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BIRD STRIKE HAZARDS TO HELICOPTERS

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ABSTRACT

Within the European Rotorcraft Forum collisions between helicopters and birds have recently been discussed in relation to joint european airworthiness requirements (JAR 27 and JAR 29). This has trigerred the RNLAF to analyse her Alouette-III and Bolkow-105 bird strike statistics with respect of flying hours and the weight of the birds concerned. The surprisingly high ratio's, compared to civil statistics used so far, stimulated to explore the newly formed European Military Bird Strike Database and to ask for experiences of NATO partners. An over-all rate of 5.4 bird strikes per 10.000 flying hours for 10 helicopter types (N = 1471) was found, including 7 - 29 % damage cases. The chance of serious accidents is estimated to be higher than 10^{-6}. Different helicopter types showed persistently differing figures. Explanations for these differences are put into question. The empirical quantitative data may affect the decision making within the Helicopter Airworthiness Study Group.

1. INTRODUCTION

Catastrophic helicopter accidents due to collisions with birds are generally not assum to occur, as they have not been described sofar (although at least two cases have be disputed). Nevertheless, helicopter bird encounters are numerous and military statisti show a fairly high frequency of bird strikes with minor damage, mostly broken transparancies but sometimes also rotor blade deformation and damage to air intakes causing riskful situations.

Recent discussions on the joint european airworthiness requirements (JAR 27 and JA 29) with respect to helicopter bird impact resistance have triggered us to explore the RNLAF database for collisions between Alouette III and Bolkow 105 helicopters and birds. Subsequently, we also checked the recently created European Database of Military Bird Strikes (ref 1) and asked our British and German colleages additional information.

The aim of this report is to supply quantitative data on bird strike rates per bird weig class as a reference for the Helicopter Airworthiness Study Group (HASG). A recent meeting of the European Rotorcraft Forum has clarified the need for such data when adopting certification standards for future helicopters. Also the coordination with US counterparts is at stake. Helicopter bird strike rates have never been reported in this detail sofar.

2. BIRD STRIKE NUMBERS: AVAILABILITY AND RELIABILITY

Bird strike statistics can be unreliable. Firstly, there may be bias due to insufficient a inconsistent reporting, and secondly, there is the statistical effect of small numbers. Reliable insight can be improved by mandatory documentation and careful analysis o many years. Alternatively, the bird strike experience of a big helicopter fleet could b monitored for a short period. But then the lumping of collisions of different helicopte types with birds in different geographical situations may hamper the analysis.

2.1 RNLAF data.

The Dutch helicopter fleet is small but uniform as it consists of only two types and h been flown over the last decade in a stable pattern with respect of flying hours and area of operation. In fig. 1 the geographical distribution of the Dutch heli bird strikes over nine years are plotted. The patterns appears to be surprisingly even, not reflect certain bird concentration areas. In fact, the map perfectly indicates the area of helicopter operations and the 'density of helicopter flying'. The two 'multi-strike dots represent Soesterberg AFB and Deelen AFB where the majority of flights started and ended and local (training) flights were performed.

Fig. 2 shows the bird strike rate per 10.000 flying hours from 1977 up to and includi 1990 for both helicopter types. The yearly number of flying hours fluctuated betwee 13.156 and 17.316 for the Alouette III and between 5.916 and 8.443 for the Bolkow 105. Given the fairly low number of 167 bird strikes over those fourteen years the ratio's are remarkedly stable. We could neither find a correlation in the fluctuations between both types nor a significant relation with indices for the bird population. So, we assume the fluctuations to reflect statistical noise. Also no long term trend can b seen.

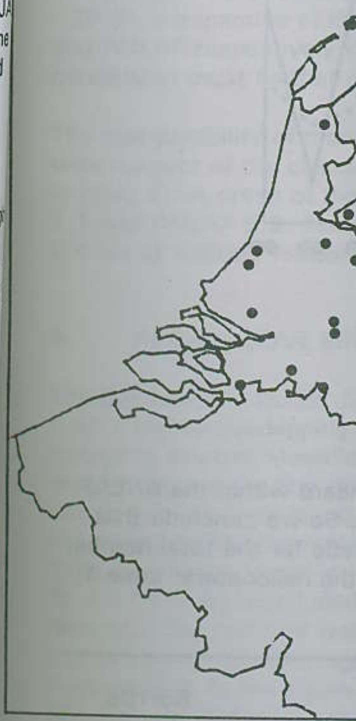

Figure 1. Geographical
1990 (N = 9

Legend:

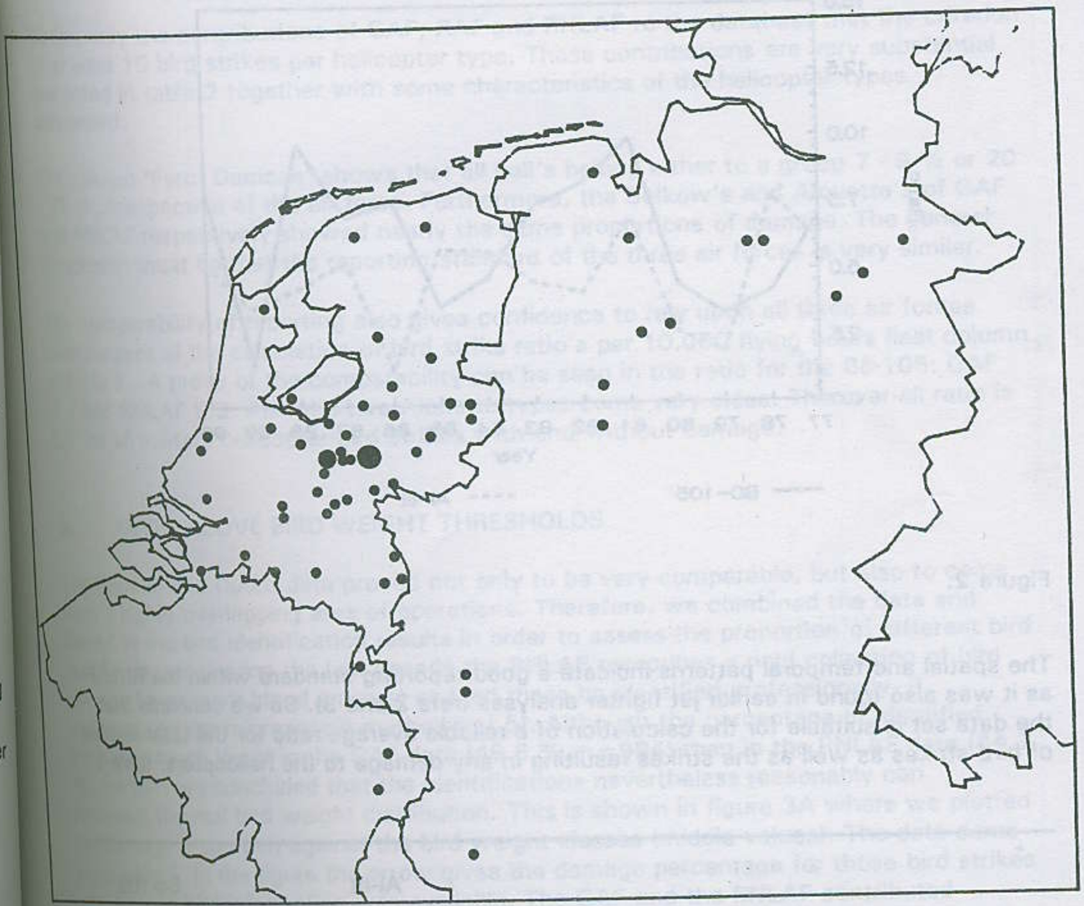

Figure 1. Geographical distribution of bird strikes with RNLAF helicopters 1982 - 1990 (N = 91, location unknown: 16).

Legend: : 1 strike
2-10 strikes
>10 strikes

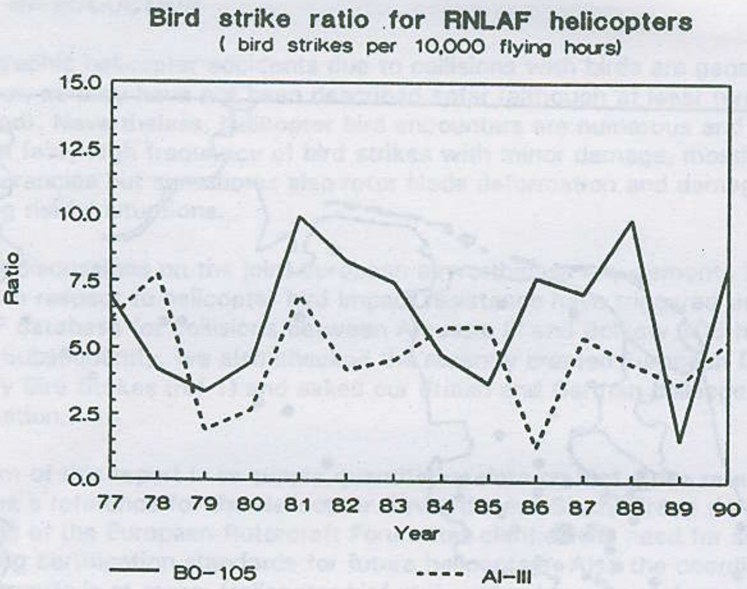

Figure 2.

The spatial and temporal patterns indicate a good reporting standard within the RNLAF as it was also found in earlier jet fighter analyses (refs 2 and 3). So we conclude that the data set is suitable for the calculation of a reliable average ratio for the total number of bird strikes as well as the strikes resulting in any damage to the helicopters: table 1.

	AI-III	Bo-105
Total flying hours 1977 - 1990	219,937	100,494
Overall ratio per 10.000 flight hours	4.73	6.27
Ratio for damage cases only	1.23	0.70

Table 1. Bird strike ratios for RNLAF helicopters during the period 1977 - 1990

Having found a ratio more than five times higher than the one disputed in the HASG (ref 4) and the high proportions of non-damaging strikes, we felt obliged to compare the RNLAF data with the much larger but less documented data sets of RAF and GAF. A check with respect of damage percentages could indicate the comparability and thus the possibility to combine the scarce data on bird weights.

2.2 European database of military bird strikes.

So far, only the contributions of GAF, RAF and RNLAF to the database met the criterion of at least 10 bird strikes per helicopter type. These contributions are very substantial and listed in table 2 together with some characteristics of the helicopter types concerned.

The column 'Perc. Damage' shows that all heli's belong either to a group 7 - 9 % or 20 - 29 %, irrespective of the air force. Furthermore, the Bolkow's and Alouette's of GAF and RNLAF respectively showed nearly the same proportions of damage. The general conclusion must be that the reporting standard of the three air forces is very similar.

The comparability of reporting also gives confidence to rely upon all three air forces with respect of the calculation of bird strike ratio's per 10.000 flying hours (last column in table 2). A prove of the comparability can be seen in the ratio for the Bö-105: GAF 7.1 and RNLAF 6.3. Also the two Alouette types come very close. The over-all ratio is 5.4 for all military helicopter-bird strikes with and without damage.

3. RATES ABOVE BIRD WEIGHT THRESHOLDS

The German and Dutch data proved not only to be very comparable, but also to come from a highly overlapping area of operations. Therefore, we combined the data and looked at the bird identification results in order to assess the proportion of different bird weight classes. During the last decade the RNLAF prescribes a rigid collecting of bird remains (even mere blood smears) and led these be identified professionally, if necessary by the microscopic method (ref 5). Although the percentage of identified birds was much lower in the GAF data (46.6 %, n=994) than in the RNLAF data (84.1 %, n=107) we concluded that the identifications nevertheless reasonably can represent the real bird weight distribution. This is shown in figure 3A where we plotted the damage proportion against the bird weight classes (middle values). The data come from table 3. In the figure the arrow gives the damage percentage for those bird strikes of which no bird information was available. The GAF and the RNLAF contributed equally to this low figure (both 5.9%). It is obvious that the non-identified birds (mainly from the German data set) all must have been small birds belonging to the lowest bird weight class. So, we added the 'unknowns' to the bird weight category '<51 grams' in order to calculate the cumulative proportion of all bird strikes over minimum bird weights (fig 3B). The last column of table 3 shows the percentage of all bird strikes above and including a certain bird weight class. Fig 3A and 3B were combined into a curve representing the cumulative proportion of all strikes with damage per minimum bird weight: fig 3C.

With fig 3B and 3C we now can calculate the chance of hitting a bird over a certain weight per flying hour, and also the chance that there will be damage. On the basis of 5.4 per 10.000 flying hours as the over-all helicopter bird strike rate over the German Plains we get fig 4. From the curves we conclude that a damaging bird strike due to a bird over 2-pound and over 4-pound will occur 4 - 5 and 2 - 3 times per one million flying hours respectively.

Table 2

Helicopter	Characteristics			GAF		RNLAF		RAF		Total	
	Front. area	Perc. transp.	Rotor diam.	Tot.	Dam.	Tot.	Dam.	Tot.	Dam.	Perc. Damage	Ratio
Gazelle	2.2	78	10.5	-	-	-	-	21	5	24	1.8
Seaking	7.3	24	18.9	13	6	-	-	43	10	29	5.2
Puma	4.1	45	15.0	-	-	-	-	168	44	26	11.4
Wessex	8.1	21	17.1	-	-	-	-	78	20	26	2.8
Al-2	2.5	75	10.0	161	33	-	-	-	-	21	4.0
Al-3	3.9	74	11.0	-	-	104	27	-	-	26	4.7
Bö-105	4.6	73	9.8	378	31	63	7	-	-	9	6,7
CH-53	10.5	23	22	112	22	-	-	-	-	20	7.0
Sealynx	5.0	43	12.8	12	1	-	-	-	-	8	-
Bell UH	3.6	68	14.6	318	21	-	-	-	-	7	5.3
Total	-	-	-	994	114	167	34	310	79	15	
Period				1979-1989		1977-1990		1981-1990			

Air Force	GAF ('79-'89)						RNLAF ('82-'90)				Grandtotal				
Helicopter	Al-2		Bö-105		Other		Al-3		Bö-105		Total			Perc.	Cum. %
Damage	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total		

Total	. . .	994	114	167	34	310	79	15
Period		1979-1989		1977-1990		1981-1990		

Air Force	GAF ('79-'89)						RNLAF ('82-'90)				Grandtotal				
Helicopter	Al-2		Bö-105		Other		Al-3		Bö-105		Total			Perc.	Cum. %
Damage	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total		
Bird weight class (grams)															
< 51	43	6	128	12	134	8	17	4	22	2	344	32	376	34.1	100.0
51 - 100	2	1	9	1	14	2	7	0	2	0	34	4	38	3,5	22.3
101 - 200	1	0	2	0	1	2	1	0	0	0	5	1	6	0.5	18.8
201 - 400	17	11	15	9	33	13	14	7	4	2	83	42	125	11.4	18.3
401 - 800	0	2	7	3	19	5	1	2	1	1	28	13	41	3.7	6.9
801 -1600	1	2	6	1	12	8	1	2	0	0	20	13	33	3.0	3.2
> 199	0	0	0	0	1	1	0	0	0	0	1	1	2	0.2	0.2
Unknown	64	11	180	5	191	12	7	1	9	0	451	29	480	43.6	-
Total	128	33	347	31	405	50	48	16	38	5	966	135	1101	100.0	
Grand total	161		378		455		64		43						

Table 3

Bird weight and damage proportion
for all GAF and RNLAF helicopter strikes

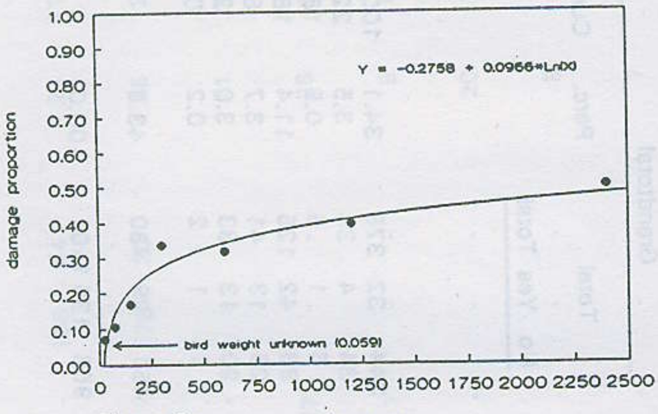

Figure 3a

Cumulative distribution of bird strikes
over minimum bird weights (GAF + RNLAF)

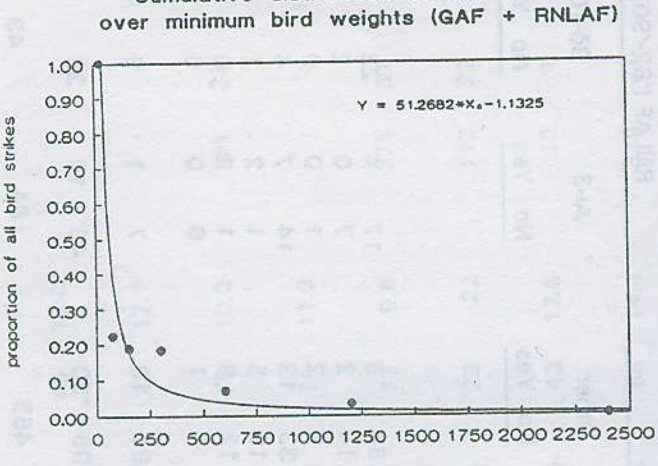

Figure 3b

Relative chance to suffer any damage
per bird weight (a and b combined)

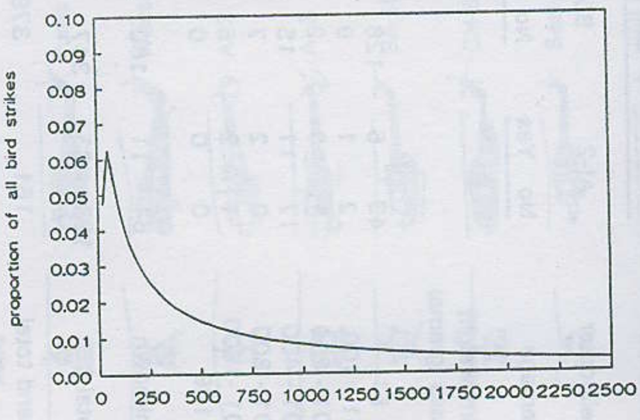

Figure 3c

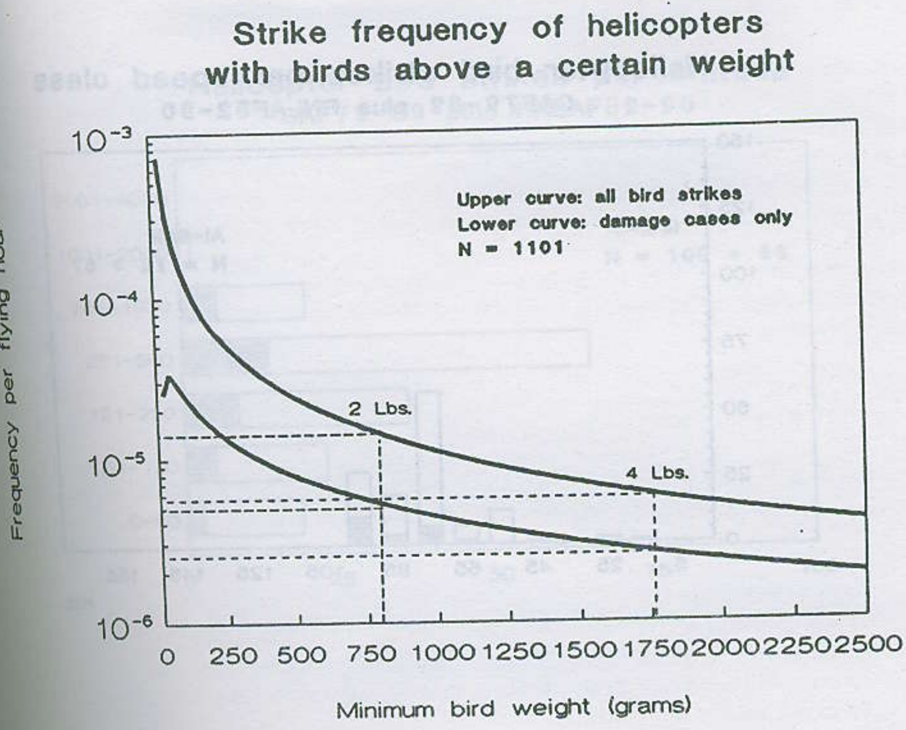

Figure 4.

4. DISCUSSION

We refrain of drawing further conclusions with respect of the type of risk connected to the quantifications given above. Of course, much depends on the design of critical parts of the helicopter which constitute only small proportions of the frontal surface. This should be discussed with helicopter designers on the basis of detailed impact resistence figures and a further analysis of the database with respect of peculiarities concerning damage.

There will be risk reduction because of the use of visors, the presence of a co-pilot and the possibilities of making emergency landings. This must have reduced the occurrence of serious accidents. But it also may have masked the initial bird strike in a chain of mishaps leading to a helicopter crash, as has been pointed out in jet fighter bird strike analysis (ref 3).

The military way of operating could have some influence on bird strike frequency. We did not collect data on the flight envelopes of the civil equivalents of our helicopter types. In stead we give in fig 5 and 6 some statistics from the Alouette II/III and Bolkow bird strikes with respect of helicopter speed and flying altitude. They show a result that seems reasonably comparable with many civil operations or give indications how to correct for deviations.

Helicopter bird strikes per speed class

GAF79-89 plus RNLAF82-90

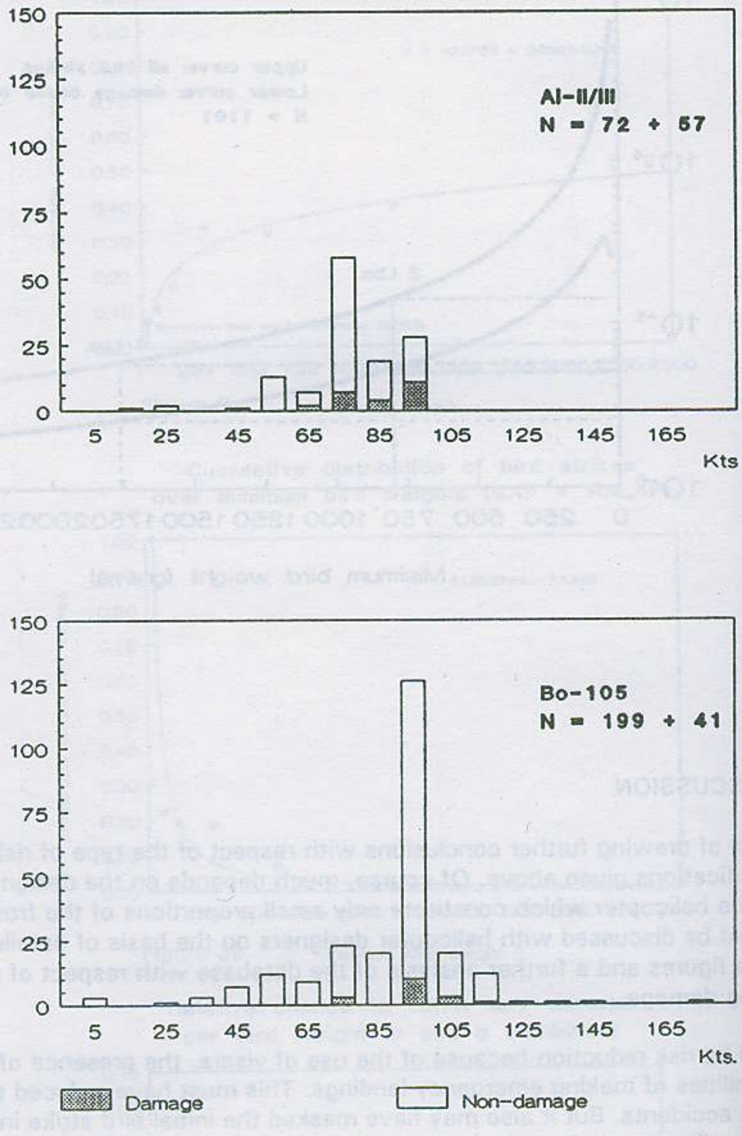

Figure 5

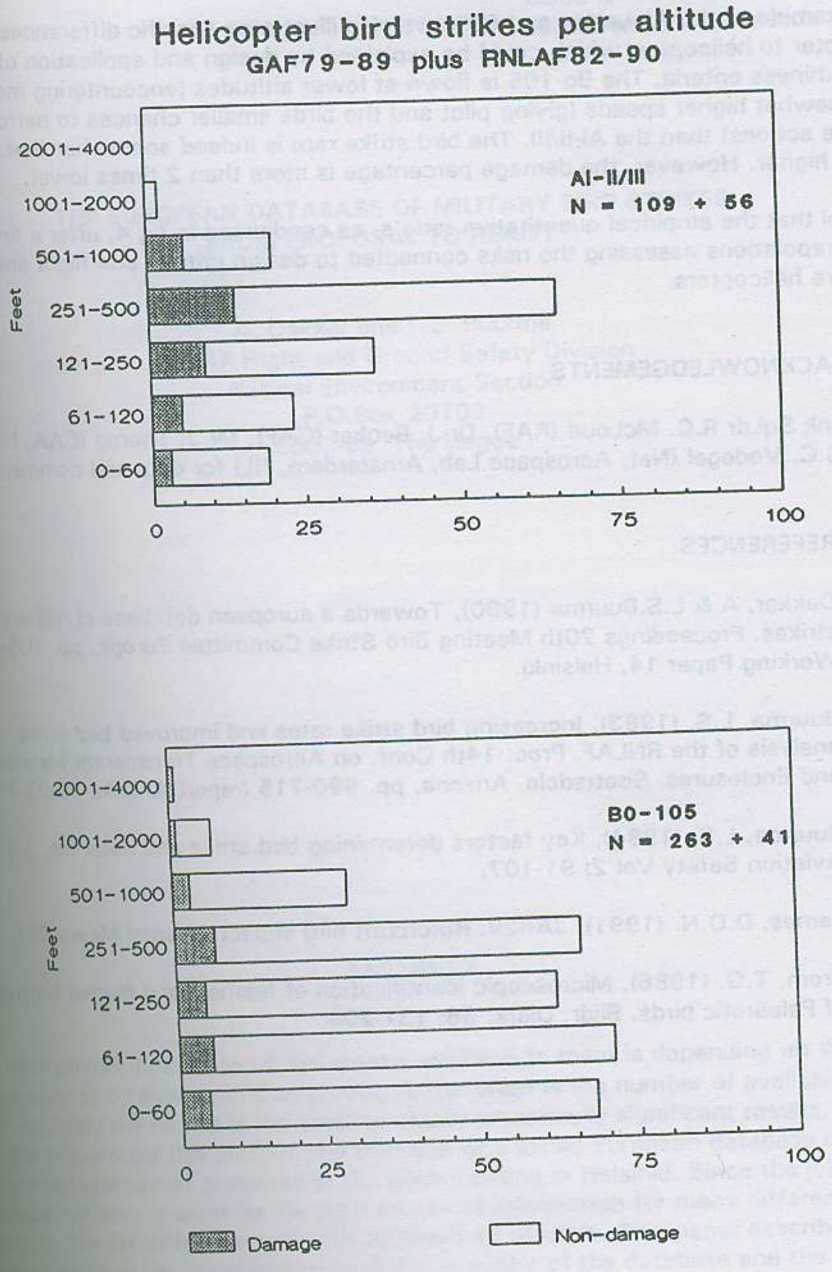
Helicopter bird strikes per altitude
GAF79-89 plus RNLAF82-90
AI-II/III
N = 109 + 56
2001-4000
1001-2000
501-1000
251-500
121-250
61-120
0-60
Feet
0
25
50
75
100
B0-105
N = 263 + 41
2001-4000
1001-2000
501-1000
251-500
121-250
61-120
0-60
Feet
0
25
50
75
100
Damage
Non-damage

Figure 6

The example of the Alouettes and Bolkows also illustrates specific differences from helicopter to helicopter, which could be explained by design and application of airworthiness criteria. The Bo-105 is flown at lower altitudes (encountering more birds) at somewhat higher speeds (giving pilot and the birds smaller chances to perform evasive actions) than the Al-II/III. The bird strike rate is indeed somewhat (but not much) higher. However, the damage percentage is more than 2 times lower.

We feel that the empirical quantitative ratio's, as condensed in fig 4, offer a firm basis for extrapolations assessing the risks connected to design criteria and flight envelopes of future helicopters.

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