C.S.No.366 of 2004. Subsequently, the said Jayapoorna Chandra Rao and his family members had filed another suit in C.S.No.63 of 2005 wherein one of us (S.M.Subramaniam, J.) was engaged by Mr.Jayapoorna Chandra Rao. Respondent Club is a party in both suits.

8. Citing the above reasons, recusal of one of us (S.M.Subramaniam, J.) from hearing the present matter has been sought for.

9. Learned Senior Counsel Mr.P.H.Arvindh Pandian appearing on behalf of the first respondent relied on the affidavit for all the above reasons. He would rely on the judgments rendered in the following cases:

(i) Ranjit Thakur vs. Union of India and Others reported in (1987) 4 SCC 611;

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(ii) State of W.B. And Others vs. Shivananda Pathak and Others reported in (1998) 5 SCC 513;

(iii) Ezsias vs. North Glamorgan NHS Trust reported vide Neutral Citation of Royal Courts of Justice, London in (2007) EWCA Civ 330;

(iv) Supreme Court Advocates on Record Association and Another vs. Union of India (Recusal Matter) reported in (2016) 5 SCC 808; and

(v) My Palace Mutually Aided Cooperative Society vs. B.Mahesh and Others reported in 2022 (5) CTC 244.

10. Per contra, learned Senior Counsel Mr.P.Wilson appearing on behalf of the appellants/State would oppose by stating that the allegations are baseless and made with an ulterior motive of stalling the proceeding. He would submit that deciding a writ petition by a single Judge, does not bar the Judge from being a member of a Division Bench nor supply ground to raise allegation of bias. That apart, the earlier writ petition was filed by the first respondent/Madras Race Club challenging the demand notice issued by the Revenue Tahsildar for recovery of lease amount. In the said writ petition, grounds raised were dealt with by the Court, observations pointed out by learned Senior Advocate for petitioner would not constitute expression of

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opinion thus plea of likelihood of bias raised by first respondent is devoid of merit.

11. Learned Senior Counsel Mr.P.Wilson would rely on the following judgments:

(i) A.Venkatasubbiah Naidu vs. S.Chellappan and Others reported in (2000) 7 SCC 695;

(ii) Subrata Roy Sahara vs. Union of India and Others reported in (2014) 8 SCC 470; and

(iii) N.G. Projects Limited vs. Vinod Kumar Jain and Others reported in (2022) 6 SCC 127.

12. This Court has carefully gone through the findings in the judgments relied on by the respective learned Senior Counsel appearing on behalf of the parties to the *lis* on hand and principles laid down by the Apex Court in the matter of recusal from a case. It would be suffice to deal with the issue raised in the present case by relying on the principles laid down by the Constitution Bench of the Hon'ble Supreme Court of India in ***Supreme Court Advocates on Record Association and Another vs. Union of India (Recusal Matter)*** *reported in* **(2016) 5 SCC 808.** This Court would like to extract the following paragraphs:

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"10. It is one of the settled principles of a civilised legal system that a Judge is required to be impartial. It is said that the hallmark of a democracy is the existence of an impartial Judge.

.....

19. In substance, the Court held that in cases where the Judge has a pecuniary interest in the outcome of the proceedings, his disqualification is automatic. No further enquiry whether such an interest lead to a "real danger" or gave rise to a "reasonable suspicion" is necessary. In cases of other interest, the test to determine whether the Judge is disqualified to hear the case is the "real danger" test.

.....

25. From the above decisions, in our opinion, the following principles emerge;

25.1 If a Judge has a financial interest in the outcome of a case, he is automatically disqualified from hearing the case.

25.2 In cases where the interest of the Judge in the case is other than financial, then the disqualification is not automatic but an enquiry is required whether the existence of such an interest disqualifies the Judge tested in the light of either on the principle of "real danger" or "reasonable apprehension" of bias.

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25.3 The Pinochet case added a new category i.e that the Judge is automatically disqualified from hearing a case where the Judge is interested in a cause which is being promoted by one of the parties to the case."

13. In the context of the principles laid down, this Court has to consider whether the reasons stated in the affidavit filed by the first respondent can be fit in, in any one of the grounds.

14. Learned Senior Counsel Mr.P.H.Arvindh Pandian would agree that one of us (S.M.Subramaniam, J.) has no financial interest in the outcome of the present case. Thus, the first principle is inapplicable.

15. He would rely on the second principle by stating that there is a reasonable apprehension in the mind of the litigant that the issues involved in the appeal may be decided against them. However, he would agree that there is no automatic recusal in the present case but the point on the ground of 'reasonable apprehension' is to be taken into consideration.

16. As far as reasonable apprehension is concerned, this Court has examined the judgment delivered in W.P.Nos.29644 to 29646 of 2017 dated 29.03.2023 and Civil Suit in C.S.No.81 of 2025. Admittedly, civil suit in C.S.No.81 of 2025 has been instituted by the respondent challenging the

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Government Order terminating the lease issued in G.O.(Ms.)No.343 Revenue and Disaster Management Department dated 06.09.2024, which is subsequent to the order passed in the writ petition. The Government letters under challenge were also issued subsequent to the writ order passed by one of us (S.M.Subramaniam, J.). The writ order has been passed by one of us (S.M.Subramaniam, J.) while sitting single in writ jurisdiction. The observations made while disposing the writ petition by the first respondent, in our considered opinion, may not have any bearing nor impact the present issue raised in the present appeal against the order of status quo in C.S.No.81/2025, which is subsequent and against a distinct/new cause of action.

17. Learned Senior Counsel Mr.P.H.Arvindh Pandian had primarily premised his submission rather request for recusal of one of us (S.M.Subramaniam, J.) on the premise that there is a reasonable likelihood of bias and that bias ought to be tested from the standpoint of the litigant and not from that of the Judge. He would submit that the proper approach for the Judge is not to look at his own mind and ask himself, however honestly, “am I biased?”, but to look at the mind of the party before him. There can be no two views on the above aspect. However, it is not every suspicion held by a party that a Judge hearing the proceedings is biased must lead to recusal. Apprehension of bias must be judged from point of view of a healthy and

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reasonable person and not on mere apprehension of a person who is whimsical. Reasonable apprehension, it may be noted, must be based on cogent materials. A lawyer or a litigant should not, rather cannot, form an apprehension of bias on the basis of a remark or observation made by a Judge in course of hearing of a case or in a previous matter involving the same parties decided by the said judge / judicial officer. If every remark of a Judge made from the Bench or observation in an order is to be construed as indicating prejudice, it is afraid most Judges will fail to pass the exacting test. It is not uncommon for judges to express opinions, tentatively formed, sometimes even strongly in the course of hearing; but that does not always mean that the case has been prejudged. This is where experience of a judicially trained mind assumes relevance for it has frequently been noticed that the view expressed by Judges breaks down on a closer examination, and often enough, some judges acknowledge publicly that they were mistaken. It is not uncommon for a Judge to revisit/reconsider an issue and arrive at a different conclusion, a reflection that a Judge is ready to change his view if good and valid reasons are found to exist. The above is an essential attribute which every Judge is expected to possess and imbibe.

18. Viewed in the above background, the observation made in the writ petition challenging a demand notice cannot be a reason to recuse from hearing an appeal against the interim order of a learned Judge in a suit filed

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for declaration of Government Order terminating the lease as null and void. Both are independent and distinct cause of action. There is not even an indirect or a remote connection muchless direct/proximate connection between the issues/subject matter in the writ petition and the suit. Thus the above reason is wholly devoid of merit, rather a pretence to avoid the Bench.

19. With regard to the other submission that of one of us having been engaged against respondent club by Mr.Jayapoorna Chandra Rao in C.S.No.63 of 2005 and C.S.No.366 of 2004. It must be clarified that the matter was transferred from High Court to Civil Court and change of vakalat was given in favour of Mr.A.Sivaji in respect of C.S.No.366 of 2004. While in respect of C.S.No.63 of 2005, the change of vakalat was given in favour of N.S Sivakumar. The allegation of likelihood on the bias that a suit was filed against the respondent club by one of us two decades back is nothing short of an attempt to avoid the bench which I'm a party. If the above reason did raise apprehension of bias, the same ought to have been raised when the writ petition in W.P.No.29644 to 29646 of 2017 was heard and disposed of by one of us. The fact that the petitioner had no objection to the writ petition being heard and absence of any request for recusal would clearly show that the above reason is an after thought and pretence/excuse to avoid the bench wherein I am a party.

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20. The third point is based on ***R. vs. Bow Street Metropolitan Stipendiary Magistrate, ex p Pinochet Ugarte (No.2)*** reported in ***(2000) 1 AC 119,*** relied by the Constitution Bench while proceeding to observe as under:

'20. The Pinochet case added one more category to the cases of automatic disqualification for a judge. Pinochet, a former Chilean dictator, was sought to be arrested and extradited from England for his conduct during his incumbency in office. The issue was whether Pinochet was entitled to immunity from such arrest or extradition. Amnesty International, a charitable organisation, participated in the said proceedings with the leave of the Court. The House of Lords held that Pinochet did not enjoy any such immunity. Subsequently, it came to light that Lord Hoffman, one of the members of the Board which heard the Pinochet case, was a Director and Chairman of a company (known as AICL) which was closely linked with Amnesty International. An application was made to the House of Lords to set aside the earlier judgment on the ground of bias on the part of Lord Hoffman.

21. The House of Lords examined the following questions:

(i) Whether the connection of Lord Hoffman with Amnesty International required him to be automatic
disqualified?

(ii) Whether an enquiry into the question whether cause of Lord Hoffman's connection with

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Amnesty International posed a real danger or caused a reasonable apprehension that his judgment is biased – is necessary?

(iii)Did it make any difference that Lord Hoffman was only a member of a company associated with Amnesty International which was in fact interested in securing the extradition of Senator Pinochet?

22. Lord Wilkinson summarised the principles on which a Judge is disqualified to hear a case. As per Lord Wilkinson -

"The fundamental principle is that a man may not be a judge in his own cause. This principle, as developed by the courts, has two very similar but not identical implications. First it may be applied literally: if a judge is in fact a party to the litigation or has a financial or proprietary interest in its outcome then he is indeed sitting as a judge in his own cause. In that case, the mere fact that he is a party to the action or has a financial or proprietary interest in its outcome is sufficient to cause his automatic disqualification. The second application of the principle is where a judge is not a party to the suit and does not have a financial interest in its outcome, but in some other way his conduct or behaviour may give rise to a suspicion that he is not impartial, for example because of his friendship with a party. This second

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type of case is not strictly speaking an application of the principle that a man must not be judge in his own cause, since the judge will not normally be himself benefiting, but providing a benefit for another by failing to be impartial.

In my judgment, this case falls within the first category of case, viz. where the judge is disqualified because he is a judge in his own cause. In such a case, once it is shown that the judge is himself a party to the cause, or has a relevant interest in its subject matter, he is disqualified without any investigation into whether there was a likelihood or suspicion of bias. The mere fact of his interest is sufficient to disqualify him unless he has made sufficient disclosure......"

And framed the question;

"….the question then arises whether, in non-financial litigation, anything other than a financial or proprietary interest in the outcome is sufficient automatically to disqualify a man from sitting as judge in the cause."

He opined that although the earlier cases have

"all dealt with automatic disqualification on the grounds of pecuniary interest, there is no good reason in principle for so limiting automatic disqualification."

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23. Lord Wilkinson concluded that Amnesty International and its associate company known as AICL, had a non-pecuniary interest established that Senator Pinochet was not immune from the process of extradition. He concluded that,

> *"….the matter at issue does not relate to money or economic advantage but is concerned with the promotion of the cause, the rationale disqualifying a judge applies just as much if the judge's decision will lead to the promotion of a cause in which the judge is involved together with one of the parties" (emphasis supplied)*

24. After so concluding, dealing with the last question, whether the fact that Lord Hoffman was only a member of AICL but not a member of Amnesty International made any difference to the principle, Lord Wilkinson opined that:

> *even though a judge may not have financial interest in the outcome of a case, but in some other way his conduct or behaviour may give rise to a suspicion that he is not impartial....*

and held that:

> *"....if the absolute impartiality of the judiciary is to be maintained, there must be a rule which automatically disqualifies a judge who is involved, whether personally or as a Director of a company, in promoting the same causes in the same organisation as is a party to the suit. There is no room for fine distinctions...."*

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This aspect of the matter was considered in P.D.Dinakaran case.'

21. It was found in ***Pinochet*** case that the issue was whether Pinochet was entitled to immunity from arrest or extradition. Amnesty International, a charitable organisation participated in the proceedings with the leave of the court. House of Lords held that Pinochet did not enjoy any such immunity. It came to light subsequently that Lord Hoffman, one of the members of the Board which heard ***Pinochet*** case was a Director and Chairman of a Company known as A.I.C.L. closely related with Amnesty International. It is in those circumstances that the House of Lords found one of the members was personally interested in a organisation which was a party to the proceeding. Factually, there is no pleading whatsoever as to how one of the Judges, whose recusal is sought for, has any personal or financial interest. In view thereof, relying on ***Pinochet*** principle is misplaced the facts of the present case.

22. Before parting, I must make it clear that the decision not to recuse but proceed to hear the matter was entirely mine. Though, I must state on discussion with my collegue on the Bench, he would also agree that I should not recuse from hearing the matter.

23. It is necessary to bear in mind that faith in the administration of

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justice is one of the pillars on which democratic institution functions and sustains. Faith in the judiciary cannot be permitted to be shaken by wayward and pelting of stones of suspicion by every disgruntled/resented litigant. It is necessary to bear in mind that as per the Third Schedule to the Constitution of India, oath or affirmation is taken by Judges that they will duly and faithfully perform the duties of the office to the best of his ability, knowledge and judgment without fear or favour, affection or ill-will and will so uphold the Constitution and the laws. Request for recusal in the present case cannot be acceded to as laid down by the Constitution Bench. Since as held by the Constitution Bench of Apex Court, if I were to accede to the prayer for my recusal, I would be initiating a wrong practice, and laying down a wrong precedent. A Judge may recuse at his own, from a case entrusted to him by the Chief Justice. That would be a matter of his own choosing. But recusal at the asking of a litigating party, unless justified, must never to be acceded to. For that would give the impression, of the Judge had been scared out of the case, just by the force of the objection. A Judge before he assumes his office, takes an oath to discharge his duties without fear or favour. He would breach his oath of office, if he accepts a prayer for recusal, unless justified. It is my duty to discharge my responsibility with absolute earnestness and sincerity. It is my duty to abide by my oath of office to uphold the Constitution and the laws. My decision to continue to be a part of the Bench, flows from the oath which I took, at the time of my elevation to this Court.

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24. In view of the above reasoning, the affidavit filed seeking recusal of one of us (S.M.Subramaniam, J.) does not merit consideration rather acceding to the above prayer would pave way to forum shopping/bench hunting thus the above prayer for recusal is not acceded to. Thus, this Court intends to proceed with the admission of the Original Side Appeal.

25. Since the interim order of status quo as stated supra would adversely affect public interest, we are inclined to modify the said order and permit the State to carryout all works relating to strengthening/development of pond and any other project of public interest and the respondent club shall co-operate and not obstruct such work. We find support in modifying the order of status quo in Section 41(ha) of the Specific Relief Act, 1963, which provides that an injunction cannot be granted if it would impede or delay the progress or completion of any infrastructure project. It is not in dispute that the strengthening/development of ponds and Eco Park are infrastructure projects sought to be implemented by the Government in larger public interest, in view thereof the order of status quo stands modified as provided *supra*.

26. Admit. Mr.Vaibhav R.Venkatesh, learned counsel accepts notice for the first respondent. Issue notice to respondents 2 to 4 returnable in four weeks. Private notice is also permitted.

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27. Post the matter after four weeks.

[S.M.S., J.] **[M.S.Q., J.]**
22.10.2025

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To

1.The Madras Race Club,
A Company registered under the Companies Act, 1913 rep. By its Secretary S.Nirmal Prasad having its office at Guindy, Chennai – 600 032.

2. The Sub Assistant Registrar,
Original Side,
High Court, Madras.

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S.M.SUBRAMANIAM, J.
AND
MOHAMMED SHAFFIQ, J.

mmi/spp

O.S.A. No.335 of 2025

22.10.2025

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ITEM NO.19 COURT NO.5 SECTION XII

S U P R E M E C O U R T O F I N D I A
RECORD OF PROCEEDINGS

Petition(s) for Special Leave to Appeal (C) No(s). 31175/2025

[Arising out of impugned final judgment and order dated 22-10-2025 in OSA No. 335/2025 passed by the High Court of Judicature at Madras]

MADRAS RACE CLUB Petitioner(s)

VERSUS

THE STATE OF TAMIL NADU & ORS. Respondent(s)

IA No. 274471/2025 - EXEMPTION FROM FILING C/C OF THE IMPUGNED JUDGMENT
IA No. 274470/2025 - PERMISSION TO FILE ADDITIONAL DOCUMENTS/FACTS/ANNEXURES
IA No. 274467/2025 - PERMISSION TO FILE ADDITIONAL DOCUMENTS/FACTS/ANNEXURES
IA No. 274472/2025 - PERMISSION TO FILE LENGTHY LIST OF DATES

Date : 30-10-2025 This matter was called on for hearing today.

CORAM : HON'BLE MR. JUSTICE PAMIDIGHANTAM SRI NARASIMHA
HON'BLE MR. JUSTICE R. MAHADEVAN

For Petitioner(s) :Mr. Gopal Subramanium, Sr. Adv.
Mr. Guru Krishnakumar, Sr. Adv.
Mr. Vaibhav Venkatesh, Adv.
Ms. Gauri Subramanium, Adv.
Mr. K. Shiva, AOR
Mr. Akash Srinanda, Adv.
Mr. Anirudh Sriram, Adv.
Mr. Jayavardhan Singh, Adv.
Mr. Raghav Kohli, Adv.
Mr. Adnan Yousuf, Adv.

For Respondent(s) :Dr. Abhishek Manu Singhvi, Sr. Adv.
Mr. Mukul Rohatgi, Sr. Adv.
Mr. P.Wilson, Sr. Adv.
Mr. Sabarish Subramanian, AOR
Mr. K.s.badhirnathan, Adv.
Mr. Apoorv Malhotra, Adv.
Mr. Lokesh Krishna, Adv.
Mr. Vishnu Unnikrishnan, Adv.
Ms. Jahnavi Taneja, Adv.
Mr. Danish Saifi, Adv.

Signature Not Verified
Digitally signed by KAPIL TANDON
Date: 2025.10.30 18:01:45 IST
Reason:

UPON hearing the counsel the Court made the following

O R D E R

1. Heard the learned senior counsel appearing for the respective parties.

2. While we are not inclined to interfere with the impugned judgment and order passed by the High Court, we clarify that the portion in paragraph no. 25 which reads, "...*permit the State to carryout all works relating to strengthening/development of pond and any other project of public interest and the respondent club shall co-operate and not obstruct such work*....." shall entitle the respondent(s)-State only to create what is required for the eco-park, and will be subject to final decision.

3. The Division Bench of the High Court shall endeavour to dispose of the application(s) expeditiously.

4. With these observations, the Special Leave Petition is disposed of.

5. Pending application(s), if any, shall stand disposed of.

(KAPIL TANDON)
COURT MASTER (SH)

(NIDHI WASON)
ASSTT. REGISTRAR(NSH)

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ANNEXURE 3

IN THE HIGH COURT OF JUDICATURE AT MADRAS

DATED : 25.11.2025

CORAM

THE HONOURABLE MR. JUSTICE **S.M.SUBRAMANIAM**
AND
THE HONOURABLE MR. JUSTICE **MOHAMMED SHAFFIQ**

O.S.A.No.335 of 2025
and
C.M.P. No.25967 of 2025

1. The State of Tamil Nadu,
   Represented by its Principal Secretary to Government,
   Revenue and Disaster Management Department,
   Fort St.George,
   Chennai 600 009.

2. The District Collector,
   Chennai District,
   Collectorate of Chennai, Singaravelar Maaligai,
   62, Rajaji Salai,
   Chennai 600 001. ... Appellants

Vs.

1. Madras Race Club,
   A Company Registered under the Companies Act, 1913,
   Represented by its Secretary S.Nirmal Prasad,
   Having its office at Guindy,
   Chennai 600 032.

2. Tamil Nadu Race Horse Owners Association
   Represented by its Secretary,
   Madras Race Club, Owner's Lounge,
   Guindy, Chennai 600 032.

3. Tamil Nadu Race Horse Trainers Welfare Association,
   Represented by its General Secretary,
   Madras Race Club, Guindy,
   Chennai 600 032.

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4. Madras Race Club Staff Welfare Association,
Represented by its Secretary,
No.12, Parasuramar Street,
Gandhi Salai, Velachery,
Chennai 600 042. ... Respondents

Prayer: Original Side Appeal filed under Clause 15 of the amended Letters Patent read with Order XXXVI Rule 1 of the Original Side Rules to set aside the Impugned "Status Quo" Order dated 04.07.2025 made in O.A.No.401 of 2025 in C.S.No.81 of 2025 and allow the present Original Side Appeal and thus render justice.

For Appellant	:	Mr.P.Wilson, Senior Counsel for Mr.D.Ravichander, Special Government Pleader
For R1	:	Mr.Vaibhav R.Venkatesh
For R2 to R4	:	No Appearance

JUDGMENT

(Judgment of the Court was delivered by *MOHAMMED SHAFFIQ J.*)

The Appeal is directed against the impugned order of "Status Quo" dated 04.07.2025 in O.A.No.401 of 2025 in C.S.No.81 of 2025. Suit in C.S.No.81 of 2025 was instituted by the 1st Respondent/ Madras Race Club to declare G.O.Ms.No.343 Revenue and Disaster Management Department dated 06.09.2024 terminating the lease dated 08.03.1946 for an extent of 160.86 acres in Venkatapuram, Adyar and Velachery Villages of erstwhile Chengalpattu District now in Chennai District and the consequential letter and

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notice issued by the Government of Tamil Nadu as null and void. In the said suit an Original Application in O.A.No.401 of 2025 was filed with the prayer not to dispossess Plaintiff/1st Respondent herein, from the suit scheduled property. An interim order of "Status Quo" was granted by the learned Judge in O.A.No.401 of 2025. Thereafter the said application was finally heard and orders reserved by the learned Judge on 18.08.2025. It was submitted, since it was taking time for pronouncing order in the said application, State filed the present Original Side Appeal, compelled by the impending rains, inasmuch as the order of "Status Quo", if were to continue would adversely impact the works commenced by the State in the suit scheduled property, which inter alia included development/strengthening of four ponds and an Eco Park conceived in larger public interest.

1.1. On hearing both sides this Court vide order dated 22.10.2025 modified the above order of "Status Quo" as under:

> *"25. Since the interim order of status quo as stated supra would adversely affect public interest, we are inclined to modify the said order and permit the State to carryout all works relating to strengthening/development of pond and any other project of public interest and the respondent club shall co-operate and not obstruct such work. We find support in modifying the order of "Status Quo" in Section 41(ha) of the Specific Relief Act, 1963, which provides that an injunction cannot be granted if it would impede or delay the progress or completion of any infrastructure project. It is not in dispute that the strengthening/development of ponds and Eco Park are infrastructure projects sought to be*

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implemented by the Government in larger public interest, in view thereof the order of "status quo" stands modified as provided supra."

1.2. Aggrieved, Respondent Race Club filed a Special Leave to Appeal in S.L.A.No(s).31175 of 2025 dated 30.10.2025. The above Special Leave Petition was disposed of with the following observations:

> *"2. While we are not inclined to interfere with the impugned judgment and order passed by the High Court, we clarify that the portion in paragraph no. 25 which reads, "...permit the State to carryout all works relating to strengthening/development of pond and any other project of public interest and the respondent club shall co-operate and not obstruct such work....." shall entitle the respondent (s)-State only to create what is required for the eco-park, and will be subject to final decision.*
>
> *3. The Division Bench of the High Court shall endeavour to dispose of the application(s) expeditiously.*
>
> *4. With these observations, the Special Leave Petition is disposed of.*
>
> *5. Pending application(s), if any, shall stand disposed of."*

1.3. Thereafter, a Civil Miscellaneous Petition in C.M.P.No.27415 of 2025 came to be filed. Learned counsel for Respondent Club raised a preliminary objection stating that in terms of the directions of the Supreme Court the application i.e., O.A.No.401 of 2025 ought to be heard by the Single

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Judge and would suggest that the expression “Division Bench” in para 3 of the order of Supreme Court was intended and only meant the Single Judge. In other words, it was submitted that the expression “Division Bench” in para 3 of the order dated 30.10.2025, of the Apex Court is an inadvertent error and would submit that this bench ought to confine itself to the Original Side Appeal, lest the Respondent Club may lose one tier of adjudication/Appeal. On the other hand it was submitted by the learned Senior Advocate appearing on behalf of the State that the Supreme Court had directed the Division Bench to dispose of the application expeditiously, i.e., O.A.No.401 of 2025.

1.4. We do not propose to examine the above question for the present, since the counsel for Respondent, sought time to obtain a clarification on the above aspect from the Apex Court. We shall thus proceed to deal with the Original Side Appeal, wherein the order of "Status Quo" granted by the Single Judge is under challenge.

1.5. It was submitted by the learned senior advocate appearing for the Appellant State that the order of "Status Quo" impedes/hinders the development in strengthening of ponds and the Eco Park which are environmental projects conceived and sought to be implemented in public interest. The above works namely creation of Ponds and development of Eco park are conceived as part of flood mitigation measures initiated by the State. He would reiterate that the State has already dug four Ponds on the suit schedule property to store excess rainwater, mitigating inundation in areas

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such as Velachery, Adambakkam, Madipakkam, and Guindy and proposes to excavate/develop additional ponds. The learned senior advocate would further submit that the State intends, to construct an Ecological Park (Eco Park), through the Horticulture Department on the suit schedule property, proposed/ intended to be utilized as a water storage area. That apart the Eco Park project is also intended/ conceived to promote tourism and to serve as a green cover and lung space for Chennai. This, it is submitted would increase the ground water table and improve hydrological cycle, which in turn would mitigate adverse impact due to climatic change.

1.6. The learned counsel for the Respondent on the other hand would confine his submissions to the scope of the orders of the Hon'ble Supreme Court, contending that, by virtue of the order dated 30.10.2025 of the Apex Court, the remedy sought for in the Original Side Appeal has, in effect, worked itself out.

2. Having heard both sides, this Court is of the view that the order of "Status Quo" dated 04.07.2025, of the learned Judge hinders/impedes the State from carrying out works related to strengthening/development of the four ponds which has admittedly been excavated and development of Eco park. The above order of "Status Quo" warrants interference for following reasons:

<u>A. Studies/papers would reveal how Chennai has been ravaged due to floods</u>

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in recent past – highlighting the need for immediate flood mitigation measures.

3. There have been several studies about the adverse impact of rains and consequential impact of floods due to change in topography in view of mushrooming of constructions in marsh lands/wetlands around the city of Chennai. However, we shall for the purpose of the present Appeal refer to one such Report Titled *"Chennai Floods 2015 – A Rapid Assessment",* prepared by the Interdisciplinary Centre for Water Research, IISc, Bangalore (May 2016) from a reading of the above report would indicate the following :-

3.1 The Report records that the floods of November–December 2015 resulted in large-scale devastation across Chennai, Kancheepuram and Tiruvallur, claiming more than 400 lives, with the State subsequently reporting a total of 470 fatalities during the North-East monsoon. As per the Report, over 4 million people were affected, nearly 1.8 million were displaced, and 1.7 million persons were accommodated in 6,605 relief camps. The estimated economic loss was approximately USD 3 billion. More than 3.042 million families suffered total or partial damage to their dwellings, over 100,000 structures were damaged, and nearly 30% of Chennai households incurred individual losses ranging between Rs.2 lakhs and Rs.20 lakhs.

3.2. The Report further records that industrial and commercial operations in the region came to a complete standstill, with the Chennai Airport remaining closed between 1st and 6th December, and losses arising solely from halted industrial production estimated at nearly Rs.15,000 crores.

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Essential commodities such as milk, water, vegetables, fuel and transport became critically scarce. The Report additionally notes the destruction of 3,82,768 hectares of crops and the loss of nearly 98,000 livestock and poultry. The magnitude of the event, as documented, underscores the urgent necessity for planned ecological buffers, sustainable land-use measures and flood-resilient infrastructure.

3.3. We are informed that in the suit schedule property 4 ponds have been dug/excavated already and requires to be strengthened/developed. State has commenced preparatory work insofar as the proposed Eco park. The above 4 ponds along with proposed additional ponds once fully developed and functional would mitigate adverse impact of floods in and around the suit schedule property including Velachery, Adambakkam, Madipakkam, Guindy, Pallikaranai and adjoining areas.

3.4. The proposed Eco park with regard to which the State has already commenced preparatory work which *inter alia* is proposed to include the following infrastructure such as sponge ponds, small ponds and water bodies is intended to act as water storage structures which would mitigate adverse impact of floods. That apart Eco park it is submitted is intended to promote tourism, maintain ecological balance, improve air quality and reduce pollution.

3.5. The above submissions on the objective behind development of ponds and Eco park as part of flood mitigation measures to alleviate the adverse impact of floods would serve and promote larger public interest. This

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underscores prima facie the need to ensure that the above works are not hindered in any manner, moreso by judicial orders.

B. Climate change – extreme weather – its impact.

4. One another aspect to which we cannot turn a blind eye are recent episodes of torrential rainfall in Chennai, which resulted in severe flooding. These events are not isolated but form part of a recurring pattern of extreme weather attributable to climate change. In this regard it may be relevant to refer to the case of Supreme Court in M K Ranjitsinh & Ors v. Union of India & Ors.,[1] wherein the Supreme Court after referring to the case of *Virender Gaur v. State of Haryana*[2], underscored the heightened constitutional obligations of the State in addressing climate-related risks and relied upon various UN climate reports. The relevant portion of the judgment is extracted hereunder:

> *“22. In Virender Gaur v. State of Haryana, this Court recognised the right to a clean environment in the following terms:*
> *“7. … The State, in particular has duty in that behalf and to shed its extravagant unbridled sovereign power and to forge in its policy to maintain ecological balance and hygienic environment. Article 21 protects right to life as a fundamental right. Enjoyment of life and its attainment including their right to life with human dignity encompasses within its ambit, the protection and preservation of environment, ecological balance free from pollution of air and water, sanitation without which life cannot be enjoyed. Any contra acts or actions would cause environmental pollution. Environmental, ecological, air, water, pollution, etc. should be regarded as amounting to violation of Article 21. Therefore, hygienic environment is an integral facet of right to healthy life and it would be impossible to live with human dignity without a humane and healthy environment. Environmental*

1. 2024 SCC OnLine SC 570
2. (1995) 2 SCC 577

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protection, therefore, has now become a matter of grave concern for human existence. Promoting environmental protection implies maintenance of the environment as a whole comprising the man-made and the natural environment. Therefore, there is a constitutional imperative on the State Government and the municipalities, not only to ensure and safeguard proper environment but also an imperative duty to take adequate measures to promote, protect and improve both the man-made and the natural environment.

.....

29. Of late, the intersection between climate change and human rights has been put in sharp focus, underscoring the imperative for states to address climate impacts through the lens of rights. For instance, the contribution of the UN High Commissioner for Human Rights to the 2015 Climate Conference in Paris emphasized that climate change directly and indirectly affects a broad spectrum of internationally guaranteed human rights. States owe a duty of care to citizens to prevent harm and to ensure overall well-being. The right to a healthy and clean environment is undoubtedly a part of this duty of care. States are compelled to take effective measures to mitigate climate change and ensure that all individuals have the necessary capacity to adapt to the climate crisis.

30. This acknowledgment of human rights in the context of climate change is underscored in the preamble of the Paris Agreement, which recognizes the interconnection between climate change and various human rights, including the right to health, indigenous rights, gender equality, and the right to development: "Acknowledging that climate change is a common concern of humankind, Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity."

31. The 2015 United Nations Environment Programme report also outlined five human rights obligations related to climate change, including both mitigation and adaptation efforts. In 2018, the UN Special Rapporteur on Human Rights and the Environment emphasized that human rights necessitate states to establish effective laws and policies to reduce greenhouse gas emissions, aligning with the framework principles on human rights

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and the environment.

32. The Inter-American Court of Human Rights issued an advisory opinion in 2017 affirming the right to a healthy environment as a fundamental human right. The IACtHR delineated state obligations regarding significant environmental harm, including cross-border impacts, recognizing the inherent relationship between environmental protection and the enjoyment of various human rights. Violations of the right to a healthy environment can reverberate across numerous rights domains, including the right to life, personal integrity, health, water, and housing, as well as procedural rights such as information, expression, association, and participation

33. In her comprehensive study exploring climate obligations under international law, Wewerinke-Singh underscores the imperative for states to both adapt to and mitigate the impacts of climate change in alignment with human rights principles. This resonates deeply with the burgeoning recognition of the right to a healthy environment as a fundamental human right within the global discourse on environmental protection and sustainability. When discussing the right to a healthy environment, it is crucial to address access to clean and sustainable energy. Clean energy aligns with the human right to a healthy environment, as first recognized by the UN Special Rapporteur on Human Rights and the Environment in 1994."

4.1. The above judgment reinforces the position that the State bears a non-delegable duty to adopt preventive, infrastructural, and regulatory measures to safeguard citizens from foreseeable climate-related harms under Article 21 and its international obligations. We are of the view that the proposed use of the suit schedule property for excavation and development of ponds and Eco park intended to function as lung space, would help maintain ecological balance and hygienic environment by reducing pollution, a step in our view in furtherance of Directive Principles which the State ought to

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endeavour to achieve as part of its Constitutional obligation. This reinforces the need to modify the order of "Status Quo" and permit State to proceed with the work of excavating, strengthening and development of ponds and Eco park.

C. Proposed projects would advance directive principle formulated in Article 39 (b) of the constitution of India.

5. The suit schedule property is admittedly Government land, and is sought to be utilised by the Government to develop projects in public interest and to mitigate losses arising from natural calamities, primarily floods. After having granted lease of suit schedule property measuring an extent 160.86 acres for horse racing and other allied activities which catered to fulfilling the interest of a handful of private individuals/entities, State after finding a range of violations of the lease conditions has terminated the lease and sought to recover dues alleged to be running to hundreds of crores has now resumed the land and has started projects in public interest aimed at sub serving common good.

5.1. At this juncture while not going into the legality or otherwise of the reasons for termination for the present, it is relevant to bear in mind that in terms of Article 39(b) of Constitution, State shall frame policies directed towards securing ownership and control of material resource of the community and ensure it gets distributed as to best sub serve the common good. In this regard it may be relevant to note that the Supreme Court in State of Tamil

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Nadu vs. L. Abu Kavur Bai[3], held that the expression 'distribute' under Article 39(b) cannot but be given full play as it fulfills the basic purpose of re-structuring the economic order. It embraces the entire material resources of the community. Its goal is so to undertake distribution as best to sub-serve the common good. It re-organizes by such distribution the ownership and control. To distribute, would mean, to allot, to divide into classes or into groups and embraces arrangements, classification, placement, disposition, apportionment, the system of disbursing goods throughout the community.[4]

5.2 The above view has been reiterated and followed on numerous occasions by the Apex court, one of them being Reliance Natural Resources Ltd. v. Reliance Industries Ltd, [5], wherein the Supreme Court while explaining the scope of Article 39(b) and the constitutional command regarding distribution of material resources contained therein emphasized that State must act to secure common good and reiterated the above views expressed in the case of Abu Kavur Bai cited *supra*.

5.3. Land is a scarce commodity and it gets even more scarce in a cosmopolitan society like Chennai, thus to permit a group of private individuals to have control over such scarce public resource may also fall foul off Doctrine of Public Trust.

D. Public interest key while granting interim injunctions

3. (1984) 1 SCC 515
4. Reliance Natural Resources Ltd. v. Reliance Industries Ltd (2010) 7 SCC 1, p22
5. (2010) 7 SCC 1

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6. It is trite that Courts would consider "public interest", while dealing with interlocutory applications and would exercise restrain if grant of injunction is shown to adversely affect public interest. Interestingly, the Apex court held that while considering grant of stay which impedes projects conceived in public interest, courts would take into account the cost involved in staying the project and adequate provisions must be made in the interim order for reimbursement of cost in case the individual fails in the litigation after obtaining an order of injunction. In this regard it may be relevant to refer to the following judgments of Raunaq International Ltd. v. I.V.R. Construction Ltd.,[6] wherein the Supreme Court underscored that interim orders must not be issued without evaluating the balance of convenience, the public interest involved and the financial impact. The relevant portion is extracted hereunder:

> *"24. Dealing with interim orders, this Court observed in Assistant Collector of Central Excise, Chandan Nagar, West Bengal v. Dunlop India Ltd. and Ors.,[1985] 2 SCR 190 at page 196 that an interim order should not be granted without considering balance of convenience, the public interest involved and the financial impact of an interim order. Similarly, in Ramniklal N. Bhutto and Anr: v. State of Maharashtra and Ors., [1997] 1 SCC 134, the Court said that while granting a Stay the court should arrive at a proper balancing of competing interests and grant a Stay only when there is an overwhelming public interest in granting it, as against the public detriment which may be caused by granting a Stay. Therefore, in granting an Injunction or Stay order against the award of a contract by the Government or a*

6. AIR 1999 SC 393

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Government agency, the court has to satisfy itself that the public interest in holding up the project far out-weighs the public interest in carrying it out within a reasonable time. The court must also take into account the cost involved in staying the project and whether the public would stand to benefit by incurring such cost.

25.Therefore, when such a Stay order is obtained at the instance of a private party or even at the instance of a body litigating in public interest, any interim order which stops the project from proceeding further, must provide for the reimbursement of costs to the public in case ultimately the litigation started by such an individual or body fails. The public must be compensated both for the delay in implementation of the project and the cost escalation resulting from such delay. Unless an adequate provision is made for this in the interim order, the interim order may prove counter productive".

(emphasis supplied)

6.1. It may also be relevant to refer to the judgment of Supreme Court in the case of Delhi Development Authority v. Skipper Construction Co. (P) Ltd.,[7] wherein the Court cautioned against mechanical grant of interim orders. The relevant portion is extracted hereunder:

"38. On this occasion, we must refer to the mechanical manner in which some of the courts have been granting interim orders - injunctions and stay orders without realizing the harm such mechanical orders cause to the other side and in some cases to public interest. It is no answer to say that "let us make the order and if the other side is aggrieved, let it come and apply for vacating it". With respect, this is not a correct attitude. Before

7. (1996) 4 SCC 622

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making the order, the court must be satisfied that it is a case which calls for such an order. This obligation cannot be jettisoned and the onus placed upon the respondents/defendants to apply for vacating it."

6.2. Applying the above tests to the present case, it is evident that the following projects viz., ponds and Eco park, on which work has commenced are firmly rooted in larger public interest. These projects are the need of the hour as far as Chennai is concerned. Over the last decade, the topography of the city has altered drastically due to unplanned/unauthorised construction of residential/commercial units over and close to water bodies while the city suffers from flooding due to rainfall resulting in large scale damage which at times has been catastrophic.

6.3. Eco park is intended to serve multiple purposes. Firstly, it is intended to mitigate the risk of flooding, which the city increasingly faces with each passing monsoon. Secondly, it is necessary to reiterate the grave concerns surrounding air pollution and AQI levels, reduction of which forms a central part of the rationale behind the Eco park. Air pollution today is not merely an environmental issue; it has become a public health emergency. The experience of the citizens of Delhi in the recent past is a stark reminder, where escalating AQI levels have led to lock downs, closure of schools, disruption of public life, and severe health impacts, particularly for vulnerable groups such as children and the elderly. Thirdly, it is intended to promote tourism. Fourthly,

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it would serve as a natural habitat to several species of flora and fauna. All of the above are conceived in public interest.

6.4. The findings in various reports including one referred supra would reveal serious systemic lapses in flood management and this in the considered view of this Court, demonstrate an urgent and compelling need for the State to undertake remedial, preventive and long-term infrastructural measures. The present projects viz., excavation and development of 4 ponds and creating of an Eco park, is conceived to improve air quality, reducing pollution sources, and preventing the city from being inundated/ravaged by floods due to rains and being pushed into the same cycle of environmental crisis.

7. We prima facie find that there is an overarching public interest in ensuring that the projects proposed in the suit schedule property are proceeded with unhindered/unimpeded. We are thus inclined to modify the order of "Status Quo" and permit the State to carry out all works related to strengthening/development of ponds to store excess rain water while permitting the development of Eco park which is conceived to mitigate adverse impact of floods, promote tourism, reduce pollution and serve as a natural habitat for several flora and founa species.

8. Accordingly, the original side appeal stands allowed. No costs. Consequently, connected miscellaneous petition is closed.

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[S.M.S., J.] **[M.S.Q., J.]**
25.11.2025

Index:Yes/No
Speaking/Non-speaking order
Internet: Yes
Neutral Citation:Yes/No
spp

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To:

1. Madras Race Club,
A Company Registered under the Companies Act, 1913,
Represented by its Secretary S.Nirmal Prasad,
Having its office at Guindy,
Chennai 600 032.

2. Tamil Nadu Race Horse Owners Association
Represented by its Secretary,
Madras Race Club, Owner's Lounge,
Guindy, Chennai 600 032.

3. Tamil Nadu Race Horse Trainers Welfare Association,
Represented by its General Secretary,
Madras Race Club, Guindy,
Chennai 600 032.

4. Madras Race Club Staff Welfare Association,
Represented by its Secretary,
No.12, Parasuramar Street,
Gandhi Salai, Velachery,
Chennai 600 042.

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S.M.SUBRAMANIAM, J.
AND
MOHAMMED SHAFFIQ, J.

spp

O.S.A.No.335 of 2025

25.11.2025

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ANNEXURE 4

GOVERNMENT OF INDIA
DIRECTOR GENERAL OF CIVIL AVIATION

AD AC NO. 6 of 2017

04TH AUGUST 2017
Rev 1. 19TH NOVEMBER 2018

AERODROME ADVISORY CIRCULAR

Subject: Guidance on Wildlife Hazard Management

A. INTRODUCTION

1. The presence of wildlife (birds and animals) on and in the vicinity of an aerodrome poses a serious threat to aircraft operational safety. Operators of licensed aerodromes are required to take the necessary actions to identify, manage and mitigate the risk to aircraft operations posed by wildlife by adopting measures likely to minimize the risk of collisions between wildlife and aircraft, to as low as reasonably practicable.

2. This circular lays down the general guidelines for establishment of wildlife management plan at an aerodrome. The principles in this document are coherent with the wildlife strike hazard reduction requirement of CAR Section 4 Series B Part I para 9.4

3. The purpose of this manual is to provide airport operator with the information necessary to develop and implement an effective bird/wildlife control setup for their aerodrome. This manual outlines organizational structures that will effectively deal with the problem of bird/wildlife control. ICAO Airport Services Manual Part 3 (Doc 9137) may also be referred for detailed guidelines. Detailed procedure related to these guidelines are required to be included in aerodrome manual

4. It is important to note that this circular on its own does not change, create, amend or permit deviations from regulatory requirements nor does it establish minimum standards.

B. ORGANIZATION SETUP WITH IN AERODROMES

1. Depending on the scale of the aerodrome (proportionate to the size, traffic and complexity), some of the functions underneath can be combined, except for the

2. Safety Manager acts independently of the other managers. The aerodrome operator should develop organization charts accordingly.

3. The following roles and responsibilities of personnel associated with wildlife management should be specified at an aerodrome in addition to Accountable Manager and safety manager, as they contribute to the effectiveness of a wildlife management program:

   a) A senior line manager responsible for the wildlife management program. He assures the wildlife risk is properly assessed, determines the policy of the program and provides the resources for the effective implementation.

   b) The wildlife control coordinator is responsible for the day-to-day management and effective implementation of the program. He is also the technical specialist within the organization that advises the senior management. He supervises the wildlife control records, identifies the wildlife risks and proposes updates of the wildlife management program.

   c) Wildlife controllers maintain the surveillance of the wildlife activity on the aerodrome, records the activity and advises the duty airside operations officers on the detected wildlife risks. They implement the wildlife control measures in accordance with the wildlife management program.

   d) The duty airside operations officer is responsible for taking the appropriate decisions including notification to ATS concerning the aircraft operations on the aerodrome based on reported wildlife observations, the advice of the personnel of the wildlife control unit, and possible wildlife occurrences and incidents.

   e) An aerodrome operator can also make use of external wildlife chasers when deemed appropriate. It is nevertheless important to underline that they always work under the responsibility of the aerodrome operator and that they are following the orders of the wildlife control coordinator.

4. The aerodrome should establish and hold Aerodrome Environment Management Committee (AEMC) meetings and delegate appropriate personnel to participate in the AEMC and to contribute to the realization of the agreed action plan in time bound manner.

5. Aerodrome personnel associated with wildlife management should be properly trained and competent:

   a) The senior management functions (Accountable manager, responsible line manager and safety manager) understand at least the nature and extend of the aviation wildlife management problem. The need for extra training depends on the task division between the wildlife control coordinator and the responsible line manager.

   b) The wildlife controller should at least be competent in the following topics:

i. aviation wildlife management program;
ii. applicable regulations;
iii. local wildlife ecology;
iv. wildlife observation and identification on the aerodrome and where practicable, beyond the aerodrome boundary;
v. on and off aerodrome habitat management;
vi. active risk reduction techniques;
vii. use of equipment for wildlife control;
viii. identification of wildlife strike remains.

c) The wildlife control coordinator is the technical specialist within the organization. He should be competent in the following topics:

i. same as the wildlife controller;
ii. planning, organizing and supervising wildlife control operations;
iii. international, national and regional regulations and their implementation;
iv. monitoring habitat changes on and in the vicinity of the aerodrome, and the development and implementation of appropriate management and control activities and the effectiveness;
v. analysis and interpretation of log records of wildlife control activities, wildlife strike reports and on- and off- aerodrome wildlife count data;
vi. actions to reduce the presence of birds and to prevent bird strikes, including new techniques and equipment;
vii. ensuring the supply and safe storing of equipment and consumables;
viii. issue of NOTAM / ATIS system warnings as required to notify stakeholders of specific wildlife hazard related information.

d) Other personnel of the wildlife control unit should be competent according to their responsibilities within the wildlife control program and the complexity of the program. In addition, they will at least understand how to survey the wildlife activity on the aerodrome, record the activity and advise the coordinator or else the duty airside operations officers, on the detected wildlife risk. An important part of their training will be dedicated to the use of the equipment and techniques used for wildlife control.

e) The duty airside operations officer understands the nature and extent of the aviation wildlife management problem and knows how to react in case of increased wildlife observations or possible wildlife occurrences and incidents.

C. WILDLIFE HAZARD IDENTIFICATION AND RISK ASSESSMENT

1. Aerodromes should conduct a formal risk assessment of their wildlife strike risk and use the results to help target their wildlife management measures and to monitor their effectiveness.

2. The total number of wildlife strikes should not be used as the only measure of risk or performance of the wildlife control measures at an aerodrome. Aerodrome

operators also conduct an inventory of bird attracting sites on and in the vicinity of the aerodrome, paying particular attention to the approach and departure corridors.

3. Wildlife live on and around aerodrome property for a variety of reasons, however they are usually attracted by such essentials to life as food, water and shelter. Typical examples of hazards are:

   a) agricultural activities- fertilizing, ploughing, harvesting,
   b) Waste, garbage dumps and landfills
   c) Sewage treatment and disposals
   d) Lakes and ponds, water reservoirs, swamps
   e) Open terrains and grass land
   f) Warm pavements and roof surfaces
   g) Trees, shrubs, bushes,
   h) Buildings, gutters, hangars,
   i) Aerodrome equipment, markers,
   j) Coast, fish processing
   k) Lights attracting insects

4. A systematic method of obtaining information regarding wildlife strike risk on and in the vicinity of the aerodrome should be used. A typical risk assessment process may involve:

   a) A hazard description, identifying wildlife species, associated habitats and seasonal factors that influence the size and the behavior of wildlife populations in the area. A basic assessment to determine whether the movement patterns of birds attracted to sites on and in the vicinity of the aerodrome may cause a risk to air traffic.

   b) The determination of the acceptability of the level of risk by combining the probability and the severity.

      i. An assessment of the probability of a wildlife strike with a particular species, taking into consideration the current mitigation procedures in place.
      ii. An assessment of the severity of the outcome of a wildlife strike, taking into consideration the size of the species. Special attention will be given to the number of birds involved (solitary or flocks) and serious multiple wildlife strikes.

   c) The identification of possible further risk management options available.

5. This process should be reviewed annually to ensure validity by identifying new risk or changes in the existing risk levels.

D. WILDLIFE MANAGEMENT PROGRAM - RISK REDUCTION TECHNIQUES

1. Based on the results of the risk assessment, an action plan is developed to eliminate, reduce or mitigate the risk. Each aerodrome implements a wildlife management program tailored to the conditions on the site. This program should

include both habitat management and active wildlife control, and might include lethal methods subject to local wildlife regulations.

1.1 HABITAT MANAGEMENT:

a) The aerodrome should be made unattractive for wildlife by adoption of habitat management strategies, adapted for the (most dangerous) type of wildlife that is targeted.

i. Fencing of the aerodrome
ii. Removal of bushes, deadwood,
iii. Removal of fruit trees
iv. Use of spikes
v. Removal of cadavers, insects
vi. Closed garbage bins, FOD policy
vii. Protecting covers over water (balls, nets)
viii. Steeper shores towards water surfaces
ix. Less attractive agriculture: beets, potatoes, chicory, turnips
x. Long grass policy

b) Aerodrome operators should establish contact with landowners around the aerodrome, develop constructive relations with them and encourage them to adopt measures to reduce the attractiveness of the site to birds or to mitigate the risk.

c) In addition to reducing the attractiveness of the site, it is also important to avoid creating new habitats on the aerodrome. And also in the vicinity of the terrain, aerodrome operators (should seek dialogue and cooperation with developers and should intervene as far as possible into planning decisions by the regional governments and incompatible land use practices in the vicinity of the aerodrome for any development that may attract significant numbers of hazardous birds.

d) The most effective habitat control measure that can be applied on the aerodrome is the management of the grass areas. Most birds dangerous to aircraft prefer short grass. Only partridges, pheasants and some small low weight birds prefer long grass. A long grass policy is no final solution and can only be successful if intensive grass maintenance is applied:

i. A rigid cutting scheme needs to be followed, depending on the season and the meteorological situation. Too long grass that falls over because it cannot support itself, also has the potential to attract birds.
ii. The use of organic or inorganic fertilizers on an aerodrome is only acceptable if this is necessary to maintain the quality of the grass land. After this process, special attention from the personnel of the wildlife control unit is necessary.
iii. Freshly cut grass should be removed from the aerodrome site as soon as possible, as it might attract a lot of wildlife activity. Dead growth and

iv. Accumulated clippings from past cuts can form an intensive layer of decaying material that might weaken the grass.
v. Special seed mixtures can limit the grass length to medium heights. The frequency of grass cutting can then be reduced. For the choice of a seed mixture, also the composition of the soil and the seed production of the grass (no agricultural grasses) have to be taken into consideration.

1.2 ACTIVE METHODS OF BIRD CONTROL

a) Before considering the use of an active method to disperse or deter wildlife on the aerodrome, consideration should be given to the fact that doing nothing may in some cases be a better choice than chasing birds away and losing control. In certain cases it can be acceptable to tolerate the presence of birds on certain parts of the airfield, if this is well documented.

b) In general, during daytime constant surveillance of the aerodrome by the wildlife control unit is necessary. At airports where the number of aircraft movements is very low (less than 1 movement per 15 minutes), the wildlife control unit should check the situation prior to any aircraft departure or arrival.

c) Bird activity is generally at lower level at night than during daytime. At night, active runways and taxiways are inspected for the presence of wildlife at regular intervals and dispersal action is taken when needed. It is recommended that active methods should be used with caution at night as the risk may be increased by fleeing animals.

d) There are various dispersal and deterring methods with varying levels of success. In most cases it is effective to use a combination of more than one method. By varying the approach used and the combination of scare techniques, often the effectiveness will be increased.

i. Human presence is the simplest method of dispersing wildlife. Also, animals will often react to the presence of the vehicle of the wildlife control unit if they associate it with being harassed.
ii. The use of distress calls is effective with certain kind of birds as long as the birds are correctly identified and the right distress calls are used. For certain species, this method cannot be used.
iii. Gas cannons and other (mobile) noise makers remain effective methods, but variation is needed to avoid habituation. These devices have to be under control of the wildlife control unit, the use of automatically generated noises can be dangerous.
iv. Kites, balloons, flags, scarecrows, reflective objects, rotating spinners are cheap visual deterrents, but they show very rapid habituation.
v. Pyrotechnic scaring cartridges / flare guns are within the limits imposed by its range more rapidly mobile than birds. It enables to control the direction of movement of target flocks. By positioning themselves and aiming the pistol appropriately, it is possible to keep a flock on track and keep the birds together.

vi. Repellents are substances that animals may find unpleasant due to their taste, smell or touch.
vii. Green laser beam guns seem to be effective to chase water birds away from the water surfaces at the airport.

1.3 LETHAL METHODS

a) If there is no other satisfactory course of action for preserving air safety, lethal methods can be employed subject to strict adherence to the wildlife and security regulations in vogue and required permissions thereto.

E. WILDLIFE STRIKE REPORTING AND RECORD KEEPING

1. Most wildlife occurrences can be defined in the following categories:

a) Confirmed strikes:
   i. any reported collision between bird or other wildlife and an aircraft for which evidence in the form of a carcass (or other remains) are found on the ground, or damage and/or other evidence is found on the aircraft.
   ii. found cadavers for which no wildlife strike was reported, but where the cause of death is indisputably a strike.

b) Unconfirmed strikes:
   i. reported collisions between a bird or other wildlife and an aircraft for which no physical evidence is found (no damage to the aircraft, no remains, no blood smears.

   ii. Other significant bird or other wildlife incidents where the presence of wildlife in the air or on the ground resulted in an effect on a flight but where no strike occurred:
   iii. near miss occurrences;
   iv. rejected take-off;
   v. go-around;
   vi. Wildlife found dead on the aerodrome where there is no obvious link with a collision with an aircraft.

2. Wildlife strikes will be reported using the Wildlife Strike Reporting Form as promulgated vide DGCA Air Safety Circulars (Air Safety Circular 02 of 2011) in vogue on the subject.

3. In the reporting and investigation of wildlife occurrences, special attention should be given to confirmed multiple bird strikes and turbine bird ingestions.

4. The aerodrome operator ensures that the species of wildlife carcasses can be identified as correct as possible after a wildlife strike by an in-house specialist or external ornithologist.

5. Reports of wildlife incidents should be made available both internally (to the wildlife control coordinator, the wildlife controllers, the duty airside operations officers and the safety management unit) and externally (to the DGCA)

6. Aerodrome operators should establish a mechanism that allows them to get informed about the wildlife strikes reported on or near their aerodrome.

7. Wildlife controllers should record the wildlife presence on the aerodrome, their control activities and the results of these actions. The intervals for recording depend on the scale of the aerodrome (proportionate to the size, traffic and complexity of the aerodrome). The logging of this information is important for two main reasons:

    a) After a wildlife strike, the aerodrome will be able to demonstrate what actions have been taken to prevent the incident.
    b) If this information is well processed and analyzed, it can be a very valuable input for the yearly risk assessment and possible update of the wildlife management program.

F. COLLECTING, RECORDING AND ANALYSIS OF WILDLIFE DATA

1. The airlines, GHAs, Maintenance staff and others should be encouraged to report all wildlife strikes to the aerodrome operators and assist them in achieving a precise assessment of the wildlife risk.

2. The airport wildlife officials should surveys the airport environment frequently to monitor the wildlife species and their habitats depending upon the severity of the wildlife hazard and to provide a complete coverage of wildlife activity as appropriate to the airport. The assessment should consider wildlife habitat, migratory routes, feeding and breeding areas, diurnal or seasonal activities and impact of human activities.

3. They should then document the numbers, type of species and location of wildlife spotted should be recorded. It should also contain the actions taken to mitigate the wildlife risk and the effectiveness of such actions taken.

4. This monitoring activity and records will help provide details of the wildlife populations and predictability of its behavior over long period of time. When this information is analyzed against the wildlife strike records, it provides the basis for trend and behavior pattern of certain species which may cause a problem at airport.

5. The data of potentially hazardous wildlife activities, unconfirmed strikes or missed strike should not be ignored and nevertheless should be analyzed to get a improved conclusion on the wildlife risk on and in the vicinity of the aerodrome.

6. Wildlife strike database should be analyzed to determine a number of trends including but not limited to:

a) risk w.r.t. a particular species
b) airport locations most susceptible to strikes
c) diurnal or seasonal activities
d) annual strike trends by species and location
e) phases of flight prone to strikes (take-off roll, initial climb, climb, cruise, descent, approach, landing roll)
f) altitude at which strikes occur
g) types of aircraft most likely to events
h) parts of aircraft most prove to strikes
i) effects of strikes on aircraft (rejected take off, emergency/precautionary landing, engine(s) shut down and other consequent effects)
j) relevant meteorological conditions (visibility, cloud cover, precipitation)
k) prior warning of bird activity by ATIS/ NOTAM/ RTF
l) costs associated with strikes; and
m) any other relevant information and remarks regarding the occurrence

7. These analyses should be periodically summarized from the daily wildlife activities log and wildlife strikes records to provide baseline data for analyzing and evaluating the wildlife hazard management programme of the aerodrome operators.

G. EVALUATING THE WILDLIFE CONTROL PROGRAMME

1. Wildlife hazard prevention should be an integral part of the aerodrome safety management system. The following questions are directed at airport management. These questions assist in determining if there is an effective bird/wildlife control programme in place at an airport.

   a) Local risk assessment

      i. Has a bird/wildlife strike reporting procedure been implemented at the airport?
      ii. What is the bird/wildlife strike rate at the airport over the last five years (with or without damage to the aircraft)?
      iii. Is there a procedure to collect regularly information about birds/wildlife, both dead (carcasses) and living?
      iv. Has a means for positively identifying carcass remains been established?
      v. How many reports from pilots are related to intrusions of wildlife, other than birds, over the last five years?
      vi. Has a list of bird/wildlife attractants at and surrounding the airport been completed?

   b) Wildlife control programme

      i. Is there a wildlife control officer responsible for the management of wildlife on the airport?
      ii. Has a land-use plan been established with regard to effective land use on and off the airport as it pertains to the wildlife control programme?
      iii. What ecological measures are implemented to reduce wildlife attractiveness

at the airport and in the vicinity?

iv. Is there a habitat management programme on the airport?

v. Are garbage dumps forbidden around the airport? If yes, within what distance are they forbidden?

vi. Is the airport fence suitable to prevent hazardous animal incursions?

vii. Which scaring methods are implemented at the airport?

viii. Have staff been employed and trained specifically to scare off birds/wildlife at the airport?

2. The aerodrome operator has to provide working procedures to assist the personnel of the wildlife control unit in their daily work. These procedures can be published as part of the wildlife management program or as a separate document.

3. Particulars of the procedure to deal with danger to aircraft operations caused by the presence of wildlife in the aerodrome flight pattern or movement area, including arrangement for assessing any wildlife hazard, arrangement for implementing wildlife control programmes, arrangement with local civil authorities for resolving conflicting issues between land use and aircraft safety along with names and roles of the persons responsible for dealing with wildlife hazards, and their telephone numbers during and after working hour shall be included in Aerodrome manual.

Sd/-
(J S Rawat)
Jt. Director General

A Brief Note on Establishment of Eco Park, Guindy

Vide G.O. (Ms.) No. 343 Revenue and Disaster Management Department Land Disposal Wing, LD 4 (1) Section Dated: 06.09.2024, the lease was terminated and land was resumed from the Madras Race Club for utilising the same for public purposes.

Based on the requisition made by Director of Horticulture and Plantation crops, out of 160.86 acres, an extent of 118.00 acres has been transferred to Department of Horticulture and Plantation Crops vide G.O. (Ms.) No.371 Revenue and Disaster Management Department Land Disposal Wing, LD 4 (1) Section Dated: 20.09.2024 on free of cost for creation of public Horticulture gardens, public green spaces and public utilities. Based on the above Government Order, the land was delivered to the Deputy Director of Horticulture, Chennai on 20.09.2024.

The land was demarcated by Tahsildar and Surveyor of Guindy and Velachery taluk in the presence of Deputy Director of Horticulture, Chennai on 24.04.2025 for further developments.

The Greater Chennai Corporation has deepened two existing ponds and excavated four new ponds within the resumed land, creating a total water storage capacity of 2,48,360 cubic metres as part of the flood mitigation measures.

A proposal to carry out preliminary works for the establishment of a new ECO Park in the Guindy and Velachery taluks of Chennai at an outlay of Rs.50 Lakhs utilising Farm Receipt Account of TANHODA has been approved by the Governing Council of Tamil Nadu Horticulture Development Agency on 08.05.2025.

2

Agriculture Production Commissioner and Secretary to the Government, Director of Horticulture and Plantation Crops and other department officials have inspected the site on 19.06.2025.

In the meantime, Request for Proposal (RFP) was called to engage consultancy services to prepare Detailed Project Report (DPR) for the establishment of an ECO Park at Guindy, Chennai on 20.06.2025.

Technical Bid was opened for Providing consultancy services for the Establishment of an Eco Park, at Guindy, Chennai on 14.07.2025 and Six consultancy firms participated and submitted their proposals.

The participating firms presented their Technical Proposal on 29.07.2025 as part of Technical Evaluation. Financial Bid was opened, evaluated and work order has been issued to M/s. HCP Design, Planning and Management Pvt. Ltd. for Providing consultancy services for the Establishment of an Eco Park on 28.10.2025.

Director of Horticulture and Plantation Crops with senior department officials have inspected the Eco Park for the initiation of preliminary works on 29.10.2025. During the inspection it was decided to take up the following works with immediate effect.

- Avenue tree planting
- Bund strengthening
- Nursery establishment

Agriculture Production Commissioner and Secretary to Government and Director of Horticulture and Plantation Crops have inspected the Eco Park for the initiation of preliminary works on 30.10.2025.

Hon'ble Minister of Agriculture – Farmers Welfare, Agriculture Production Commissioner and Secretary to Government and Director of

Horticulture and Plantation Crops have inspected the Eco Park on 31.10.2025 to oversee the works being carried out.

Hon'ble Chief Minister of Tamil Nadu has inaugurated the Avenue Tree Planting, Nursery and Bund strengthening works in the Guindy Eco Park on 01.11.2025. As on 03.11.2025, a total of 495 avenue trees has been planted along a 2.5 km stretch, and bund strengthening works have commenced.

S. No.	Name of the Plant	Quantity Planted
1.	Magizham	64 Nos
2.	Senbagham	56 Nos
3.	Nagalingam	55 Nos
4.	Kadambam	48 Nos
5.	Punnai	56 Nos
6.	Poovarasu	10 Nos
7.	Pungan	66 Nos
8.	Naval	10 Nos
9.	Neer Marudhu	15 Nos
10.	Arasa maram	53 Nos
11.	Spathodea	17 Nos
12.	Tabebuia	14 Nos
13.	Lagerstroemia	9 Nos
14.	Mahogany	13 Nos
15.	Cardinia	9 Nos
	Total	**495 Nos**

The proposed Eco Park is planned to include components such as a Nature-based Children's Play Area, Open Activity Lawn, Lakeside Cafeteria, Sensory Gardens, Cactus and Succulent Garden, Butterfly Garden, Aviary Habitat Centre, Perennial Flower Garden, Orchidarium, Shaded Walkways, Herbal Garden integrating Siddha traditions, Natural Lake Edge and

Wetland, Bird Habitat Islands, Forest Experience Zone, and Walking Trails and it has proposed to request fund based on the Detailed Project Report (DPR).

In continuation of the establishment of nursery on 01.11.2025, at the Eco Park, Guindy, sale of flowering & other Ornamental plants, seeds and tree saplings are made available for the Public. TANHODA outlet has been established to sale horticultural products.

On 06.11.2025 AND 08.11.2025, Joint Director of Horticulture, Farms has inspected the progress of works at the Eco Park, Guindy. Security room has erected near the entrance of Gate No. 7.

11/11/2025

for **Director**
Department of Horticulture
and Plantation Crops

Annexure

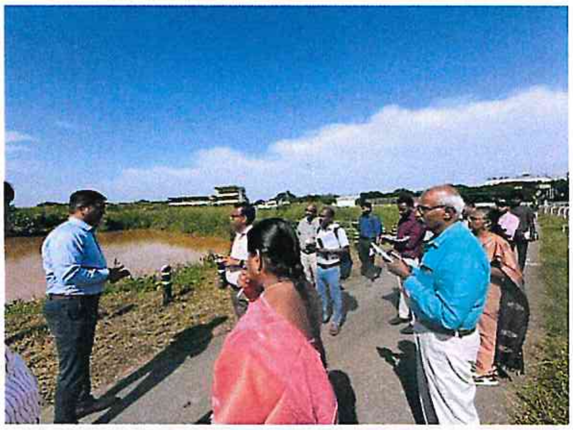

Survey conducted by the Revenue Department officials on 24.04.2025



Ponds excavated by the Greater Chennai Corporation

6


Inspection of the site by the Agriculture Production Commissioner and Secretary to Government, Agriculture-Farmers Welfare Department and Director of Horticulture and Plantation Crops

Director of Horticulture and Plantation Crops and Other department officials have inspected the Eco Park for the initiation of preliminary works


Hon'ble Minister of Agriculture – Farmers Welfare, Agriculture Production Commissioner and Secretary to Government and Director of Horticulture and Plantation Crops have inspected the Eco Park for the initiation of preliminary works

Hon’ble Chief Minister of Tamil Nadu has inaugurated the Avenue Tree Planting, Nursery and Bund strengthening works in the Guindy Eco Park on 01.11.2025.

Hon’ble Chief Minister of Tamil Nadu has inaugurated Nursery in the Guindy Eco Park on 01.11.2025.

Hon'ble Chief Minister of Tamil Nadu has inaugurated the Avenue Tree Planting in the Guindy Eco Park on 01.11.2025.

Hon'ble Chief Minister of Tamil Nadu has inaugurated Bund strengthening works in the Guindy Eco Park

Bund strengthening works in the Guindy Eco Park

Agriculture Production Commissioner and Secretary to Government has planted avenue tree plants

Director of Horticulture and Plantation Crops has planted avenue tree plants

Director of Agriculture has planted avenue tree plants

Joint Commissioner, Commisonarate of Land Administration has planted avenue tree plants

As on 03.11.2025, 447 trees have been planted

T1

Park Office

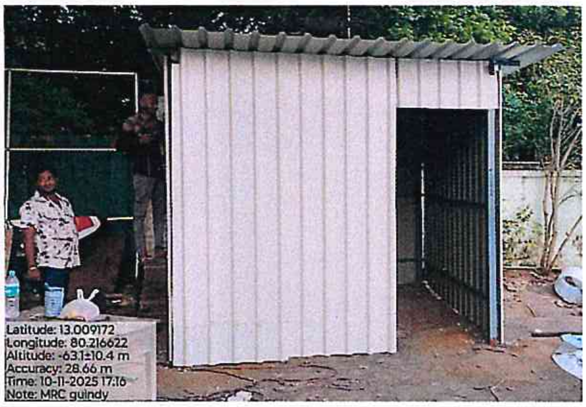
Horticulture Nursery

Nursery Sales Outlet

12

Joint Director of Horticulture (Farms) inspected the site on 06.11.2025

TANHODA Outlet



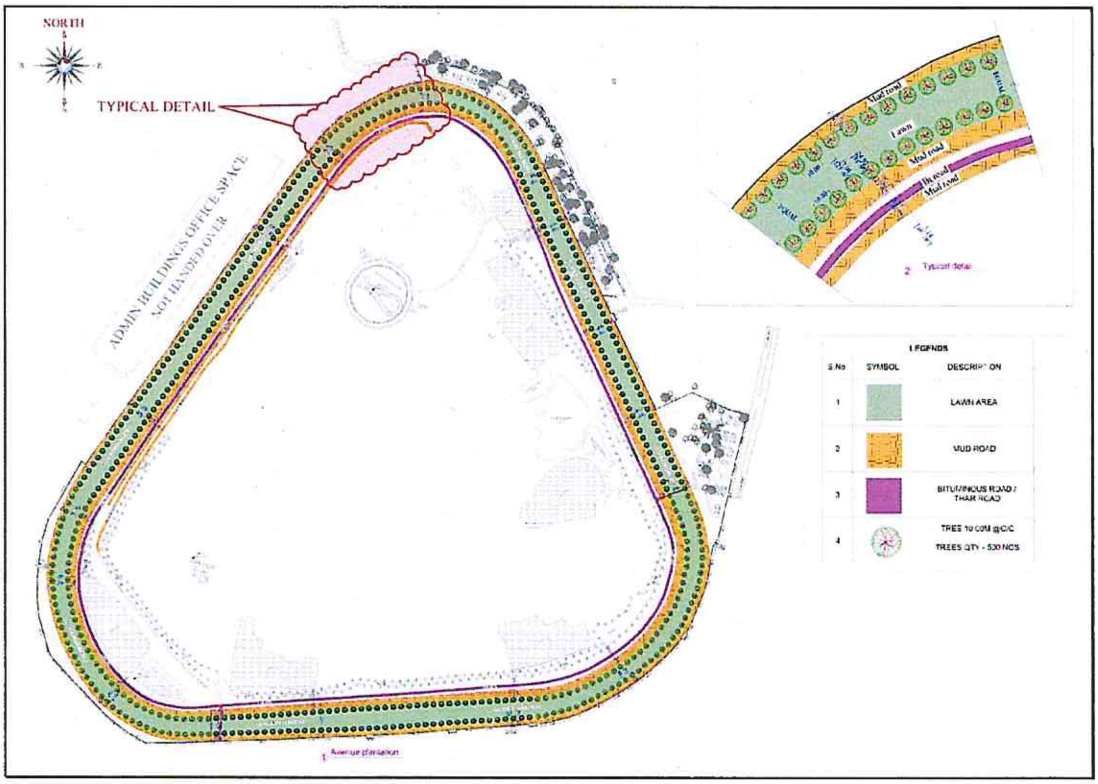
Security Room


Basin creation for Avenue Tree Plants

66

ANNEXURE 7

Proposed layout for Avenue Tree Planting



15

Concept plan of Proposed Guindy Eco Park

17

ANNEXURE 8

SUNDAY TIMES OF INDIA, CHENNAI
NOVEMBER 2, 2025

WORK TO FORTIFY POND BANK BEGINS

R Ramesh Shankar

NEW ECO PARK SITE: Chief minister M K Stalin, along with other ministers and mayor R Priya, on his way to launch work to strengthen banks of waterbodies being set up on premises of Madras Race Course at Guindy on Saturday. The work will be carried out by the horticulture department

Sunday, November 2, 2025
CHENNAI

THE HINDU
Chennai

4

Work begins for eco-park on Madras Race Club grounds

The Hindu Bureau
CHENNAI

Chief Minister M.K. Stalin on Saturday inaugurated a horticulture nursery, launched a tree plantation drive, and initiated bund-strengthening works for the development of ponds at the proposed eco-park on the Madras Race Club grounds at Guindy in Chennai.

The State government has proposed to develop a 118-acre eco-park, which would include the development of four ponds as flood-control and rainwater preservation measures, on the Madras Race Club grounds, with an aim to repurpose and adaptively transform the area into a vibrant public space that supports biodiversity, promotes environmental learning, and brings people closer to nature. The proposed eco-park project will feature facilities including a water fountain plaza, waterbodies, an open activity lawn, dense green pockets and an experimental forest, an arboretum, and bird habitat islands.

Mr. Stalin also inspected the nursery, which has horticultural crops such as asparagus, anthurium, poinsettia, dracaena, aglaonema, rose varieties, bougainvillea, and marigold. Deputy Chief Minister Udhayanidhi Stalin, Ministers M.R.K. Panneerselvam, Ma. Subramanian, and P.K. Sekarbabu, and veteran journalist N. Ram were present.

Chief Minister M.K. Stalin launching a tree plantation drive on the Madras Race Club grounds in Chennai on Saturday. B. VELANKANNI RAJ

DT NEXT

ANNEXURE 9

Residents flock to Guindy Eco Park's horticulture hub for affordable, quality plants

The centre also sells affordable organic fertilisers, soil mixtures, bio-inputs, seeds and essential gardening tools, making it a one-stop destination for home gardeners

Author : DTNEXT Bureau

Update:2025-11-17 22:48 IST

Guindy Eco Park

CHENNAI: Chennai residents are increasingly turning to the newly upgraded horticulture nursery and retail centre at the Guindy Eco Park, a space that is fast emerging as the city's go-to destination for quality plants, sustainable garden supplies and expert guidance.

Revamped by the Tamil Nadu Horticulture Development Agency (TANHODA), the nursery has become a people-centric green hub, offering everything from ornamental saplings and medicinal plants to indigenous species, indoor plants, vegetable seedlings, and rare varieties that typically remain out of reach for urban gardeners.

The centre also sells affordable organic fertilisers, soil mixtures, bio-inputs, seeds and essential gardening tools, making it a one-stop destination for home gardeners.

Officials said the initiative aims to encourage city dwellers to embrace gardening, promote urban greening, and provide reliable and reasonably priced plant varieties directly to the public. Visitors also receive hands-on guidance from horticulture experts on plant care, home gardening and balcony farming, a service that has earned enthusiastic response from first-time gardeners.

Families visiting the Eco Park are increasingly stopping by the centre to pick up flowering saplings, fruit-bearing plants, and decorative greens. Staff members say the surge in footfall reflects rising public interest in sustainability and home gardening.

To further expand public engagement, the department is planning to launch awareness drives, live demonstrations and special outreach events that can help more households adopt eco-friendly gardening practices.

Horticulture officials said the centre reinforces Tamil Nadu's commitment to promoting sustainable living, expanding urban green spaces and offering accessible environmental resources for all.

For details, residents may contact 98400 72385 or 99402 45997.

Tags:

Guindy Park | Horticulture

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உங்கள் மூட்டுகள் மீண்டும் ஆரோக்கியமாக உணர உதவுங்கள்.

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25

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UNITED NEWS OF INDIA

Tuesday, Nov 18 2025 | Time 10:21 Hrs(IST)

States »

South

Posted at: Nov 17 2025 2:58PM

Horticulture Nursery at Guindy Eco park emerges preferred destination for garden enthusiasts

Chennai, Nov 17 (UNI) The Department of Horticulture and Plantation Crops newly strengthened Horticulture Nursery and TANHODA Outlet at Eco Park, Guindy in Chennai city is rapidly emerging as a preferred destination for garden enthusiasts, home growers, and families exploring eco-friendly weekend activities.

Strategically located inside the proposed Eco Park at Guindy, the nursery showcases a wide range of ornamental plants, fruit saplings, medicinal species, indoor plants, native tree varieties, and high-quality planting materials produced by the state-owned nurseries.

The outlet managed by Tamil Nadu Horticulture Development Agency (TANHODA) also offers organic inputs such as bio-fertilisers, bio-control agents, potting mixtures, seeds and horticultural tools at affordable rates.

Officials said the initiative aims to promote green living, encourage urban kitchen gardening, and provide the public with easy access to quality planting materials.

The nursery is also serving as a knowledge point where visitors receive basic guidance on gardening, plant care, and home landscaping from trained staff.

Families visiting near the proposed Eco Park are increasingly stopping by the nursery, appreciating the neatly arranged plant collections and user-friendly displays.

With seasonal flowering plants, saplings for terrace gardens and native species gaining popularity, the outlet has seen a steady rise in footfall.

The Department is also planning special promotional activities, including hands-on demonstrations and gardening awareness programmes, to further boost public engagement.

Officials said that the outlet supports the Government's wider mission to increase green cover, encourage urban horticulture, and create self-sustaining eco-friendly recreational spaces in Chennai.

The Horticulture Department urged the public to visit the Eco Park nursery and make use of the diverse plant varieties and resources available.

UNI GV 1455

Tags: #Horticulture Nursery at Guindy Eco park emerges preferred destination for garden enthusiasts

UNI Photo

NEW DELHI, NOV 17 (UNI):- Prime Minister Narendra Modi during 6th Ram Nath Goenka Lecture in New Delhi on Monday. UNI PHOTO 1541U

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More News

India produces 10 11 million tonnes of tropical root and tuber crops

18 Nov 2025 | 8:10 AM

Thiruvananthapuram, Nov 18 (UNI) India currently produces 10.11 million tonnes of tropical root and tuber crops from 4.06 lakh hectares, with cassava and sweet potato together contributing nearly 71 per cent of the national output.

see more..

Telangana Cabinet clears December deadline for Panchayat polls

18 Nov 2025 | 8:06 AM

Hyderabad, Nov 18 (UNI) The Telangana government has ended the uncertainty surrounding local body elections by deciding to conduct Gram Panchayat polls by December.

see more..

Kerala local body polls: SEC imposes strict Media, AI content restrictions

18 Nov 2025 | 7:46 AM

Thiruvananthapuram, Nov 18 (UNI) The State Election Commission of Kerala has issued stringent instructions directing all media organisations to strictly adhere to the prescribed code of conduct during the upcoming local body elections.

see more..

CPM threats drove BLO to suicide: Congress

18 Nov 2025 | 2:40 AM

Thiruvananthapuram, Nov 17 (UNI) Kerala Pradeep Congress Committee (KPCC) president Sunny Joseph, MLA, today demanded a factual and impartial probe into the suicide of BLO Aneesh George, alleging that political pressure and CPM threats had pushed the polling official to take his own life.

see more..

BLO suicide: Kerala Unions boycott SIR duties, demand justice for Aneesh George

18 Nov 2025 | 2:24 AM

Thiruvananthapuram, Nov 17 (UNI) The suicide of Booth Level Officer (BLO) Aneesh George in Kannur has snowballed into a powerful statewide protest, with employees' unions and BLO organisations launching an unprecedented boycott of Special Intensive Revision (SIR) duties and demanding sweeping reforms in the treatment of grassroots election workers.

see more..

Tuesday, Nov 18 2025 | Time 10:21 Hrs(IST)

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ANNEXURE 10

Home / செய்திகள் / Environment Park Guindy

பொதுமக்களின் கவனத்தை ஈர்க்கும் கிண்டி சுற்றுச்சூழல் பூங்காவில் உள்ள தோட்டக்கலை நாற்றங்கால், தன்ஹோடா விற்பனை நிலையம்

04:46 PM Nov 17, 2025 IST

தினகரன்

தலையங்கம் அரசியல் இந்தியா தமிழகம் குற்றம் ஆன்மிகம் மருத்துவம் மகளிர் வேலைவாய்ப்பு சமைய

சென்னை: கிண்டி சுற்றுச்சூழல் பூங்காவில் உள்ள தோட்டக்கலை மற்றும் மலைப்பயிர்கள் துறையினால் புதிதாக ஏற்படுத்தப்பட்ட தோட்டக்கலை நாற்றங்கால் மற்றும் தமிழ்நாடு தோட்டக்கலை வளர்ச்சி முகமையின் விற்பனை நிலையமானது சுற்றுச்சூழல் மற்றும் தோட்டக்கலை ஆர்வலர்களின் வார இறுதியை இயற்கையுடன் செலவிடும் விருப்பமான இடமாக வேகமாக வளர்ந்து வருகிறது.கிண்டியில் அமையவுள்ள சுற்றுச்சூழல் பூங்காவிற்குள் அமைந்துள்ள இந்த நாற்றங்கால், பல்வேறு வகையான அலங்கார தாவரங்கள், பழ மரக்கன்றுகள், மருத்துவ செடிகள், உட்புற தாவரங்கள், பூர்வீக மர வகைகள் மற்றும்

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துறையால் தயாரிக்கப்படும் உயர்தர நடவுச்செடிகளை காட்சிப்படுத்தும் கூடமாக விளங்குகிறது. தமிழ்நாடு தோட்டக்கலை வளர்ச்சி முகமை நிர்வகிக்கும் விற்பனை நிலையம், மலிவு விலையில் உயிர் உரங்கள், உயிரி கட்டுப்பாட்டு பொருட்கள், மண் கலவைகள், விதைகள் மற்றும் தோட்டக்கலை கருவிகள் போன்ற தோட்டக்கலை சார்ந்த உள்ளீடுகளையும் விற்பனைக்கு வழங்குகிறது.

Advertisement

Camps on Unclaimed

Reserve Bank of India

தோட்டக்கலை அதிகாரிகள் கூறுகையில் இந்த முயற்சி மக்களின் வாழ்க்கையினை பசுமையுடன் செலவிட ஊக்குவிக்கவும், நகர்ப்புறங்களில் தோட்டக்கலையை ஊக்குவிக்கவும் மற்றும் பொதுமக்களுக்கு தரமான நடவுச்செடிகள் வழங்குவதை உறுதி செய்யவதையும் நோக்கமாகக் கொண்டு அமைக்கப்பட்டுள்ளன. பயிற்சி பெற்ற ஊழியர்களிடமிருந்து தோட்டக்கலை, தாவர பராமரிப்பு மற்றும் வீட்டுத் தோட்டம் குறித்த அடிப்படை வழிகாட்டுதல்களை பார்வையாளர்கள் பெற்று பயன்பெறும் திடலாகவும் இந்த நாற்றங்கால் செயல்படுகிறது என தெரிவித்தனர்.

சுற்றுச்சூழல் பூங்கா அமையவுள்ள இடத்திற்கு அருகில் வருகை தரும் பொதுமக்கள், நாற்றங்கால் பண்ணைக்கு வருகை தந்து, நேர்த்தியாக தேர்ந்தெடுக்கப்பட்ட தாவர வகைகள் பார்வையிட்டு பயன்பெற்று வருகின்றனர். பருவகால பூக்கும் தாவரங்கள், மொட்டை மாடித் தோட்டங்களுக்கான மரக்கன்றுகள் மற்றும் அலங்கார செடிகள் மக்களிடையே பிரபலமடைந்து வருவதால், விற்பனை நிலையத்திற்கு வருகை தொடர்ந்து அதிகரித்து வருகிறது.பொதுமக்களின் ஈடுபாட்டை மேலும் அதிகரிக்க, நேரடி செயல் விளக்கங்கள் மற்றும் தோட்டக்கலை விழிப்புணர்வு திட்டங்கள் உள்ளிட்ட சிறப்பு விளம்பர நடவடிக்கைகளையும் தொடங்கிட தோட்டக்கலை துறை திட்டமிட்டுள்ளது.

சென்னையில் பசுமைப் பரப்பை அதிகரிப்பது, நகர்ப்புற தோட்டக்கலையை ஊக்குவித்தல் மற்றும் தன்னிறைவான சுற்றுச்சூழல் பொழுதுபோக்கு இடங்களை உருவாக்குதல் ஆகிய அரசாங்கத்தின் உயரிய இயற்கை சார்ந்த நோக்கங்களை உறுதி செய்யும் விதமாக இந்த விற்பனை நிலையம் அமைந்துள்ளது என துறை அதிகாரிகள் எடுத்துரைத்தனர்.சுற்றுச்சூழல் பூங்கா தோட்டக்கலை நாற்றங்காலை பார்வையிடவும், பல்வேறு தாவர வகைகளை குறைந்த விலையில் பெற்று பயன்பெறவும் தோட்டக்கலைத் துறை பொதுமக்களை அன்புடன் கேட்டுக்கொள்கிறது. மேலும் விவரங்களுக்கு 91 98400 72385 மற்றும் 91 99402 45997 ஆகிய எண்களை தொடர்புக்கொள்ளவும்.

மேலும் தோட்டக்கலை நாற்றங்கால், விற்பனை மையம் மற்றும் சுற்றுச்சூழல் பூங்கா அமைக்கும் பணிகளை தோட்டக்கலை மற்றும் மலைப்பயிர்கள் துறை இயக்குனர் திரு. பெ. குமரவேல் பாண்டியன் இ.ஆ.ப அவர்கள் 15.11.2025 அன்று ஆய்வு செய்து அவற்றை மேம்படுத்திட உரிய அறிவுரைகள் வழங்கினார். ஆய்வின் போது தோட்டக்கலை துணை இயக்குனர், சென்னை திரு. செ. பாலசுப்பிரமணியம் மற்றும் இதர துறை அலுவலர்கள் உடனிருந்தனர்.

Advertisement

Horticulture Nursery and TANHODA Outlet at Guindy Eco Park Draw Public Attention

Chennai: The Department of Horticulture and Plantation Crops newly strengthened Horticulture Nursery and TANHODA Outlet at Eco Park, Guindy is rapidly emerging as a preferred destination for garden enthusiasts, home growers, and families exploring eco-friendly weekend activities.

Strategically located inside the proposed Eco Park at Guindy, the nursery showcases a wide range of ornamental plants, fruit saplings, medicinal species, indoor plants, native tree varieties, and high-quality planting materials produced by the state-owned nurseries. The outlet managed by Tamil Nadu Horticulture Development Agency (TANHODA) also offers organic inputs such as bio-fertilisers, bio-control agents, potting mixtures, seeds, and horticultural tools at affordable rates.

Officials said the initiative aims to promote green living, encourage urban kitchen gardening, and provide the public with easy access to quality planting materials. The nursery is also serving as a knowledge point where visitors receive basic guidance on gardening, plant care, and home landscaping from trained staff.

Families visiting near the proposed Eco Park are increasingly stopping by the nursery, appreciating the neatly arranged plant collections and user-friendly displays. With seasonal flowering plants, saplings for terrace gardens, and native species gaining popularity, the outlet has seen a steady rise in footfall.

The Department is also planning special promotional activities, including hands-on demonstrations and gardening awareness programmes, to further boost public engagement.

Officials highlighted that the outlet supports the Government's wider mission to increase green cover, encourage urban horticulture, and create self-sustaining eco-friendly recreational spaces in Chennai.

The Horticulture Department has urged the public to visit the Eco Park nursery and make use of the diverse plant varieties and resources available. For more details, contact the mobile numbers +91 98400 72385 and +91 99402 45997.

Further, Mr. P. Kumaravel Pandian, I.A.S, the Director of Horticulture and Plantation Crops inspected the Horticulture Nursery, TANHODA Sales Centre and the other establishment works related to Guindy ECO Park on 15.11.2025 and gave appropriate suggestions for their improvement. During the inspection, Mr. S. Balasubramaniam, Deputy Director of Horticulture, Chennai and other departmental officers were present.

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ANNEXURE 11

சென்னை

அலங்கார தாவரங்கள், மருத்துவச் செடிகள்: குறைந்த விலையில் பெறலாம்

சென்னை கிண்டி சுற்றுச்சூழல் பூங்கா நாற்றங்கால் மற்றும் தோட்டக்கலை வளர்ச்சி முகமையின் விற்பனை நிலையத்தில் அலங்கார தாவரங்கள், மருத்துவ செடிகளை

தினமணி செய்திச் சேவை

Updated on: 18 நவம்பர் 2025, 4:23 am

சென்னை: சென்னை கிண்டி சுற்றுச்சூழல் பூங்கா நாற்றங்கால் மற்றும் தோட்டக்கலை வளர்ச்சி முகமையின் விற்பனை நிலையத்தில் அலங்கார
த்துவ செடிகளை குறைந்த விலையில் வாங்கி
மக்களுக்கு அழைப்பு விடுக்கப்பட்டுள்ளது.

ழக தோட்டக்கலை வளர்ச்சி முகமை வெளியிட்டுள்ள
தாட்டக்கலை மற்றும் மலைப்பயிர்கள் துறை சார்பில்,
கலை நாற்றங்கால் மற்றும் தமிழ்நாடு தோட்டக்கலை
யின் விற்பனை நிலையம் தொடங்கப்பட்டு உள்ளது.

மயவுள்ள சுற்றுச்சூழல் பூங்காவுக்குள் உள்ள இந்த
ல்வேறு வகையான அலங்கார தாவரங்கள், பழ
ருத்துவச் செடிகள், உட்புற தாவரங்கள், பூர்வீக மர
துறையால் தயாரிக்கப்படும் உயர்தர நடவுச் செடிகள்
பனைக்கும் வைக்கப்பட்டுள்ளது.

நிலையத்தில் குறைந்த விலையில் உயிர் உரங்கள்,
டுப் பொருட்கள், மண் கலவைகள், விதைகள்,
நவிகள் போன்ற தோட்டக்கலை சார்ந்த உள்ளீடுகளும்
ப்படுகிறது.

ல பூக்கும் தாவரங்கள், மாடித் தோட்டங்களுக்கான
லங்காரச் செடிகளும் விற்கப்படுகிறது.

பற்ற ஊழியர்களிடம் இருந்து தோட்டக்கலை, தாவர பராமரிப்பு மற்றும் வீட்டுத் தோட்டம் குறித்த அடிப்படை வழிகாட்டுதல்களும் வழங்கப்படுகிறது. இந்த சுற்றுச்சூழல் பூங்கா தோட்டக்கலை நாற்றங்காலை பார்வையிடவும், பல்வேறு தாவர வகைகளை குறைந்த விலையில் பெற்று பயன்பெறவும் விரும்பும் பொதுமக்கள் 9840072385, 9940245997 என்ற எண்களில் தொடர்பு கொள்ளலாம் என்று அதில் தெரிவிக்கப்பட்டுள்ளது.

x

Ornamental plants, medicinal plants Available at low prices

The public has been invited to purchase ornamental plants and medicinal plants at affordable prices from the nursery and sales outlet of the Tamil Nadu Horticulture Development Agency located at the Eco Park, Guindy, Chennai.

According to a press release issued by the Tamil Nadu Horticultural Development Agency, a horticulture nursery and a sales outlet have been established by the Department of Horticulture and Plantation Crops.

In Eco Park, Guindy, Chennai high-quality planting materials produced by the Department — including various types of ornamental plants, fruit saplings, medicinal plants, indoor plants, and native tree saplings are available for sales.

The Horticulture sales outlet also offers bio-fertilizers, terrace gardening inputs, potting mixtures, seeds, Seasonal flowering plants ornamental plants and essential gardening tools at reasonable price.

In addition, basic guidance on plant maintenance and terrace gardening is being provided by horticulture staff at the park. Public may contact 98400 72385 or 99402 45997 for enquiry, as stated in the release.

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COMPETITION IN THE AIR: BIRDS VERSUS AIRCRAFT

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PERSPECTIVES IN ORNITHOLOGY

COMPETITION IN THE AIR: BIRDS VERSUS AIRCRAFT

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THE FIRST KNOWN aircraft fatality that was directly attributable to a bird occurred in 1912, when a gull (*Larus* sp.) was caught in the control cables of an aircraft, causing it to crash. Since that time, aircraft have generally increased in size to carry more passengers. Bird–aircraft conflicts are becoming more common recently, which is possibly due to increased numbers of both aircraft (e.g. an estimated 28 million jets now take off in the United States as compared to 18 million in 1980) and some kinds of bird species (e.g. Canada Geese [*Branta canadensis*], in the United States have quadrupled to 2 million since 1985). Between 1990 and 1998, there were an estimated 22,000 bird–aircraft collisions in the United States, which cost an annual $400 million in aircraft repairs. This bird–aircraft conflict takes place around the world, although the species, situations, and severity differ. It is estimated that at least 350 people have been killed in bird–aircraft collisions worldwide.

Understanding bird–aircraft conflict is critical due to monetary reasons and the potential threat to human life. Despite the severity of the situation, bird–aircraft conflict has largely remained on the fringes of rigorous ornithological investigations, and sound ornithological understanding is still required to find long-term management solutions for that conflict. I hope that this review will stimulate ornithologists to show more interest in this crucial issue.

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HUMAN SAFETY AND ECONOMICS

Incidents.—On average, the aircraft of the U.S. Air Force incur 2,500 bird strikes annually (Lovell 1997). Out of those, one human death occurs per 2,000 strikes (Neubauer 1990). Most air crashes occur when a bird hits the windshield or is inducted into the engine. In terms of civilian aircraft, over 5,000 bird strikes were reported in the United States during 1999 alone. Between 1950 and 1999, 286 serious bird-related accidents of military aircraft (in which the aircraft were destroyed or there were fatalities) occurred in 32 countries. Of those accidents, 63 were fatal, which resulted in 141 deaths (Richardson and West 2000). These bird-strike incidents, at least in some cases, are minimum estimates because pilots only report 20 to 30% of actual strikes (Burger 1985). Pilots are thought to underreport bird strikes either because they are unaware of the strikes or because of the inconvenience of filing reports (Solman 1978, Linnell et al. 1999, Brown and Hickling 2000). Sometimes, strikes by large bird species (>350 g) such as Brahminy Kites (*Haliastur indus*) and Cattle Egrets (*Bubulcus ibis*) go unreported by pilots (N. Sodhi pers. obs.). Therefore, runway carcass searches must supplement pilot reports to correctly evaluate the bird threat at airports.

Economic losses.—The cost of repairing an aircraft damaged by a bird strike can vary from very little to millions of dollars when an aircraft is lost. The aircraft component that is most frequently damaged by bird strikes is the engine. International Civil Aviation Organization's (ICAO) analysis shows that bird strikes damaged 200 engines on or near airports around the world in 1996. The cost of repair due to bird ingestion can range from $250,000 to $1 million, depending on the type of engine. However, there have been cases in which the cost of aircraft repair has been as high as $6 million, as was the case for an Air France Concord that was struck by a number of Canada Geese in 1995 on approach to the John F. Kennedy International Airport in New York City. It is predicted that bird–aircraft conflict will become costlier due to the plans for increased numbers of wide-bodied jets in the air (Robinson 2000).

The cost of the bird management program at the Christchurch International Airport in New Zealand is about twice that of repairs to aircraft that are damaged by bird strikes. However, that does not include the costs of lost flight time, passenger disruption, and passenger safety (Chilvers et al. 1997). Annually, aircraft spend 461,000 h on ground in the United States due to bird strikes (Cleary et al. 1999). The cost of bird strikes in terms of human morbidity and mortality has not been rigorously investigated (Neubauer 1990). One human fatality can cost up to $2.5 million. Other studies show that bird management actions have halved the cost of repairs to aircraft that are damaged by birds (e.g. Solman 1973).

Military versus civil aircrafts.—Military aircraft are usually more vulnerable to bird strikes than civil aircraft because they typically travel at high speeds at low altitudes (30 to 300 m), where most birds fly. Approximately 54% of the bird strikes on military aircraft and 90% of those to civil aircraft around the world occur in or near to airfields (e.g. during take off) (Smith 1986, Neubauer 1990, Cleary et al. 1999). However, those figures should be viewed with caution because bird strikes *en route* can go unreported. Military aircraft are also vulnerable at bombing ranges where pilots do not always adequately detect approaching birds (Neubauer 1990). The number of reported bird strikes on military aircraft in the United States increased steadily between 1974 and 1987. However, that could have been due to heightened pilot awareness of the need to report collisions. Thus, bird–aircraft collisions are not uncommon and can result in loss of life and high costs.

Why do Birds Collide with Aircraft?

Airfields can provide good resources (e.g. foraging and nesting sites) for some bird species (e.g. Kershner and Bollinger 1998). However, they can be hazardous habitats due to the danger of getting hit by an aircraft. The ability to avoid an aircraft may involve learning to judge the threat and flying in a manner to evade it successfully. As bird strikes typically occur four to six times per 10,000 aircraft movements, it is possible that most individual birds succeed in evading an aircraft. However, it is critical to understand why evasive behavior does not always work. Birds should typically be good at sound and color signal detection. Those abilities, however, can vary with species and individuals. How nutritional stress, parental duties, disease, and ecotoxins (e.g. neurotoxins) affect a bird's ability to evade an aircraft remains poorly understood (Kelly et al. 2000). For example, carcasses versus live individuals in airports can be compared to determine whether dead individuals have disproportionately more parasites. Therefore, exciting research avenues remain open to understand which characteristics may make individuals more likely to collide with aircraft.

It is also possible that due to a lack of previous near-fatal encounters, most birds do not perceive an aircraft as a threat or potential predator. Limited evidence suggests that the amount of air traffic affects birds' evading abilities. The chance of bird strikes increases with the reduction of air traffic on a runway (Burger 1985). Birds probably get acclimatized to the lack of traffic and become less vigilant. Therefore, airport mangers must take specific action (e.g. disperse birds before resuming aircraft activity) when a runway has been inactive for several hours.

Recent design improvements might have made aircraft more vulnerable to bird collisions. Due to public and economic pressure, quieter, larger, and faster aircraft have been developed. Faster and wider-bodied aircraft are struck more often by birds than are the older, narrower-bodied jets (Burger 1983). For example, birds strike 737 passenger jets less frequently than the larger 767 jets (Chilvers et al.

1997). With the wider bodied aircraft, birds have to fly twice as far to escape than they do for the older small-bodied aircraft. Perhaps birds are also unable to hear the newer, larger-bodied quieter aircraft. Engine recording playbacks have shown that the escape distance from third generation quieter jet engines is much less than older, noisier engines (Solman 1981). At least for some species, aircraft noise may have little affect on daily activities (Conomy et al. 1998a). Furthermore, it may be hard for birds to distinguish aircraft noise from background noise at airports.

Species respond differently to aircraft characteristics (e.g. visual and auditory cues; Conomy et al. 1998b), suggesting that some bird species might be better at learning to avoid aircraft, but the evidence remains anecdotal. For example, American Crows (*Corvus brachyrhynchos*), Northern Harriers (*Circus cyaneus*), and American Kestrels (*Falco sparverius*) were not reported to strike aircraft, despite being common at the John F. Kennedy International Airport in New York City (Burger 1985).

Numerous questions remain unanswered as to why some birds do not or cannot perceive the aircraft as threat. Modifications to the newer aircraft might have made them less detectable and difficult to evade.

Which Birds are Hitting Aircraft?

Around the world, gulls (*Larus* spp.) account for a majority of strikes on civilian as well as military aircraft (e.g. Van Tets 1969, de Jong 1970, Solman 1978, Burger 1985, Smith 1986, Dolbeer et al. 2000). At the Lihue Airport in Kauai, Hawaii, the body mass of birds that hit the aircraft ranges from 13 to 1,300 g (Linnell et al. 1996). Individuals of heavier bird species are more hazardous to aircraft (Dolbeer et al. 2000). The average body mass of the bird species that caused fatalities or injuries to aircraft occupants is 5.1 kg (Neubauer 1990).

Several authors have suggested that disproportionately more immature individuals may be involved in aircraft strikes. Significantly more young than adult individuals of Herring (*L. argentatus*), Ring-billed (*L. delawarensis*), and Laughing (*L. atricilla*) gulls strike aircraft at the John F. Kennedy International Airport (Burger 1985). However, such is not the case for the Great Black-backed Gull (*L. marinus*). The reason for these species differences is not clear, but young individuals are probably either less capable of perceiving an approaching aircraft as a threat or less successful at evading it.

All things being equal, a solitary individual will cause less damage to an aircraft than will a flock. The number of birds that strike aircraft varies with species. Usually, ducks, geese, herons, owls, and doves collide with aircraft as individuals. However, shorebirds and starlings usually hit aircraft in flocks.

Is There a Dangerous Time?

Numerous factors can affect bird strikes on aircraft. Below, I discuss some of the more important factors.

Timing of bird strikes.—At the Christchurch International Airport in New Zealand, bird strikes peak at midmorning (0900), and there is another, smaller peak at night (2000) (Chilvers et al. 1997). However, strikes by sparrows peak at about 0800, whereas those by gulls peak at midday. At the John F. Kennedy International Airport, most gull strikes occur between 0500 and 0900 (Burger 1985), but non-gull strikes do not show any diurnal peak time. Although approximately 10 to 17% of bird strikes can occur during night (Neubauer 1990, Satheesan and Grubh 1992), nocturnal birds are generally ignored in bird strike monitoring and control. That may be partly due to difficulty in sampling nocturnal birds and, in some cases, difficulty in accurately assigning the timing of strikes to bird carcasses that are found at airports.

Effects of weather.—For the U.S. Air Force aircraft, 61% of bird strikes occur during clear weather, when both birds and aircraft are more active (Neubauer 1990). To save energy, migratory birds usually use tail wind to fly. However, wind speed does not significantly affect bird strikes (Manktelow 2000). There is a positive correlation between bird strikes and mean monthly rainfall at Lihue Airport (Linnell et al. 1996). That correlation is probably because of increased seed production along the runways during the rainy months, which attracts granivorous birds. Similar results have been found in the United Kingdom (Manktelow 2000).

Seasonal variation.—The chance of a bird strike is 5× higher during the migratory season than at other times (Jerome 1976). Bird strikes with the U.S. Air Force aircraft usually peak coinciding with the spring and fall migration (Neubauer 1990). Other authors have reported similar results (e.g. Blokpoel 1976). A large number of fatigued birds probably results in more bird strikes during migration. Heightened pilot awareness during the migratory season may also be at least partly responsible for more reporting.

More bird strikes occur in April than at any other time of year at the Christchurch International Airport. That is the time when fledglings are abundant, and they are possibly less successful at evading aircraft (Chilvers et al. 1997).

Can Pilots do Anything?

Approximately 90% of bird strikes occur <1,500 m above ground, but there are records of bird strikes at altitudes >2,000 m (Satheesan 1990). For military aircraft, 56% of bird strikes occur at <300 m above the ground (Neubauer 1990). Jerome (1976) makes a number of recommendations for pilots to minimize bird strikes. They include scanning the skies before take off, avoiding taking off into the sun, switching the aircraft lights on in areas of high bird concentration, keeping the windshield heat on to withstand a greater impact force, and maintaining lower safe airspeeds. Above all, Jerome recommends that pilots should report bird sightings and suspected and actual bird strikes to control towers. Hence, pilot vigilance can prevent some, but not all, bird strikes.

Improvements to Aircraft Design

Aircraft speed is a major factor in crashes due to bird strikes (Niering 1990). That is because the kinetic energy that is dissipated during a bird strike increases with the aircraft speed. There is probably no jet engine in the world that can ingest as large a bird as a Canada Goose and still fly (Eschenfelder 1990). Based on bird-strike data, efforts are underway to improve aircraft so that they can withstand a greater impact (Niering 1990). Those efforts include new material designs for aircraft engine compressor blades, stronger windshield design, and more damage-resistant wings. For military aircraft, windshields need further strengthening modifications, and some of the older aircraft are probably still vulnerable during bird strikes (Neubauer 1990). Previous lessons are sometimes taken into account when making recommendations to improve aircraft design. When a DC10 remained in the air for 10 min after two of its three engines were hit by birds in 1973, the Bird Strike Committee of Europe recommended that European airbuses should have three engines instead of two (Solman 1978).

The current engine certification standards remain vague and are primarily based on the amount of bird flesh ingestion rates. Artificial birds should be used for such tests because it is a humane course of action, and will probably assist in standardization across different aircraft manufacturers. However, existing bird models use only body mass specifications with little biometric data such as density and shape. Research is now underway to develop a better artificial bird for aircraft engine testing (Budgey and Allan 2000). There still is a need to further educate the aviation industry so that more effective bird-proof aircraft are designed.

Monitoring, Predictability, and Education

Before 1960, bird strikes were not seriously considered. However, in 1960, a departing aircraft at the Logan International Airport in Boston ingested European Starlings (*Sturnus vulgaris*) into three of its four engines. The aircraft crashed, and 62 of the 72 people on board died. A review of bird strike data at that time revealed data deficiency and a lack of coordination in its collection. In 1965, the ICAO started to collect bird-strike reports from participating states. With the introduction of the ICAO's bird strike information system (IBIS) in 1980, bird strike reporting became automated. From 1980 until 1998, data on ~78,000 bird strikes were collected from 190 participating states and territories. In the United Kingdom, each airport is required to report all bird strike incidents that result in damage or danger. However, to my knowledge, bird strike reporting in the United States is voluntary.

Different techniques have been used to warn the pilots and flight schedulers of potential bird threats. Radar has been used to monitor bird movements and warn the relevant personnel (Solman 1981, Short et al. 2000). In the 1980s, the Bird Airplane Strike Hazard Team (BASH) of the U.S. Air Force developed a bird avoidance model (BAM). Using historical data of bird distribution, BAM provides pilots with information on the specific locations and times of high bird activity within the continental United States. BAM has been used by the airline industry since its implementation in 1983. A recent study shows that BAM can be useful in predicting bird threats on low-flight-level routes (Lovell and Dolbeer 1999). BAM information for the continental United States is now available on the Internet, with data arranged in biweekly intervals for different times of the day (e.g. dawn and dusk) (see Acknowledgements). BAM and similar monitoring programs are being used or developed in other areas of the world (Leshem 1994, Oost et al. 2000, Verbeek et al. 2000). However, the models—which are primarily based on bird migration information—may need to be recalibrated if global climate change alters the migratory behavior of birds, as has been predicted (Zalakeuicius 2000).

Not all wildlife species are equally hazardous to aircraft. Dolbeer et al. (2000) ranked the species according to their potential hazard to aircraft in the United States. This ranking was conducted so that managers would not waste money and effort in targeting the wrong species. As expected, heavier bird species such as vultures and geese were more hazardous to aircraft than lighter species such as sparrows and swallows. However, that ranking should be viewed with caution because it did not take behavior such as flocking into consideration. A flock of birds can cause greater damage to an aircraft than can a single individual.

In addition to predicting the bird hazard, the education of the relevant personnel is the key to success in reducing the bird hazard at airports. A three-day course is offered for military and civilian airport personnel in the United Kingdom. The course content includes bird biology, habitat management, dispersal techniques, and data recording and analysis (Deacon 2000). The ICAO sponsors bird hazard workshops with similar objectives.

There has been a concern that inadequate resources are allocated for studying and solving bird–aircraft conflict (Short et al. 2000). Predicting and avoiding the bird threat to aircraft are critical issues, and more research is certainly needed to fine-tune the existing models and techniques. Educating the relevant personnel is equally important so that effective management is implemented.

Management

The ICAO recommends that airports should take steps to both monitor and reduce the bird hazard to aircraft. Each airport has its own specific bird hazard problems that depend on the bird species involved, and the habitat types within and surrounding the airports. Hence, a single management recipe that applies across all airports is not possible.

Bird management can be broadly grouped into short-term or long-term action. Short-term action includes scare tactics (e.g. the playing of distress calls) and shooting. Long-term management includes habitat modifications so that airfields and their surroundings become less conducive for birds. One of the problems with short-term control action has been habituation. Birds usually become habituated to bird distress calls within four to six weeks, and reach pretrial numbers in eight weeks (Baxter 2000). The other problem is that birds usually stay in an area before and after the use of calls. The removal of birds through trapping and culling has been practiced at various airports (Blokpoel 1976). However, bird removal can also pose problems because more hazardous individuals that are naïve about aircraft might replace experienced residents. That may be counterproductive, but the removal of juveniles can still be effective.

Innovative methods have sometimes been used to counter the bird hazard. For example, border collie dogs (*Canis familiaris*) are being used to chase birds from airfields (e.g. Southwest Florida International Airport at Fort Myers; Ryan 1999). Such an effort at the Vancouver International Airport in Canada resulted in a 40% reduction of bird numbers over a year (Patterson 2000). Similarly, in Canada, trained Peregrine Falcons (*Falco peregrinus*) and Gyrfalcons (*F. rusticolous*) have been used to drive birds away from airports during daylight hours (Solman 1973). However, that technique has limited value for airports that have flights during the night and during adverse weather conditions.

In the United Kingdom, all airports are recommended to maintain grass at 20 cm high (Smith 1986). That is based on the assumption that most birds are reluctant to feed in tall grass areas because of difficulty in effectively scanning for predators. However, such grass can result in a high population of small mammals, which can attract birds of prey. Heathrow Airport in the United Kingdom has recently been experiencing problems due to growing numbers of Canada Geese. Pilots have been warned of these birds, and nearby farmers around this and other British airports are being educated to make their properties less inviting habitats for that species. Canada Geese have also been causing nuisance at British parks, and there is now a program underway to limit their productivity through contraceptive pills and the pricking of eggs. Chemicals have been used to reduce the bird hazard. The Manchester International Airport in the United Kingdom applies lumbricides in the grass on runway edges to prevent earthworms from moving on to the runways and thus attracting birds (Smith 1986). However, the large-scale use of lumbricide is not recommended due to possible harmful effects such as poor grass growth and drainage problems (Allan and Watson 1990).

For increased effectiveness, a combination of both short and long-term management actions is used at some airports. At the John F. Kennedy International Airport, as many as 315 bird strikes occur every year, of which over 80% are caused by gulls (Dolbeer et al. 1993). Bird strikes between 1979 and 1990 increased more than two-fold. The possible reason for that increase was that in the nearby Jamaica Bay Wildlife Refuge during the same period, Laughing Gull numbers increased from 15 pairs to 7,629 pairs. The shooting of gulls in 1991 and 1992 resulted in a 66 to 89% reduction in gull strikes. A study that attempted to understand the environmental factors attracting high number of Laughing Gulls was also conducted at that airport (Buckley and McCarthy 1994). The study concluded that Laughing Gulls were primarily attracted to the oriental beetle (*Anomala orientalis*) in the short grass (≤5 cm) areas of the airport. Management action was recommended to remove ecological features such as short grass areas and standing water, and to reduce beetle populations. Similar approaches have been employed elsewhere, whereby food abundance (e.g. soil fauna) is monitored to recommend minimizing its availability to bird species (Allan and Watson 1990, Yang et al. 1998).

At the John F. Kennedy International Airport, two vehicles patrol the runways between 0600 and 2000. The crews on those vehicles are equipped with devices such as bird distress call tapes to disperse birds (Burger 1985). Moreover, active environmental management action is being taken by removing trees that provide roosts for starlings, and the drainage of water bodies that attract waterbirds. All-round management has also been practiced at Gatwick Airport in the United Kingdom, and at Schipol Airport in The Netherlands (Smith 1986, Van Geuns 1984). Management action cut bird strikes in half at Schipol Airport (Van Geuns 1984). However, that was not the case at the Christchurch International Airport, where agricultural practices outside of the airport hindered successful management (Chilvers et al. 1997).

Due to large human populations, high species diversity, and poor garbage disposal, the bird hazard at tropical airports is usually high, and its management is difficult. For example, a study that was conducted at the Dar Es Salaam International Airport in Tanzania found that the presence of household as well as aircraft-generated refuse and poultry within the airport and surrounding areas attracted crows and birds of prey (Howell and Msuya 1993). Effective management seemed difficult due to the constant encroachment of local residents into airport compounds for activities such as refuse deposition and goat (*Capra hircus*) grazing. The management of vultures in India shows that effective management can still be possible in developing countries. Annually, $70 million is spent in India to repair aircraft that are damaged by vultures. Vulture numbers can be significantly reduced by removing carcasses within 100 and 200 km radii of civil and military airports, respectively (Satheesan and Satheesan 2000).

Architects and horticulturists can use some of the recommendations at early stages of airport development to attract fewer birds. For example, the building of ledges can be minimized to repel nesting birds such as House Sparrows (*Passer domesticus*). Soil can be seeded within monoculture grass, or trees can be planted widely apart so that they do not become roosts for mynas and starlings. It is much better to evaluate the bird hazard before selecting a site for an airport, as has been done in Portugal

(Pessoa et al. 2000). Similarly, habitat restoration and enhancement projects near airports should consult, during the early stages of development, personnel who are involved in reducing the bird threat at those airports.

As shown above, well-rounded management can reduce the bird hazard at airports. The advances that ornithology has made in understanding bird distribution and habitat associations can be relied upon for effective management.

Conclusion

Airports attract some bird species by providing them with resources such as food and nesting sites. Those birds can be hazardous to landing and departing aircraft. To eliminate or reduce that hazard, airports around the world should have rigorous bird monitoring and management programs. Such programs should also target surrounding areas, because not all hazardous birds are restricted to sites within airports. Different airports may have different problems depending upon species and habitat types. Hence, although a widely applicable management scenario may not be possible, there is a need to develop a rigorous international standard for reducing bird threats to aircraft. There is also a need for better information transfer among airports, particularly in relation to those in developing countries. The Internet can be an excellent tool for such information transfer (see Appendix). Models that predict *en route* bird threats may have to be updated should there be changes in bird distribution and migratory behavior. The aviation industry needs to consult ornithologists more closely in bird proofing its aircraft. Deep ornithological knowledge may be required to eliminate or reduce bird threats to aircraft. Great opportunities for ornithological research exist in the realm of bird–aircraft conflict and hopefully more funding will be channeled into studying that conflict.

With this review, I in no way wish to imply that humans should have air superiority over birds. Birds provided the inspiration for humans to build aircraft, and now a detailed understanding of their biology could be the most effective tool in minimizing bird–aircraft collisions.

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APPENDIX. More information on bird strikes can be found at the addresses below.

International Bird Strike Committee
% Royal Netherlands Air Force
P.O. Box 20703
2500 ES Den Haag
The Netherlands
http: / / www.int-birdstrike.com

International Civil Aviation Organization
999 University Street
Montreal, Quebec H3C 5H7
Canada
http: / / www.icao.int /

Civil Aviation Safety Authority Australia
http: / / www.casa.gov.au

Transport Canada
Safety and Security
Aerodrome Safety Branch
330 Sparks St., Place de Ville
Tower C, Ottawa, Ontario K1A ON5
Canada
http: / / www.tc.gc.ca / CivilAviation / menu.htm

Civil Aviation Authority
Kingsway, London
United Kingdom
http: / / www.caa.co.uk /

German Bird Strike Committee
P.O. 1162
D-56831 Traben-Trarbach
Germany
http: / / www.davvl.de /

Bird Strike Committee Italy
http: / / web.tiscali.it / birdstrike /

Bird Strike Committee USA
6100 Columbus Avenue
Sandusky, Ohio 44870, USA
http: / / www.birdstrike.org

The Federal Aviation Administration
Room 810
800 Independence Avenue, SW
Washington, D.C. 20591, USA
http: / / www.faa.gov

ANNEXURE 13

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Height Distribution of Birds Recorded by Collisions with Civil Aircraft

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Research Article

Height Distribution of Birds Recorded by Collisions with Civil Aircraft

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Abstract

The National Wildlife Strike Database for Civil Aviation in the United States contained 38,961 reports of aircraft collisions with birds (bird strikes) from 1990–2004 in which the report indicated the height above ground level (AGL). I analyzed these strike reports to determine the distribution of all strikes and those strikes causing substantial damage to aircraft by height. For the 26% of strikes above 500 feet (152 m) AGL ($n = 10,143$), a simple negative exponential model, with height as the independent variable, explained 99% of the variation in number of bird strikes per 1,000-foot (305-m) interval. Strikes declined consistently by 32% every 1,000 feet from 501–20,500 feet (153–6,248 m). For strikes at ≤500 feet, passerines, gulls and terns, pigeons and doves, and raptors were the identified species groups most frequently struck. For strikes at >500 feet, waterfowl, gulls and terns, passerines, and vultures were the species groups most frequently struck. For strikes that resulted in substantial damage to the aircraft, 66% occurred at ≤500 feet, 29% between 501–3,500 feet (153–1,067 m), and 5% above 3,500 feet. A higher ($P < 0.001$) proportion of strikes between 501–3,500 feet caused substantial damage to the aircraft (6.0%) than did strikes at ≤500 feet (3.6%) or at >3,500 feet (3.2%). For strikes at ≤500 feet, July–October were the months with the greatest proportion of strikes relative to aircraft movements. For strikes at >500 feet, September–November and April–May had more strikes than expected. About 61% of the reported strikes above 500 feet occurred at night, compared to only 18% of civil aircraft movements. Thus, about 7 times more strikes occurred per aircraft movement at night compared to day above 500 feet. This analysis confirmed that management programs to reduce strikes should focus on the airport environment because 74% of all strikes and 66% of strikes causing substantial damage occur at ≤500 feet. To minimize significant strike events occurring outside the airport (>500 feet), efforts to predict or monitor bird movements using bird avoidance models and bird-detecting radar need to focus on heights between 500 and 3,500 feet AGL, with special emphasis on night movements of birds during April–May and September–November. (JOURNAL OF WILDLIFE MANAGEMENT 70(5):1345–1350; 2006)

Key words

aircraft, airport, bird, bird strike, civil aviation, damage, height, migration, nocturnal, waterfowl.

Aircraft collisions with birds and other wildlife (wildlife strikes) are an increasingly serious economic and safety problem, related in part to increasing populations of various large-bird species (e.g., Canada geese [*Branta canadensis*], Dolbeer and Eschenfelder 2002). Cleary et al. (2005) estimated wildlife strikes (98% involving birds) cost the civil aviation industry in the United States about $500 million per year from 1990–2004. Allan and Orosz (2001) estimated that bird strikes annually cost commercial air carriers over US$1.2 billion worldwide from 1999–2000. Bird strikes with civil and military aircraft from 1988–2005 killed at least 192 people and destroyed 144 aircraft (Richardson and West 2000, Thorpe 2003, Thorpe 2005, R. A. Dolbeer, United States Department of Agriculture, unpublished data).

The Federal Aviation Administration (FAA) has a standard form (5200–7) for the voluntary reporting of bird and other wildlife strikes with civil aircraft in the United States. The FAA has entered strike reports into a national database since 1990. Management programs to reduce bird strikes have focused on dispersing birds from the airport environment (Cleary and Dolbeer 2005) because over 70% of wildlife strikes in the database occur below a height of 500 feet (152 m) above ground level (AGL; Cleary et al. 2005). I consider the airport environment to encompass an area out to 10,000 feet (3,048 m) from the runway, which is the distance where aircraft on approach typically descend below 500 feet AGL. The FAA-recommended restrictions on land uses that attract birds (e.g., landfills) extend to a distance of 10,000 feet from runways for airports servicing turbine-powered aircraft (Cleary and Dolbeer 2005).

However, there have been bird strikes reported at heights up to 32,000 feet (9,754 m) in the United States (Cleary et al. 2005) and 37,000 feet (11,278 m) in Africa (Laybourne 1974). My objective was to examine bird-strike reports for civil aircraft in the United States to determine the distribution of strikes by height (AGL) in relation to season of year and time of day (daylight vs. dark). This analysis may prove useful to ornithologists interested in the height distribution of migrating and soaring birds and to people in the aviation industry and wildlife management profession attempting to reduce the probability of bird strikes in the airport environment and off-airports at heights above 500 feet.

Methods

I used data from the FAA's National Wildlife Strike Database for Civil Aviation (Cleary et al. 2005). I used strike reports from January 1990–December 2004, excluding strikes with nonbird species and bird strikes without a reported height.

To examine the relationship between height above 500 feet and number of strikes, I grouped the number of strikes into 20 1,000-foot (304-m) intervals from 501–1,500 feet

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(153–457 m, interval 1 with a mean height of 1,000 feet [304 m]) to 19,501–20,500 feet (5,944–6,248 m, interval 20 with a mean height of 20,000 feet [6,096 m]). I used 1,000-foot increments centered on 1,000-foot intervals because outside the airport environment, pilots often report strikes to the nearest 1,000-foot interval. Using height interval as the single independent variable and number of reported strikes per interval as the dependent variable, I determined the equation that gave the best correlation (Statistix 2003).

To determine if strikes at certain height bands were more hazardous to aircraft than at others, I used Chi square analysis (Statistix 2003) to test the null hypothesis that the proportion of reported strikes causing substantial damage to the aircraft did not differ among height bands from 0–500 feet, 501–3,500 feet (153–1,067 m), and above 3,500 feet. The FAA classified bird-strike-related damage as substantial when the aircraft was destroyed or incurred damage or structural failure that adversely affected the structural strength, performance, or flight characteristics of the aircraft and that normally required major repair or replacement of the affected component (International Civil Aviation Organization 1989, Cleary et al. 2005).

To determine if the frequency of all strikes varied throughout the year for strikes above and below 500 feet, I used a Multinomial test (Statistix 2003) to test the null hypothesis that the monthly proportion of reported strikes and strikes causing substantial damage did not differ from the monthly proportion of aircraft movements by commercial air carriers, 1990–2004 (FAA 2005).

To determine if the frequency of strikes differed between night and day for strikes above and below 500 feet, I used a Multinomial test to test the null hypothesis that the proportion of reported strikes during night and day (one-half hour before sunrise to one-half hour after sunset) did not differ from the proportion of aircraft movements during night and day, 1990–2004. I used the number of aircraft movements during night and day for itinerant (i.e., nonlocal) air traffic at all Canadian airports below 60° latitude, 1995–2003 (M. Villeneuve, Aviation Statistics, Transport Canada, unpublished data). Data for the proportion of night and day movements in the United States mimic the data for Canada, but were not available (E. C. Cleary, FAA, personal communication).

Results

From 1990–2004, there were 38,961 reported bird strikes in which the height was provided; 74% of these strikes occurred within 500 feet of the ground, 19% from 501–3,500 feet, and 7% above 3,500 feet (Table 1). Fifty percent (14,375) of the strikes at ≤500 feet, 27% (2,021) of the strikes from 501–3,500 feet, and 12% (331) of the strikes above 3,500 feet identified the species or species group involved. For strikes at ≤500 feet, passerines, gulls and terns, pigeons and doves, waterfowl, and birds of prey were the species groups most frequently struck. For strikes above 500 feet, waterfowl, gulls and terns, passerines, birds of prey, and vultures were the species groups most frequently struck. Waterfowl comprised 53% of the identified birds struck above 3,500 feet.

Height Distribution of Strikes Above 500 Feet

For the 26% of strikes occurring above 500 feet, a negative exponential model with height as the independent variable explained 99% of the variation in number of bird strikes per 1,000-foot interval (Fig. 1). The number of strikes declined consistently by 32% every 1,000 feet from 501–20,500 feet.

Table 1. Species groups of birds reported as struck by civil aircraft in the United States at heights ≤500 (152 m), 501–3,500 (153–1,067 m), and >3,500 feet above ground level (AGL), 1990–2004.

	Height (feet) AGL			
Species group	**0–500**	**501–3,500**	**>3,500**	**Total**
Passerines (Passeriformes)	4,317	357	55	4,729
Gulls/terns (Laridae)	4,062	471	49	4,582
Pigeons/doves (Columbidae)	1,962	70	5	2,037
Waterfowl (Anatidae)	1,160	656	177	1,993
Hawks/eagles/kites (Accipitridae)	1,247	169	20	1,436
Shorebirds (Charadriiformes)	555	11	7	573
Herons/egrets/bitterns/storks (Ciconiiformes)	362	27	2	391
Vultures (Cathartidae)	162	194	11	367
Owls (Strigiformes)	281	10	2	293
Grouse (Tetraonidae)	98	1	0	99
Cranes (Gruidae)	47	8	0	55
Nighthawks/swifts (Caprimulgidae/Apodidae)	44	8	1	53
Pelicans (Pelecanidae)	22	8	1	31
Cormorants (Phalacrocoradicae)	15	9	1	25
Albatrosses (Diomedeidae)	14	0	0	14
Rails/coots (Rallidae)	7	4	0	11
Loons/grebes (Gaviidae/Podicipedidae)	3	7	0	10
Miscellaneous birds	17	11	0	28
Total known birds	14,375	2,021	331	16,727
Total unidentified birds	14,431	5,448	2,355	22,234
Total birds	28,806	7,469	2,686	38,961

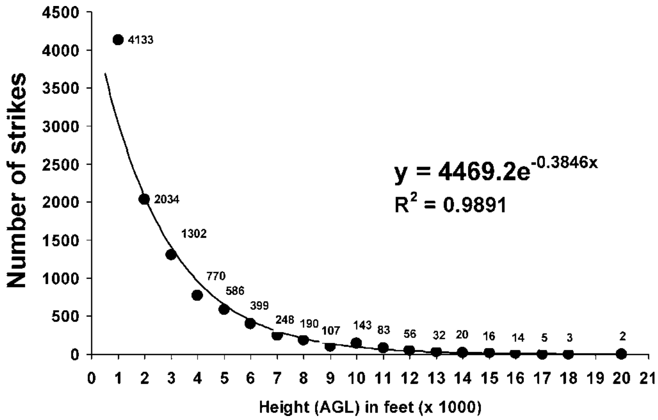

Figure 1. Number of reported bird strikes with civil aircraft in the United States from 1990–2004 as a function of 20 1,000-foot (305-m) height intervals from 501–1,500 feet (153–457 m, interval 1) to 19,501–20,500 feet (5,944–6,248 m, interval 20) above ground level (n = 10,143 strikes). The number of reported strikes declined consistently by 32% for each 1,000-foot gain in height. There were 28,806 strikes reported from 0–500 feet (152 m) and 12 strikes reported from 20,501–32,500 feet (6,249–9,906 m) not included in this analysis.

Thus, whereas 74% of the total reported strikes occurred at ≤500 feet, 19% occurred between 501–3,500 feet and only 7% occurred above 3,500 feet (Table 2).

Proportion of Strikes Causing Substantial Damage by Height Band

Whereas 26% of all strikes occurred above 500 feet, 34% of all strikes causing substantial damage occurred above 500 feet. A higher ($P < 0.001$) proportion of strikes between 501–3,500 feet caused substantial damage to the aircraft (6.0%) than did strikes at ≤500 feet (3.6%) or at >3,500 feet (3.2%; Table 2).

Proportion of Strikes by Month

For both strikes above and below 500 feet, the proportion of strikes occurring each month was different ($P < 0.001$) than expected based on the proportion of aircraft movements during those months (Table 3). For strikes at ≤500 feet, July–October were the months with the greatest proportion of strikes; August was the peak month. The months December–April had fewer strikes than expected. For strikes at >500 feet, September–November and April–May had more strikes than expected and December–February and June–July had fewer than expected.

Proportion of Strikes by Day and Night

Overall, there were about 2.5 times more strikes reported during daylight hours than at night (Table 4). However, because an estimated 4.5 times more aircraft movements occurred during day than at night, about 1.8 times more strikes per aircraft movement occurred at night than in the day ($P < 0.001$). This overall higher strike rate at night was due to the pronounced proportion of strikes above 500 feet occurring at night. About 61% of the reported strikes above 500 feet occurred at night compared to 18% of aircraft movements ($P < 0.001$). In contrast, proportionally fewer strikes occurred at ≤500 feet at night (16%), compared to the 18% of aircraft movements at night ($P < 0.001$). Above 500 feet, about 7 times more strikes occurred per aircraft movement at night compared to day (Table 4).

Discussion

My analysis confirmed (Dolbeer et al. 2000, MacKinnon 2002) that management programs to reduce bird strikes with civil aircraft should focus on the airport environment because 74% of all strikes and 66% of strikes causing substantial damage to aircraft occurred at ≤500 feet. An analysis of data on the 25 large-transport aircraft (>5,700 kg takeoff weight) crashes caused by bird strikes worldwide since 1960 also supported these findings (Richardson and West 2000, Thorpe 2003, 2005). Bird strikes occurred at <500 feet in 23 of the 25 (92%) accidents.

The months of July–October, especially August, were the months with the highest strike rates below 500 feet. With the addition of large numbers of recently fledged birds, populations of most bird species in North America are at their highest levels in late summer (Dolbeer 1998). In addition, these young birds are less adept than older birds at avoiding aircraft (Burger 1985, Kelly et al. 2001). During this pre-autumn-migration period, most strikes (84%) at ≤500 feet occurred during the day, probably when birds were undertaking localized movements for foraging and roosting.

Aircraft during climb and descent provide a unique method of sampling bird numbers at heights above 500 feet that lack the influence of bird-management actions on the ground at airports (Cleary and Dolbeer 2005). Above 500 feet, strikes declined exponentially by a remarkably consistent 32% per 1,000-foot interval up to 20,500 feet. The fact that the numbers of strikes reported independently by thousands of pilots over a 15-year period generated such

Table 2. Proportion of bird strikes with civil aircraft in the United States causing substantial damage at heights ≤500 (152), 501–3,500 (153–1,067), and >3,500 feet (1,067 m) above ground level (AGL), 1990–2004.

Height of aircraft (feet AGL)	All reported strikes		Reported strikes with substantial damage		% of strikes causing substantial damage[a]
	No.	% of total	No.[a]	% of total	
0–500	28,806	74	1,023	66	3.6
501–3,500	7,469	19	445	29	6.0
>3,500	2,686	7	85	5	3.2
Total	38,961	100	1,553	100	4.0

[a] The proportion of strikes and strikes causing substantial damage differed ($P < 0.001$, $\chi^2 = 94.9$, 2 df) among height bands.

Table 3. Percent of strikes to civil aircraft in the United States occurring at ≤500 and >500 feet (152 m) above ground level by month and the ratio of these percentages to the percent of aircraft movements each month, 1990–2004.

	% of total			Ratio: % of all strikes/% of movements[d]	
Month	**Aircraft movements[a]**	**Strikes ≤500 feet[b]**	**Strikes >500 feet[c]**	**≤500 feet**	**>500 feet**
Jan	8.04	4.33	2.88	0.54	0.36
Feb	7.52	3.71	3.25	0.49	0.43
Mar	8.43	4.86	6.48	0.58	0.77
Apr	8.22	5.86	9.22	0.71	1.12
May	8.49	8.23	11.40	0.97	1.34
Jun	8.47	9.05	4.01	1.07	0.47
Jul	8.77	13.33	4.76	1.52	0.54
Aug	8.92	15.50	8.63	1.74	0.97
Sep	8.22	12.43	16.64	1.51	2.02
Oct	8.59	10.42	19.19	1.21	2.23
Nov	8.05	7.44	9.72	0.92	1.21
Dec	8.28	4.85	3.83	0.59	0.46
Total	359,315,179	28,806	10,155		

[a] Based on total number of aircraft movements by month for commercial aircraft in the United States, 1990–2004 (Federal Aviation Administration 2005).
[b] The proportion of strikes at ≤500 feet occurring each month was different ($\chi^2 = 4{,}932$, 11 df, $P < 0.001$) than expected based on the proportion of movements each month.
[c] The proportion of strikes at >500 feet occurring each month was different ($\chi^2 = 3{,}653$, 11 df, $P < 0.001$) than expected based on the proportion of movements each month.
[d] Ratios above and below 1.0 indicate that the number of strikes occurring that month were greater or lesser than expected, respectively, than would have occurred if the proportion of aircraft-striking birds was equal to the proportion of aircraft movements.

a consistent exponential decay in relation to height suggests that the mean height distribution of birds above 500 feet has a fundamental relationship to some physical parameter, perhaps air density or energy expenditure to gain height.

Although some birds occasionally migrate at or soar to extreme heights of >20,000 feet (Alerstam 1990), I found that 93% of the strikes (and presumably birds) were below 3,500 feet. Only 5% of the reported strikes causing substantial damage to aircraft occurred from 3,500 feet up to 32,500 feet (9,906 m), compared to 29% between 501 and 3,500 feet and 66% at or below 500 feet. Bellrose (1971) documented heights of nocturnally migrating birds from a small airplane and found a similar pattern. Bellrose (1971) determined that the location of the majority of birds was between 500–1,000 feet, with numbers rapidly dropping off to almost 0 by 5,000 feet (1,524 m).

Above 500 feet, the peak months of strikes were April–May and September–November, which differed from the seasonal pattern below 500 feet. These spring and autumn months coincide with peak migration periods when birds are more likely to be flying at heights above 500 feet (Bellrose 1971, Alerstam 1990, Gauthreaux and Belser 2003). Because many birds migrate at night (Bellrose 1971, Gauthreaux and Belser 2003), this also helps explain the increased nocturnal strike rate above 500 feet compared to <500 feet.

To assist pilots in avoiding birds and significant strike events at heights above 500 feet (i.e., outside the airport environment), researchers have undertaken efforts to predict

Table 4. Percent of strikes to civil aircraft in the United States occurring at ≤500 and >500 feet (152 m) above ground level during night and day (one-half hour before sunrise to one-half hour after sunset), 1990–2004, and the ratio of these percentages to the percentage of aircraft movements during night and day.

	% of total				Ratio: % of strikes/% of movements[a]		
Time	**Aircraft movements[a]**	**Strikes ≤500 feet**	**Strikes >500 feet**	**Total strikes**	**Strikes ≤500 feet**	**Strikes >500 feet**	**Total strikes**
Night	18.2	15.6	60.8	28.1	0.86	3.34	1.54
Day	81.8	84.4	39.2	71.9	1.03	0.48	0.88
Total		22,612	8,609	31,221			
Ratio: night/day	0.22	0.19	1.55	0.39	0.83[b]	6.96[c]	1.75[d]

[a] The proportion of aircraft movements during night and day is based on data from Transport Canada for 1995–2003 (see Methods). Night movements annually ranged from 16.7–19.7% (mean 18.2%) of total movements (40,744,109) for the 9-yr period.
[b] The proportion of strikes at ≤500 feet during night and day was different ($\chi^2 = 99.0$, 1 df, $P = <0.001$) than expected, based on the proportion of movements during night and day.
[c] The proportion of strikes at >500 feet during night and day was different ($\chi^2 = 10{,}469.7$, 1 df, $P < 0.001$) than expected, based on the proportion of movements during night and day.
[d] The proportion of total strikes during night and day was different ($\chi^2 = 2{,}048.6$, 1 df, $P < 0.001$) than expected, based on the proportion of movements during night and day.

and monitor bird movements using bird-avoidance models (Lovell and Dolbeer 1999, Kelly et al. 2000) and bird-detecting radar (Ruhe 2000, Bell 2003, Gauthreaux and Belser 2003). Based on my findings, these efforts need to focus on heights below 3,500 feet, with special emphasis on movements of birds at night during periods of migration, especially April–May and September–November. Furthermore, the exponential reduction by 32% of the mean probability for a bird strike for every 1,000-foot increase in height is a general rule that may be useful for planners of military low-level training flights (Lovell and Dolbeer 1999). For example, changing the height of a training flight from 1,500 feet to 3,500 feet would reduce the mean probability of a bird strike by 54%.

Waterfowl were by far the most frequently struck species above 500 feet and especially above 3,500 feet. These species typically have large (>1 kg) body masses and migrate in flocks, making them particularly hazardous to aircraft traveling at higher speeds (Dolbeer and Eschenfelder 2002). Civil aviation authorities in the United States, Canada, and Mexico already have rules or proposed rules to restrict aircraft to indicated airspeeds of 250 knots (463 km/hr) or less below 10,000 feet, in part because of concerns about strikes with these larger bird species (Sowden and Kelly 2002, Eschenfelder 2005). Because of a fundamental relationship between energy (e), mass (m), and velocity (v) expressed in the equation $e = 0.5\ mv^2$, aircraft velocity is even more critical than bird mass in determining the energy imparted to an aircraft by a strike (Dolbeer and Eschenfelder 2002). To reduce the probability and severity of strikes with these larger species, pilots should minimize flight time and airspeed below 10,000 feet and especially below 3,500 feet at night during periods of migration by increasing the rate of climb on departure and delaying descent into these zones on arrival until necessary to descend to land. Increasing the rate of climb will result in a reduction in airspeed (Sowden and Kelly 2002), which is of critical importance.

I did not attempt to conduct comparative analyses by species of birds because identification to a species group occurred in only about 23% of the bird strikes above 500 feet. As improvements in the identification of struck species through feather and DNA analysis occur (Hermans et al. 1996, Dove 1997, Hebert et al. 2003) and as sample sizes increase with additional years of bird-strike data, comparisons of height distributions by various species and species groups of birds should be possible.

Management Implications

Management programs to reduce bird strikes with civil aircraft should focus on the airport environment because 66% of strikes causing substantial damage to aircraft occurred at ≤500 feet. Daylight hours during the months of July–October, especially August, had the highest strike rates below 500 feet. Outside the airport environment, the height zone from 500 feet to 3,500 feet is the most hazardous, especially at night. Because strikes decline exponentially by 32% per 1,000-foot increase in height above 500 feet, military planners can substantially reduce the mean probability of bird strikes by increasing the height of training flights. A 2,000-foot increase in height (e.g., from 1,500 feet to 3,500 feet) translates to a 54% reduction in the mean probability of a strike. Pilots of civil transport aircraft should minimize flight time and airspeed during climb and descent flight phases below 10,000 feet and especially below 3,500 feet at night during periods of migration to reduce the probability and severity of strikes.

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ANNEXURE 14

Birds and aircraft are competing for space in crowded skies

Statistics show that birds and other wildlife are a growing problem for aircraft operators, with civil aircraft in the United States alone involved in some 7,000 wildlife strikes during 2005

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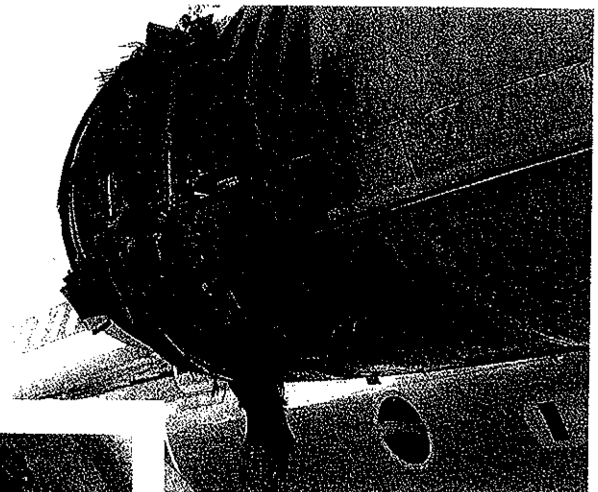
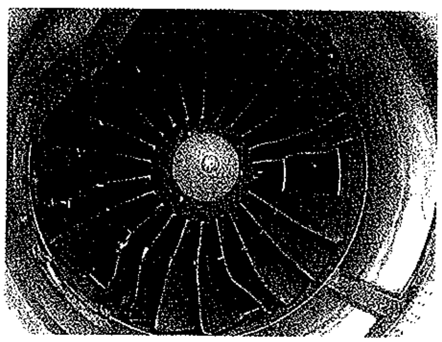
BIRDS and other wildlife are an increasing problem for the aviation industry. There are a number of reasons for this worsening trend, which is illustrated by statistics on wildlife strikes that have been collected over a period of years.

One reason for the growing number of strikes can be traced to highly successful programmes funded by governmental organizations during the past 30 years, among them initiatives to regulate pesticide use, expand wildlife refuge systems and restore wetlands. Coupled with land-use changes, these conservation efforts have resulted in dramatic increases in the populations of many wildlife species in North America, Europe and elsewhere.

Among the 36 largest bird species in North America, 24 have shown significant population growth in the past three decades; at the same time, only three of these large species have shown a decline. The non-migratory population of Canada geese resident in the United States — a bird that weighs from three to five kilograms — more than tripled from 1 million to 3.5 million between 1990 and 2005. The double-crested cormorant population on the Great Lakes of the United States and Canada have increased from some 100 nesting pairs in 1972 to over 130,000 pairs by 2005 (see figure, page 22). Double-crested cormorants typically weigh about two kilograms, and have a body density that is 30 percent more dense than gulls and geese.

While the number of large birds has been on the rise, it is noteworthy that most aircraft components, including engines, are not tested or certified for collisions with birds weighing more than 1.8 kilograms. There have been a number of strikes causing significant damage, including uncontained engine failures and cockpit penetrations, with birds weighing much less than 1.8 kilograms.





Wildlife strikes, the vast majority of which involve birds, cost airlines about $500 million per year in the U.S. alone. Above: An uncontained engine failure and fire occurred after a cormorant was ingested into this MD-80's port engine in September 2004. Left: Engine damage resulting from collision with two Canada geese in September 2003; one fan blade separated from the disk and penetrated the fuselage.

Many birds have adapted to urban environments and find that airports, which offer expansive areas of grass and pavement, are attractive habitats for feeding and resting. Other wildlife, such as deer and wild dogs, are attracted to airport environments for similar reasons.

Yet another factor in the growing number of strikes is the quieter engines found on modern aircraft, which are less apparent to birds than the older, noisier powerplants.

Some 7,100 wildlife collisions with civil aircraft were reported in the United States during 2005, compared to 1,719 strikes in 1990. Some experts have estimated that wildlife strikes, of which 98 percent involve birds, cost the U.S. civil aviation industry about $500 million per year between 1990 and 2004 (all financial figures in U.S. currency). One researcher has estimated that bird strikes cost commercial air carriers worldwide over $1.2 billion annually during 1999-2000.

At least 195 people have died and 168 aircraft have been destroyed as a consequence of bird and other wildlife strikes with civil and military aircraft since 1988, according to unpublished data collected by a number of scientists, including the author. Researchers have also established that at least 17 civil aircraft have been destroyed by deer strikes in the United States since 1983.

Mitigating the risk

There are a number of measures that airport authorities can take to minimize the hazards posed by wildlife. One important step is to ensure that they comply

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with the ICAO standards regarding bird hazards to aviation. These call for authorities to:

- assess the extent of the hazard posed by birds on and in the vicinity of airports;
- take necessary action to decrease the number of birds; and
- eliminate or prevent the establishment of any site in the vicinity of the airport which would be an attraction to birds and thereby present a danger to aviation.

These provisions, originally developed as recommended practices in 1990, were upgraded to mandatory standards in 2003 as a consequence of the increasing threat to aviation worldwide caused by birds. The new requirements contained in Annex 14 to the *Convention on International Civil Aviation* (also known as the Chicago Convention)[1] represent a significant challenge for many airports throughout the world.

Based on the findings of the assessment of bird hazards, airports should develop and implement a wildlife hazard management plan. Wildlife hazard management plans typically call for the airport to remove habitat and food attractive to wildlife. They also involve the use of various techniques, ranging from netting, pyrotechnics, lasers and even patrols with trained falcons or dogs, to exclude, disperse or remove hazardous wildlife. Wildlife hazard management plans normally require the establishment of an airport wildlife hazard working group to monitor and coordinate wildlife control activities at the airport.

Because the management of hazardous birds and other wildlife is a complex endeavour involving numerous species protected by national or local laws, professional biologists trained in managing wildlife damage are needed to conduct assessments and to develop and oversee *wildlife hazard management plans for airports.* The U.S. Federal Aviation Administration (FAA) and Department of Agriculture have published a 348-page manual, Wildlife Hazard Management at Airports, that provides detailed guidance and background material. The document is available on the web (http://wildlife-mitigation.tc.faa.gov).

Although the management of wildlife hazardous to civil aviation is primarily an airport's responsibility, there are actions that can be taken by air carriers and pilots to assist in reducing the number of damaging wildlife strikes. For example, if concentrations of birds are on a runway, pilots should not attempt take-off until the birds have been dispersed by airport operations personnel. It is important therefore to report wildlife hazards observed at the airport to the air traffic control (ATC) tower or airport operations.

U.S. Department of Agriculture

Professionally trained personnel are needed to conduct assessments and to develop and oversee wildlife hazard management plans for airports.

It should never be assumed that birds will see an approaching aircraft and disperse. Operators cannot rely on on-board radar, lights, noise or spinner markings to alert birds to approaching aircraft.

Pilots should also avoid airspeeds of more than 250 knots below 10,000 feet above ground level (AGL), especially at times of the year when birds are migrating. Aircraft speed is more critical than bird size (body mass) in causing collision damage.

Air carriers must ensure that all food waste in ramp areas is covered and inaccessible to birds and, likewise, they must prohibit the feeding of birds by their employees.

Even when there is no obvious damage, flight crews should report all wildlife strikes. The correct identification of the species struck is critical. Local biologists can often identify the species by examining feather remains. (In the United States, feather remains sent to the Smithsonian Institution will be identified free-of-charge.)

Air carriers need to provide pilots, mechanics and maintenance personnel with education and guidance concerning the actions and techniques cited above. Finally, airlines should obtain local representation on the wildlife hazard task force at airports where strike problems have been experienced.

Frequently asked questions

Any educational effort undertaken by air carriers should address the questions frequently asked by operating personnel. The most frequently asked questions in the author's experience are highlighted below, as well as brief answers based on U.S. bird strike data and derived primarily from the report, *Wildlife strikes to Civil Aircraft in the United States,* 1990-2004, which was published in 2005.[2]

Q: *At what height above ground level do most strikes occur? Do bird strikes ever occur at heights greater than 500 feet AGL?*

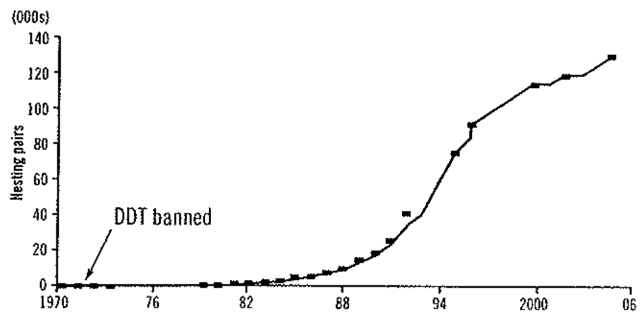
A: The world height record for a bird strike is 37,000 feet. In the United States, bird strikes have been reported up to 32,000 feet, but most collisions (57 percent) causing substantial damage occur below 100 feet. Thus, wildlife control on the airport is critical to reducing strikes. An additional 9 percent of strikes with substantial damage occur between 100 and 500 feet, while 29 percent occur above 500 feet and below 3,500 feet. Only 5 percent of strikes involving serious damage occur above this height.

Because a significant number of strikes involving substantial damage occur between 500 and 3,500 feet (over 445 were reported for civil aircraft in U.S. airspace during the 1990-2004 period), pilots should climb as expeditiously as possible in areas and during seasons of high bird activity in order to minimize exposure time. They should also avoid high-speed flight below 10,000 feet, since speed is an important factor in the type of damage caused by a strike. This is because the damaging force of a bird strike is generated by mass times velocity squared.

Do more strikes occur during take-off or landing? More strikes occur during landing; in fact, about 40 percent more bird strikes and 66 percent more deer strikes are reported during the landing phase of flight (i.e. the approach and landing roll) compared to the take-off run and climb.

Shouldn't birds sitting or standing on the runway notice an approaching aircraft and move out of harm's way? Pilots should not assume, as noted above, that birds will detect the aircraft in time to avoid a strike. Studies have indicated that about 80 percent of birds will attempt to avoid approaching aircraft, but their avoidance reaction may be too late or inappropriate.

One explanation is that birds often face into the wind when standing and usually take-off and land into the wind, which means that they often will face away from an approaching aircraft at airports. Furthermore, birds are apparently less able to detect modern aircraft with quieter engines, which are now far more prevalent at most airports than older and noisier aircraft.



Breeding population of cormorants on the Great Lakes of North America, 1970-2005

Do birds normally dive or climb when taking evasive action in response to an approaching aircraft? An analysis of pilot observations of bird reactions to approaching aircraft indicated that when the aircraft was higher than 500 feet AGL, 87 percent of birds that showed a defined reaction attempted to dive, while just 8 percent of these birds attempted to climb. In contrast, below 500 feet AGL only 25 percent of the birds encountered attempted to dive and 32 percent tried to climb. These data suggest that avoidance manoeuvres by birds are governed to some extent by the height of the encounter. Birds above 500 feet AGL will usually dive when they detect an approaching threat and, if an avoidance manoeuvre is possible, the pilot in these circumstances should try to fly above the birds encountered. However, it is important to bear in mind that birds flying close to the ground across a runway exhibit unpredictable manoeuvres when trying to avoid an aircraft.

Are bird strikes only a problem during daylight? Many bird species, including geese and ducks, migrate at night. Waterfowl will also actively feed at night. If left undisturbed, gulls and other species will sometimes rest on runways overnight. While it is true that about 2.6 times more total strikes to civil aircraft occur during daylight than at night, the probability of a strike in terms of the number of aircraft movements is actually greater at night. This is especially true for strikes above 500 feet AGL. Only 16 percent of all strikes above 500 feet occur during daylight, compared to 61 percent of strikes at night.

What about the season of the year? Are some months worse than others for bird strikes? In North America, the period of July-November, and especially the month of August, is the worst period for damaging bird strikes below 500 feet AGL. In the northern hemisphere, bird populations are at their highest levels during late summer and contain many young birds that are not skilled flyers. Above 500 feet, the periods of September-November and April-May are the most dangerous seasons in North America because these are the peak times for migration.

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Standing water is a strong attractant to waterfowl, gulls, and wading birds such as egrets and herons. Airport managers should strive to eliminate all standing water.

Are strikes more likely under certain weather conditions? More strikes occur on rainy days compared to dry days, based on statistical analyses of strike data. This increase in strikes might be related to the greater abundance of invertebrate food (such as earthworms) at the soil surface during wet weather and the tendency of birds such as gulls to wait out storms by standing on pavement.

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Are bird strikes more likely to occur to wing-mounted engines or fuselage-mounted engines? Wing-mounted engines were five times more likely to be struck by a bird than engines mounted on the fuselage, a conclusion based on an analysis of engine strikes per 10,000 movements by commercial air carriers in the United States during 1990-99.

Does the deployment of on-board radar disperse birds from the path of an approaching aircraft? It is true that many species of birds are more sensitive than humans to certain stimuli. Some bird species, for example, use the earth's magnetic field as a navigational cue during migration, and some birds have shown an aversion to microwave radiation. Birds also can detect light waves in the ultraviolet range beyond what humans see. There is no scientific evidence, however, that birds detect radar deployed on aircraft. Furthermore, even if birds did detect such microwave radiation, there is no evidence that such detection would be sensed as a threat and cause birds to avoid the aircraft.

What about visual devices, such as pulsating landing lights or painted engine spinners, to alert birds of approaching aircraft? Studies have shown that birds often respond to light beams by performing abrupt avoidance manoeuvres. There is anecdotal evidence and limited experimental data suggesting that pulsating landing lights might reduce bird strikes. Regarding visual markings, one commercial air carrier detected a slightly reduced rate of engine strikes for aircraft with white-painted spinners compared to those with unmarked spinners in a two-year study that was published in 1988. It does not appear, however, that any follow-up study has been conducted. Additional research is needed to determine if there are strategies that could be optimized — examples include the use of electromagnetic signals, landing light pulse and wave-length frequency, and the reflective characteristics of aircraft paint — to make aircraft more visible to birds.

Do ultrasonic devices keep birds out of hangars and off the airfield? Ultrasonic devices are not effective against birds in hangars or on the airfield. Several experiments have documented that birds do not hear in the ultrasonic range any better than humans. In fact, most birds are less able to hear higher frequency sounds than humans.

Gerry Ercolani

It should never be assumed that birds will see an approaching aircraft and disperse.

Why should a pilot report a bird strike? Will reported strikes result in negative publicity for the company? National wildlife strike databases are essential to provide a scientific foundation for methods to reduce the costs and safety hazards of strikes. Scientists and airport managers cannot solve a problem they do not understand, and airports are less likely to take actions to reduce strikes if these events are not documented. Documentation of the problem also is an important means of educating the public about the need to manage wildlife at airports. In the United States, publicly released statistical analyses and summaries of data from the national wildlife strike database do not identify the airport, air carrier or engine manufacturer.

How does someone report a strike and ensure that the bird species is properly identified? Each country needs to establish a reporting procedure based on the ICAO Bird Strike Information System (IBIS). Reports compiled at the national level should be forwarded to ICAO.

In the United States, bird strikes can be reported electronically to the FAA using Form 5200-7, available at http://wildlife-mitigation.tc.faa.gov. Several air carriers have established links so that strike reports filed internally are automatically reported to the FAA. The form also can be printed, filled out manually and mailed postage-free. Wildlife biologists working at airports can often identify the species struck if sufficient remains are available.

Conclusions

As highlighted above, ICAO has responded to the growing hazard of bird strikes by introducing more stringent provisions for mitigating wildlife hazards at airports. Recommended practices have been upgraded to standards, and airports worldwide need to ensure that they are in compliance with these ICAO requirements as well as national regulations.

Integrated management programmes such as those carried out by biologists from the U.S. Department of Agriculture and other organizations at many airports in the United States provide examples of successful efforts to minimize wildlife hazards to aviation.

Finally, there is a need to better educate pilots and air carrier personnel regarding the reporting of wildlife strikes and the actions that can be taken to reduce the probability of strikes. Moreover, research is needed to obtain a better understanding of behavioural reactions of birds to approaching aircraft, and methods of enhancing the awareness of birds to these aircraft. Indeed, future research results may make it necessary to modify some of the findings and conclusions presented in this article. □

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1. The technical annexes to the Chicago Convention, numbering 18 in all, contain provisions for the safe, secure, orderly and efficient development of international civil aviation.
2. The 53-page report, prepared by E.C. Cleary, R.A. Dolbeer and S.E. Wright, was published in 2005 by the U.S. Department of Transportation, FAA as Serial Report No. 11, DOT/FAA/AS/00-6 (AAS-310). The document is viewable at http://wildlife-mitigation.tc. faa.gov/.

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This article was accompanied by a lengthy list of references that has not been reproduced here. For more information concerning wildlife hazard management or reference material, readers may contact the author via e-mail (richard.a.dolbeer@usda.gov).

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Increasing trend of damaging bird strikes with aircraft outside the airport boundary: implications for mitigation measures

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Abstract. A basic tenet of programs to mitigate the risks of bird strikes with aircraft has been to focus management efforts at airports because various historical analyses of bird-strike data for civil aviation have indicated the majority of strikes occur in this environment during take-off and landing at ≤500 feet above ground level (AGL). However, a trend analysis of bird-strike data involving commercial air carriers from the U.S. National Wildlife Strike Database for Civil Aviation, 1990 to 2009, indicates that this tenet should be revised. The percentage of all strikes that occurred at >500 feet AGL increased significantly from about 25% in 1990 to 30% in 2009. The percentage of all damaging strikes that occurred at >500 feet increased at a greater rate, from about 37% in the early 1990s to 45% during 2005 to 2009. I also examined trends in strike rates (strikes/1 million commercial aircraft movements) for strikes occurring at ≤ and >500 feet. From 1990 to 2009, the damaging strike rate at >500 feet increased from about 2.5 to 4.0, whereas the damaging strike rate for strikes at ≤500 feet has remained stable at about 5.0 since 2000. An analysis of strike data for Canada geese (*Branta canadensis*), the most frequently struck bird species with a body mass >1.8 kg, showed a pattern similar to that for all species. I conclude that mitigation efforts incrementally implemented at airports in the United States during the past 20 years have resulted in a reduction of damaging strikes in the airport environment. This reduction in strikes has occurred in spite of increases in populations of Canada geese and many other species hazardous to aircraft. However, these successful mitigation efforts, which must be sustained, have done little to reduce strikes outside the airport. Increased efforts now are needed to eliminate bird attractants within 5 miles of airports, to further develop bird-detecting radar and bird-migration forecasting, and to research avian sensory perception to enhance aircraft detection and avoidance by birds.

Key words: bird strike, Canada goose, human–wildlife conflicts

HIGHLY SUCCESSFUL PROGRAMS funded by governmental and conservation organizations during the past 40 years (e.g., pesticide regulation, expansion of wildlife refuge systems, wetlands restoration, environmental education), coupled with land-use changes, have resulted in dramatic increases in populations of many large (>1.8 kg) bird species in North America (Dolbeer and Eschenfelder 2003). As one example, the population of Canada geese (*Branta canadensis*, >3.6 kg) in North America increased from 2.5 million to 5.3 million during 1990–2009 (U.S. Fish and Wildlife Service 2009, Dolbeer and Seubert 2009). The non-migratory component of the Canada goose population almost quadrupled from 1.0 million to 3.9 million. Many of these larger birds have adapted to urban environments and found that airports, with their expanses of grass and pavement, are attractive habitats for feeding and resting. In addition, modern turbofan-powered aircraft, with quieter engines, are less obvious to birds compared to noisier piston-powered aircraft and older turbine-powered aircraft (Burger 1983, Kelly et al. 1999).

For these reasons, birds and other wildlife in the vicinity of airports are an increasing problem for the aviation industry. At least 229 people died and 221 aircraft were destroyed worldwide as a result of bird and other wildlife strikes with civil and military aircraft from 1988 to 2009 (Richardson and West 2000; Thorpe 2003, 2005; 2008; Dolbeer, unpublished data).

The U.S. Federal Aviation Administration (FAA) has initiated several programs to address this safety issue. A foundation for these programs was the development of a National Wildlife Strike Database for Civil Aviation which contains all strikes reported to the FAA since 1990. Various analyses of these strike data aggregated over years have indicated that, on average, >70% of bird strikes with civil aircraft occurred at <500 feet (152 m) above ground level (AGL; Dolbeer 2006, Dolbeer et al. 2011). Based on these analyses, guidance developed by the FAA to mitigate the risks of bird strikes has focused on dispersing birds from the airport environment (Cleary and Dolbeer 2005). The airport environment, as discussed in this paper, encompasses an area out to 10,000 feet (3,048 m) from air operation areas (runways, taxiways, and ramps), which is the distance where aircraft on approach typically descend to <500 feet AGL. FAA-recommended restrictions on land uses that attract birds (e.g., landfills) extend to a distance of 10,000 feet from runways and taxiways for airports servicing turbine-powered aircraft (FAA Advisory Circular 150/5200-33b [Cleary and Dolbeer 2005, FAA 2010*a*]).

Airports in the United States certificated by the FAA for passenger traffic that experience wildlife hazards are required (14 Code of Federal Regulations, Part 139.337) to conduct a wildlife hazard assessment and, in most cases, develop and implement a wildlife hazard management plan. There has been a steady increase in the development and improvement of wildlife hazard management plans for certificated airports in the United States over the past 20 years. For example, biologists from the U.S. Department of Agriculture, Wildlife Services (WS) program provided assistance on 822 airports (including 410 of the 559 certificated airports) to mitigate wildlife risks in 2009 compared to only 42 and 193 airports (certificated and non-certificated) assisted in 1990 and 1998, respectively (Begier and Dolbeer 2010). As another example of the increasing importance of wildlife management at airports, attendance at Bird Strike Committee-USA annual meetings (which focus primarily on mitigation efforts at airports) grew from about 100 attendees in 1992–1995 to 200 in 1998 and 450 in 2008 (Dolbeer, unpublished data).

However, not all serious strike events occur at ≤500 feet AGL. A notable example occurred on January 15, 2009, when US Airways Flight 1549 made a miraculous forced landing in the Hudson River after ingesting birds in both engines of the Airbus 320 at about 2,800 feet AGL and 4.5 miles (7.2 km) from LaGuardia Airport, New York (National Transportation Safety Board 2010). Subsequent analyses of bird remains retrieved from each engine showed that the strike was caused by a flock of Canada geese (Marra et al. 2009). This highly publicized event dramatically demonstrated to the world at large that birds can bring down large transport aircraft. The event also demonstrated that wildlife management actions at airports to mitigate bird strikes, such as habitat alterations and bird dispersal programs emphasized by FAA guidance (Cleary and Dolbeer 2005), would not have prevented this strike.

If airport-based management actions are reducing bird strikes, then the strike rate (i.e., number of strikes and damaging strikes per 1 million aircraft movements) should be declining in the airport environment. Because there have been no operational efforts launched to date for civil aviation to mitigate strikes away from the airport, strike rates outside the airport environment should not have declined or perhaps they may even have increased in concert with increasing populations of many bird species that are hazardous to aircraft (Dolbeer and Eschenfelder 2003). To test these hypotheses, I undertook a trend analysis of reported bird strikes in the FAA's National Wildlife Strike Database for Civil Aviation occurring at ≤ and >500 feet AGL, 1990 to 2009.

Methods

I selected all reported strikes from the database, 1990 to 2009, involving birds and commercial aircraft (air carrier, air taxi, and commuter aircraft). Strikes involving mammals and reptiles, which represent 2% of strike reports, were excluded because these strikes always occur on the airport (with the exception of bats, which comprised <0.3% of the strike reports). I used commercial aircraft only because these aircraft almost exclusively use certificated airports where most of the wildlife hazard mitigation efforts have occurred (Dolbeer et al. 2008). Reports in which the height AGL at which the strike occurred was unknown also were excluded from the analysis.

Strike reporting that involve civil aircraft is voluntary but strongly encouraged by the FAA (Cleary et al. 2005, Dolbeer 2011). An analysis of strike reports has indicated a bias toward reporting damaging strikes as opposed to non-damaging strikes (Dolbeer 2009). Thus, my trend analyses examined all reported strikes (i.e., those with and without reported damage), and as subsets of all reported strikes, those strikes resulting in any level of damage to aircraft (from minor to destroyed) and strikes resulting in substantial damage (including aircraft destroyed). Strikes are classified as substantial damage when the aircraft incurs damage or structural failure that adversely affects the strength, performance, or flight characteristics and that would normally require major repair or replacement of the affected component (International Civil Aviation Organization 1989, Dolbeer et al. 2011). As another means of minimizing bias that may result from uneven reporting over years, I compared the percentage of strikes (as opposed to absolute numbers) occurring at ≤ and >500 feet AGL. To examine trends in strike rates over years, I calculated the number of strikes per 1 million commercial aircraft movements (FAA 2010*b*).

Canada geese are the most frequently struck large (>1.8 kg) bird species in the database (Dolbeer and Eschenfelder 2003; Dolbeer et al. 2011) and one of the most hazardous (i.e., likely to cause damage if struck) species to aviation (Dolbeer and Wright 2009). Thus, I conducted analyses similar to that described above for Canada geese only. Because the population of Canada geese in North America is estimated each year (U. S. Fish and Wildlife Service 2009), I also examined population-adjusted trends in yearly strike rates (strikes per 1 million aircraft movements per 1 million Canada geese).

Linear regression analysis was conducted to determine if there were statistically significant trends in the percentage of strikes at ≤ and >500 feet AGL for the 20-year period, 1990 to 2009. R^2 values >0.31 were significant at the 0.01 probability level with 18 *df* (Steele and Torrie 1960). For the analyses of strike rates, I compared empirically the mean rates for 4, 5-year time intervals (i.e., 1990–1994, 1995–1999, 2000–2004, and 2005–2009).

Results

Composition of data, 1990 to 2009

Overall, the database contained 99,411 strike reports for 1990 to 2009, of which 50,941 involved birds and commercial aircraft where height AGL of strike was reported (Table 1). Of these 50,941 reported strikes, 4,832 (9.5%) indicated damage to the aircraft, and 1,327 (3%) indicated substantial damage (Table 2).

The database contained 1,238 strikes involving Canada geese of which 584 involved commercial aircraft in which the height AGL of strike was reported (Table 1). Of these 584 strikes, 287 (49%) indicated damage to the aircraft and 101 (17%) indicated substantial damage (Table 2). The estimated Canada goose population in North America increased 2.1 fold from about 2.5 million in 1990 to 5.3 million in 2009 (Table 1).

Commercial aircraft movements in the United States increased from 23.3 million in 1990 to a peak of 29.5 million in 2000. Movements during 2001 to 2009 fluctuated between 25.5 million and 29.3 million (Table 1).

Trends in strikes at ≤ and >500 feet AGL for all birds, 1990 to 2009

The percentage of all reported strikes that occurred at >500 feet increased ($P < 0.01$) from about 25% in the early 1990s to 30% during 2005–2009 (Appendix, Figure 1). The percentage of all damaging strikes that occurred at >500 feet increased ($P < 0.01$ to a greater extent), from about 37% in the early 1990s to 45% during 2005 to 2009. The percentage of all substantial-damage strikes occurring at >500 feet AGL also increased ($P < 0.01$) from about 20% in the early 1990s to 35% during 2005 to 2009.

Trends in strike rates for all strikes and for damaging strikes showed different patterns (Appendix, Figure 2). From 1990 to 2009, the overall strike rate increased steadily both for strikes at ≤500 feet and for strikes at >500 feet. In concert with the overall strike rate, the rate of damaging strikes at >500 feet also increased steadily from about 2.6 during 1990–1994 to 4.3 during 2005–2009. In contrast, the damaging strike rate at ≤500 feet increased from 4.4 during 1990–1994 to 5.3 during 1995–1999, but then has remained near this level (5.3 to 5.4) during 2000–2004 and 2005–2009. The substantial-damage strike rate at ≤500 feet has declined from about 1.9 to 2.1 during 1990–1994 and 1995–1999 to 1.3 during 2005–2009. In contrast, the rate for substantial damage strikes at >500 feet has changed little, fluctuating between 0.5 during 1990–1994 to 0.9 during 1995–1999 and 0.8 during 2005–2009.

Trends in strikes at ≤ and >500 feet AGL for Canada geese, 1990 to 2009

Trends in strikes for Canada geese showed patterns similar to, but more pronounced than, those for all species. The percentage of all Canada goose strikes that occurred at >500

Table 1. Reported strikes at ≤500 and >500 feet above ground level (AGL) involving all birds and Canada geese (*Branta canadensis*) only for commercial aircraft (air carrier, commuter, and air taxi) in USA; number of Canada geese and number of commercial aircraft movements, 1990 to 2009.[a]

	Number of strikes (all birds)			Number of strikes (Canada geese)				
Year	≤500 ft AGL	>500 ft AGL	Total	≤500 ft AGL	>500 ft AGL	Total	No. of Canada geese (× 10^6)[b]	Aircraft movements (× 10^6)[c]
1990	837	344	1,181	10	5	15	2,514	23.27
1991	1,105	388	1,493	12	7	19	2,780	24.79
1992	1,178	381	1,559	10	5	15	3,096	25.18
1993	1,144	382	1,526	21	6	27	3,505	25.57
1994	1,230	371	1,601	26	8	34	3,729	26.59
1995	1,256	412	1,668	26	9	35	4,284	27.05
1996	1,253	419	1,672	19	7	26	4,461	27.59
1997	1,408	502	1,910	13	3	16	4,457	27.77
1998	1,469	513	1,982	28	14	42	4,507	28.01
1999	1,675	622	2,297	26	12	38	4,996	28.76
2000	2,049	774	2,823	25	14	39	4,960	29.54
2001	1,965	754	2,719	23	18	41	4,732	29.16
2002	2,078	840	2,918	31	13	44	5,187	27.63
2003	2,155	827	2,982	24	12	36	5,418	27.91
2004	2,392	932	3,324	16	12	28	5,200	28.89
2005	2,323	1,098	3,421	15	15	30	5,057	29.25
2006	2,485	1,023	3,508	16	10	26	5,484	28.31
2007	2,687	1,099	3,786	8	12	20	5,495	28.47
2008	2,556	1,110	3,666	14	11	25	5,461	27.95
2009	3,428	1,477	4,905	21	7	28	5,298	25.48
Total	36,673	14,268	50,941	384	200	584		

[a] Data from National Wildlife Strike Database (Dolbeer et al. 2011), excluding 17,526 and 61 strikes involving all birds and Canada geese, respectively, in which height AGL was not reported.
[b] Estimated population of Canada geese in Canada and the United States (U.S. Fish and Wildlife Service 2009).
[c] Departures and arrivals by commercial aviation aircraft in USA (FAA 2010*b*).

Table 2. Reported strikes causing substantial damage at ≤500 and >500 feet above ground level (AGL) involving all birds and Canada geese only for commercial aircraft (air carrier, commuter, and air taxi) in USA, 1990 to 2009.[a]

	Number of damage (substantial damage) strikes (all birds)			Number of damage (substantial damage) strikes (Canada geese)		
Year	≤500 ft AGL	>500 ft AGL	Total	≤500 ft AGL	>500 ft AGL	Total
1990	96 (47)	57 (7)	153 (54)	6 (2)	2 (0)	8 (2)
1991	107 (53)	69 (14)	176 (67)	5 (3)	2 (1)	7 (4)
1992	102 (39)	64 (16)	166 (55)	7 (3)	3 (0)	10 (3)
1993	109 (40)	70 (16)	179 (56)	5 (3)	3 (1)	8 (4)
1994	140 (60)	71 (16)	211 (76)	8 (3)	5 (2)	13 (5)
1995	143 (69)	90 (26)	233 (95)	15 (6)	7 (1)	22 (7)
1996	133 (67)	87 (26)	220 (85)	8 (3)	4 (1)	12 (4)
1997	163 (59)	105 (26)	268 (85)	2 (1)	3 (1)	5 (2)
1998	145 (35)	104 (25)	249 (60)	12 (7)	9 (2)	21 (9)
1999	154 (56)	122 (26)	276 (82)	13 (4)	8 (3)	21 (7)
2000	176 (52)	139 (20)	315 (72)	9 (4)	11 (1)	20 (5)
2001	153 (45)	102 (12)	255 (57)	12 (6)	10 (2)	22 (8)
2002	152 (44)	114 (17)	266 (61)	14 (4)	10 (4)	24 (8)
2003	154 (40)	118 (21)	272 (61)	7 (4)	10 (5)	17 (9)
2004	145 (41)	106 (21)	251 (62)	6 (3)	7 (2)	13 (5)
2005	145 (55)	123 (29)	268 (84)	3 (1)	7 (4)	10 (5)
2006	143 (36)	132 (22)	275 (57)	6 (2)	9 (2)	15 (4)
2007	145 (25)	111 (24)	256 (49)	3 (1)	8 (5)	11 (6)
2008	132 (28)	113 (13)	245 (40)	5 (0)	8 (0)	13 (0)
2009	173 (37)	125 (25)	298 (62)	10 (2)	5 (2)	15 (4)
Total	2,810 (928)	2,002 (399)	4,832 (1,327)	156 (62)	131 (39)	287 (101)

[a] Data from National Wildlife Strike Database (Dolbeer et al. 2011). These data exclude 2,120 and 24 damaging strikes involving all birds and Canada geese, respectively, in which height AGL was not reported.

feet increased ($P < 0.01$) from about 25% during the early to mid-1990s to about 40% during 2005–2009 (Appendix, Figure 3). The increase in the percentage of all damaging strikes and substantial-damage strikes that occurred >500 feet was more dramatic, growing from about 25% during the early 1990s to about 50% during 2005 to 2009 ($P < 0.01$).

The rates for all Canada goose strikes occurring at ≤ and >500 feet exhibited similar trends of increase during both 1990–1994 and 2000–2004 and subsequent declines during 2005–2009. However, the decline was greater (from 0.83 to 0.53 [36%]) for strikes at ≤500 feet than for strikes at >500 feet (from 0.48 to 0.39 [19%]; Appendix, Figure 4). For damaging and substantial-damage strike rates, the pattern of increase for strikes occurring at ≤ and >500 feet was similar to that shown for all strikes during both 1990 to 1994 and 1995–1999. However, for both damaging strikes and substantial-damage strikes, the rate for strikes occurring at ≤500 feet subsequently declined from being equal to or above the rate for strikes at >500 feet during 2000–2004 to below the rate for strikes at >500 feet during 2005–2009.

Trends in strike rates for Canada geese at ≤ and >500 feet adjusted for the 2.1-fold increase in the goose population during 1990–2009 also showed clear differences (Appendix, Figure 5). The population-adjusted strike rate at ≤500 feet declined from about 0.19 during 1990–2004 to 0.11 during 2005–2009. In contrast, the population-adjusted strike rate at >500 feet showed little change from 1990–1994 to 2005–2009, and approached the declining rate for strikes at <500 feet during 2005–2009. The population-adjusted rates for damaging strikes and substantial-damage strikes at ≤500 feet were higher than the rates for strikes at >500 feet during 1990–1994 and 1995–1999 but had declined below the rates for strikes at >500 feet during 2005–2009.

Discussion and conclusions

The trend analyses of strike data for all birds and for Canada geese support the hypothesis that mitigation efforts incrementally implemented at airports in the United States since 1990, and especially since about 2000, have resulted in a reduction of damaging strikes in the airport environment. Although Begier and Dolbeer (2010) and Wenning et al. (2004) provided examples of these successful mitigation efforts, those efforts at airports have done little to reduce strikes outside the airport environment. Based on trends in damaging strikes for all birds and for Canada geese, my hypothesis was supported that the risk to commercial aircraft for strikes at >500 feet AGL is growing faster than the risk for strikes at <500 feet.

The steady increase in the overall strike rate for all species both at ≤ and >500 feet AGL from 1990 to 2009 can be explained, at least in part, by the fact that there has been an increase in the voluntary reporting of strikes during this time period (Dolbeer 2009). This increase in the reporting of strikes for all species, coupled with the overall 2.1-fold increase in the Canada goose population and increases in many other large-bird species (Dolbeer and Eschenfelder 2003), makes the decline in the number and rate of damaging strikes at ≤500 feet AGL even more impressive. The decline in Canada goose strikes at ≤500 feet AGL is especially remarkable because the non-migratory (i.e., resident) component of the population, which attempts to graze and rest on airports year-round, has increased almost 4-fold during 1990–2009 (U.S. Fish and Wildlife Service 2009, Dolbeer and Seubert 2009).

Although the data indicate that damaging strikes at airports at ≤500 feet AGL have not increased in the United States since about the year 2000, these low-altitude strikes still comprise the majority of damaging strikes. Furthermore, 27 of the 30 bird strikes that have resulted in the destruction of large (>5,700 kg take-off mass) transport aircraft worldwide since 1967 occurred at ≤500 feet AGL (Dolbeer 2008, unpublished data). Thus, efforts to reduce the number of damaging strikes at airports must be sustained, building upon the successes demonstrated above and guidance provided in Cleary and Dolbeer (2005).

There are at least 3 areas where efforts should be enhanced to mitigate the risk of damaging bird strikes occurring outside of the airport at >500 feet AGL. First, there should be increased attention directed to elimination of bird attractants within the 10,000-foot separation distance from AOAs and within 5 miles of AOAs in departure and arrival airspace (FAA

Advisory Circular 150/5200-33b [FAA 2010*a*], Blackwell et al. 2009).

Second, there is a need to integrate real-time and historical knowledge of movements of hazardous bird species into flight planning for airports. Specifically, increased efforts are needed in the field-testing and refinement of bird-detecting radar systems (Nohara et al. 2005) to monitor arrival and departure airspace at airports (e.g., Klope et al. 2009). The ultimate goal will be to integrate bird-detecting radar into air traffic control in a manner analogous to what has been accomplished with wind-shear detection and avoidance. In conjunction with airport-based radar, bird migration forecasting based on historical bird migration and bird-strike data and real-time information from NexRad weather radar (filtered to detect birds and not weather) should be developed for civil aviation in a manner now used by the military (DeFusco 2000, Kelly et al. 2000).

Third, research is needed on avian sensory perception and reaction to moving objects. Such research may lead to the development of aircraft lighting systems (which could include various pulse rates and wavelengths in the electromagnetic spectrum) to enhance detection, speed perception, and avoidance of departing and arriving aircraft by birds (Blackwell and Bernhardt 2004, Dolbeer and Wright 2004, Blackwell et al. 2009). As an added bonus, these 3 initiatives should also assist in further reducing strikes at ≤500 feet, as well as at >500 feet AGL.

Acknowledgments

I thank M. J. Begier, B. F. Blackwell, T. L. DeVault, and S.E. Wright (WS) for advice in preparing this report. I also acknowledge former FAA staff biologists E. A. LeBoeuf and E. C. Cleary for their work to develop a national program to mitigate the risks of wildlife strikes at airports from 1989 to 2007. The findings and conclusions expressed do not necessarily reflect current FAA policy decisions regarding the reporting of wildlife strikes or the mitigation of bird and other wildlife risks to aircraft.

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RICHARD A. DOLBEER was a scientist with USDA Wildlife Services from 1972 to 2008 where he led a series of research projects to resolve conflicts between humans and wildlife in the United States and abroad. He has published >170 scientific papers and book chapters. He was recognized in 2000 by the 65,000-member Airline Pilots Association for "scientific integrity and worldwide leadership in the reduction of wildlife hazards to aviation." He was the 2005 winner of the U.S. Federal Aviation Administration Excellence in Aviation Research award. He has been recognized with the Lifetime Achievement Award by the Jack Berryman Institute for Wildlife Damage Management and was the 2008 winner of the Caesar Kleberg Award for Applied Wildlife Research, presented by The Wildlife Society. In 2008, he was presented with the 17th Mike Khuring Award by the International Birdstrike Committee. He served as chairperson of Bird Strike Committee–USA from 1997 to 2008. He received degrees from the University of the South (B.A., biology), the University of Tennessee (M.S., zoology), and Colorado State University (Ph.D., wildlife biology). Currently, he manages his small farm and works as a consultant in the aviation industry and science advisor to the U.S. Department of Agriculture, Wildlife Services program. He has been married to Saundra for 43 years and has 2 children and 6 grandchildren.

Appendix

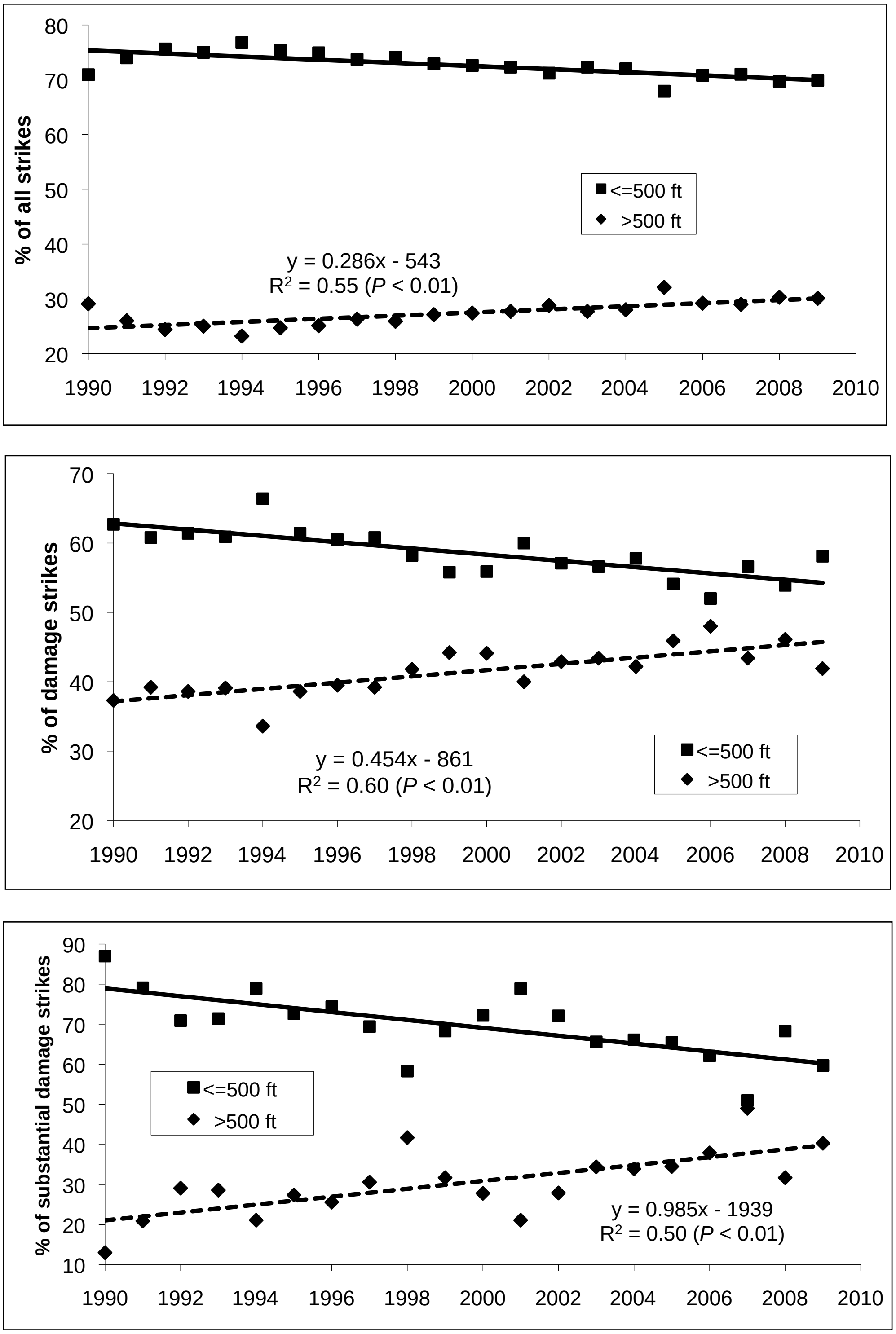

Figure 1. Percentage of reported bird strikes (top graph), strikes indicating damage (middle graph), and strikes indicating substantial damage (bottom graph) at ≤ and >500 feet above ground level (AGL)for commercial aircraft in the United States, 1990–2009 (see Tables 1 and 2 for sample sizes). In each graph, the equation and R^2 value are presented only for strikes at >500 feet AGL (R^2 value is the same and slope is the same [but negative] for strikes ≤500 feet AGL). R^2 values >0.31 are significant (P < 0.01, 18 *df*; Steel and Torrie 1960).

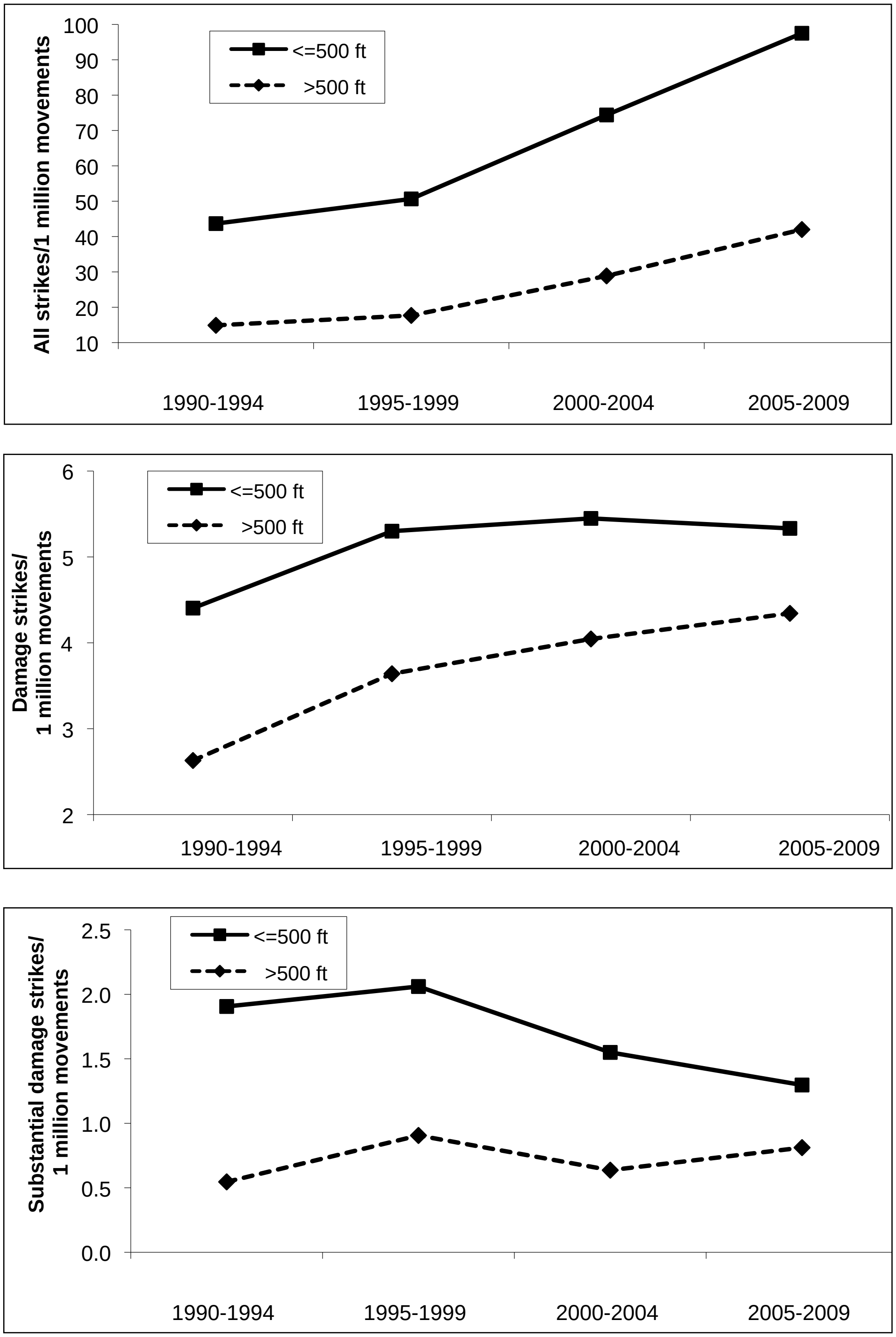

Figure 2. Mean strike rate per 5-year period (all bird strikes, top graph), strikes with damage (middle graph), and strikes with substantial damage (bottom graph) per 1 million aircraft movements for commercial aircraft in the United States, 1990–2009 (see Tables 1 and 2 for sample sizes).

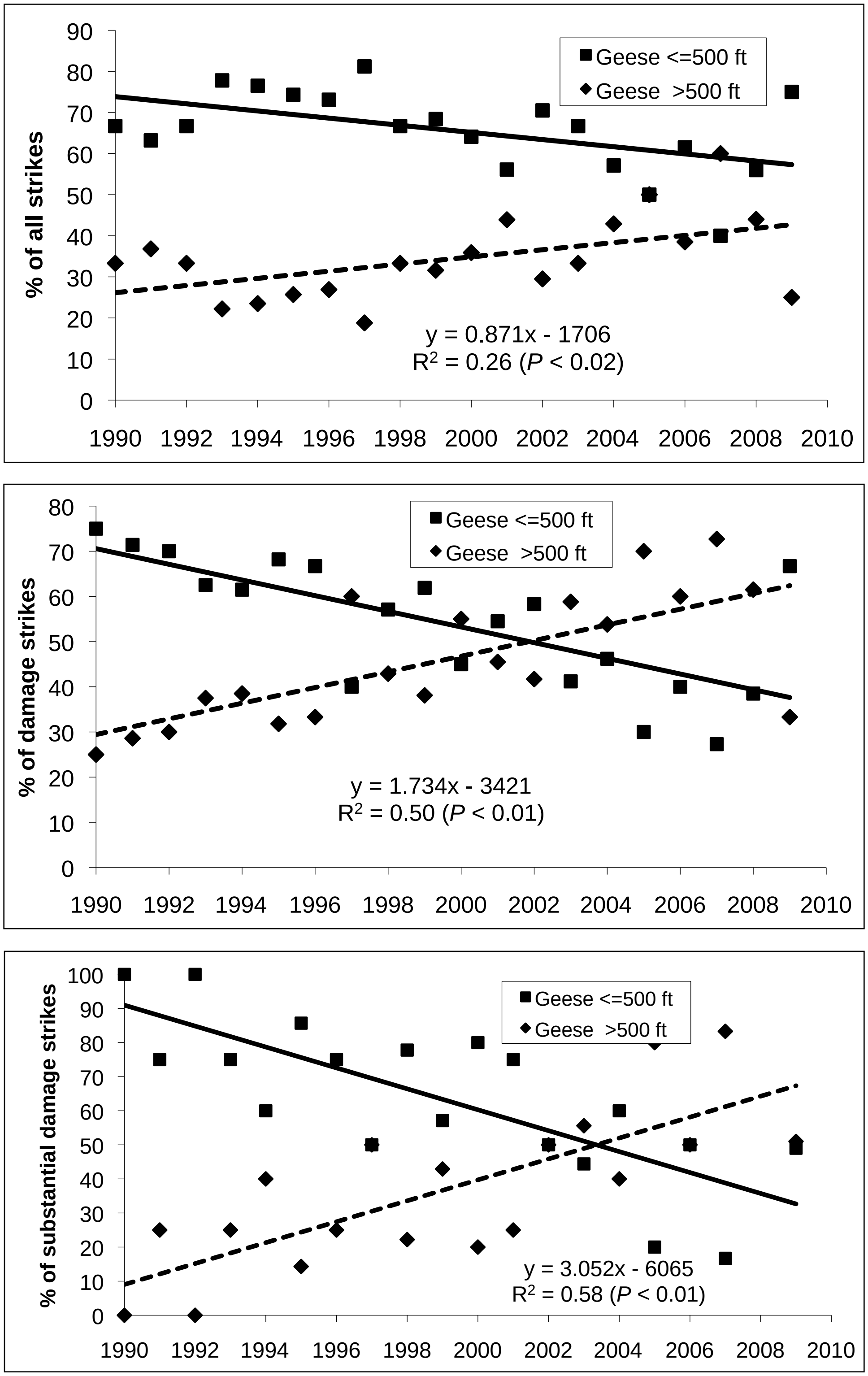

Figure 3. Percentage of reported Canada goose (*Branta canadensis*) strikes (top graph), strikes indicating damage (middle graph), and strikes indicating substantial damage (bottom graph) at ≤ and >500 feet above ground level (AGL) for commercial aircraft in the United States, 1990–2009 (see Tables 1 and 2 for sample sizes). In each graph, the equation and R^2 value are presented only for strikes at >500 feet (R^2 value is the same and slope is the same [but negative] for strikes ≤500 feet AGL). R^2 values >0.31 are significant ($P < 0.01$, 18 *df*; Steel and Torrie 1960).

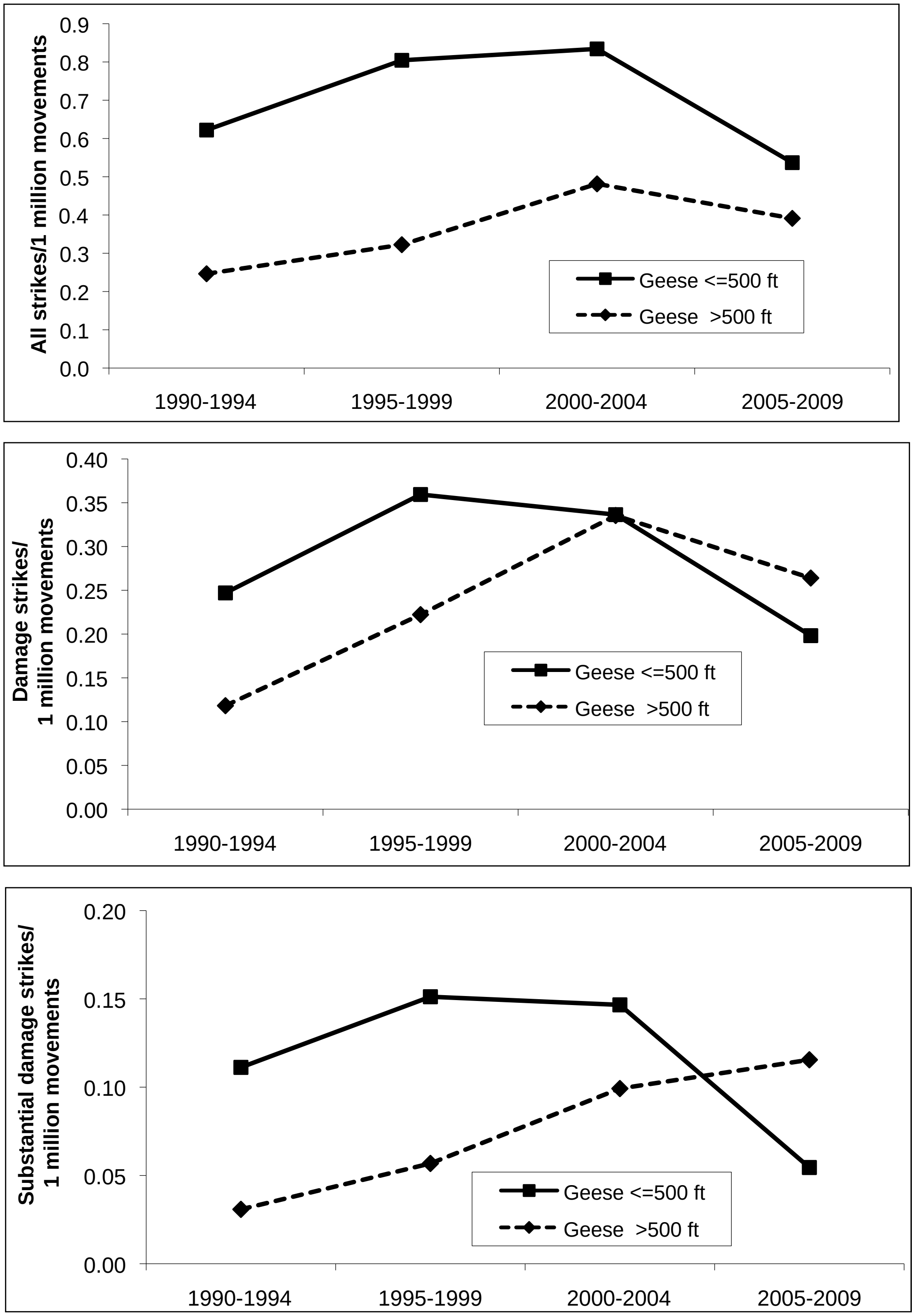

Figure 4. Mean Canada goose (*Branta canadensis*) strike rate per 5-year period (all strikes, top graph), strikes with damage (middle graph), and strikes with substantial damage (bottom graph) per 1 million aircraft movements for commercial aircraft in the United States, 1990–2009 (see Tables 1 and 2 for sample sizes).

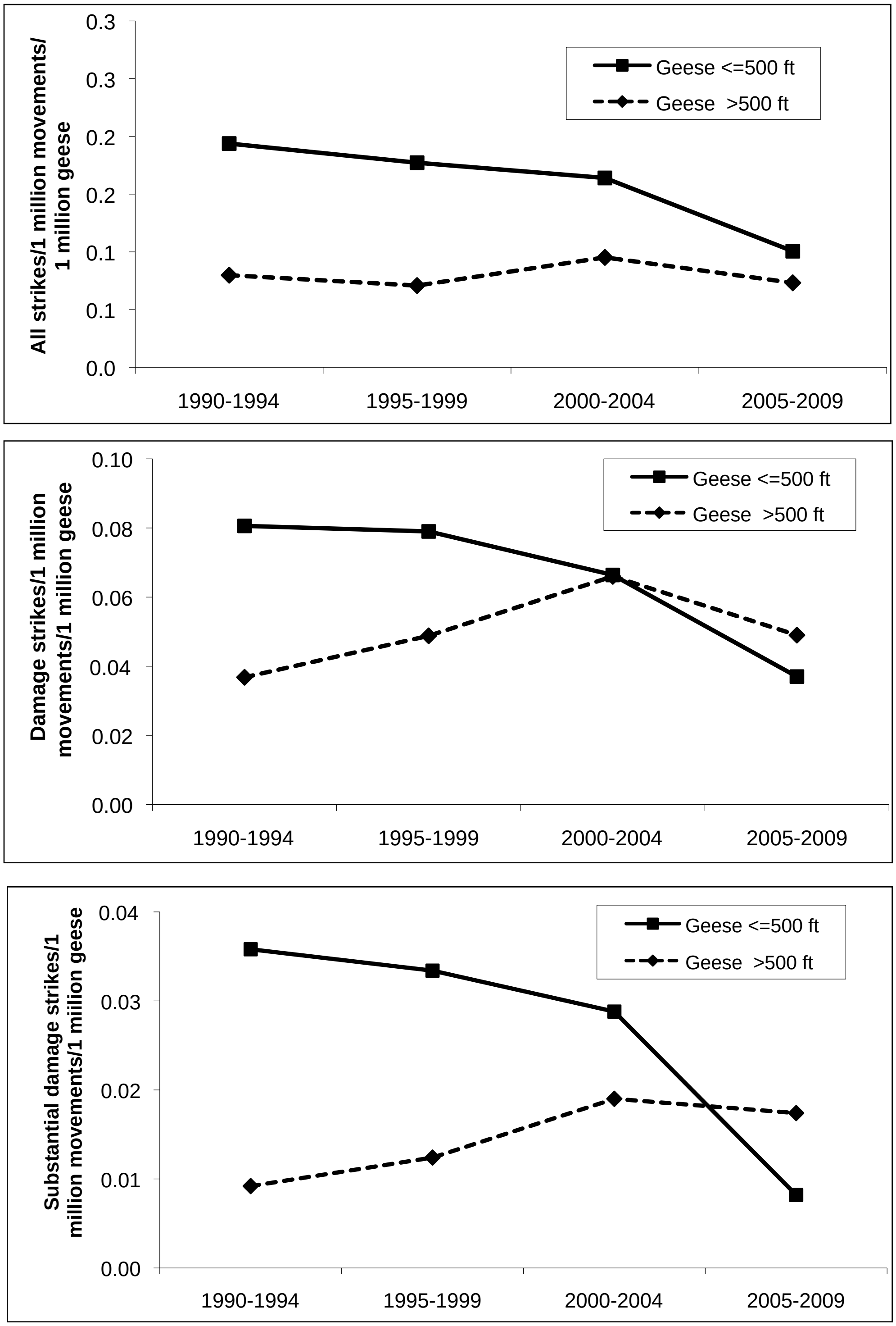

Figure 5. The population-adjusted Canada goose (*Branta canadensis*) strike rate (all strikes, top graph), strikes with damage (middle graph), and strikes with substantial damage (bottom graph) per 1 million aircraft movements per 1 million geese) for commercial aircraft in the United States, 1990–2009 (see Tables 1 and 2 for sample sizes).

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Review

The Bird Strike Challenge

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Abstract: Collisions between birds and aircraft pose a severe threat to aviation and avian safety. To understand and prevent these bird strikes, knowledge about the factors leading to these bird strikes is vital. However, even though it is a global issue, data availability strongly varies and is difficult to put into a global picture. This paper aims to close this gap by providing an in-depth review of studies and statistics to obtain a concise overview of the bird strike problem in commercial aviation on an international level. The paper illustrates the factors contributing to the occurrence and the potential consequences in terms of effect on flight and damage. This is followed by a presentation of the risk-reducing measures currently in place as well as their limitations. The paper closes with an insight into current research investigating novel methods to prevent bird strikes.

Keywords: airport; air traffic management; aviation; bird strike; operations; risk; safety; wildlife management

1. Introduction

Collisions between birds and aircraft are as old as aviation. The first recorded bird strike was experienced by the Wright Flyer III on 7 September 1905 [1]. Bird strikes are regular events. Depending on the country, average bird strike rates between 2.83 and 8.19 per 10,000 aircraft movements were reported in civil aviation for the past years. Examples are provided in Table 1.

Table 1. Average bird strike rates (number of strikes per 10,000 aircraft movements) for different countries.

Country	Bird Strike Rate	Period Considered	Source
Australia	7.76	2008–2017	[2]
Canada	3.51	2008–2018	[3]
France	3.95	2004–2013	[4]
Germany	4.42	2010–2018	[5]
UK	7.76 (all) 4.62 (confirmed)	2012–2016	[6]
USA	2.83	2009–2018	[7]

Nevertheless, while collisions between birds and aircraft usually result in lethal consequences for the bird, aircraft damage is rare. Two to eight percent of all recorded bird strikes result in actual aircraft damage in civil aviation [6–10]. Regarding operational impacts, between six and seven percent of all reports indicate a negative operational effect on the flight [6,7,10]. It is estimated that bird strikes cause annual costs of at least one billion US $ to the worldwide commercial aviation industry [11]. Due to incomplete reporting, these figures have to be interpreted as conservative estimates [12–14].

As accidents have demonstrated, collisions between birds and aircraft also bear the potential for catastrophic outcome for the involved aircraft. As of 11 November 2019, bird strikes were determined to have caused 618 hull losses and 534 fatalities since the beginning of aviation [1].

To understand the factors contributing to the risk of bird strikes and find suitable measures for their prevention, broad data analysis is a prerequisite. This requires consequent reporting by the parties noticing bird strikes [15]. Furthermore, international standards and common definitions are needed. Thereby, the focus lies on civil aviation in general and commercial aviation in particular. The first section of this paper deals with the current state of data availability and consistency. Subsequently, the factors determining the risk of bird strikes are introduced. Thereafter, measures taken on the ground, in the air and by regulatory means as well as their limitations are presented. Finally, current research and its potential to further reduce the risk of bird strikes is discussed.

2. Definitions and Data Availability

Bird strikes are defined as *a collision between a bird and an aircraft which is in flight or on a take off or landing roll* [16]. To include other animals colliding with aircraft, the term can be broadened to *wildlife strike*. In general, statistics are provided for birds and terrestrial animals separately, for example by the aviation authorities of Canada, the United States of America (USA) and the United Kingdom (UK). One exception is Australia, where all flying animals, including flying foxes and bats, are included in the bird strike statistics [2,6,7,10].

This paper focuses on collisions involving birds and the term *bird strike* is used. First, the vast majority of wildlife strikes occur with birds, for example: 98% in Australia, 95% in Canada and 95% in the USA [2,7,10]. Second, terrestrial animals can be prevented from entering airport perimeters, for example by installing fences [17]. In contrast, birds can enter airfields regardless. Furthermore, they do not only pose a risk on the airfield, but also in the approach and departure corridors. The related challenges are addressed in this paper.

International Civil Aviation Organization (ICAO) requests its contracting states to report bird strikes [18]. Data are usually collected by the Civil Aviation Authorities (CAA). Its quality relies on consistent reporting by the parties involved in aircraft and airport operations: The pilots, maintenance crews, air traffic control and wildlife control. In recent years, the importance of complete bird strike reporting has been recognized and has since been encouraged or even enforced by many CAAs across the world. Within this context, the European Union (EU), which previously had no consistent reporting regulations among its member states, put into force mandatory bird strike reporting in 2015 [19]. All parties involved in air traffic operations within the EU have been obliged to report observed bird and wildlife strikes [20]. In Australia, mandatory reporting has already been in place for several years. Furthermore, in many countries, action has been taken to increase the motivation to report. This has resulted in increasing numbers of bird strike reports. For example, in the USA, where a mainly voluntary reporting system is in place, the ratio between all reported bird strikes and all bird strike occurrences increased from 41% to 91% for commercial aircraft in the period from 1990 to 2013 [13]. When including airports, which handle general aviation and commercial traffic, the share amounts to 47%. In the UK, pilots have been required to report all bird strikes since 2004. Before, only damaging bird strikes had to be reported [21]. The number of reports strongly increased since the implementation of this mandate [22]. Both in the USA and UK studies, the reason for the rise is mainly attributed to better reporting, rather than increased bird strike risk. The authors of both studies (Refs. [13,22]) reason with the ratio between number of damaging strikes and all strikes. In case of an increased risk, the rise of reports would be expected to be similar for damaging and non-damaging strikes. However, in both countries, the proportions of damaging strikes fell. This is supported by the latest USA data for the period until 2015, as visualized in Figure 1. In the subsequent years, a slight increase can be observed. Data from the years to follow will have to confirm if this represents the beginning of a trend in the opposite direction and bird strike risk is increasing.

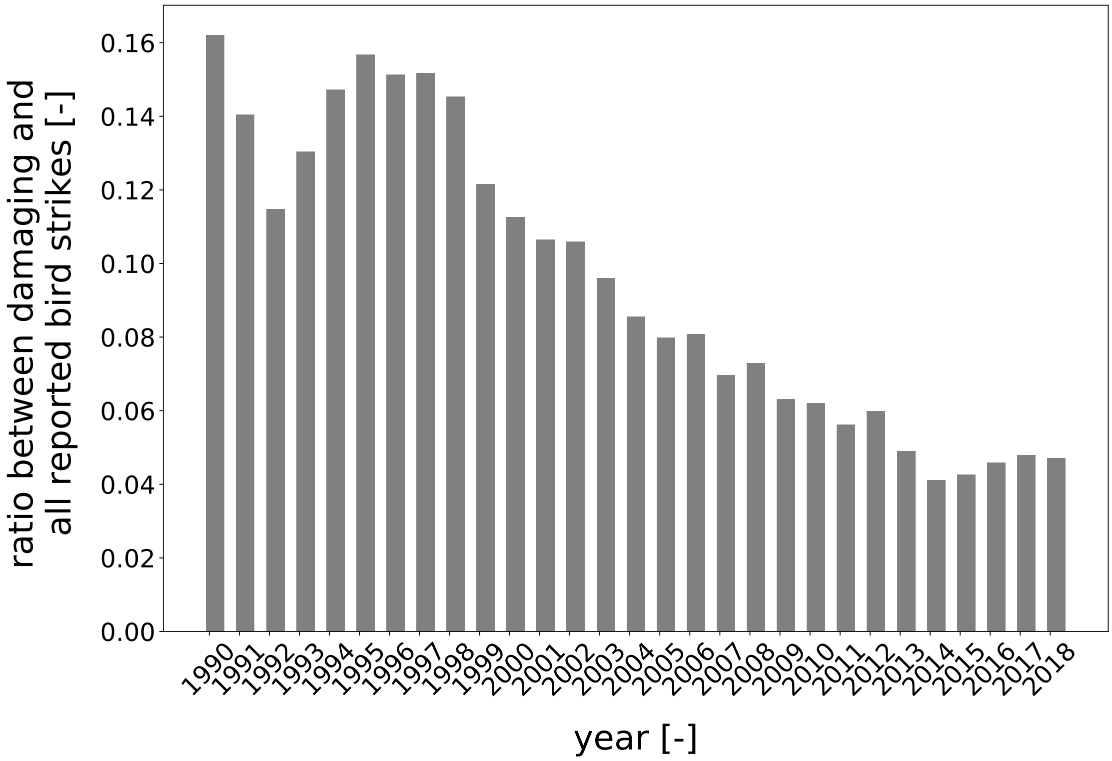

Figure 1. Ratio between damaging strikes and all strikes in the USA between 1990 and 2018. Source: [7].

Over the past few years, bird species hazardous to aviation have expanded and adapted to urban areas [23,24]. As air traffic is rising as well [25], the likelihood of encounters increases due to a higher number of airspace users. However, due to better reporting, the increasing trend in the number of bird strikes does not necessarily—or at least not exclusively—imply a rising risk of bird strikes.

The bird strike data collected and the level of detail published vary among the different countries. For example, some countries provide the altitude distribution via flight phases, others in altitude bands of various intervals. Therefore, comparisons of bird strike rates in particular and statistics in general have to be performed carefully.

The subsequent chapters describe the factors contributing to the bird strike risk. The ICAO defines a safety risk as *the predicted probability and severity of the consequences or outcomes of a hazard* [26]. This definition is applied here.

3. The Probability of Bird Strikes

The probability of bird strikes is determined by many parameters such as altitude, time of day, environmental conditions, geographical location, season and the aircraft itself [27]. This chapter provides an overview of these individual components.

3.1. Altitude

The highest probability of bird-aircraft collisions is at low altitudes [28]. According to Dolbeer et al. [29], 88% of the bird strikes in the USA over the past 27 years have occurred below 2500 ft (71% below 500 ft). A European study concluded that even 95% of all strikes occur below 2500 ft (70% below 200 ft), when considering worldwide traffic [30]. The probability decreases with increasing altitude, as Figure 2 visualizes. This corresponds to the flight phases for which most bird strikes are reported: takeoff, initial climb, landing and approach [31]. However, the share of damaging bird strikes increases with increasing altitude. Contributing factors are a higher kinetic energy due to increasing bird size and rising aircraft velocity. Furthermore, while mitigation measures at airports have been shown to be successful in reducing the number and consequences of bird strikes, outside the airport boundaries, the options for counteracting measures are limited [32].

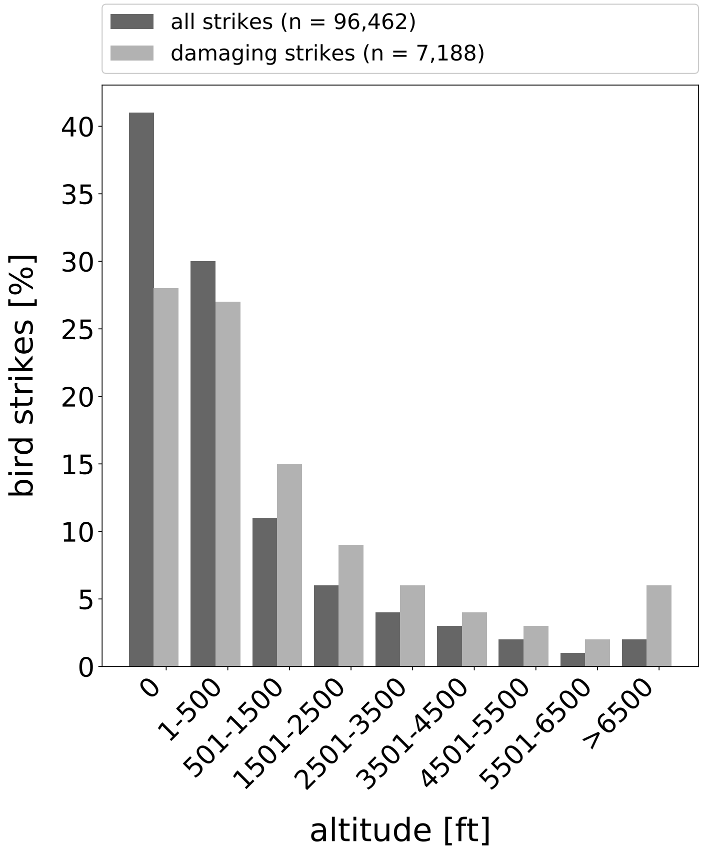

Figure 2. Distribution of bird strikes by altitude band that occurred between 1990 and 2018 in the USA, where the altitude was known (72% for all strikes, 70% for damaging strikes). Source: [7].

3.2. Season

The likelihood of bird strikes depends on seasons. Figure 3 illustrates the distribution of bird strikes over the year for regions in the northern and southern hemispheres. It can be seen that, during the respective winters, the risk of collisions between birds and aircraft is lowest. In contrast, during summertime, when the juveniles of many bird species fledge especially in the countries in the Northern hemisphere [33–35], the highest number of bird strikes is recorded. During spring and autumn, an increased bird activity due to migration between summer and winter residences leads to more strikes [36,37].

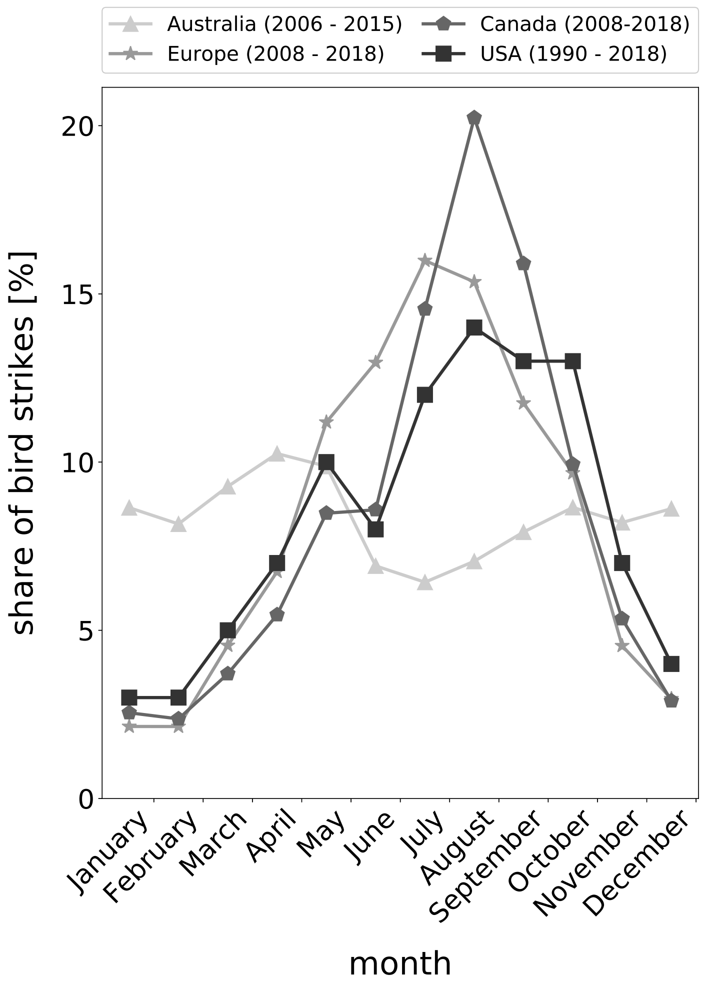

Figure 3. Seasonal distribution of bird strikes for Australia, Europe, Canada and the USA [7–10].

3.3. Location and Environmental Conditions

The probability of bird strikes depends on the geographical location [36]. This is related to the abundance of different bird species with variable behavior, size or tendency for flocking. In the direct airport environment, the landscape characteristics are a determining factor [38]. In regions situated along a migratory flyway, the danger of collision remarkably increases during migration seasons [36,37]. Another factor to be considered is the time of day. When comparing the number of bird strikes to the number of flights, most occurrences take place during the night [39,40]. This is caused by increased bird activity at night, especially for migrating birds [41]. Furthermore, many airports cease dispersing activities at night. However, because much more air traffic takes place during the daytime, the absolute number of strikes is higher in this period [31,42].

In addition to the geographical location, the attractiveness of an airport's environment also strongly influences the risk of bird strikes. The ICAO requests the bird strike hazard to be assessed at every airport [43]. In case of a determined bird strike risk, action should be taken to reduce the number of hazardous birds at and around the airport.

Furthermore, potential attractants such as sources of food and water on the field as well as in the vicinity of the airport should be prevented or eliminated, as they significally influence the risk of bird strike [38,43]. For this purpose, the ICAO's Airport Service Manual [44] requests an airport wildlife management plan which has to include the environment up to a radius of 13 kilometers around the airport, and, if necessary, beyond. Namely, *significant attractants*—sources for food, water and shelter—should be removed and off-airport bird monitoring performed [44].

Not only the presence of birds but also the characteristics of aircraft using a certain airspace have an influence on the likelihood of bird strike. These influences are described subsequently.

3.4. Aircraft Characteristics

Individual aircraft characteristics are another determining factor in the probability of bird strike. Due to their large size and high suction effect, turbofan engines are more likely to ingest birds than other engine types [45]. Moreover, due to their higher speeds during take-off and landing, turbofan aircraft are more difficult to avoid than other aircraft types [46]. Over the last years, turbofan engines increased in diameter [47], which increases the risk of ingestion even further. The number of turbofan aircraft as well as their share in the total number of aircraft increased significantly over the last years: In 2006, 20,444 commercial turbofan aircraft were registered, which corresponds to 79.6% of the commercial aircraft fleet of the time. In 2015, the number of commercial turbofan aircraft amounted to 22,690, which corresponds to 86.5% of all commercial aircraft [48,49]. According to Canadian data from 2008 to 2018, turbofan aircraft experienced 1.7 times more bird strikes than aircraft equipped with propellers [10].

Aircraft noise emission has an effect as well: the quieter an aircraft, the higher the risk that birds cannot avoid them, as they hear the aircraft approaching too late to initiate a successful avoidance manoeuvre [50]. Over the past years, airlines have been replacing their older aircraft fleet with more efficient and quieter aircraft which contributes to an increase in bird strike risk [47,51].

4. The Severity of Bird Strikes

The consequences of a bird strike for the aircraft involved are depending on the circumstances of the individual collision. The major criterion is kinetic energy

$$E_{kin} = \frac{1}{2} \cdot m \cdot v^2 \tag{1}$$

where E_{kin} refers to kinetic energy in $Joule$, m to mass in kg and v to velocity in $\frac{m}{s}$.

With regard to mass, the number of birds involved, their biomass as well as parts of the aircraft hit, determine the consequences of a collision for the aircraft [24]. Considering the velocity component, due to the high relative difference, mainly the aircraft's speed is relevant.

Based on data from the Federal Aviation Administration (FAA)'s National Wildlife Strike Database for Civil aviation, Dolbeer performed a study to evaluate the consequences for damages resulting from bird strikes below and above 500 ft in 2011 [32]. Even though the majority of strikes—approximately 75% in the period between 1990 and 2009—happen below 500 ft, only 55% to 65% of the damaging strikes took place in this altitude band. This indicates that a large proportion of strikes above 500 ft cause in damage, which is also reflected in Figure 2. This observation is supported by a study performed for the European Aviation Safety Agency (EASA) in 2009 [24] that takes into account data from civil aircraft from the UK and Canada for the period between 1990 and 2007. For these countries, 57% of all strikes happened during take-off and landing, 39% during climb and approach and approximately 1% during en-route flight for the observed period. The remaining 3% of all strikes happened during taxi and parking. The amount of damage per flight phase increases with increasing height: 3.7% of all strikes during take-off and landing, 7.9% of all strikes during approach and climb, and 34% of the en-route bird strikes caused damage. This can be explained by larger aircraft velocities at higher altitudes as well as by the fact that larger birds such as Canada Geese and Turkey Vultures fly at higher altitudes [24,52,53]. The combination of these two factors lead to a significant increase in the kinetic energy of the impact and thus to a higher probability of damage with increasing height.

4.1. Parts Struck

The majority of bird strikes hit the large front-parts of the aircraft: the nose, the wings' leading edges, and the engines. The shares of strikes to the various parts differ between different sources (e.g., [2,7,31]). Exemplary, Figure 4 presents the proportion of damaging and non-damaging strikes per aircraft component. The magnitude of damage resulting from a bird strike strongly depends on the part(s) struck. Small parts such as the pitot tube and lights are most vulnerable to damage due to their exposed positions and missing requirements on impact-resistance. The danger of hazardous consequences for the aircraft is especially high, when large or multiple birds are ingested into one or more engines because this can lead to partial or total loss of thrust. This is reflected by the accident statistics: Out of the 30 accidents involving hull losses and fatalities that happened since 1960, 23 were a result of one ore more engines struck [1,54,55]. Currently, approximately 94% of the world's aircraft fleet is equipped with two engines only [49]. Due to the resulting smaller redundancy, the danger is larger when birds are ingested [51]. Thereby, substantial engine damage is most likely during departure [56]. Over the past years, two major crashes occurred due to the ingestion of birds in both engines of twin-engine aircraft. In January 2009, an Airbus A320 aircraft lost thrust in both engines during initial climb out of LaGuardia Airport after the ingestion of several Canadian Geese. The crew successfully performed an emergency landing on the Hudson river [57]. In August 2019, a similar accident took place in Moscow when the crew of an Airbus A321 performed a successful emergency landing in a corn field after the engines failed due to ingestion of multiple gulls during departure [58]. In both cases, all passengers and crew survived.

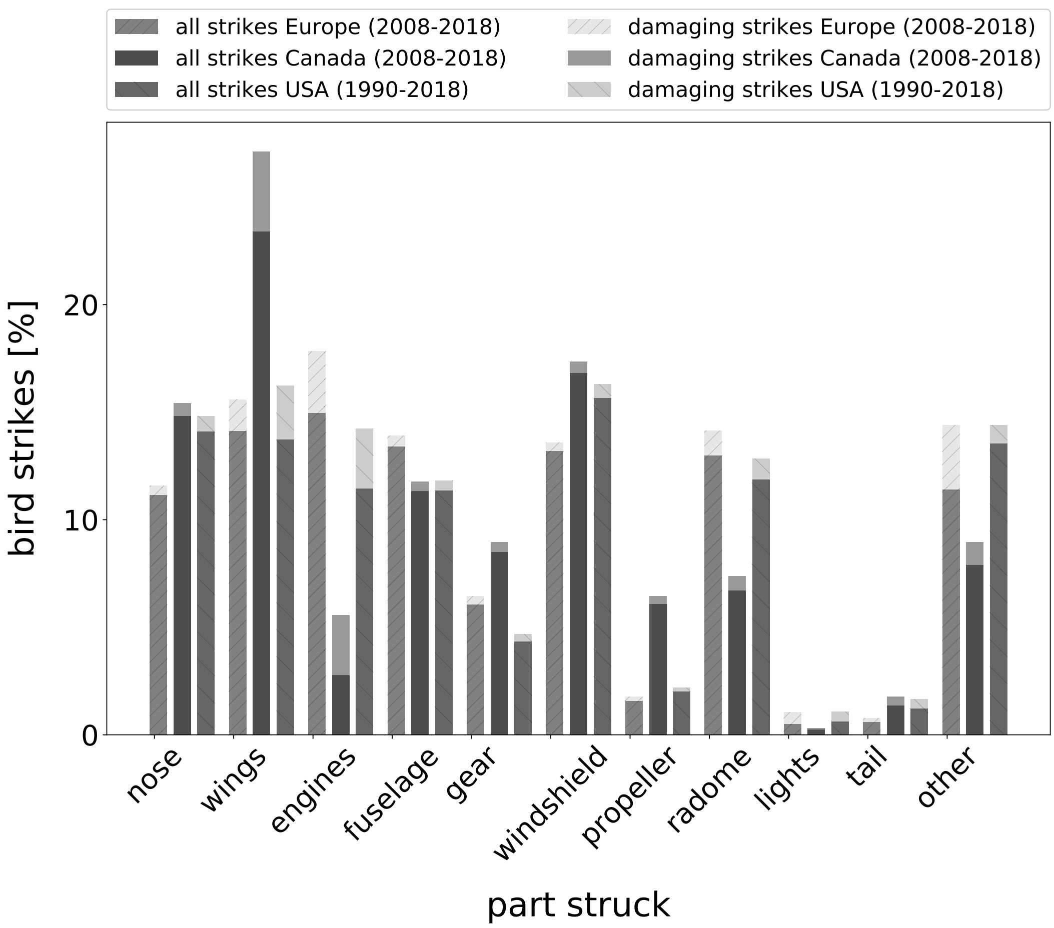

Figure 4. Total number of bird strikes per part indicating number of damaging strikes for Europe, Canada and the USA [7,8,10].

4.2. Risk of Accidents

The number of serious bird strike-related accidents are comparable to serious accidents due to other environmental causes, as Figure 5 shows. This figure compares the share of fatal and hull loss accidents resulting from environmental hazards for the periods 1960–1999 and 2000–2015. To compensate for the different length of the compared periods, the shares and not absolute numbers of accidents are provided. Over the last few decades, technological improvements and additional safety equipment have been introduced to reduce the number of windshear and turbulence related accidents [59]. The effect of these measures, especially on turbulence-related accidents, is visible in Figure 5. On the other hand, the shares of serious accidents due to bird strike, lightning strike and thunderstorm increased.

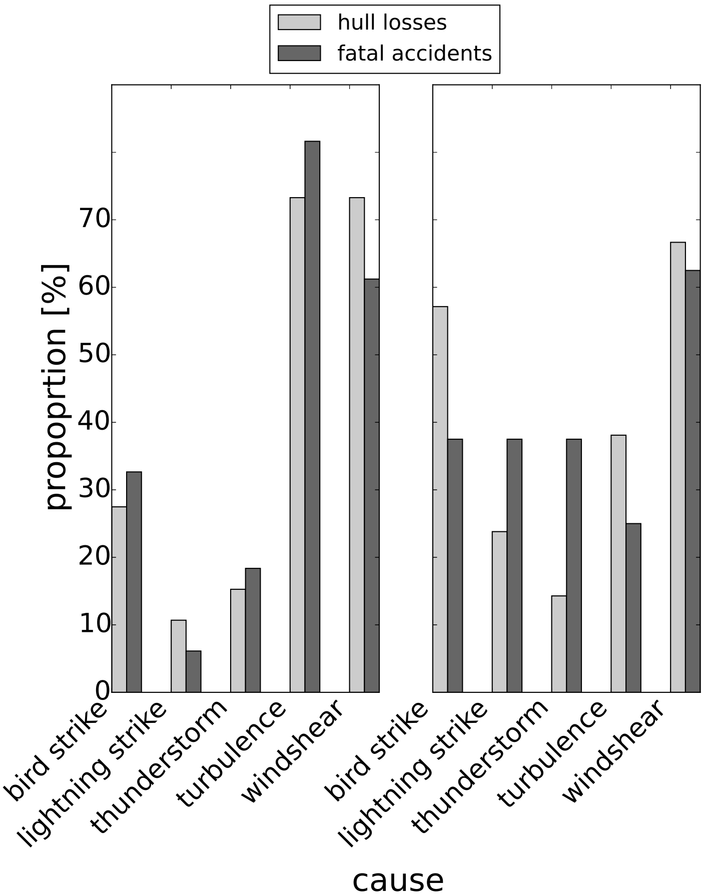

Figure 5. Comparison of different accident causes for the periods 1960–1999 (**left**) and 2000–2015 (**right**) (sources: [55,60]).

4.3. *Effect on Flight*

Depending on the magnitude of the damage, there is a direct operational effect on the flight. In addition to the aircraft involved, airport operations and other airspace users may also be impaired. Table 2 provides an overview of operational impacts for various countries and continents. In addition, the worldwide reports collected by ICAO [31] are presented. While the share between *none* and *unknown* varies among the sources, the effect-categories have a similar influence.

Independent of their impact on a flight, an examination to ensure the airworthiness of the aircraft involved has to be performed before the next departure [61]. Therefore, not only damaging but all recognized bird strikes affect operations and consequently result in costs. Furthermore, airport operations might be impaired—for example due to temporary runway closure to remove bird remains.

Table 2. Reported operational effects in Europe, Canada, the USA as well as world-wide in percentages [8,10,14,31].

Operational Impact	Europe (2008–2018)	Canada (2008–2018)	USA (1990–2018)	Worldwide (2008–2015)
none	95 [a]	69	56	83
unknown		21	46	12
precautionary landing	1	5	3	1
aborted take-off	1	2	1	1
engine shut-down	<1	<1	<1	<1
other	3	3	1	3

[a] Europe groups *none* and *unknown* into one category.

4.4. Costs of Bird Strikes

Little information is available about the costs resulting from bird strikes. This is related to the reluctance of airlines to report damage costs due to competitive reasons [62]. Global estimates are from the early 2000s. For example, depending on the damage caused, Sodhi approximated in 2002 that the costs for engine repairs range from US $ 250,000 to one million US $ [50]. Allan et al. approximated in 2003 the total annual costs for the world aviation fleet to be approximately one billion US$ [63]. Based on data obtained from United Airlines (UAL) for the years between 1999 and 2002, costs of a non-damaging strike sum up to approximately US $22,417 per strike. This includes, for example, an aircraft check following a bird strike. They conclude that the average costs for a damaging strike amount to US$225,329. More recent data are available from the FAA [7], which is summarized in Table 3. Some of the reported strikes between 1990 and 2015 include information about repair and indirect costs. Indirect costs result from lost revenues, passenger rebooking, aircraft rescheduling and flight cancellations. On average, the repair costs amounted to US $ 164,595, the average indirect costs to US $ 27,599 , resulting in total average costs of US $ 192,194 per damaging strike. However, this information was included only in a small proportion of all reports, as Table 3 indicates. Hence, these numbers might not be representative. Furthermore, due to incomplete reporting of strikes in general, the authors of the study presume a strong underestimate. Therefore, projected costs are based on the averages obtained from the reports that include cost information. These are also presented in Table 3.

Table 3. Repair and indirect costs resulting from wildlife strikes in the US from 1990 to 2018 [7].

Cost Type	Total/Average	Reported Cost (US $)	Projected Cost (US $)	Number Reports	
repair costs	total	4.6 M	4465 M	4534	2.2%
	average	158,573	154 M	156	
indirect costs	total	726,044	962 M	3683	1.7%
	average	25,036	33 M	127	
total costs	total	5.3 M	5427 M		[a]
	average	183,609	187 M		

[a] Some reports might contain both information about repair and indirect cost. Hence, a total number of reports cannot be obtained.

Another type of cost can be expressed in aircraft downtime. Based on the 5% of reports including information about aircraft downtime in [7], an average of 101 hours per strike result. When including missing reports, the authors project an average of 4521 days of aircraft downtime per year due to wildlife strikes.

5. The Counteracting Measures

To reduce the risk of bird strikes, many measures have been implemented. They can either be ground- or aircraft-related. On the ground, the focus of bird strike hazard reduction in civil aviation explicitly lies on the airports and their direct surroundings. This is related to the altitude distribution of bird strikes with the highest risk at low altitudes [40,44]. In this context, the ICAO requests airports to maintain a wildlife strike program [43,44].

In addition to the measures to prevent bird strikes, regulations to minimize the risk of damage are in force. These are described in the end of this section.

5.1. Mitigation Measures on the Ground

Successful bird strike prevention at airports requires the identification of hazardous species as well as the the understanding of the types and reasons of their movements [64,65] Multiple risk assessment procedures have been developed to support the bird strike units in prioritizing and performing their measures. Depending on the model, the input parameters include species, their abundance and potential to cause damaging strikes as well as cost-estimates (for example [22,46,51,66]).

These range from habitat management to exclusion, harassment, capture, and shooting of wildlife [51]. Within *habitat modification*, the airport grounds are made as unattractive to birds as possible, by removing sources for water, food and shelter or by making them inaccessible [67]. Habitat management is considered as the foundation of successful and long-term wildlife management. *Exclusion* can partly be achieved by wires, netting or covers. Furthermore, chemical repellents such as anthraquinone or methyl anthranilate are used [51]. The category *harassment* includes all techniques which aim at chasing away birds which have already entered the airfield. The main groups of harassing tools are auditory deterrents such as gas exploders, alarm and distress calls as well as pyrotechnics, visual repellents such as effigies, predator models, lasers, reflecting materials, lights, mirrors as well as drones, trained dogs and falconry [68]. The category *capture and relocation* includes trapping of birds on the airfield and reassigning them to new habitats further away from the airport. Among others, a minimum distance between the airport and translocation area should be kept to limit returns to the airport [69]. The *lethal* category covers shooting of birds and pursues two goals. First, the population density of critical bird species should be limited to reduce the risk of strikes. Second, by shooting target individuals of a group, habituation to other techniques by the remaining birds should be limited. The efficacy of shooting birds is not entirely clear. Furthermore, lethal methods are forbidden or restricted in many countries [70,71].

The described efforts at airports are vital for reducing the risk of bird strikes and many control programs have shown positive effects (see, e.g., [7,23]). However, airport-bound wildlife management is limited in its efficacy. Firstly, birds can grow accustomed to harassing methods, which reduces their effectiveness over time. Secondly, the range of the dispersing measures lies within the airport boundaries rather than in the entire area with increased risk, i.e., below 3000 ft [28,38]. Considering that there is an increasing trend of damaging strikes outside the airport boundaries [32], expanding the horizon of bird strike hazard mitigation beyond the airport fences is essential [28].

Therefore, aircraft-related risk-reducing measures have been researched over the past few years, as described in the following section.

5.2. Aircraft-Related Mitigation Measures

Various studies on bird reactions to approaching aircraft have been performed to study the options of reducing strikes by enhancing the perceivability of the aircraft (e.g., [72–77]). They commonly concluded that many bird species try to avoid collisions with aircraft. However, due to their reaction time and the aircraft's high speed, especially during flight, the birds' attempts to escape are often unsuccessful. This is even true for experienced birds. Even though they were found to initiate their escape earlier than inexperienced birds, the remaining time to collision is usually insufficient to prevent a collision [78]. By increasing an aircraft's perceivability, birds can detect its approach earlier and the chances for a successful avoidance manoeuvre rise [72,79]. The majority of research in this area has focused on increased visibility. A rather general study analysed the correlation between fuselage color and bird strike risk [75]. The authors concluded that it is likely that *'enhancing aircraft visually through a bright color scheme might facilitate a bird's ability to detect and distinguish aircraft shape in time to perform* *avoidance behavior.'*. For turboprop aircraft, such an effect can be gained by applying colored patterns to the propeller to enhance the aircraft's contrast against the sky [80,81].

Research on increasing aircraft lighting found that pulsing light has the potential to enhance avian visual awareness [73,74,82]. However, as visual perception depends on the bird species, different pulsing frequencies and wavelengths might be required [83]. An experiment identified that certain wavelengths do trigger strong avoidance reactions of birds, while other wavelengths did not cause any behavioral response. This implies that the choice of lights to be installed can support successful collision avoidance [77].

Long-term tests with two airlines demonstrated the safety potential of implementing a pulsing light system to aircraft. The system tested pulses for the existing landing and logo lights to enhance aircraft visibility and the predictability of the aircraft's flight path at night. The system was installed on aircraft from Alaska Airlines, a regional airline in the USA for a duration of three years. Compared to the three years previous to installation, the number of bird strikes had decreased by 33.5% [84]. In another trial, ten aircraft of Qantas Airways were equipped with the system. The installation remained between 12 and 24 months. Compared to the fleet's non-equipped aircraft, a reduction in bird strikes between 54% and 66% resulted [85]. Therefore, pulsing lights seem to be a promising addition to wildlife management at airports, especially to prevent bird strikes at low velocities.

5.3. Regulatory Mitigation Measures

Table 4 indicates that the majority of reported bird strikes do not result in any severe consequences for the involved aircraft. This has three main causes. Firstly, many bird strikes involve small birds (cf. e.g., [45]). Because of their lower mass, they have low kinetic energy and are therefore much less likely to cause damage. The second reason is the impact-resistance of aircraft. To meet the certification requirements by the Civil Aviation Authoritys (CAAs), aircraft have to be able to withstand a certain impact caused by birds, as described subsequently. Thirdly, requirements for reduced aircraft speeds below 10,000 ft have proven effective [27].

Table 4. Magnitudes of damage resulting from bird strikes in Europe and the US in percentages [8,14].

Damage	Europe (2008–2018)	USA (1990–2015)
none	63	51
unknown/uncertain	30	46
minor [a]	4	2
substantial [b]	2	<1
destroyed	<1	<1

[a] After experiencing minor damage, simple repairs or a replacement without extensive inspection suffices to render the aircraft airworthy [86]; [b] When experiencing substantial damage, an aircraft's structural strength, performance or flight characteristics are adversely affected and a major repair is required [86].

5.3.1. Certification Requirements

Aircraft have to meet certification requirements to prove their airworthiness [87]. In this chapter, the European regulations as defined by EASA and the US regulations by the FAA are considered. Depending on their size, aircraft are grouped into categories. Airplanes used for commercial aviation are either in the category Normal (EASA)/Normal Category Airplanes (FAA) or Large Aeroplanes (EASA)/Transport Category Aircraft (FAA). The categories and their descriptions, which are mostly corresponding, can be found in Table 5. By 2014, approximately 97% of aircraft in the worldwide commercial fleet were certified as Large Aeroplanes/Transport Category Aircraft; the remaining 3% were certified as Normal/Normal Category Airplanes [49]. In Europe, the majority of commercial aircraft is certified by the standard *CS 25—Large Aeroplanes* [88]. The US-American counterpart consists of the Federal Aviation Regulations (FAR) *14 CFR Part 25—Transport Category Airplanes* [89]. These regulations contain the following requirements regarding damage-tolerance of aircraft parts.

Table 5. Certification categories relevant for commercial aviation aircraft in Europe and the US (CS: Certification Specifications; CFR: Code of Federal Regulations).

Europe—EASA	**US—FAA**
CS-23 Normal Aeroplanes aeroplanes with a passenger-seating configuration of 19 or less and a maximum certified take-off mass of 8618 kg (19,000 lbs) or less [90]	*14 CFR Part 23 Normal Category Airplanes* airplanes with a passenger-seating configuration of 19 or less and a maximum certificated take-off weight of 19,000 lbs or less [89]
CS-25 Large Aeroplanes turbine-powered aeroplanes of more than 5700 kg (12,500 lbs) maximum certified take-off weight, excluding commuter airplanes which are covered by the category Normal Aeroplanes [88,91]	*14 CFR Part 25 Transport Category Aircraft* multi-engine airplanes with more than 19 seats or a maximum take-off weight greater than 19,000 lbs [92]

- Windshield: withstand without penetration an impact of a 2 lb bird at cruise speed.
- Structure: Successfully completing a flight after an impact with a 4 lb bird when the aircraft's velocity relative to the bird along the aircraft's flight path equals cruise speed at sea level or 0.85 cruise speed at 8000 ft, whichever is more critical.
- Empennage: Successfully completing a flight after an impact with an 8 lb bird at cruise speed (FAA only).
- Pitot tubes: sufficient separation to prevent damage to all of them in case of a bird strike.

Aircraft in the category *CS 23–Normal Aeroplanes* respective *14 CFR Part 23—Transport Category Airplanes* only have to prove an impact-resistance of the windshields. Both the European and the US regulations demand that *each windshield and its supporting structure directly in front of the pilot must withstand, without penetration, the impact equivalent to a two-pound bird when the velocity of the aeroplane is equal to the aeroplane's maximum approach flap speed.* [89,90]. Consequently, category 23 aircraft are more vulnerable to damage due to collisions with birds.

Regarding the impact-resistance of engines, which have to be certified independently of the aircraft, separate EASA and FAA regulations are in force. To prove that an engine responds in a safe manner to bird ingestion, it must undergo an engine ingestion test. The European regulations (CS-E 800 [93]) demand tests considering the ingestion of single large birds and large flocking birds. The FAR add tests for small and medium single and flocking birds [94]. Depending on the engine's diameter, different criteria regarding bird mass and thrust settings are required. In all tests, the ingestion of the bird must not lead to a hazardous engine effect. EASA defines the following events as *Hazardous Engine Effects* [93]:

i. *non-containment of high-energy debris,*
ii. *concentration of toxic products in the engine bleed air for the cabin sufficient to incapacitate crew or passengers,*
iii. *significant thrust in the opposite direction to that commanded by the pilot,*
iv. *uncontrolled fire,*
v. *failure of the engine mount system leading to inadvertent engine separation,*
vi. *release of the propeller by the Engine, if applicable,*
vii. *complete inability to shut the engine down.*

5.3.2. Speed Limitations

A further reason why only a small number of all bird strikes lead to aircraft damage results from regulations for maximum aircraft speeds of 250 kts (Knots-Indicated Airspeed (KIAS)) below 10,000 ft as a matter of Air Traffic Control (ATC) airspace organization. Among others, the limitation of speed should reduce the kinetic impact of bird strikes in the areas where bird strikes mostly occur [29,40]. Many countries such as Canada, Mexico, the USA and Germany have applied such a regulation [95,96].

6. The Next Step

Over the past few years, the awareness has risen that increasingly includes the parties actually handling air traffic—ATC and the pilots—is vital to further reduce the risk of bird strikes in civil aviation [28]. Currently, the controllers can provide general warnings on bird activity in the airport area based on visual observations or reports by pilots [27,97]. Pilots in commercial aviation can mainly enhance their situational awareness by studying current bird strike risk information in the form of BIRDTAMs (a special form of Notice to Airmen (NOTAM) which provides information on current bird strike risk [98]) and bird migration reports, where available [27,98,99]. Furthermore, they should stay alert throughout the flight and report observations on enhanced bird activity as well as experienced bird strikes [27]. In general aviation, route planning should consider the avoidance of areas abundant of birds in addition. By flying at high altitudes, the probability, and by flying at low speeds, the impact of a potential bird strike can be reduced [27,99].

To introduce operational bird strike prevention further involving ATC and pilots, experiences from military aviation can serve as an example. As military operations are often performed at low altitude, military aircraft spend much more time in areas with high bird densities than civil aircraft. Hence, military operations are more vulnerable to bird strikes than their civil counterparts. For this reason, several air forces across the world have started to implement procedures to adjust flight planning based on current bird strike risk since the 1970s (e.g., [100–102]). In the beginning, this mainly included flight restrictions during peaks of bird migration [37]. With developments in technology and increasing data-sets to model and predict bird movement, a more dynamic and short-term planning to avoid high-risk air spaces at a given time has become possible [28]. The military efforts have mainly focused on en-route intervention of flight operations for low-level training flights [37,102]. For civil aviation, an application of these procedural approaches at and around the airports would be useful and is seen as an important next step in bird strike prevention [28]. In contrast to military aviation which has a certain flexibility in flight planning, civil aviation is bound to schedules [103]. Therefore, regular flight restrictions in cases of high risk are unfeasible. On the other hand, dedicated real-time warnings of high-risk situations resulting in short-term delays could be applicable. Different levels of advice could be possible. First, the general situational awareness of the pilots could be raised. Second, aircraft taking off could be advised to adjust their rate of climb to quicker pass critical zones. In addition, third, in case of high collision risk, air traffic could temporarily be held back.

According to Annex 15 of ICAO, ATC shall provide current information on the *presence of birds constituting a potential hazard to aircraft operations* [104]. However, in order to be able to give precise warnings rather than general information on bird movement, additional surveillance technology is required.

An increasing number of airports have installed radars dedicated to tracking birds, so-called avian radars, over the past few years. They are designed to track individual birds as well as flocks of birds up to distances of 11 km and heights of 1.5 km [105]. While initial installations covered two-dimensional positions only, systems providing three-dimensional positions are increasingly becoming available. Moreover, radar ranges are increasing and the data quality is improving. Thus far, these radars are mainly used by local wildlife control to detect hotspots of bird movements at the airfield. However, avian radars, possibly in combination with other surveillance technology such as thermal or video imaging, have the potential to serve as input for procedural, real-time bird strike prevention. A unique implementation of a radar-based bird strike advisory system for civil aviation is located at the Durban King Shaka International Airport, South Africa [28,106]. During summer, around three million swallows visit a roosting site which is located on the extended runway center line, 2.6 km from the airport. At dawn and dusk, the birds move in large flocks to and from this site. The radar is used to detect these movements. Based on the observed risk level, ATC is advised to temporarily hold back air traffic. Contributing factors to the successful implementation of the procedures are the detectability of huge swarms of birds by avian radars, the short and distinctive periods of threat and the relatively low number of aircraft movements at the airport [28]. The general introduction of comparable procedures at other airports could be limited by the following factors. In contrast to King Shaka airport, bird strike risk is more random at other airports with respect to number of birds and time of day. The ability of avian radars to detect individual birds, even large ones, close to the ground as well as with increasing distance from the radar, is limited [107–109]. Therefore, not all birds are observed by the radar and no warning for potentially critical strikes can be presented due to the missing information. Moreover, tracks of individual birds are more difficult to predict than those of swarms. This reduces the potential positive effect on safety and to superfluous warnings in case of falsely predicted bird movement. Furthermore, bird strike risk is distributed throughout the day. This could lead to increased workload for the controllers and to to unjustifiable reduction in runway capacity at high-density airports.

An ongoing FAA study has addressed the question of workload increase for controllers when involving them in the bird strike hazard reduction process [110]. In human-in-the-loop simulations, controllers were presented with four test conditions in which they had to control air traffic at an airport. In the baseline scenario, bird activity information was provided as observations by pilots transmitted via radio, representing current procedures. In the three remaining conditions, information was provided in different ways via the controller's Human–Machine Interface (HMI). Initial results indicate that the controllers appreciate the increased situational awareness. Moreover, the controllers reported a reduction in workload when receiving dedicated bird strike risk information via their HMI in contrast to information reported by pilots. A European study focuses on the potential effects on an airport's safety and runway capacity when implementing procedural risk-reduction methods [111,112]. Fast-time simulations involving deterministic bird and aircraft movement revealed a potential for increasing safety and reducing cost with only a small impact on runway capacity [112]. Ongoing research is evaluating the effect when the limited predictability of birds is taken into account.

Alternatively to ground-based warning systems, there are ideas to integrate radar-based alerting systems into the aircraft [113]. Independent of the chosen approach, a close collaboration between research and operational personnel is crucial for a successful implementation of new measures [114].

The presented initiatives to apply operational bird strike prevention based on the positive results from military aviation are preliminary. Nevertheless, they demonstrate the potential to further reduce the risk of bird strike by applying procedural measures.

7. Conclusions

Collisions between birds and aircraft pose a serious risk to aviation. They mostly influence airport and aircraft operations and the efficiency of the air traffic management system. Furthermore, with their potential for severe damage and accidents, they pose a threat to aviation safety and a significant cost to the airline industry. The measures applied at airports, aircraft-mounted systems as well as regulations have reduced the risk and potential of accidents. Initial research on operational bird strike prevention by including air traffic controllers and pilots shows further potential to enhance avian and aviation safety.

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ANNEXURE 17

RESEARCH

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Avian diversity and bird-aircraft strike problems in Bahir Dar International Airport, Bahir Dar, Ethiopia

Tsegaye Tefera, Dessalegn Ejigu* and Nega Tassie

Abstract

Background: Bahir Dar International Airport and its surrounding habitats are known for their rich avifaunal diversity, which results in bird-aircraft collisions as a fundamental problem in the area. A study on bird diversity and bird-aircraft strikes at Bahir Dar International Airport was conducted between February 2020 and August 2020. Based on its vegetation structures, the study area was classified into four habitat types namely; bushland, grassland, wetland, and modified habitats. Transect and point count methods were used to collect data on avian diversity and abundance. Questionnaire surveys, interviews, and document analysis were used to gather information about incidents and protection measures against bird-aircraft strike problems. Shannon–Wiener diversity index, Simpson's similarity index, ANOVA, and chi-square test were used for data analysis.

Results: A total of 80 avian species belonging to 15 orders and 40 families were identified in the study area. The highest species diversity (H' = 3.59) and species evenness (E = 0.96) were recorded in modified habitats during the wet season. Relative abundance categories of birds in the study area showed that most were uncommon birds. Birds pose severe threats to aircraft in the airport and 92.3% of the respondents replied that most bird-aircraft strikes occurred early in the morning and late in the afternoon when birds remain more active. The majority (88.5%) of questionnaire participants confirmed that bird-aircraft strike incidents frequently occurred during the time of takeoff and landing of the aircraft. It is also known that on average forty bird-aircraft collisions per year happen at the airport.

Conclusion: Bahir Dar International Airport is rich in its bird diversity that recalls the aviation authority to work in collaboration with different organizations to avoid bird-aircraft strike problems using different control measures without compromising the conservation of birds.

Keywords: Aircraft, Bahir Dar, Bird strike, Shannon–Wiener diversity, Species evenness

Background

Birds are vital components of biodiversity, and they are the best known and highly significant organisms in the natural world [1]. They play a great role as bio-indicators and biocontrol agents [2, 3]. Although birds occupy most of the earth's surface, the majority of them are found only in particular regions and habitats [4]. Topographic diversity and variability of climate in Ethiopia contribute to its rich avian diversity [5]. Moreover, millions of migratory birds come to Ethiopia having flown all the way through the eastern flyway which makes the country one of the main corridors for migratory species. However, various anthropogenic disturbances occurring in natural habitats would affect the availability of various food items that influence on diversity, abundance, and distribution of birds [6].

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Ethiopia harbors over 860 species of birds and represents 9.5% of the World's and 39% of Africa's avian species of which nineteen species are endemic to Ethiopia, three are rare species, fourteen other species are shared with Eritrea, and thirty-one are globally threatened [4]. Moreover, over 1230 Important Bird Areas (IBAs) have already been identified in Africa of these, 73 being in Ethiopia [1].

Different environmental variables including food, temperature, and competition have been found to influence avian species diversity and abundance [4]. Urban environments provide birds with considerable quantities of food and roosting sites [7], and airports are one of the structural features of urban environments. The natural environment and human activities inside and in the immediate vicinity of airports provide a wide variety of natural and human-made habitats for birds that offer them diverse food items, nesting and roosting sites, shelter, and other facilities [8].

Bird-aircraft strike is a major hazard to the aviation industry [9] and it is one of the serious concerns for economic and flight safety reasons [10, 11]. The first worldwide recorded fatality due to a bird-aircraft collision occurred in 1912 [11, 12] and the incidents were rare during the beginning of the aviation industry, which resulted in slight damage [12]. However, the number and frequency of bird-aircraft collisions increased significantly over the last decades due to an increase in the number of flight operations combined with increasing numbers of birds of prey and small gregarious bird species, especially during migration [1]. More than one hundred bird species have been recorded to cause worldwide bird-aircraft strike problems [13]. Generally, bird-aircraft strikes cause an annual loss of about 1.2 billion USD in the global aviation industry [7]. Ethiopian airlines annually lose more than five million birr [> 100 K USD] to maintain equipment damaged by bird-aircraft strikes [14]. For example, a flock of speckled pigeons collided with Boeing-737 in 1988 at Bahir Dar International Airport resulting in the death of more than 30 people and the complete destruction of the aircraft [15].

The occurrence of birds at the airport depends on the attractiveness of habitats within and around the airports [16]. Bird-aircraft collisions are becoming a fundamental problem, especially in areas where airports are closer to water bodies, farmlands, grasslands, and damping sites [11]. Therefore, the need for effective bird control measures at airports and their vicinity has increased through the years. It is important that airport authorities show due emphasis on protecting bird-aircraft strike problems by employing effective bird control measures that are appropriate for their situation [7, 12].

There have been many studies conducted on avian ecology in East African countries including Kenya, Uganda, and Tanzania [17]. However, very few studies were conducted in Ethiopia [18]. Bahir Dar International Airport and its surrounding areas have bird-friendly habitats where diverse species of birds exist that demand research on the extent of bird-aircraft strike problems and its controlling measures. Thus, the main objective of this study is to investigate the avian diversity and bird-aircraft strikes at Bahir Dar International Airport and recommend appropriate control measures to prevent the problem.

Results

Species composition

A total of 80 species of birds belonging to 15 orders and 40 families were identified at Bahir Dar International Airport. Seasonal avian diversity showed that 79 and 69 species were recorded during the wet and dry seasons, respectively, of which 68 species were common both during the wet and dry seasons. But eleven species of birds were recorded only during the wet season, while one species was recorded only during the dry season (Table 1).

The highest number of families were recorded for the order Passeriformes (14 families) followed by Charadriiformes (5 families), Pelecaniformes and Bucerotiformes (4 families each), and the lowest was recorded under the orders Anseriformes, Accipitriformes, Columbiformes, Coraciiformes, Ciconiiformes, Gruiformes, Galliformes, Coliiformes, and Suliformes (1 family each). Moreover, order Passeriformes had the highest number of species (20 species), followed by Pelecaniformes (13 species), Accipitriformes and Columbiformes (7 species each), Anseriformes (6 species), Bucerotiformes, Charadriiformes, and Piciformes (5 species each), Coraciiformes and Ciconiiformes (3 species each), Musophagiformes (2 species), and the other four orders were found to be with the lowest number of species (1 species each) (Fig. 1).

In addition, the conservation status of birds was identified using International Union for Conservation of Nature (IUCN) Red List and National Red List Data Book. Among the total 80 species of birds recorded in the study area, two species; wattled ibis (*B. carunculata*) and black-winged lovebird (*A. taranta*) were endemic to Ethiopia and Eritrea, one species namely the hooded vulture (*N. monachus*) was critically endangered, and two species i.e., tawny eagle (*A. rapax)* and Abyssinian ground hornbill *(B. abyssinicus*) were vulnerable. Out of the total species of birds recorded in the area, 14 species were migrants and 66 were found to be residents.

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Table 1 List of bird species recorded during wet and dry seasons in the study area and their distribution in the four study habitats

Common name	Scientific name	Family	Order	Habitat types				Seasons		
				Bushland	Grassland	Modified habitat	Wetland	dry	wet	both
Abdim's stork	*Ciconia abdimii*	Ciconiidae	Ciconiiformes		✓	✓				✓
Abyssinian ground horn bill	*Bucorvus abyssinicus*	Bucorvidae	Bucerotiformes	✓					✓	
African Sacred ibis	*Threskiornis aethiopicus*	Threskiornithidae	Pelecaniformes				✓			✓
African black duck	*Anas sparsa*	Anatidae	Anseriformes				✓			✓
African black-headed oriole	*Oriolus larvatus*	Oriolidae	Passeriformes	✓						✓
African darter	*Anhinga rufa*	Anhingidae	Suliformes				✓			✓
African fish eagle	*Haliaeetus vocifer*	Accipitridae	Accipitriformes				✓			✓
African grey hornbill	*Lophoceros nasutus*	Bucerotidae	Bucerotiformes	✓						✓
African hoopoe	*Upupa africana*	Upupidae	Bucerotiformes		✓	✓				✓
African jacana	*Actophilornis africanus*	Jacanidae	Charadriiformes				✓			✓
African mourning dove	*Streptopelia decipiens*	Columbidae	Columbiformes		✓	✓				✓
African open billed stork	*Anastomus lamelligerus*	Ciconiidae	Ciconiiformes		✓		✓		✓	
African paradise Monarch	*Terpsiphone viridis*	Monarchidae	Passeriformes	✓	✓	✓				✓
African spoon bill	*Platalea alba*	Threskiornithidae	Pelecaniformes				✓			✓
African thrush	*Turdus pelios*	Turdidae	Passeriformes		✓	✓				✓
African wattled lapwing	*Vanellus senegallus*	Charadriidae	Charadriiformes		✓	✓	✓			✓
Black-billed barbet	*Lybius guifsobalito*	Lybiidae	Piciformes	✓		✓			✓	✓
Black-billed wood dove	*Turtur abyssinicus*	Columbidae	Columbiformes		✓	✓				✓
Black-billed wood hoopoe	*Phoeniculus somaliensis*	Phoeniculidae	Bucerotiformes	✓		✓				✓
Black crake	*Amaurornis flavirostra*	Rallidae	Gruiformes				✓			✓
Black-headed heron	*Areda melanocephala*	Ardeidae	Pelecaniformes		✓		✓			✓
Black-headed weaver	*Ploceus melanocephalus*	Ploceidae	Passeriformes	✓		✓				✓
Black-winged love bird	*Agapornis taranta*	Accipitridae	Accipitriformes	✓		✓				✓
Cardinal woodpecker	*Dendropicos fuscescens*	Picidae	Piciformes	✓						✓
Cattle egret	*Bubulcus ibis*	Ardeidae	Pelecaniformes		✓		✓			✓
Common bulbul	*Pycnonotus barbatus*	Pycnonotidae	Passeriformes	✓		✓				✓
Common fiscal	*Lanius collaris*	Laniidae	Musophagiformes	✓		✓				✓
Common Sand piper	*Actitis hypoleucos*	Scolopacidae	Charadriformes				✓		✓	
Dark chanting goshawk	*Melierax metabates*	Accipitridae	Accipitriformes	✓		✓				✓
Double toothed barbet	*Lybius bidentatus*	Lybiidae	Piciformes	✓		✓			✓	
Eastern Grey plantain eater	*Crinifer zonurus*	Musophagidae	Musophagiformes	✓		✓				✓
Egyptian goose	*Alopochen aegyptiaca*	Anatidae	Anseriformes		✓		✓			✓
Giant kingfisher	*Megaceryle maxima*	Alcedinidae	Coraciiformes	✓						✓

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Table 1 (continued)

Common name	Scientific name	Family	Order	Habitat types				Seasons		
				Bushland	Grassland	Modified habitat	Wetland	dry	wet	both
Glossy ibis	*Plegadis falcinellus*	Threskiornithidae	Pelecaniformes				✓			✓
Great white egret	*Ardea alba*	Ardeidae	Pelecaniformes		✓		✓			✓
Great white pelican	*Pelecanus onocrotalus*	Pelecanidae	Pelecaniformes				✓			✓
Greater blue-eared starling	*Lamprotornis chalybaeus*	Sturnidae	Passeriformes	✓	✓	✓				✓
Grey woodpecker	*Dendropicos goertae*	Picidae	Piciformes	✓		✓				✓
Grey-headed kingfisher	*Halcyon leucocephala*	Alcedinidae	Coraciiformes	✓				✓		
Northern Grey headed sparrow	*Passer griseus*	Passeridae	Passeriformes	✓	✓	✓				✓
Grey heron	*Ardea cinerea*	Ardeidae	Pelecaniformes				✓			✓
Hadada ibis	*Bostrychia hagedash*	Threskiornithidae	Pelecaniformes		✓	✓	✓			✓
Hamerkop	*Scopus umbretta*	Scopidae	Pelecaniformes				✓			✓
Helmeted Guineafowl	*Numida meleagris*	Numididae	Galliformes	✓	✓					✓
Hooded vulture	*Necrosyrtes monachus*	Accipitridae	Accipitriformes		✓	✓				✓
Knob-billed duck	*Sarkidiornis melanotos*	Anatidae	Anseriformes				✓			✓
Laughing dove	*Spilopelia senegalensis*	Columbidae	Columbiformes	✓	✓	✓				✓
Lemon dove	*Columba larvata*	Columbidae	Columbiformes		✓	✓				✓
Little egret	*Egretta garzetta*	Ardeidae	Pelecaniformes				✓			✓
Long-crested eagle	*Lophaetus occipitalis*	Accipitridae	Accipitriformes	✓		✓				✓
Marabou stork	*Leptoptilos crumenifer*	Ciconiidae	Ciconiiformes				✓			✓
Namaqua dove	*Oena capensis*	Columbidae	Columbiformes			✓				✓
Northern black flycatcher	*Melaenornis edolioides*	Muscicapidae	Passeriformes	✓		✓			✓	
Nubian woodpecker	*Campethera nubica*	Picidae	Piciformes	✓		✓				✓
Olive thrush	*Turdus olivaceus*	Turdidae	Passeriformes	✓	✓	✓				✓
Pied crow	*Corvus albus*	Sturnidae	Passeriformes	✓	✓	✓				✓
Pin-tailed whydah	*Vidua macroura*	Viduidae	Passeriformes			✓				✓
Red-billed firefinch	*Lagonosticta senegala*	Anatidae	Anseriformes			✓				✓
Red-billed oxpecker	*Buphagus erythrorhynchus*	Buphagidae	Passeriformes		✓				✓	
Red-cheeked cordon bleu	*Uraeginthus bengalus*	Estrildidae	Passeriformes	✓					✓	
Red-eyed dove	*Streptopelia semitorquata*	Columbidae	Columbiformes		✓	✓				✓
Rueppell's robin chat	*Cossypha semirufa*	Muscicapidae	Passeriformes			✓				✓
Ruppell's weaver	*Ploceus galbula*	Ploceidae	Passeriformes	✓		✓				✓
Senegal thick-knee	*Burhinus senegalensis*	Burhinidae	Charadriformes				✓		✓	
Silvery-checked hornbill	*Bycanistes brevis*	Bucerotidae	Bucerotiformes	✓		✓				✓

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Table 1 (continued)

Common name	Scientific name	Family	Order	Habitat types				Seasons		
				Bushland	Grassland	Modified habitat	Wetland	dry	wet	both
Speckled mousebird	*Colius striatus*	Coliidae	Coliiformes	✓		✓				✓
Speckled pigeon	*Columba guinea*	Columbidae	Columbiformes	✓	✓	✓				✓
Spur-winged goose	*Plectropterus gambensis*	Anatidae	Anseriformes				✓			✓
Spur-winged lapwing	*Vanellus spinosus*	Laridae	Charadriiformes				✓			✓
Striped kingfisher	*Halcyon chelicuti*	Alcedinidae	Coraciiformes	✓		✓				✓
Swainson's sparrow	*Passer swainsonii*	Passeridae	Passeriformes		✓					✓
Tawny eagle	*Aquila rapax*	Accipitridae	Accipitriformes	✓						✓
Tropical boubou	*Laniarius major*	Malaconotidae	Passeriformes	✓		✓				✓
Village indigobird	*Vidua chalybeate*	Viduidae	Passeriformes			✓				✓
Wattled ibis	*Bostrychia carunculata*	Threskiornithidae	Pelecaniformes		✓		✓		✓	
White-faced whistling duck	*Dendrocygna viduata*	Anatidae	Anseriforme				✓			✓
Yellow billed egret	*Ardea intermedia*	Ardeidae	Pelecaniformes				✓			✓
Yellow-billed kite	*Milvus aegyptius*	Accipitridae	Accipitriformes	✓	✓	✓				✓
Yellow-fronted canary	*Crithagra mozambica*	Fringillidae	Passeriformes	✓	✓	✓			✓	
Yellow wagtail	*Motacilla flava*	Motacillidae	Passeriformes		✓					✓

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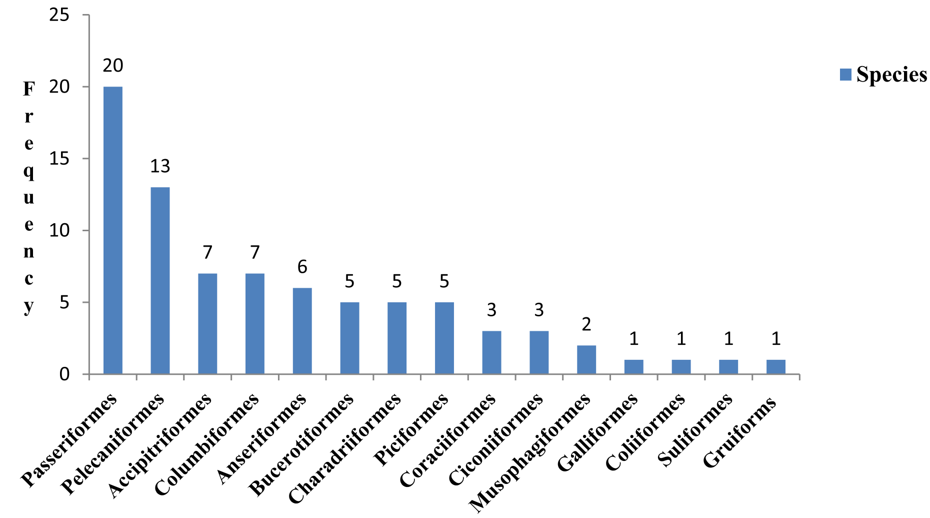

Fig. 1 Frequencies of species within each order

Table 2 Species diversity of birds in the four study habitats

Habitat type	Seasons	No of species	No of individuals	H´	Hmax	E
Bushland	Dry	29	1016	3. 11	3.37	0.92
	Wet	35	1184	3.34	3.55	0.94
Grassland	Dry	21	947	2.78	3.04	0.91
	Wet	29	1073	3.22	3.36	0.95
Modified habitat	Dry	31	1145	3.20	3.43	0.93
	Wet	42	1720	3.59	3.73	0.96
Wetland	Dry	25	1239	2.94	3.22	0.91
	Wet	28	1628	3.14	3.33	0.94

Key: H'=Shannon-Weiner deiversity index, Hmax=lns, E=Shannon's equitability index

Species diversity

Avian species diversity varied among the four habitat types. The highest species diversity (H´=3.59) was recorded in modified habitats during the wet season and the lowest (H´=2.78) was in grassland habitats during the dry season. The highest species evenness (E=0.96) was obtained in modified habitats during the wet season, while the lowest (E=0.91) was in wetland and grassland habitats during the dry season. The highest species richness (42 species) was recorded in modified habitats during the wet season and the lowest (21 species) was in grassland habitats during the dry season (Table 2).

The overall avian diversity in the whole study area showed that relatively more species diversity (H´=4.14) and evenness (E=0.94) were recorded during the wet season compared to the dry season (Table 3).

Table 3 Specie diversity of birds in the whole study area during dry and wet seasons

Seasons	No of species	No of individuals	H´	Hmax	E
Dry	69	4347	3. 89	4.23	0.92
Wet	79	5605	4.14	4.36	0.94

Abundance of birds

There were 5605 and 4347 individual birds recorded in the study area during the wet and dry seasons, respectively, and this showed that relatively the highest number of individual birds were obtained during the wet season. However, the overall abundance of birds in the area did not show a significant difference between the two seasons ($F_{(1,146)}=0.70$; $p>0.05$). During the wet season,

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the abundance of birds showed significant differences among the four habitat types ($F_{(3,130)} = 4.44$; $P < 0.05$). Birds' abundance as a function of season and habitat type has also confirmed that season and habitat are not related ($\chi^2(4) = 2$, df = 1; $p = 0.157$). And the relative abundance of avian species did not show a significant difference between the wet and dry seasons ($F_{(1,146)} = 0.86$; $P > 0.05$).

In addition, during the dry season, speckled pigeon (*C. guinea*) with 365 individuals was relatively the most abundant species in the study area followed by greater blue-eared glossy starling (*L. chalybaeus*) with 267 individuals, and red-eyed dove (*S. semitoruquata*) with 218 individuals. During the wet season, speckled pigeon with 281 individuals was also relatively the most abundant species followed by black-headed weaver (*P. melanocephalus*) with 252 individuals, and great white pelican (*P. onocrotalus*) with 202 individuals. Thus, speckled pigeon was found to be the most abundant species during the two seasons. On average, relatively the most abundant avian species during the dry and the wet seasons in their decreasing order were speckled pigeon ($n = 323$), greater blue-eared glossy starling ($n = 227$), black-headed weaver ($n = 225$), red-eyed dove ($n = 191$), and great white pelican ($n = 189$) (Supplemental Tables 2 and 3).

Species similarity

Simpson's similarity index (SI) of avian species in the four study habitats showed that the highest (SI = 0.74) and the lowest (SI = 0.54) species similarity were recorded between bushland and modified habitats during the wet and dry seasons, respectively, (Table 4).

Bird-aircraft strike problems

A structured questionnaire was administered to 23(88.5%) male and 3(11.5%) female respondents. Professionally, 20(76.9%) of the respondents were bird controllers, 4(15.4%) officers, and 2(7.7%) section heads who have years of work experience in the airport.

Of the total respondents, 21(80.8%) of them confirmed that they have seen bird-aircraft collision incidents in the airport. The problem was more frequent during the summer as it was supported by 17(65.4%) of the respondents. The majority 24(92.3%) of questionnaire participants replied that most bird-aircraft strike problems occurred early in the morning and late in the afternoon.

Regarding bird-aircraft strike occurrences, the majority of respondents replied that they encountered dead birds due to collisions with aircraft. It was also known that forty bird aircraft collisions per year occurred at the airport. The majority 23(88.5%) of the study participants recalled that bird-aircraft strike incidents frequently occurred during the time of takeoff and landing of the aircraft.

Although 19 (73.1%) of the respondents replied that the speckled pigeon ($n = 323$) was the most problematic avian species frequently causing bird-aircraft strike problems at the airport, other species such as marabou stork ($n = 44$), yellow-billed kite ($n = 37$), Egyptian goose ($n = 80$), and tawny eagle ($n = 23$) were also usually involved in the bird-aircraft strike incidents at the same airport. Besides birds, other wildlife species such as hyena (*Crocuta crocuta*), Ethiopian hare (*Lepus starcki*), and common duiker (*Sylvicapra grimmia*) were also involved in wildlife-aircraft strike problems.

There are different controlling methods used by the airport office to prevent bird-aircraft strikes. These include selective removal of trees, mowing of grasses, surveying of birds and other animals using vehicles, removing birds' nests around the airport, draining ditches of water, using sounds of guns for large flocks of birds, discouraging birds using whips, removing dead bodies and other wastes, and establishing strong security fences along the runway to prevent large land-dwelling animals. The majority (73.1%) of the respondents confirmed that most of the strike controlling measures include expelling birds and other wildlife away from the airport area during takeoff and landing of aircraft.

Discussion

A total of 80 avian species were identified in Bahir Dar International Airport during the study period. This showed that this airport is rich in its avifauna diversity compared to similar airports in the other parts of the country such as Mekele International Airport which

Table 4 Similarity of bird species among the study habitats during the wet and dry seasons

Habitats	Bushland		Grassland		Modified habitat		Wetland	
	wet	dry	wet	dry	wet	dry	wet	dry
Bushland	1	1	0.64	0.65	0.74	0.54	0.64	0.63
Grassland	-	-	1	1	0.70	0.58	0.66	0.65
Modified habitat	-	-	-	-	1	1	0.64	0.57
Wetland	-	-	-	-	-	-	1	1

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harbors 68 avian species [19]. This might be due to differences in resource availability and proximity of the airport to Lake Tana, one of the five Biosphere Reserves in Ethiopia [20].

Most species of birds in the Bahir Dar International Airport are available in the area throughout the year. However, there are some avian species that are observed only during the wet season. This might be due to variations in food availability and weather conditions [21]. The highest number of avian species was recorded under the order Passeriformes, which is in line with similar research findings in other parts of Ethiopia [22–24]. The modified habitat harbors relatively the highest number of species throughout the year, which is also supported by the findings of [23] that emphasize the presence of diversified microhabitats in modified habitat contributes to this result. Moreover, the food shifting behavior of birds when food is scarce during the dry season would also result in an increase in avian diversity in the modified habitat.

The lowest avian species diversity was recorded in grassland habitats during the dry season. This could be associated with scarcity of food sources and the occurrence of various anthropogenic disturbances in grassland habitat. This is also in line with the findings of [25] and [26] who claimed that anthropogenic activities including overgrazing, habitat degradation, and habitat fragmentation eventually cause migration and local extinction of birds. According to [27], avian species abundance is directly or indirectly affected by spatial variation and the degree of anthropogenic activities. Furthermore, [21] reported that the distinct seasonality of rainfall and variations in the availability of food sources contribute to variations in the abundance of avian species between the wet and dry seasons.

The highest avian species evenness was recorded in modified habitats during the wet season, while the lowest was in wetland and grassland habitats during the dry season. This indicated that in modified habitat successful avian species equally forage the available resources and this contributes to relatively higher avian species evenness in this type of habitat. In contrast in wetland and grassland habitats, feeding guild-specific bird species out-compete the available resources and they become dominant in the utilization of the available resources, which contributes to reducing species evenness. The differences in resource competition, breeding nature, foraging habit, and niche specialization among the distinct species of birds in each habitat result in fewer species evenness [28–30].

The highest and the lowest number of birds were recorded in modified habitats and grassland habitats during the wet and dry seasons, respectively. This difference might be associated with variations in resource availability among the different habitats. Moreover, the difference in abundance of birds between the modified and grassland habitats could also result in variation in the degree of anthropogenic disturbances between the two habitats. This result is similar to the findings of [21] who reported that variations in the abundance of birds are determined by food availability and breeding sites.

Relative abundance categories of birds in the study area showed that most of them were uncommon birds since out of the total 80 avian species identified in the study area, only 12 species were frequent, but all other 68 species were uncommon birds. This might be associated with better niche specialization of the uncommon birds in the area. Consistent with this result, [31] described that the presence of uncommon birds in a certain area might be due to the breeding nature, large home range, and niche requirement of the species. The result of this study is also in line with the findings of [32] who reported that the majority of birds in Bole International Airport were found to be uncommon birds.

The highest and the lowest avian species similarity were recorded between the bushland and modified habitats during the wet and dry seasons, respectively. The similarity of avian communities between two different habitats might be due to their geographical proximity, similar ecology, and similar extent of disturbances in such habitats. The lowest avian community similarity between different habitats could be due to habitat-specific differences in foraging adaption and the response of birds to different anthropogenic disturbances. The result of this study is in line with the findings of [33] who described that the similarity of avian species composition between different habitats indicates a tendency for similar habitats to have similar species composition. Hence, in the present study, the highest and the lowest avian community similarities between bushland and modified habitats during the dry season might be influenced by differences in seasonal variation in the two habitats.

The questionnaire and interview results about bird-aircraft strike problems in Bahir Dar International Airport indicated that the majority of the respondents have observed birds die from these strikes. It is also reported that on average forty bird-aircraft strikes occurred annually in the airport. Although the strikes did not cause considerable damage to the aircraft, a substantial number of birds were found dead from these strike incidents. A study conducted by [18] reported that thirty-six bird-aircraft strikes per year occurred in Bole International Airport. To minimize bird-aircraft strikes, the aviation authority should use different bird-controlling measures

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in places where the competition for space between airports and birds is the strongest [34].

The respondents of this study described that most bird-aircraft strikes in Bahir Dar International Airport took place during takeoff and landing especially early in the morning and late in the afternoon. There seems to be an association between the time of the strike and the behavior of birds. This could be due to the occurrence of more aircraft traffic density and higher activity of birds during these times of the day. Similarly, [35] reported that 93% of the collisions occurred during the takeoff run, in the first phase of ascend, and in the final stage of landing. This result is also supported by other research findings [36] which described that bird-aircraft strikes are most frequently occurring in the morning and in the evening when birds are more active in foraging.

The respondents of this study also reported that most bird-aircraft strikes in Bair Dar International Airport occurred during the summer season. Besides the foggy weather condition, food and other resources are more abundant during summer which results in increasing the size of the local bird population with a subsequent increase in collision frequencies in the airport. This is in line with the findings of [37] who described that the frequency and distribution of bird-aircraft strikes had peaks that coincided with the period of migration of birds. Like other airports [9], bird-aircraft strikes in Bahir Dar International Airport are a regular threat to flight operation. Birds pose a real threat to flight safety although most collisions do not end in catastrophes [12].

In Bahir Dar International Airport the most catastrophic and fatal bird strike incident that claimed the lives of thirty-five people occurred in 1988. The majority of birds that are known to cause aircraft strikes during landing and takeoff in the airport include speckled pigeons, marabou stork, yellow-billed kite, Egyptian goose, and a tawny eagle in their decreasing order of causing the strikes. Most bird-aircraft strikes in Bole International Airport were also caused by the most abundant bird species, the pigeons [18] as higher abundance is positively correlated with the number of strikes. One of the main factors for the increase in the frequency of bird-aircraft strikes is increasing the number of birds in the area [38, 39]. Similarly, in Bahir Dar International Airport it is the speckled pigeon with relatively the highest individual abundance that causes frequent bird-aircraft strike problems. Moreover, other avian species such as the greater blue eared glossy starling, black-headed weaver, red-eyed dove, and great white pelican are often involved in bird-aircraft strike incidents. On the contrary, species with lower population sizes such as marabou stork, yellow-billed kite, Egyptian goose, and tawny eagle are also considered to be problematic species regarding bird-aircraft strike incidents in this airport. This showed that the abundance of birds in the area is not the only factor that has been correlated with bird-aircraft strike problems, but the behavioral activity of each bird might also play a significant role in such incidents.

Besides birds, land-dwelling animals such as hyenas and Ethiopian hares were also reported to pose strikes in the airport during takeoff and landing of the aircraft. This result is similar to the findings of [39] who described that large ground-dwelling animals can cause problems to aircraft operations and aircraft movements.

The main controlling measures for bird-aircraft strikes used by Bahir Dar International Airport include expelling birds away from the landing and takeoff areas. Thus, the aviation authority office needs to use varieties of bird-controlling measures including different scarring devices and habitat management techniques to discourage birds and other wildlife species from the airport vicinity.

Conclusion

Bahir Dar International Airport is known for its rich avifaunal diversity with a relatively high population size for each species. This diverse avian species community is because of the availability of different habitats and sufficient resources. More importantly, the proximity of Bahir International Airport to Lake Tana and associated wetlands enables the area to harbor relatively high avian species diversity. However, habitat changes due to various anthropogenic activities notably livestock grazing, and expansion of farmlands have negatively affected the diversity and abundance of birds in the area.

The findings of the present study revealed that most bird-aircraft strikes occurred early in the morning and late in the afternoon when birds remain more active. Hence, to minimize bird collisions with aircraft, the aviation authority should revise the flight schedules and try to make less traffic load early in the morning and late in the afternoon. It is also better to develop appropriate habitat management options which attract a lower number of birds into the airport. Moreover, the aviation authority in collaboration with different organizations should design and implement comprehensive protective strategies including visual, tactile, auditory, and chemical repellents to control the population of birds in the airport and avoid bird-aircraft strikes. Moreover, the office should also use appropriate risk assessment methods, especially for those birds which cause the greatest risk, and target them to control and avoid the strike problems.

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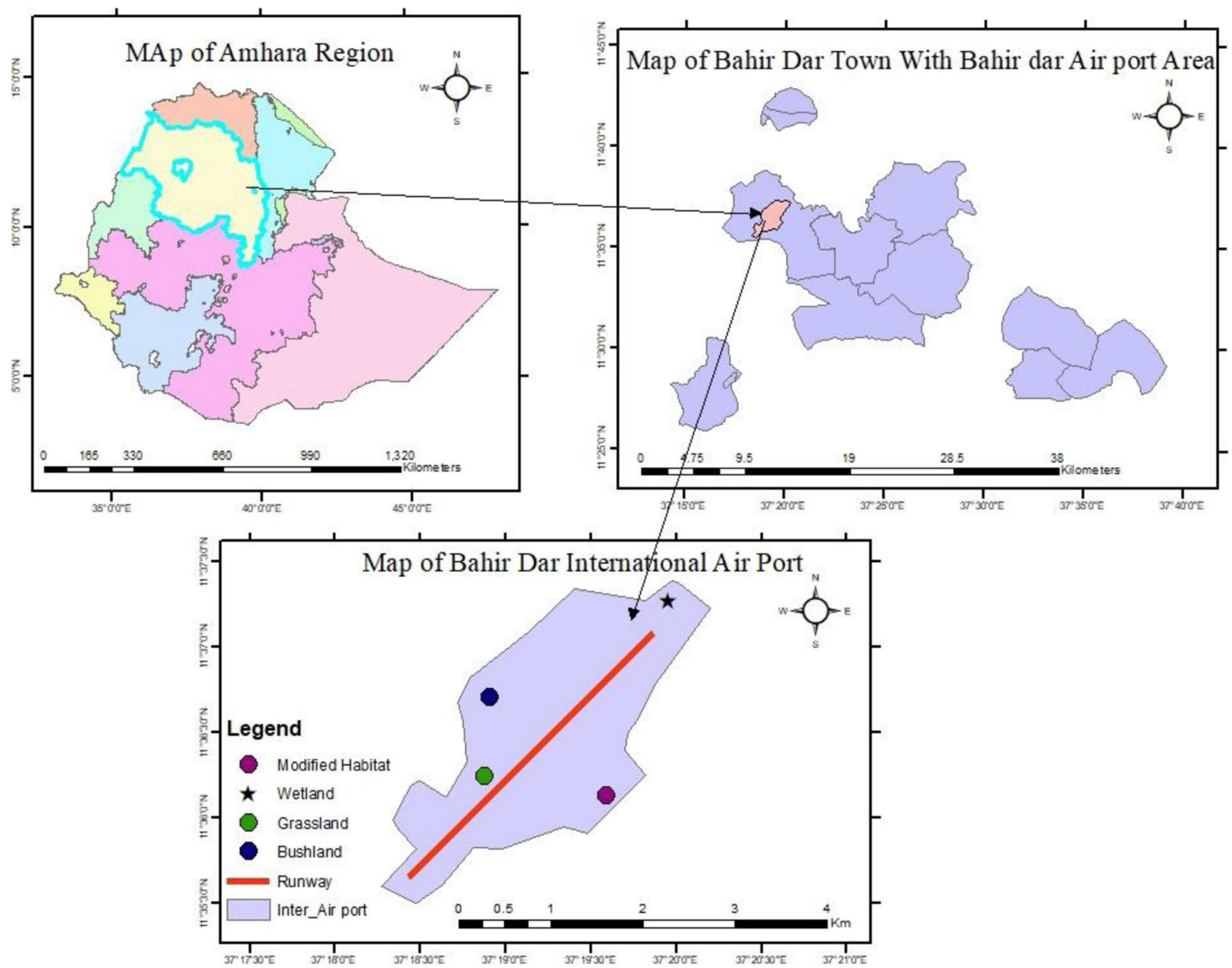

Fig. 2 Location map of the study area

Methods

Description of the study area

Bahir Dar International Airport, established in 1954, is one of the International Airports in Ethiopia located 8 km to the northwest of Bahir Dar City, the capital of Amhara National Regional State. It is geographically located at 11°36′30″N latitude and 37°19′30″E longitude at an elevation of 1821 m a.s.l (Fig. 2). Its main runway length and width are 3100 m and 45 m, respectively. The airport and its surrounding habitats are dominated by grassland, bushland, wetland, and modified habitats. There are a lot of tourist attraction sites around the airport including ancient monasteries and churches on the Islands of Lake Tana. Furthermore, the airport's scenery with the Lake Tana and the beautiful city Bahir Dar create great pleasure for the travelers.

Ten years of rainfall and temperature data of the study area showed that the highest average monthly rainfall was 391.92 mm recorded during July and the lowest was 1.02 mm during January and the average monthly minimum and maximum temperatures were 6.46°c and 31.87°c recorded during January and April, respectively [40].

Sampling design

The study area was classified into four habitat types and the sampling unit within each habitat type was determined based on vegetation type, structure, and area coverage. As a result, it is classified into bushland, grassland, wetland, and modified habitats. Modified habitat in this study is described as a habitat where human activities change their original status including aircraft runways, adjacent habitats inside the airport premises, and farmlands and grazing lands outside but closer to the airport. Among the four habitat types, three habitats namely bushland, grassland, and modified habitats are found inside the airport, while the wetlands and additionally modified habitats are located immediately outside the airport directly on the way to Lake Tana. Line transect and point

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count methods were used for studying the diversity and relative abundance of birds [41] in and around the airport.

The line transect method was used in wetland, grassland, and modified habitats since the areas are open, while the point count method was applied in relatively dense bushland habitats [42]. Blocks and sampling plots were established for transect and point count methods, respectively. The number of blocks and sampling plots were determined according to the size and type of vegetation cover of the study habitats. The average length and width of the transects were 200 m and 50 m, respectively. Transects were separated from each other by 100 m, and a total of 10 sample blocks (each comprising five transect lines) and eleven sample plots (each comprising five sampling points) were used.

Data on bird-aircraft strike incidents and methods of its control were assessed using questionnaire, interviews, and document analysis techniques. As a result, twenty-six respondents (twenty-three males and three females) among 100 officers and field workers were selected using the purposive sampling method. The selection of the respondents was made on the basis of the relevance of their jobs to bird strike control activities in the airport area.

Data collection

The point count method was used to collect data in the bushland habitat, and transects were used in the wetland, grassland, and modified habitats. During the point count method, suitable sites were selected and birds were identified and counted from a fixed position within a 25 m radius for a specific period of 10 min at every point. All birds seen and heard within this 25 m radius were recorded. To minimize the disturbance during counting, a waiting period of 5 min prior to counting was applied.

Using the transect count method, birds were counted by walking at 2 km per hour and at a uniform pace throughout the whole transects. However, sometimes the speed of walking on the routes was determined by the number of birds present and the extent of difficulties in recording them.

Dry season data were collected from February to April 2020 and data for the wet season were collected from June to August 2020. Census data for the dry and wet seasons were collected twice a day when most birds are active early in the morning (6:30–9:00 a.m.) and late in the afternoon (4:00–6:30 p.m.) for five days per month with a total of 150 survey hours during the whole study period.

Field observations were made to identify birds at the species level using binoculars with a magnification power of 10 and an objective lens diameter of 50 (10 × 50). Species identifications were carried out using an appropriate field guidebook [43] and photographs were taken for further identification of birds. Movement patterns of birds that usually cross the runway were recorded to evaluate the problems of birds to aircraft strikes. The time of the day when the bird flight was the highest and activities performed by the birds such as flight direction and flock size were also recorded.

To assess the extent of bird-aircraft strike problems in Bahir Dar International Airport, questionnaire surveys were administered to 23(88.5%) male and 3(11.5%) female respondents. Structured interviews were employed to collect additional data to assess the status of bird-aircraft strike problems and their control measures applied in the airport. Secondary data were also obtained from the aviation authority office, Bahir Dar branch, to access previous information about bird-aircraft strikes in the airport.

Data analysis

Association of birds and seasons with habitat types were analyzed using the chi-square test, and one-way analysis of variance (ANOVA) was used to check the mean abundance of species differences among the four habitat types and between seasons. Moreover, avian species diversities in each habitat type were calculated using Shannon–Wiener diversity (H'), and evenness (E) indices [4].

Shannon Wiener diversity index is calculated as:

$H' = —\Sigma\ Pi \times Ln\ (Pi)$ where,

H' = Shannon–Wiener diversity index.

Pi = the proportion of each species in the sample.

Ln (Pi) = natural logarithm of this proportion.

Species evenness is by Shannon's equitability index (E) which is calculated by:

$\mathbf{E} = \frac{\mathbf{H'}}{\mathbf{Hmax}}$ where,

E = Shannon–Wiener evenness index.

H' = Shannon–Wiener diversity index.

Hmax = lns.

Ln = Log normal.

S = Total number of species.

Simpson's similarity index (SI) was also used to evaluate the similarity of species between two different habitats in both seasons using the following formula:

SI = 2C/A + B where,

SI = Simpson's similarity index,

A = number of species that occur in habitat 'A'.

B = Number of species that occur in habitat 'B'.

C = Number of common species that occur in both habitat 'A' and 'B'.

The relative abundance of bird species in each habitat was calculated by:

Relative abundance $= \frac{n}{N} \times 100$ where,

n = Number of individual species.

N = the total number of individuals of all species.

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Table 5 Relative abundance score categories

Relative abundance	Relative abundance score	Abundance category
<0.1	1	Rare
0.1–2.0	2	Uncommon
2.1–10.0	3	Frequent
10.1–40.0	4	Common
>40	5	Abundant

Relative abundance values were used to ordinarily categorize each species under the following five abundance categories [42] (Table 5).

Abbreviations
ANOVA: Analysis of Variance; IBAs: Important Bird Areas; IUCN: International Union for Conservation of Nature.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s40850-022-00135-8.

Additional file 1: Suplemetal Table 1. Bird order, family, genera,species, status and lifestyle of birds in the study area. **Suplementary Table 2.** Relative abundance of birds in dry season. **Suplemetal Table 3.** Relative abundance of birds during wet season.

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Authors' contributions
TT proposed the research idea, TT, DE, and NT designed the study, and participated in data collection, data organization, data analysis, and preparation of the manuscript. All authors have read and approved the final manuscript.

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Availability of data and materials
All data generated and analyzed during this manuscript preparation are available on the hands of the corresponding author.

Declarations

Ethics approval and consent to participate
The study was evaluated and approved by Bahir Dar University, Science College, Research Ethical Committee, and permission is also given from Bahir Dar International Airport Office. Informed consent was obtained from all respondents who participated in the interview and from the Manager of Bahir Dar International Airport. Moreover, all methods used in this study were performed in accordance with the relevant guidelines.

Consent for publication
Not applicable.

Competing interests
All the authors declare that they have no competing interests.

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