INTERNATIONAL BIRD STRIKE COMMITTEE IBSC 24/WP 10
Stara Lesna, Slovakia, 14 - 18 September 1998

IS THERE A BIRD STRIKE SYNDROME? : PRELIMINARY RESULTS FROM AUTOPSY FINDINGS.

Karina Lyne[2], Irene Gassner[2], Ray Bolger[1] and Thomas C. Kelly[12]

1. **Aer Rianta, Dublin Airport, Co. Fingal, Ireland.**

2. **Department of Zoology and Animal Ecology, University College, Lee Maltings, Prospect Row, Cork, Ireland.**

***(correspondence)**

ABSTRACT

This study investigated the pattern of injuries to birds which were found dead at Dublin Airport, Ireland. Cadavers were deep frozen at the airfield, prior to being autopsied at University College, Cork. An autopsy procedure was developed and the most frequently occurring sets of injuries were identified. Broadly, these involved fractures to the skull, the bones of the axial and appendicular skeleton, the sternal and sternal ribs, and the limbs, as well as trauma to the internal organs. X rays were found to be unnecessary as fractures and other gross injuries were macroscopically identifiable at autopsy. Interestingly, most trauma is seen on the ventral surface of the bird's body. This and other patterns of injury are listed and analysed. The results are discussed in the context of identifying a possible Bird Strike Syndrome. This study established for the first time a framework for the autopsy of bird strike - related carcasses.

Keywords: Birdstrike syndrome, Identification, Traumatic injury. Autopsy

Objectives
The principal objectives of this study are:

(a) To identify, at postmortem examination, the pattern of injuries sustained by birds in a collision with an aircraft
(b) To establish if there is a classical "syndrome" which permits the ready identification of a carcase as victim of a bird strike.

Materials & Methods

Study Area

This study was undertaken at Dublin Airport which is the Republic of Ireland's largest and busiest airfield. Over 10 million passengers utilised the airport in 1997. Aircraft movements number about 150,000 per annum and are dominated by the Boeing 737 and aircraft of similar design. However there are also quite large numbers of movements involving turbo-propellar-type aircraft, especially the Fokker 50.

Autopsy Methods

The Bird Patrol attached to the Fire Station at Dublin Airport collected all the avian remains utilised in this study. These were gathered either during routine inspections of the airfield or were extracted from aircraft engines following ingestion.
If a birdstrike was reported, details of the type of aircraft involved and its phase of flight were recorded.
If a strike was not reported, information regarding the previous aircraft movement operating in the manouvering area is also documented.
The specimen was labelled with the date and time of collection, location and weather conditions, and, where possible, the aircraft type, placed in a polythene bag and deep frozen.

Post Mortem

Prior to the post mortem examination the birds were removed from the freezer to ensure that they were sufficiently thawed. The postmortem then followed a routine procedure, modified from Siegmann (1983). Adjustments had to be made, because the focus of this study was on gross injuries to the body of the bird - commensurate with it having been involved in a bird strike - rather than the detection of infectious disease and associated lesions.

Using a scissors an incision was from between the maxilla and mandible to the cloaca removing only the integument at this stage (Fig.2). Incisions were then made through the bones of the shoulder girdle and on either side of the sternum midline through the *pectoralis major* and *minor* muscles (Fig.3). The sternum and the sternal ribs were then severed which exposed the thoracic and abdominal cavities. The different organ systems were then carefully examined and any abnormalities recorded. A detailed postmortem report was completed for each individual bird examined (Appendix 1).

Data Analysis

For the purposes of this study the broad anatomical categories, listed below, were utilised. Specific terms follow Procter and Lynch (1993).
The Skull = skull fractures and decapitation but excluding minor surface lesions and bruising to the head.
The Axial and Appendicular Skeleton = the avian skeleton excluding the skull, the sternum and sternal ribs, and the wings and legs. The Sternum and the Sternal Ribs.
The Limbs = the skeletal structures of the wings and legs.
The Internal Organs = the organs of the thorax and abdomen excluding the urogenital and nervous systems while including the brain.
The Thorax = Ventrally, the region from the base of the neck to the posterior extremity of the *pectoralis* muscles.
The Abdomen = ventrally, the area directly posterior to the thorax extending to the cloaca.

The analysis of the data utilised Minitab - Release 10 Xtra. Minitab Inc. The Chisquared significance values were checked against a table (Thompson, 1941).

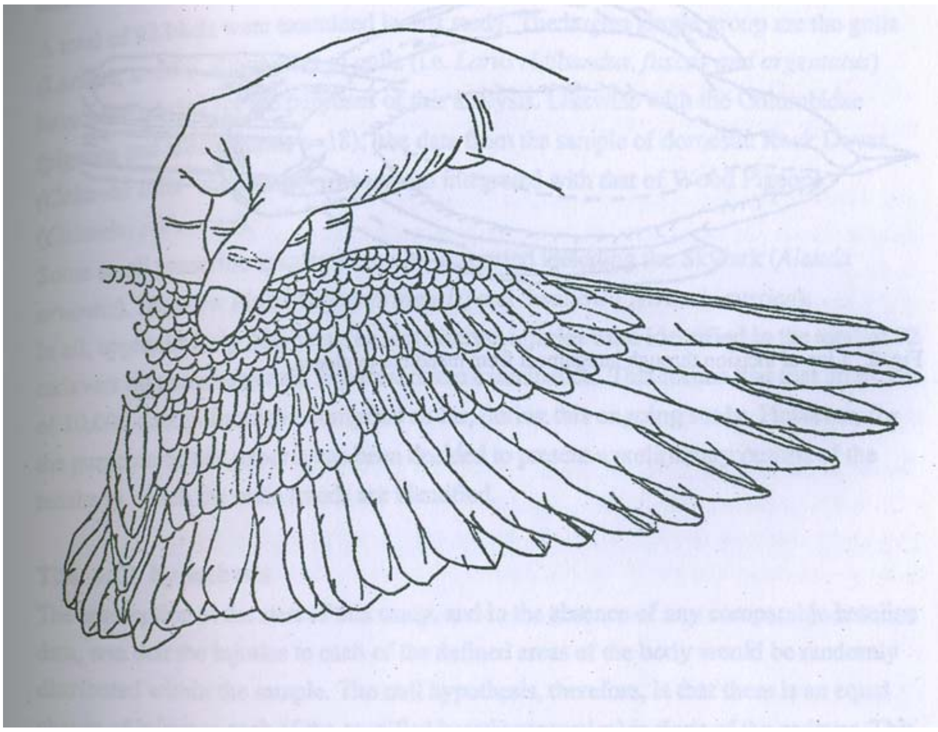


Fig.1. Manual examination for fractures of wing bones

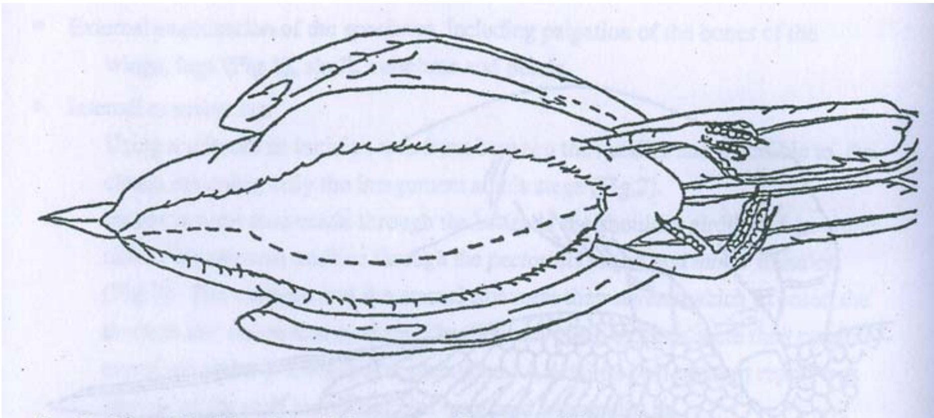


Fig. 2. Line of incision through integument from mandible to cloaca.

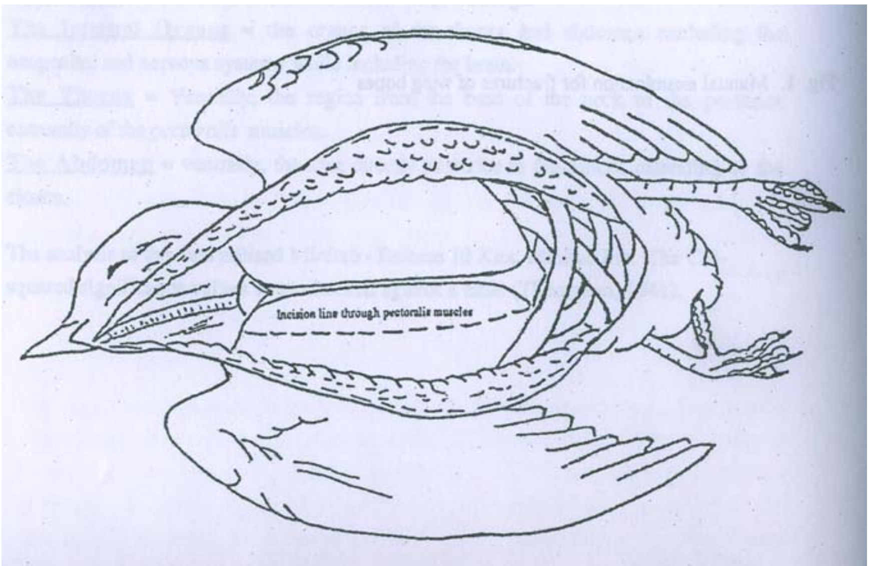


Fig. 3. Line of incision through pectoralis muscles.

A total of 92 birds were examined in this study. The largest single group are the gulls (Laridar; n=35). All species of gulls (i.e. *Larus ridibundus, fuscus and argentatus)* have been pooled for the purposes of this analysis. Likewise with the Columbidae (pigeons and allied forms; n=18); the data from the sample of domestic Rock Doves *(Columba livia* var *domestica)* has been integrated with that of Wood Pigeons *(Columba palumbus).*
Some small passerine species were also autopsied including the Skylark *(Alauda arvensis),* Meadow Pipit *(Anthus pratensis)* and Swallow *(Hirundo rustica).*
In all, approximately 160 more or less discrete injuries were identified in the total of 92 cadavers that was subjected to post mortem examination. This means that that in excess of 10,000 data points have compiled so far, during this ongoing study. However, for the purposes of this paper it has been decided to present a preliminary outline of the results in which the main trends are identified.

The null hypothesis

The assumption at the start of this study, and in the absence of any comparable baseline data, was that the injuries to each of the defined areas of the body would be randomly distributed within the sample. The null hypothesis, therefore, is that there is an equal chance of injury to each of the specified broad anantomical regions of the cadaver. This analytical approach may be too general. For example, each of the body regions is not of equal size and some are perhaps more likely to be injured (e.g. the limbs) than others. Nevertheless, in keeping with our objective to identify the general trend in the data set, Chi squared tests were performed to establish the statistical significance of any deviations from the expected pattern.

General Injury Patterns In All Birds Skull

Skull Damage

Fig.4 shows the pattern of injury to the avian skull in the total sample of cadavers. It can be seen that approximately one third of the birds examined suffered palpable injuries to the skull and head (n= 34; 37%, Fig. 4). This means only a minority of birds exhibited identifiable damage (including complete decapitation) to the head and cranium. This proportion is less, but not quite statistically significantly less (x2=3.749, df = 1 p <0.053) than that which would have been seen if the trauma to the skull was randomly distributed.

Skeletal : Axial and Apeendicular (excluding limbs, skull. sternum and sternal ribs)_Damage

Fig. 4 shows the pattern of skeletal (excluding areas listed above) injury to the total sample of birds. Approximately three quarters of all the birds showed visible damage to this portion of the body (n=66; 71.7 %, Fig.4). The areas involved were the Axial (i.e. vertebral column but excluding the skull, sternal ribs and sternum) and Appendicular (limbs excluded, but pelvic and pectoral girdles included) skeleton. This defined domain of the body was damaged in a higher than expected proportion of cases ($x2=9.127$, df = l, $p<0.003$).

Sternum-and sternal ribs injuries

Fig.4 shows that over one third of the bird sample had discernible injuries to the sternum and sternal ribs (n=37; 40.2%, Fig.4). The observed pattern is not significantly different from the expected ($x2 = 1.778$, df = 1, ns).

Limb Injuries

Fig. 4 shows the pattern of injury to the limbs in the total bird sample. It can be seen that nearly three quarters of the sample had experienced obvious injuries to the limbs (n=73; 79.4%, Fig. 4).This proportion is considerably higher than expected ($x2=I7.341$, df = 1, $p< 0.0001$). Limb injuries range from palpable fractures to partial or complete loss of a leg(s) or wing(s). It was noticed that where limb damage did occur the injuries were sometimes bilateral. It was found that 32 (43.83 %) of the birds exhibited bilateral damage, whereas 41(56.94 %) displayed unilateral limb injury (Left=22, Right=19).
A Chi-squared test showed that the latter pattern is not significantly different from the expected ($X2=0.440$, df=l, ns).

Injuries to the internal organs including the brain

Approximately half of the birds exhibited damage to the internal organs (n=51; 55.4%, Fig.4) - a proportion that is not significantly different from the expected *($x2=0.545$,* df=1, ns).

Thoracic Injuries

A total of 59 birds (64.1%, Fig.4) exhibited injuries to the thorax. Although the observed pattern is not significantly different from the expected ($x2=3.749$, df=1, $p<0.053$) the trend suggests that relatively more birds experience severe trauma to the thorax.

Abdominal Injuries

Approximately two thirds of the birds showed some form of damage to the abdomen (n=6l; 66.3%, Fig.4*)*. This proportion is significantly greater than is expected ($x2=5.025$, df=1, $p<0.025$).

Plane of the injury

Only 4 birds, of the total sample of 92, showed injury which was exclusive to the dorsal surface, while 53 displayed damage which was confuted to the ventral surface. This ratio, (based on a much higher proportion of cadavers showing ventrally suffered trauma) is a very significant deviation from the expected *($x2=25.024$,* df=1, $p<0.0001$).
Since 16 birds showed palpable damage to both surfaces, it could be said that 20 birds displayed dorsal damage, whereas 69 birds exhibited ventral damage. Again, this pattern is very significantly different from the expected ($x2=14.053$, df=1, $p<0.0001$).

Injury Patterns in Gulls

Skull damage in gulls

A total of 14 (40%) gulls autopsied in this study displayed obvious injuries to the head and skull (Fig.5). This figure is slightly higher than that for the total sample of birds (see Fig.4).
Moreover, the pattern of injuries to *the* gull cranium is effectively random within the sample ($x2=0.921$, df=1, ns).

Skeletal: Axial and Appendicular (excluding limbs, skull, sternum and Sternal ribs) damage in gulls

Approximately three quarters of the gull cadavers showed injuries to the defined segments of the axial and appendicular skeleton (n=25; 71.4% Fig.5). Although this is almost an identically higher proportion to that recorded for the total sample of birds, it is not statistically significantly different from the expected i.e. random distribution $X2=3.81$, df=1, $p<0.051$). Nevertheless, it is obvious that the trend is for relatively more gulls to suffer injuries to this defined area.

Sternal and sternal-ribs damage in gulls

Fig.5 shows that approximately half of all the gulls examined displayed visible damage to the sternum and sternal ribs (n=19; 54.3%, Fig.5), a pattern that is not significantly different from the expected (x2=0.229, df=1, ns).

Limb injuries in gulls

Fig.5 shows that almost all the cadavers in the gull sample gull had palpable injuries to the limbs (n=3 1; 88.6%, Fig.5). This injury profile is very significantly greater than that which is predicted in the null hypothesis (X2=12.992, df=1, p<0,0001).

Damage to the internal organs of gulls

It was found that approximately two thirds of the gulls suffered damage to the internal organs (n=23; 65.7%, Fig-5). Although this is quite a high proportion exhibiting such trauma it is not significantly different from the expected (x,2=2.100, df=1, p<0.148).

Thoracic injury to gulls

Slightly greater than two thirds of the gulls exhibited some form of thoracic injury (n=24; 68.6%, Fig.5). Again, although this is relatively large number of individual cadavers showing these injuries, it is not significantly different from the expected (X2=2.855, df=1, p<0.090).

Abdominal injury in gulls

Approximately three quarters of the gull carcases had suffered injury to the abdominal region (n=27; 77.1%, Fig.5). This high proportion is significantly different from the expected ratio (x2=6.119, df=1, p<0.014).

Injury patterns in Pigeons

Skull damage in pigeons

It is clear that only a very small proportion suffered injuries to the head and skull (n=2; 11%, Fig.6). A Chi-squared test shows that the observed proportion is significantly less than the expected ratio (x2=6.415, df=1, p<0.011).

Skeletal : Axial and Appendicular (excluding limbs, skull, sternum and sternal ribs) damage in pigeons

Approximately two thirds of birds in the pigeon sample showed axial and appendicular skeletal damage (n=12; 66.7%, Fig.6). This is not significantly different from the expected 1:1 ratio (x2=1.029, df=1, ns).

Sternal and sternal-ribs damage in pigeons

It can be seen that nearly one half of the sample suffered injuries to the sternum and sternal ribs (n=8; 44.4%, Fig.6). This proportion does not deviate from the expected 1:1 ratio (x2=0.111, df=1, ns).

Limb injuries in pigeons

It is evident that nearly two thirds of the pigeon sample exhibited palpable injuries to limbs (n=11; 61.1%, Fig.6). Again this figure does not differ from the expected ratio (x2=0.450, df=1, p<0.502).

Internal or-an - including brain - damage in pigeons

Slightly greater than half of the pigeon sample displayed damage to the internal organs (n=10; 55.6% Fig.6). The observed pattern is not significantly different from the expected ratio (x2=0.111, df=1, ns).

Thoracic injury in pigeons

Fig.6 shows that a large number of the pigeons suffered visible thoracic injuries (n=11; 61.1%, Fig.6). However this proportion is not significantly different from the expected ratio ($x2$=0.*450,* df=1, p<0.502).

Abdominal injury in pigeons

A large majority of pigeons had obvious abdominal injuries (n=16; 88.9%, Fig.6). This very high proportion is significantly greater than predicted by the null hypothesis (X2=6.415, df=1, p<0.011).

Post mortem results in all groups compared

The injury profiles in the three groups of birds are shown in Fig.4-6. The data is presented as the percentage frequency of occurrence of each type of injury in the different assemblages of cadavers. Some trends are obvious - though caution should be exercised in view of the preliminary nature of the results and the small sample sizes especially in the gull and pigeon categories.

It is char, for example, that many fewer pigeons (= 10%) suffered injuries to the head than did the gulls (- 40%) and that overall this is the least frequently struck area of the body. By contrast the overwhelming majority of gulls (almost 90%) suffered injuries to the limbs, whereas the corresponding pattern of trauma occurred in less than 60 % of pigeons. When the overall injury profiles are compared statistically using the Spearmans Rank correlation analysis it can be seen (Figs. 7, 8 and 9) that there is much similarity in the trauma suffered by the different groups of birds. The injury profile found in gulls is highly correlated (Fig. 7. r,=0.9643, n=6, p< 0.001) with that recorded in the total sample. Likewise, the pattern in pigeons (Fig.8. r,= 0.8036, n=6, p <0.027) is closely correlated with the whole sample, though not to the same degree as in the gulls. The latter group's injuries are also very similar to those in the pigeons (Fig.9. r,= 0.8393, n=6, p < 0.0I6).

Discussion

Although this study has identified some striking trends in the profile of injuries to birds which have been struck by aircraft, it also suffers from a number of limitations. As mentioned, the overall sample size is relatively small and those of the individual groups of birds i.e. gulls and pigeons allow for only a preliminary analysis. The sample sizes relating to various types of aircraft and to the different phases of flight are still insufficient for a useful application of statistical tests.

The study would not have been possible without the facility of deep freezing the carcasses. Even so, it is not always possible to prevent the onset of putrefaction, which is well known to be accelerated by traumatic injury, especially on warm summer days, when runway usage may be at a maximum. This can result in unavoidable delays in the retrieval and storage of specimens. Tissue decomposition, in turn, can obscure the exact pathology associated with the bird strike incident. Carcasses which are lying on runways may also be subject to further insult in the course of normal air traffic movements. Vehicular traffic may also be responsible for birds being killed on runways or adjacent grasslands, and an immediate objective of this study is to profile the injury pattern of so called "road casualties " in birds.

Some of the carcasses were recovered from the ground following bird strikes which occurred at altitudes of up to 1000'. A Wood Pigeon, for example, was struck at 500', and, as this species weighs 0.5 kg, it (and others) may have suffered additional injuries from the impact with the runway surface.

Finally, it is possible that some of the carcases found routinely on runways, have been the victims of vortex induced impact damage. This study has not been able to address such a problem However, the data set is very large and algorithms will be developed to analyse and quantify the patterns within the totality - rather than specific categories- of injuries. The problems facing the analysis of such complex data is comparable to those addressed by numerical taxonomists in the 1960's (Sokal and Sneath 1963, Sneath and Sokal 1973, Quicke,1993).

Most birds involved in a collision with an aircraft are killed instantly. It is :-.
expect therefore that injuries to the body of the victim would be severe an some
cases, where ingestion has occurred the bird is obliterated and, excetionally, in others

the victim may recover and fly off.

In this study injuries identified at the post mortems included fractures of the skull, the axial and appendicular skeleton, the sternum and sternal ribs, and the limbs. Significant damage to internal organs of the thorax and abdomen were also frequently observed. In addition this study has revealed that, at Dublin Airport, the overwhelming majority of birds sustained injuries to the ventral surface. Although there does not appear have been any comparable study, this very clear-cut finding is unexpected. One possible explanation is that most of the birds autopsied in this study had been struck while overflying the airfield (see Kelly, Murphy and Bolger,1996). Birds approaching aircraft which are airborne some times "slow down' to avoid collision (Kelly and Bolger in preparation). Such individuals would most likely be struck from underneath and especially in the case of gulls -with their upwardly extended wings and dangling legs- might also sustain severe injuries to the limbs. This study found that almost 90% of gulls had palpable limb injuries. Approximately the same proportion of pigeons (mostly C. *livia* var *dvmesrica)* had abdominal injuries and here it is known that vast majority, if not all, the victims were struck while overflying the active runways. It remains to be seen, therefore, if the pattern of trauma discovered in this study is typical of those sustained by overflying birds as distinct from injuries suffered by individuals struck while on the runway or having just risen from its surface. Also unexpected is the relatively low frequency (approximately one third overall) of serious injuries to the skull. When the most prevalent avian group, the gulls, are analysed separately it is apparent that this pattern of injury correlates closely with that of the total sample (within which of course the gulls are the largest group). The only deviation from the total bird sample was that the frequencies of the various injuries were higher among the gulls. By contrast, when the pigeons are considered separately it is found that the frequency of injury to the skull is particularly low. This is anomalous since the pattern of injury to the other defined structures correlates with that of the total bird sample. It is now known that bird species of the same size and weight may differ in density (Seamans, Hamershock and Bernhardt 1993; Allan 1994, 1996; Short and Seamans 1996), and it is possible that this variation in basic properties of the body structure could result in parallel differences in the type and severity of injuries sustained following a collision with an aircraft 'this may also explain why there is such a high level of injury to the ventral area; that is the "soft underbelly" is simply more likely show the effects of traumatic injury than would the more robust dorsal surfaces. While this study has identified the outline of a bird strike syndrome it is obvious that further improvements can be made. Firstly, although X-rays were not employed, this technique would help to clarify the degree of injury, particularly to areas like the sacral vertebrae which are difficult to palpate. Secondly, the autopsy results could be greatly improved by increasing the overall sample size, and especially of birds which were struck by different types of aircraft and in the different phases of flight.

Conclusion

The bird strike syndrome which has been tentatively identified consisted essentially of the following diagnostic trauma:

(a) Injuries mainly located on the ventral surface of the bird victim
(b) Multiple fractures to the limbs
(c) Damage to the Axial and Appendicular skeleton
(d) Damage to the abdomen and thorax.
(e) Evisceration of the gut and other abdominal viscera.

Acknowledgements

We acknowledge the assistance of the Chief Fire Officer, Mr. Sean Brett and his staff at the Fire Station, Dublin Airport, for the collection, tagging and deep freezer storage of the bird carcases.
We are also grateful to Professor M. F. Mulcahy for the provision of facilities at the Department of Zoology and. Animal Ecology, University College, Cork We are grateful Mr Rick Mundy and Dr. David Barnes for their comments on the manuscript Dr. David Barnes and Dr. Paul Galvin very kindly assisted in the production of the figures.

Fig. 4 The number, and per cent frequency of occurrence of the specified injuries in the total cadaver sample.

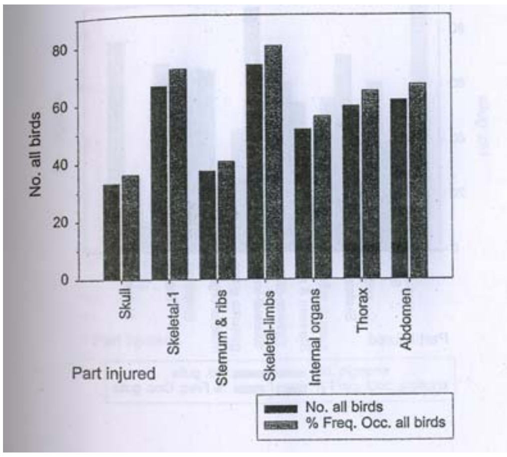


Fig. 5 The number, and per cent frequency of occurrence of the specified injuries in the sample of gull carcasses.

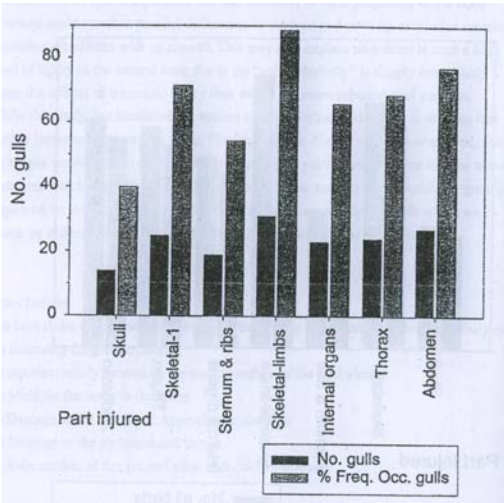


Fig. 6 The number, and per cent frequency of occurance of the specified injuries in the sample of pigeon cadavers.

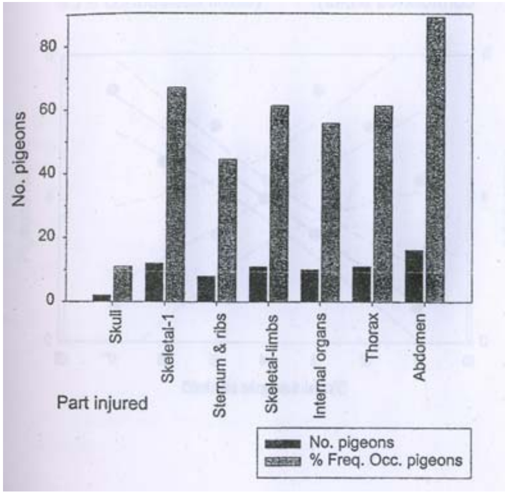


Fig. 7 Spearman rank plot of ranked frequency of specificied injuries in the total bird sample (x axis) versus that in the gull cadavers (y axis). (The hatched lines are 95% condidence limits)

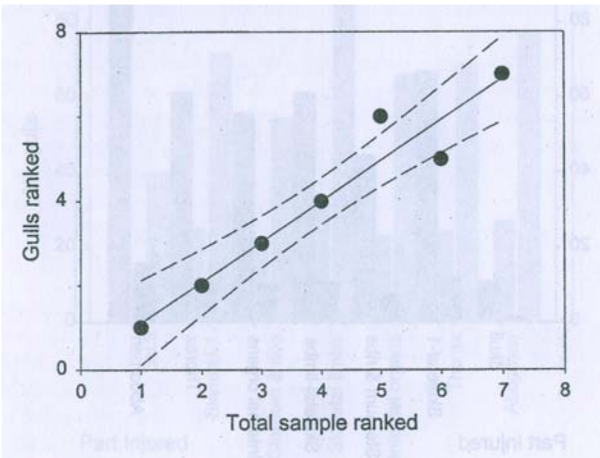


Fig. 8 Spearman rank plot of ranked frequency of specificied injuries in the total bird sample (x axis) versus that in the pigeon cadavers (y axis). (The hatched lines are 95% condidence limits)

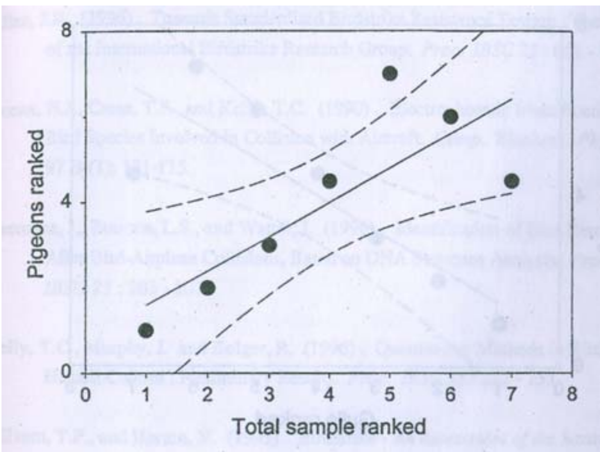
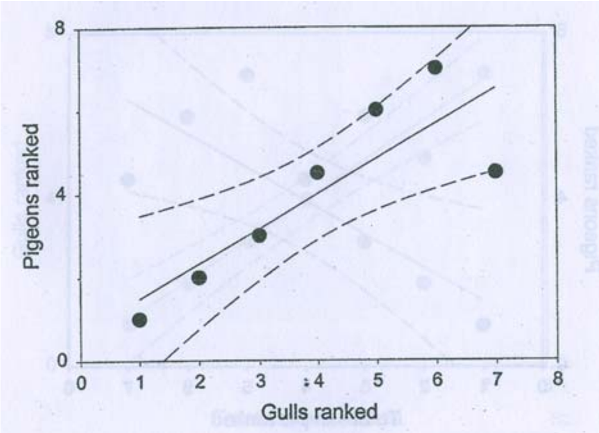


Fig. 9 Spearman rank plot of ranked frequency of specificied injuries in the pigeon sample (x axis) versus that in the gull cadavers (y axis). (The hatched lines are 95% condidence limits)



Pigeons ranked
Gulls ranked
0
4
8
0
1
2
3
4
5
6
7
8

References

Allan, J.R. (1994). The Central Science Laboratory Birdstrike Research Club. Proceedings of the 22nd. Birdstrike Committee Europe Vienna : 83 - 90.

Allan, J.R. (1996). Towards Standardised Birdstrike Resistance Testing : The Work of the International Birdstrike Research Group. Proc. IBSC 23: 611 - 616.

Doran, H.3., Cross, T.F. and Kelly, T.C. (1990) . Electrophoretic Identification of Bird Species Involved in Collision with Aircraft. Comp. Biochem. Physiol. 97 B (1): 171-175.

Hermans, J., Buurma, L.S., and Wattel, J. (1996) . Identification of Bird Remains After Bird-Airplane Collisions, Based on DNA Sequence Analysis. Proc. IBSC 23: 203 - 207.

Kelly, T.C., Murphy, J. and Bolger, R. (1996). Quantitative Methods in Bird Hazard Control : Preliminary Results. Proc. IBSC 23 : 227 - 233.

Milsom, T.P., and Horton, N. (1995). Birdstrike - An assessment of the hazard on UK civil aerodromes 1976-1990. Central Science Laboratory. MAFF. United Kingdom.

Prast, W., Shamoun, 1., Bierhuizen, B., Roslaar, C.S., Schalk, P.H., Wattel, J., Los, W., Leshem, Y., Yom-Tov, Y. and Buurma, L.S. (1996) . BRIS; A Computer Based Bird Remains Identification System. Further Developments. Proc. IBSC 23 : 197- 201.

Proctor, N.S., and Lynch, :'.J. (1993). Manual of Ornithology. Avian Structure and Function. Yale.

Quicke, D.L.J. (1993). Principals and Techniques of Contempory Taxonomy. Chapman & Hall.

Quinn, P.J., and Crinion, R.A.P. (1984). A Two Year Study of Botulism in Gulls in the Vicinity of Dublin Bay. Irish Veterinary Journal 38: 214 - 219.

Seamans, T.W., Hamershock, D.M., and Bernhardt, G.E. (1993). Determination of Body Density for Twelve Bird Species. IBIS 137: 424 - 428.

Short, J.J., and Seamans, T.W. (1996). Tissue Density Determination in Intact Birds.ProcJBSC 23: 617 – 626.

Siegmann, O. (1983). Kompendium der Geflugelkrankheiten, 4., neubearbeitete Auflage, Verlag M.&H. Schaper, Hannover.

Sneath, P.H.A., and Sokal, R.R. (1973). Numerical Taxonomy, W.H. Freeman, San Francisco, California.

Sokal, RR., and Sneath, P.H.A. (1963). Principals of Numerical Taxonomy, W.H.Freeman & Co, San Francisco.

Thompson, C.M. (1941). Tables of the Percentage Points of the X2-Distribution Biometrika, 32:188-189.

APPENDIX 1

Postmortem Report:

Reference Number:	Postmortem Number:
Species:	Sex:
Date Found:	Location Found:
Date of Postmortem:	Pathologist:

1.BASIC MEASUREMENT
Photographs take

2.GROSS POSTMORTEM

Carcase condition: External

Examination

Nutritional state (describe)
NE NAD A body orifices
mouth
eyes
ear openings
nose
Cloaca/anus
NE NAD A ectoparasites
NE NAD A wings
NE NAD A legs
Integument

NE NAD A feathers
NE NAD A skin
s.c. fatty tissue

Muscoskeletal System

NE NAD A skull
- NE NAD A Premaxilla
  - NE NAD A frontal process
  - NE NAD A maxillary process
- NE NAD A Dentary
  - NE NAD A Articular
  - NE NAD A Angular
- NE NAD A Frontal
- NE NAD A Parietal
- NE NAD A Occupital
  - NE NAD A occipital crest
  - NE NAD A paroccipital process
    - NE NAD A Occipital complex
    - NE NAD A Occipital condyle
    - NE NAD A Foramen magnum

    - NE NAD A Periotic capsule
      - NE NAD A Sphenoid complex

- NE NAD A Maxilla
- NE NAD A Nasal
  - NE NAD A Mesothmoid (interorbital septum)
  - NE NAD A Lacrimal
- NE NAD A Jugal (zygomatic arch)
- NE NAD A Quadratojugal
  - NE NADA A Pterygoid
      - NE NADA A Bassipterygoid
      - NE NADA A Parasphenoud rostrum
      - NE NADA A Vomer
      - NE NADA A Palatine
      - NE NADA A Palatine process
- NE NADA A Quadrate
- NE NADA A Squamosal region

NE NADA A Atlas
NE NADA A Axis

NE NADA A other bones
NE NADA A Cervical vertebrae
NE NADA A Thoracic vertebrae
NE NADA A Synsacrum
NE NADA A Ileum
NE NADA A Ischium
NE NADA A Pubis
NE NADA A Caudal vertebrae
NE NADA A Pygostyle

NE NADA A Caracoid
NE NADA A Furcula
NE NADA A Vertebral ribs
NE NADA A Scapula
NE NADA A Sternal rostrum
NE NADA A Keel
NE NADA A Sternum

NE NADA A Humerus
NE NADA A Radius
NE NADA A Ulna
NE NADA A Ulnare/Radiale
NE NADA A Carpometacarpus
NE NADA A First digit, phalanges 1 & 2
NE NADA A Second digit, phalanx 2
NE NADA A Second digit, phalanx 1
NE NADA A Third digit, phalanx 1

NE NADA A Femur
NE NADA A Fibula
NE NADA A Tibiotarsus
NE NADA A Tarsometatarsus
NE NADA A First digit
NE NADA A Metatarsals
NE NADA A Second digit
NE NADA A Third digit
NE NADA A Forth digit

NE NADA A Muscles head/neck
NE NADA A Adductor muscles
NE NADA A Depressor mandibulae
NE NADA A Complexus

NE NADA A Semispinalis
NE NADA A Logus colli
NE NADA A Multifidis cervicis
NE NADA A Intertransversales

NE NADA A other muscles

Thorax/Abdomen

NE NADA A Latissimus dorsi
NE NADA A Sartorius
NE NADA A Iliotibialis
NE NADA A Semitendinosus

NE NADA A Semimenbranosus
NE NADA A Obliquus abdominus externus
- NE NADA A Obliquus abdominus internus
- NE NADA A Transversus abdominus

NE NADA A Semimenbranosus
NE NADA A Pectoralis major
- NE NADA A Supracoracoideus (pectoralis minor)
- NE NADA A Costosternalis
- NE NADA A Scapulo-humoralis anterior
- NE NADA A Scaleneus
- NE NADA A Serratus anterior
- NE NADA A Serratus posterior
- NE NADA A External intercostals

Wing

- Pectoralis major

NE NADA A Patagialis longus
NE NADA A Flexor carpi ulnaris
NE NADA A Extensors of the digits
NE NADA A Interosseus ventralis
- NE NADA A Biceps brachii
- NE NADA A Triceps brachii
- NE NADA A Expansor secondariorum
- NE NADA A Patagialis accessories
- NE NADA A Patagialis brevis
- NE NADA A extensor carpo radialis
- NE NADA A Pronator longus et brevis
- NE NADA A Extensor carpi obliquus
- NE NADA A Extensor carpi
  - Latissimus dorsi
    - NE NADA A Teres major
    - NE NADA A Ulnaris lateralis
    - NE NADA A Extensor carpi radialis
    - NE NADA A Deltoideus

Pelvis/Leg
- Iliotibialis (gluteus maximus)
- Semitendinosus
- Semimembranosus
- NE NADA A Caudofemoralis
- NE NADA A Sartorius
  - NE NADA A Quadriceps femoris
  - NE NADA A Ambiens
  - NE NADA A Adductor longus
  - NE NADA A Obturator internus

NE NADA A Gastrocnemius
NE NADA A Flexor perforans et perforatus II
NE NADA A Flexor perforans er pertoratus III
NE NADA A Peroneus longus
NE NADA A Tibialis anterior
NE NADA A Flexor digitorum longus (Sehne vorn Gastrocnemius?)
NE NADA A Extensor digitorum longus
- NE NADA A Flexor hallucis
- NE NADA A Extensor hallucis

Tail

NE NADA A Levator caudae
NE NADA A Lateralis caudae

NE NADA A Depressor caudae

Nervous System

NE NADA A brain
NE NADA A spinal cord
NE NADA A peripheral nerves

Cardiovasular System

NE NADA A pericardial sac
NE NADA A myocardium
NE NADA A valves
NE NADA A arteries, veins
Heart weight:

Resporatory System

NE NADA A nasal cavity
NE NADA A sinuses
NE NADA A anterior thoracic air sacs
NE NADA A trachea, bronchi
NE NADA A lungs
NE NADA A pleura
Vessels injected: yes no

NE NADA A oblique septum
NE NADA A posterior thoracic air sac

Abdominal Cavity

NE NADA A liver

Alimentary Tract

NE NADA A mouth
NE NADA A crop
NE NADA A oesophagus
NE NADA A proventriculus
NE NADA A gizzard

NE NADA A duodenum/small intestine
NE NADA A caeca/large intestine
NE NADA A cloaca
NE NADA A anus
Mesenteric vessels injected
Chyle

Urogenital System

Ovaries/testes
(describe)
NE NADA A Vas deferens
NE NADA A Ostuim
NE NADA A Magnum/isthmus/uterus
NE NADA A Mesotubarium membrane
NE NADA A vagina/penis
NE NADA A kidneys

NE NADA A ureters

Cloaca

NE NADA A coprodeum
NE NADA A urodeum
NE NADA A proctodeum

NE NADA A abdominal air sacs

Lymphatic and Endocrine System

NE NADA A adrenals
NE NADA A hypophysis
NE NADA A pancreas
NE NADA A thyroids
NE NADA A spleen
NE NADA A thymus
NE NADA A lymph nodes
NE NADA A tonsils

NE = not examined
NAD = nothing abnormal detected
A = abnormal

Description of Abnormalities (add extra pages, if necessary_

Diagnosis (in order of importance):

a.
b.
c.
d.
e.