BIRD STRIKE COMMITTEE EUROPE **BSCE 23/WP35**

London, 13-17 May 1996

STUDY OF BIRD BEHAVIOUR TO BIRD STRIKE PREVENTION

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Summary

There is a need to study some biological aspects -- 1. Bird behaviour concerning aircraft; 2. Control of bird behaviour at airports; 3. Prediction of migratory behaviour of birds -- to solve bird strike problem.

Aircraft is indifferent factor for birds, but become a repellent at short distance. Probabilities of bird strike increase in some cases: -- birds run into aircraft for the first time (migrants and juveniles); -- low noise of landing plane; -- birds take off facing into wind; -- curved flight of aircraft relatively birds; -- condition decreasing distance of acoustic and visual detection.

Scaring and ecological control methods are the most efficient to prevent birds from visiting airport area.

Scaring methods (bioacoustical, pyrotechnic and so on) at airdromes have some shortcomings viz. Short distance of action, necessity of bird detection on runway, getting use to frighten factors, conformation of these factors. Their main merits are in their good scaring effect to migrants and juveniles. Ecological methods prevent birds from landing on the ground but do not stop their flying over airport. One of them is frighten for some birds but attractive for the others.

Both landing and flash lights are imperceptible for birds at daytime. Probability of strike increase at night when birds could not see aircraft silhouette but see landing lights that attract them.

Radar and visual observations of migrating birds allow to predict time, altitude and way of flight in connection with weather and use this data in other countries through BIRDTAM.

To prevent such collisions in the future, practice of detailed analysis of circumstances all of bird strikes, search and utilisation of new methods are the most effective. This is concern with such strikes for which now impossible to recommend some of definite method. It is appeared to be the possibility to create original on-plane radar system to discover, recognize and avoid birds in flight.

Key Words: Local Movements, Control Methods, Attractants, Aircraft Appearance, Lights, Bird Populations, Migration, Detection, Radar

1. Introduction

Problem of bird hazards to aircraft have arisen as result of abrupt increase in number and danger of the bird strikes. The first step in solving this problem is to study bird behaviour and to understand reasons why birds appear on aircraft way and impossibility to avoid a strike with birds. Besides that, inspection of airport is required to study reasons of birds attraction and what measures of bird behaviour control should be taken to prevent similar collision in the future. Because of almost absolute impossibilities to control bird behaviour away from aerodromes it is necessary to use methods of bird detection and prediction of their intensive migration (that is prediction of migratory behaviour) to fly around areas of bird aggregation. Briefly, it is analysis, control and prediction of bird behaviour along aircraft route. Present paper is a result of studies covered more than 30 years period and include -- investigations of the bird behaviour with analysis of more than 3000 bird strike reports, ornithological inspection of about 60 airports, creation and testing of scaring and ecological methods of bird control at aerodromes, radar and visual observation of the bird migration.

2. Bird behaviour in respect to aircraft.

Pilot of high-speed aircraft cannot prevent a collision with birds (Jacobi, Beklova, 1981). Only pilot of light aircraft can sometimes detect bird flocks and avoid collision. Birds have got substantially more possibilities to elude approached aircraft. A high-flying and noiseless aircraft moving under small corner speed is indifferent for birds at land that do not pay any attention for them. When a large strong noised aircraft crop up near birds it scares them away from nests, roosting places and feeding grounds. This kind of behaviour is provoked by pistonprop biplane AN-2 at height of 100 m or significantly more noising helicopter at height 200 m. In both cases aircraft (helicopter) as a source of engine noise became a repellent for birds. During repeated flights were noticed a habituation without taking of or panic among birds.

We could observe a number of behaviour adaptations in birds nesting or feeding in areas of very intensive aircraft flights. For instance, in spite of intensive jet aircraft flights hereabouts a Teal (*Anas* sp.) continued to incubate its eggs at distance of 5 m of runway at Tallinn airport. Adapted to pay no attention to strong noise, the teal did not fly away when noise tractor passed over them. The bird and its eggs were run down by trailer road-roller for rolling of grass. In Odessa region, the Ukraine, Rooks (*Corvus frugilegus*) nested at rookery of about 4500 nests that was placed in trees along the border of air force fire ground. During bombardment birds flew to bomb crater, to get invertebrates amongst "ploughing" ground. Birds were so habituated to noise and low flying fighter-bombers, that more half rooks of all nests did not take off when strong noise helicopter with powerful air whirl wind down flew over them. Rooks nested at aerodromes preferred to fly around runway during intensive aircraft flights. At St. Petersburg airport nudge flocks of Hooded Crows (*Corvus cornix*) and Jackdaws (*Coloeus monedula*) crossed the road of taking off and landing aircraft while flying from roosting to feeding place and back. When aircraft was approaching that flock a large "gap" in bird stream have been created. Some bids accelerated their flight others part put the braked on and turbojet aircraft flew into that "hollow" without bird striking.

All these examples show, that the multiplicity of birds in airdrome vicinity do not always lead to augmentation of number of bird strikes. If aircraft are not common part for the birds environment, birds have to learn, either by themselves or from their parents or flock members how to behave safely with respect to approaching aircraft.

A bird strike analysis reveals reasons and situations when aircraft transform from indifferent or repellent stimuli to killer for birds. Run into aircraft in the first instance birds (youngs or migrants) that could not anticipate aircraft flight path to avoid collision with them and became a victim of strikes first (Jacobi, 1986).

Both analysis of bird strikes and study of bird behaviour show a number of factors that increased the probability of bird strikes - reduction of visibility during dark period or under clouds during sudden approach of aircraft from them; when birds land and take off from runway contra wind; when bird attention paid to search and getting of food, mostly at and over runway; during descend, when engines noise is less then in take off; when aircraft changes height or makes a turn, through difficulty anticipate the flight path of the aircraft; when a flock of birds feeding or loafing on the runway take off just ahead the approaching aircraft. During take off and landing, wide-fuselage aircraft (B-747, A-300) give less noise than narrow-fuselage ones (B-707, B-727, B-737), but higher speed. The former collide with birds as 6 time more as the latter (Burger, 1983). The presence in some migratory flocks of starlings only young birds; Defence tactics of the starling's and wader's tight flocks fly in a zigzag fashion was rescued from sighting raptor attack, but not prevented a bird strike.

At the same time bird flocking behaviour helps to avoid strikes, because of possibility to detect planes earlier. Besides that, experienced adults flying in the front of flock could make manoeuvres to avoid strike. Young birds following them have a chance to learned how to avoid from approached aircraft. At the same time delay in take off when young birds begin their flight after adults could be a cause of collision with aircraft.

We repeatedly observed how flying goose changed direction of their flight, apparently, to avoid a strike with aircraft crossed their route some minutes later. During survey flights on helicopter over Lenkoran Bay, Azerbaijan, at height of 50 m we observed large flock of ducks (about 7000) that successful turn aside from helicopter flying course at distance of 100 m.

Thus, taking into consideration all factors which could increase probability of bird strikes, helps to search and use methods of their prevention in future.

3. Control of Bird Behaviour at Airport

According our experience in testing and using some of methods of bird behaviour control at airports we consider some merits and demerits of these methods (Jacobi, 1982): active repellents (bioacoustic, pyrotechnic, raptors etc.), creation of ecologically unattractive for bird feeding, resting, roosting, and intensification of aircraft scaring effect at birds.

3.1 Active Repellents.

The most effective at our aerodromes is pyrotechnic signal pistol, that looks like a pistol, normally used for firing coloured signal flares. Having combined visual and acoustical scaring action it is an universal repellents for all species of birds.

Frequent usage of pyrotechnics lead to losing their effectiveness obviously for residents adapted to avoid bird strikes. Therefore pyrotechnics stay most effective against migrants and juveniles that are the most dangerous for aircraft. The main demerit of this method is in short distance of action (100-120 m) and a need in detection of birds that is difficult at long runway, at night and drive to birds. It is impossible to prevent flight of single birds or small flocks across airport; possibility returns of birds at former place after car departure

Broadcasting distress and alarm calls by car loudspeaker have been used to frighten birds away at distance of 200-300 m. When their distress calls were playing gulls, corvids usually fly towards loudspeaker, climb and gradually disperse when the broadcast stops. For acceleration of scaring effect usually use repetition of distress call or shot of signal flare.

We observed reaction of Starlings (*Sturnus vulgaris*) at distress call in the nature. Fire a gun caused impetuous take off large flock of Starlings feeding on the ground. Then all birds turning by funnel over several wounded starlings, uttering distress call. After second shot the flock fly away. May be it was exploratory reaction (what is it?), or help to wounded birds. During the breeding season or when a bird is hungry it may show a less-then normal response at tape distress or alarm calls. Nevertheless birds will gradually learn that their broadcast or alarm cry call does not constitute a genuine hazard and may stop responding. But the same call can scare away a migratory and young birds, which are the most dangerous for aircraft. At night distress call caused panic among birds, but it is very difficult to find birds in this time. Because of flight toward loudspeaker and sometime unpredictable results of car bioacoustical scaring air-staff of some airport stopped use this method. Despite that, ten 25 W loudspeaker have been placed along one side of Tallinn airport runway successfully scare away Black-headed Gull sitting on the ground for many years. Gull strike have noticed only when air-stuff did not see gulls at runway or from disrepair of apparatus.

A number of active methods have been tested, but did not used for active bird strike prevention at aerodromes because weak scaring effect and habituation (bird corpses in abnormal position, gas cannon), impossibility to work at night and during intensive aircraft flight (bird of prey, remote-controlled model of aircraft, moto-deltaplan with on-board bioacoustical device (Ilyichev, Birgukov, Nechval, 1995) .

3.2. Methods To Reduce The Attractiveness Of Airports For Bird

Since all airports are differ ecologically and operationally, a ecological methods to reduce local bird problems through changing of local habitat vary widely for different airports. It is necessary good knowledge of bird ecology to propose effective methods to reduce the feeding attractiveness of airfield.

There are a number of interesting decision of this task. For example I see in Germany good earthworm-proof gutter along both sides runway. It prevented earthworms from crossing on runway after rain. It is important to keep runway clean from dead animals, including birds, killed by aircraft which might attract Hooded Crows or Kites (*Milvus* sp.) . At runway airport of Riga Hooded Crows have ate a Herring Gulls, brought down by aircraft, but themselves haven't collided with them. The Fox (*Vulpes vulpes*) lived near runway, took these dead birds toward burrow to feed pups.

Many birds have congregating during hay-harvesting. Rooks, Crows, Starlings, Storks (*Ciconia ciconia*) quickly get all living that suddenly appears at surface of mowing down grass during following for mowing machine. Survived animals quickly were hide under grass and bird accumulation disappeared. For prevention such situation we recommended conduct such operation in aerodromes area at night or within large gaps between aircraft flights.

Thick high grass near runway prevent from searching and getting insects for insectivorous birds. At the same time seeds of some plants, for example *Polygonum aviculare*, are carried by wind at runway attracting pigeons. In moving grass, seeds become inaccessible for pigeons. Good decision to decrease attractiveness of rubbish heap is to create garbage processing factory. Sometime rooks and gulls from colony near airport prefers to fly to get the forage to rubbish heap and agricultural fields without crossing airport. On this basis I gave recommendation to create new landfills in 10 km from airport Domodedovo centre in direction, where rook flight route from large colony in trees near airport storehouses toward landfill did not crossed a runway. Similar method was used by Dr. Laty in Nice, France, to divert of gulls from spending the night at runway, toward lit place with forage to destruct.

An interesting solution have been found by ornithologists at airports of Vilnius, Lithuanian, to do the poplar (*Populus* sp.) unfit for rook nesting. Large boughs where rooks have usually placed their nests have been cut off. As the result of this action trees were covered with a brush of small dense twigs preventing creation of new nests. Usually a colony moved to the nearest favorable place or numbers of nest at neibouring colony have been increased. Result of that work for bird strike prevention is unknown. There are no such results of mass collection and destruction of eggs at Black-headed Gull (*Larus ridibundus*) colony at lake Yulemiste near Tallinn airport too (Shergalin, 1990). It is unknown too what gave transference of this colony on other shore of lake at distance of 6 km after deepening bottom and covering by water former place of colony. Transforming airport area into ecologically unattractive place for birds do not prevents their flights over that area. Nevertheless a bird accumulation do not took off from such places and bird strike here never have been prevented more lasting and reliable.

3.3 On-Board Lights To Disperse Birds

Unusual appearance, size and noise of flying aircraft soaring away birds. And some bird species, especially waterfowl, actively try to avoid approaching aircraft. The presence of strong lights on the aircraft give the birds more time to detect it and to anticipate its flight path. In Russia landing lights has been turned on during landing and taking off below 1 km. In sunny day landing and flashing lights slightly or quite not increase visual distance of plane detection. In dull weather the light of landing lights attract bird attention and, perhaps, increase distance of aircraft detection and probability avoiding bird strike. Birds do not see aircraft when it fly toward birds across clouds. A night bird could see only bright lights but could not see silhouette of aircraft. Such phenomena was statistically confirmed for turbojet Tupolev aircraft (TU-104, TU-124, TU-134, TU-154) with two powerful landing lamps on both side of cockpit at short distance one from another. Landing lights of this aircraft more often damaged by bird strike then ones of turboprops IL-18, AN-24 with landing lights at wings and directed under corner forward. Their light beam was crossed in front of aircraft (Jacobi, 1983).

Below-mentioned facts could explain such phenomena. Caged Robin (*Erithacus rubecula*) kept in a dark room became jump in one direction toward light point instead of undirected jumps before (Vilks, Liepa, Michelson, 1970). Attraction of lighthouses and mortality of birds from collision with them decreased if birds saw lighting tower silhouette (Isidzava, 1961). Number of bird strike with aircraft flying against large stream of birds abruptly decreased when besides landing light frontal part of aircraft have been were lit too (Larkin, Torre-Bueno, Griffin, Walcott, 1975).

Interesting information was received from pilots working in Arctica that orange colored aircraft of Arctic Aviation had more scaring effect at bird then common lightly colored aircraft.

4. Study of Bird Behaviour for Prediction of Mass Migration

There are many accidents because of bird strikes during their migration. Radar and visual observations permitted to understand adaptive peculiarities of bird behaviour during migrations. This adaptation have mostly expressed in extreme condition -- at night when it is impossible to use landmarks or while crossing ecological barriers (sea ducks over land, land birds over ocean) (Jacobi, 1994). On this basis can predict mass migration of birds in dependence from various endogenous and exogenic factors. Under such condition there were within- and inter-flocks communication (visual in daytime and acoustical at night) sometimes on area of several hundreds km,. Good visibility during At daytime flock size, distance between flocks and altitude of migration increased. Reverse correlation can be found during bad visibility. During dark period migrants flew in stream of single birds or small groups. Passerines form large friable flock at distance 50-300 m between birds. Waders and ducks fly in flocks various both in size and in form. Inner and inter flock signalling of the former were realized through comparative often calls, the latter - apparently by wing whistles.

All member of soaring bird flock in daytime can more quickly and at more distance detect and use the thermic or raising air-stream of wind, have been found by one of her member, to elect optimal route of migration.

Bird gathering in flocks facilitate searching for food. It is assistance for fat deposition before long distance non-stop migration. Only flight in tail wind permits make a long-distance non-stop migration. It is known that wind speed increase with altitude and there is clockwise shift of the wind direction on higher altitudes. Therefore the increase of flight altitude give its acceleration to the tail wind. Well feed Passerine and waders wait for tail wind to begin mass migration across sea. Tail wind is the signal to start and to realize successful crossing ecological barriers. Bird congregation in large flocks and their migration in bottle neck route is depended on ecological conditions at limited area that is favourable for birds. Waves of mass migration are depended on distance between observation point and point where migration started.

Birds experienced in navigation fly ahead of flock following on after another at start and during migration. Young birds following experienced adults in flocks and familiar groups receive navigational experience too (waiting for tail wind, imprinting celestial cues). So true navigation experience reproduces from generation. Then more flocking population, then more it experience in navigation searching for and getting of food using of thermic defence from hazard, including aircraft. Factually, flockness in connection with bird species, migratory state, weather, visibility use of landmarks are the index of mass migration. Due to there is possibility to predict direction, route, altitudes, density of migration, terms and place of migratory start and use for planning a places and altitudes forthcoming flights of aircraft to avoid bird strike.

Our radar and visual observation of sea duck during intensive spring migration in the west Estonia were used for transmission of BIRDTAM from Tallinn airport to the Helsinki-Vantaa airport.

There are large-scale bird distribution maps, based on visual and radar information on many military and some civil aviation airports in Russia. Seasonal and daily distribution of areas with bird aggregations and migratory routes over airport, as well as in surrounding are plotted on these maps, sometimes on routs of low flying fighters during training flights.

To warning actual bird movements is useful air reconnaissance of weather. Usually one hour before the training flights on their routes fly the fighter with experienced pilot who estimates weather and ornithological situation.

Bird warnings based mostly at visual information are issued in Russia. When meteostaff of military airports with assistance of local ornithologists, hunters, birdwatchers, radar operators and air reconnaissance detect mass migration, it broadcast coded. bird warning to Air Force Meteocentre in Moscow. Those reports have processed, and are issued as the radio message like BIRDTAM and can be used on all airports of country to keep aircraft farther from birds.

5. Bird strike prevention as a problem

On receiving bird strike data and identification of birds we were try to give recommendation to prevent similar collusion in the future. For a number of bird strikes it were impossible. For example, transport turboprop AN-12 landed at aerodrome in Vilnius, Lithuanian, collided with a flock of Starlings of about 100 birds at height of 20 m in 300 m away from the runway. Plane flew with landing lights. The flock took off contra wind and was swinging round. In this moment aircraft caught up and brought down 29 birds, which were young migrating birds judging by their plumage and late date of arriving. Tracks of strikes were noticed at wings, cockpit glass, oil-radiator, chassis, and in airintake of engines. One engine have to be changed. Plane stay on repair for a week. Previous turboprop AN-24 landing in 14.30 that flock sat on the ground in interval 27 minutes for search for food on humid ground after raining. Traffic controllers did not see how this flock was landing. Therefore, the prevention of this strike was impossible.

Annually, every one pistonprop biplane AN2 has several collisions with small passerines (swallows, skylarks, sparrows and so on) during agricultural flight at height of 10-15 m. It was not means to prevent mass flights of swallows along runway of Krasnodar flight school and swallows strike of training fighters. As a result of such collisions eight engines have been damaged and replaced for August and September 1970. Perhaps warm runway attracts swallows for getting insects.

Practically we cannot prevent numerous swift strikes in the day time and at night (Jacobi, 1980) that are sometimes very serious at various altitudes. So turboprop IL-18 ascended from airport Sochi at height of 1800 m had swift strike which made a gap in plane nose and damage radar. In July 1982 fighter MIG-21 collided with swift at height of 120 m near aerodrome of Borisoglebsk during landing at night. The engines were stopped. Pilot had to catapult. Fighter was broken.

Now tracking radar can see and recognize a single swift in flight but it do not permit to prevent swift-strikes. It is impossible to predict cropping up single soaring bird (eagle, vulture, kite, stork, pelican and so on) in front of aircraft and prevent the collision. The same situation is true for single flying bird of any species. For example, during ascend at height 300 m pilot noticed flashing object but did not feel any strike with his turbojet TU-104. 2.5 hours later after finishing that flight from Sukhumi to Moscow, wing of Herring Gull (*Larus argentatus*) was found in airintake. Fighter SU-7 collided with Wood Sandpiper (*Tringa glareola*) during night training flight over airport Eisk flying school, the Sea of Asov. Stroke of small wader of 13 g of weight at speed 600 km per hour and height of 500 m made a hole in sharp nosed suspension fuel tank and 600 liter of kerosine were lost. Crush of fighter MIG-29 on 8 July 1989 because of one bird strike on 160 m height and at 180 km per hour speed during unveiling International Salon Aeronautics and Cosmos at airport Bourge, Paris, cannot prevent neither pilot nor aerodrome staff. We cannot to do it now.

It is interesting bird strike which cannot be prevented have happened in aerodrome of Kjevik, Norway, on 13 April 1985 (Bentz, 1985). Remains of Peregrine Falcon (*Falco peregrinus*) female with Pochard (*Aythya* sp.) in her claws was found on the runway just after taking off Boeing -737. Peregrine Falcon and Pochard are rare breeding birds in Norway. Peregrine Falcon was apparently a migrant as it was ringed as a nestling in June 1983 in Finnish Lapland.

According aircraft engineer report, two fighters MIG-21 collided with swallows when they carried out couple taking off at aerodrome of Marguleshty, Moldova. One of birds stroke to lower part of fighter's wing and by rebound unlocked the larch of cover that held rockets under the wing. The cover opened and rockets began to fall off to the ground. Another swallow have broken plastic cover of fuse in one of rockets on the other fighter. In both cases rockets did not blow up due to being on safety lock. If they did not fighters might explode in the latter case.

One engine of turboprop IL-18 have stopped while running along runway at Vnukovo Airport, Moscow. The plane moved out the runway. One passenger was killed due as a result of that accident which has happened because of a Pigeon (*Columba livia*) that collided with the plane. Feathers of that bird were found by me in the engine removed for inspection. Pilots did not watched any birds before collision and did not feel strikes during both of those collisions.

Sure, we cannot describe lots other bird strikes in this paper which were impossible to prevent. Many similar cases could reveal among list and summarized the circumstances of military and civil aviation crushes as a result of encounters with birds in the whole world.

6. Conclusion

It is note in conclusion that flocking birds behaviour permits to detect the aircraft approaching at greater distance then single birds. Therefore collision bird flocks with aircraft take place in bad visibility and other situations preventing in-time detection of aircraft and evasive manoeuvres from them. For aircraft is easier detect and predict flocking migration on route of aircraft to keep the latter further from birds.

Therefore it is necessary now pay more attention of biologists and engineers to search and utilize new more effective bird behaviour control at aerodromes and away from them for prevention similar concrete accidence in the future. Good perspective for bird strikes prevention in air can give a creation of patent device of Dr. Nebabin, Odessa, the Ukraine, for avoiding birds in flight. Work Principle of this device is in automatic radar recognition of flying birds before on-board radar then giving of impulse to plane height rudder for automatic self-avoiding flight above birds.

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