

**A COMPARISON OF THE INJURY SYNDROMES ASSOCIATED WITH
DIFFERENT SOURCES OF AVIAN MORTALITY**

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Abstract

The Pattern of Trauma shown by birds which have been struck by aircraft- known as the bird strike syndrome, has been outlined in a previous study (LYNE ET AL. 1998). The current research programme will compare and contrast the pattern of injuries incurred as a result of a collision with an aircraft with those which occur as a result of colliding with motor vehicles, shot with shotguns and killed by avian predators. The study has focused on the age and condition of the bird as well as its sex and moult status. Necropsies were performed on deep frozen cadavers. Typical patterns of injury have been recorded on digital camera for subsequent use in establishing a database of injuries. The emphasis in this study is in establishing a quantitative classification of the suite of injuries including those which occur during landing and takeoff of both turbo-prop and turbo-jet type aircraft. An attempt will be made to compile a trauma index, which will be used in the quantitative comparison of the range and combination of injuries associated with the different categories of bird strikes.

1. Introduction

Macroscopic identification of birds through runway sweeps is the simplest technique used to identify birds involved in aircraft collisions (LINNELL ET AL, 1996). The identification of bird species in the general airport environment together with those that have been struck by aircraft is important in providing sound statistics (SHAMOUN-BARANES, 1998).

LYNE ET AL (1998) details necropsy results of 92 bird carcasses collected at Dublin airport, Ireland. This study provided a preliminary description of a "Bird Strike Syndrome" and revealed that an overwhelming majority of birds in this sample had sustained injuries to the ventral surface. One suggested explanation for such a trend was that birds "slowed down" when in close proximity to aircraft in an attempt to avoid collision (KELLY, MURPHY & BOLGER, 1996).

The current study has three main objectives. Firstly, to identify a suite of injuries associated with bird-aircraft collisions and to find a quantitative method of defining such trauma. Secondly, to distinguish bird-aircraft collision injuries from those associated with other causes of mortality. Finally, to develop a photographic database of injuries associated with a number of different sources of trauma - related avian mortality with a view to allowing the cause of death to be easily diagnosed.

These objectives will be achieved through detailed necropsy of bird carcasses found at airports, as well as those collected from road verges, below overhead lines. In addition, comparisons will be made with those involved in collision with windows, and those individuals which have been killed by avian predators, as well as those which have died from gun shot injuries. The injury related pathology of these cadavers will be compared based on trauma scoring systems developed for human medical purposes. This system allocates a score to an injury based on its severity or threat to life (COPES ET AL, 1990). All cadavers will be photographed.

2. Materials and methods

2.1 Study areas

This projects uses two main study areas, Dublin and Cork airports (51⁰50'50" N, 8⁰29'40"W, and 53⁰25'40"N, 6⁰14'27"W respectively), two of the largest and busiest airports in the Republic of Ireland. Over 15 million passengers passed through Dublin airport in 2002. In 2001 1.8 million passengers passed through Cork airport.

A parallel study involving road-killed specimens will include individuals collected from primary and secondary routes in the Cork region (Ordnance Survey: X075730).

2.2 Specimen collection

Bird patrol units at both Dublin and Cork airport collected cadavers for this study. Cadavers were collected through routine inspections of the airfield as well as from aircraft following collisions. All specimens were labelled with the time and date of collection as well as the location in which they were found and the prevailing weather conditions. In cases where a strike has been reported, or where birds have been removed the hull, undercarriage, wings and engines, the type of aircraft and the phase of flight is also noted. Cadavers are stored in polythene bags and deep-frozen.

Road killed individuals are collected through daily scanning of both primary and secondary routes. Only freshly killed samples are collected to reduce any confounding effects of individuals that have been struck repeatedly by cars. The location in which the bird was found as well as the date and weather conditions are recorded. Specimens are stored in polythene bags and deep-frozen.

2.3 Necropsy methods

2.3.1 External examination

Specimens are allowed sufficient time to fully defrost. The necropsy follows routine procedure as described in Waine (1996) with some minor amendments due to the focus on gross injury (see LYNE ET AL, 1998).

Any identifying marks such as rings, microchips etc are noted. The following measurements are recorded from all cadavers- weight, tarsal length, maximum chordal length, beak length and head length (Redfern & Clarke, 2001). The condition of the cadaver is scored based on fat scores (0-8) and/or pectoral muscle scores (0-3) (see BAIRLIEN ET AL, 1995).

The bones are examined, palpating each joint and long bone for any fractures, dislocations or joint effusions. The integument is also checked for any signs of injury such as puncture wounds or contusions.

The feathers are examined and photographed to observe any signs of abnormal wear, fractured veins, discolouration, abnormal development, cysts, stress marks, and/or ectoparasites. The stage of moult is noted.

The uropygial (preen) gland at the base of the tail is examined for any abnormalities. Any discharges from the nares, buccal cavity, eyes, ears, vent and wounds are noted. The presence or absence of the eyes is also noted to indicate if any post mortem predation has occurred.

The legs, feet and cere are examined for any encrustations. The beak is also checked for any breakages.

2.3.2 Internal examination

Preparation and initial incision

Smaller birds are pinned on a cork board in dorsal recumbency with limbs outstretched and tense. The bird is soaked with a dilute disinfectant detergent and the feathers are parted down the ventral midline in preparation for the initial incision. The skin is incised through the skin along the midline from the gonys to the vent. The skin is eased away from the underlying thorax and *pectoralis* muscles by blunt dissection and the condition on the muscle along with the presence of subcutaneous fat is observed.

Removal of superficial muscles and examination of the buccal cavity

The buccal cavity is opened allowing the lower mandible to be reflected. The buccal cavity and infraorbital sinuses are examined. The pectoral muscles are reflected away from the sternum and ribs. For individuals which have been involved in multiple strikes (two/more individuals struck during the same incident or found together on collection) a sample of the pectoral muscle is taken using a sterilised scalpel blade. This is to allow DNA analysis at a later date. The trachea and oesophagus are dissected along their length. The midline of the abdominal muscles is incised and the insertion of the muscles to the rib cage cut. The abdominal contents are examined for any haemorrhaging etc. The abdominal tunic is reflected to reveal the underlying post-hepatic septum.

Removal of the sternum and the examination of the viscera in situ

The ribs are cleared of the overlying muscle and cut along the line of angulation. The sternum is lifted away from its caudal edge and dissected away from the thoracic air sacs and the pericardium. The sternum is removed by dislocating the joints between the coracoid bones and the edge of the sternum. Any damage to the sternum is noted. The heart, lungs and liver are examined *in situ* for any contusions, haemorrhaging or lesions. The post hepatic septum is removed.

Examination of the thoracic and abdominal organs

The crop and oesophagus are removed using blunt dissection and examined for the presence of any parasites. The trachea is removed and held up to the light to examine for any parasites within. The liver and gastrointestinal tract are separated out. The gastrointestinal tract is removed and its organs including the duodenum, colon, spleen and pancreas are examined for any signs of damage. A section of the kidney and gonads are taken and examined for any sign of abnormalities.

Examination of the skull, brain and spinal cord

The skin is removed from the skull using blunt dissection. Any staining of the skull is noted before its removal for examination of the brain. The brain is sectioned and any signs of contusions or haematomas are noted.

The skin is removed from around the spinal cord through blunt dissection to observe if any bruising, haemorrhaging or fracture has taken place.

2.4 Injury recording

Each injury is assigned a score based on an anatomical scoring system used in trauma medicine, the Abbreviated Injury Scale (AIS), COPES ET AL (1990). Injuries are ranked on a scale of 1-6 [Table I] with 1 being minor and 6 unsurvivable. Organ injury scales have also been developed to provide physicians with a common nomenclature by which to describe injuries to various organs and their severity (MOORE, 1989; MOORE, 1990; MOORE, 1992; MOORE, 1994; MOORE, 1995). Injuries can be scaled based on mechanism, such as blunt or laceration, or anatomic description, haematoma, laceration, contusion, vascular. Bilateral injuries to organs or extremities will increase the AIS score.

Table I. *Abbreviated Injury Scale (AIS)*

AIS Score	Injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Unsurvivable

Another tool used in medical trauma research is the Injury Severity Score (ISS), Baker *et al* (1974). This anatomical scoring system uses the AIS to provide an overall score for patients with multiple injuries. Broadly based on the ISS injuries in this study will be allocated to one of the six body regions described in Table II.

Table II. *Description of body regions into which injuries are classified*

Region	Description
Head & neck	Including the skull, brain and cervical vertebrae, excluding frontal area
Frontal skull region	Frontal area of the skull including beak
Thorax	Ventrally the region from the base of the posterior extremity of the <i>pectoralis</i> muscles including sternum, ribs
Abdomen	Ventrally the region directly posterior to the thorax extending to the cloaca
Extremities	Skeletal and muscular structures of the wings, legs including caudal region of the spine and pubic bone
Vertebral column	Vertebral column excluding caudal and cervical vertebrae

Each body region receives a single score based on its most serious injury. If for example the abdominal region receives both a minor contusion to the liver (AIS 2) and a complex rupture of the spleen (AIS 5) then the score for the abdominal region is AIS 5; i.e. the maximum score received by the region. The end result of this type of classification will be a series of six trauma (AIS) scores for each cadaver studied.

2.5 Data analysis

The aim of using trauma-scoring techniques to describe the patterns of injury permits quantitative relationships between patterns of injury to be calculated using the techniques of numerical taxonomy (Sokal & Sneath, 1963). Traditionally, numerical taxonomy classifies organisms based on relative similarities and “distances” of as many measurable characteristics as possible. Organisms are normally compared on the basis of the presence of absence of certain traits. The objects to be classified are termed OTUs or Operational Taxonomic Units.

In the case of this study the OTUs will be gross injuries (e.g. Head & neck 5, Thorax 3, Abdomen 2, etc). These injuries/OTUs will be compared using the characters listed in *Table III* to create clusters using UPGMA (Unweighted pair-group method using arithmetic averages). This will allow a phenogram to be constructed, a tree-like diagram that can graphically represent similarity/dissimilarity among specimens or groups of specimens.

Table III: Characters by which similarity of OTUs (gross injuries) will be measured

Characters	
Cause of death (aircraft, car, overhead wire collision, predatory attack etc)	Relatedness (multiple strikes only)
Aircraft type *	Age of individual (Immature/Adult)
Phase of flight*	Sex of individual
Part of aircraft struck*	Collection date (season)
Order	Body condition-fat score
Species	Body condition-pectoral muscle score
Number of individuals involved in strike	

*Where applicable

The advantage of using numerical taxonomy lies in its use in distinguishing which injury patterns are most closely associated to one another based on the characters listed in *Table III*. For example, damage to the integument may be closely associated with damage to the underlying organs. Conversely, this analysis would determine which features of a collision incident (characters listed above) would be most likely to affect the type of injuries sustained. The characteristics of an individual, which may increase its chance of involvement in a bird strike, will also be assessed (i.e. age, sex, body condition etc) through further statistical analyses.

2.6 Photography

With the aid of a photographic catalogue this study hopes to compile a “Colour Atlas of Bird Injuries” associated with bird aircraft collisions, which would allow such injuries to be easily distinguished from injuries associated with other causes of mortality, such as predatory attack, collision with overhead wires etc. The ultimate aim of this would allow maximum accuracy of recording bird strikes at airports with the minimum of expertise.

3. Results

As this study is in its early stages, insufficient data has been collected to allow statistical analysis. However, some interesting trends have been detected.

One such trend indicates that damage to overlying muscles such as the *pectoralis major* is often a sign of more serious internal damage to the underlying organs such as the liver. Figure 1 and Figure 2 show such associated injuries in a woodpigeon *Columba palumbus*.

LYNE ET AL (1998) found that only a minority of birds sampled (37%) exhibited injuries to the cranium. In the current study it appears so far, that larger bird species such as gulls (Laridae) and rooks (*Corvus frugilegus*) are unlikely to incur significant damage to the cranium. Smaller passerine species such as the meadow pipit *Anthus pratensis* and the greenfinch *Carduelis chloris* however appear to have a higher frequency of significant injury to the cranium, as illustrated in Figure 3. Staining of the skull is common in cadavers but this is only likely to indicate intracranial haemorrhaging when accompanied by skull fracture [Figure 3]. This is unlike the pattern seen in Figure 4 where post mortem change due to freezing and/or decomposition can cause staining of the skull.

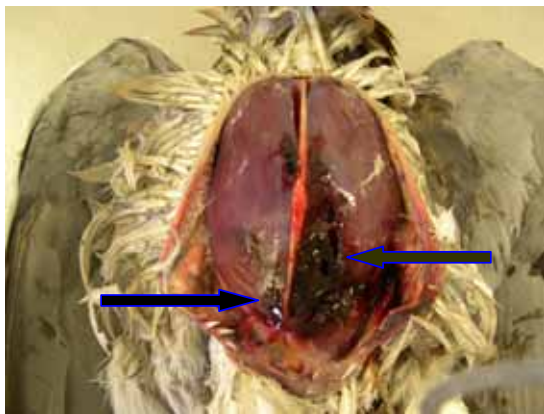


Figure 1: Woodpigeon with injuries to *pectoralis major*

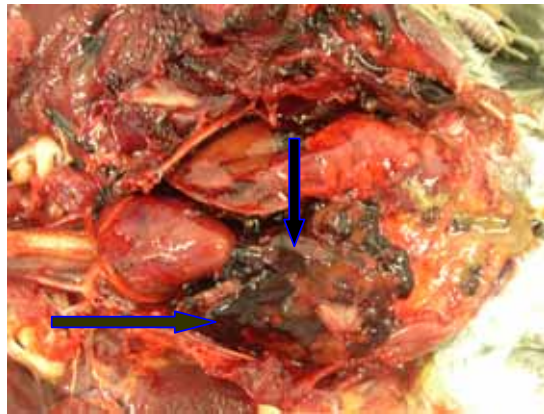


Figure 2: Woodpigeon with haemorrhaging of thoracic cavity



Figure 3: Greenfinch showing fracture of the skull accompanied by staining of the skull due to intracranial haemorrhaging



Figure 4: Staining on Feral pigeon skull not by fracture or intracranial haemorrhaging

4. Discussion

The primary aim of this project is to examine whether or not the majority of bird carcasses found at airports have been killed by aircraft. The project also aims to develop a simple method of distinguishing injuries associated with bird-aircraft collision from other traumatic or disease related injuries. This will be achieved both through multivariate analyses of injury patterns and the creation of a photographic database of injuries.

Since aircraft travel very quickly, relative to the velocity birds over-flying the runway, it seems reasonable to assume that the majority of birds hit by aircraft will only be struck once. Further, it is likely that the force of an impact will generally knock the bird off course and out of the plane's flight path. Therefore, in cases where the suite of injuries contradict the expected pattern, then the distribution of the trauma, such as an equally severe injury to opposite sides of the thorax or dorsal and ventral surfaces, may be due at least partly, to factors other than aircraft strike. This may include birds that have been struck by aircraft and received additional injuries due to ground impact. Another reason may be the force of jet blast or the vortices left behind an aircraft (see LYNE ET AL. 1998 and subsequent discussion). Similarly injuries, which are consistent with predatory attack or *post-mortem* scavenging, need to be distinguished from those caused by aircraft strike.

While numerous publications detail the species which are most frequently involved in aircraft collisions (JACOBY, 1998; ALLAN ET AL, 1999), few if any have examined in detail other factors such as the sex, age and condition of the bird which may increase their risk of bird strike. Interspecific differences in auditory acuity, i.e. relative sensitivity to high and low frequency sounds (HEFFNER, 1998), as well as interspecific differences in visual acuity (KING & MCLELLAND, 1979) could mean that the risk posed by different aircraft designs may be greater or lesser depending on the bird species. Undoubtedly, a large sample size would be required to adequately investigate this hypothesis, however where possible attempts will be made to address this question in the present study.

Bird cadavers collected at airports provide an invaluable source of data not only for bird strike research but also for many science disciplines including research in flocking behaviour/relatedness, epidemiology, biomechanics research, ecotoxicology and museum collections. Consistency in collection of cadavers and data recording is undoubtedly needed to create a fuller picture of the nature of bird-aircraft collision.

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