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A Review of Bird Control Methods at Airports

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Abstract- Birds are a serious problem at airports threat to aviation safety. Since the early days of aviation, collisions of aircraft and birds have taken place, sometimes with fatal consequences. Generally, the damage due to their size of the bird species involved, hunting behavior, and hovering/soaring habits. The combination of abundant food sources, open space, and availability of perching structures on airport grounds and near runway/taxiway areas provides ideal hunting opportunities for many raptors. Also, the behavior of bird species influences the risks, for instance flocking or certain migration patterns and flying altitudes. Development of larger, faster and quieter aircraft, jet engines and intensification of air traffic caused an increase in the number of incidents. Military exercises involve flying at high speed an low altitude, and are exposed to a more serious risk.

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I. Introduction

During the 1966 Bird Control, we began to look at birds as a hazard to aircraft, and a possible new role was emerging for the pest control industry. Ten years later, we have yet to see the concept of bird control as seen through the eyes of our Canadian and European counterparts. You know of the assistance role the Air Force is playing in reducing bird strikes, and the Federal Aviation Administration is beginning to actively participate in bird control programs.

Raptors are often attracted to airports by the presence of birds, rodents, or other small mammals that are accommodated by the stands of poorly-maintained grass and border, or edge, habitats present. [Desoky, 2014; Baker and Brooks, 1981] found raptors to be highly dependent on voles for food at Toronto International Airport .Success has been seen in habitat modification as a means of reducing bird strikes. The Canadians [Blokpoel, 1976] have reduced damaging bird strikes significantly. Air Canada's average yearly cost for damage in 1959-63 was $173,000. From 1969-73, just ten years later,

Raptors, including hawks, vultures, and eagles, were the fourth most common bird group reported in bird strikes to the FAA from 1990 -1998 (Cleary *et al.* 1999), and hawks, more specifically, were the fifth most common bird group reported in bird strikes in Canada from 1991 -1997 (Transport Canada 1998). Red-tailed hawks were the sixth most common bird species reported in U.S. Air Force bird strikes from 1985-2001, resulting in over $13 million in damage costs (Transport Canada, 1994 and USAF 2001).

This case was reduced to an average of $86,000 per year. This is remarkable when you consider the increases in flight operations, repair costs, and inflation over the ten-year period. Modification of the airfield environment is possible, and the Air Force is doing it routinely at many bases. A more complex problem is land use, which attracts birds beyond the airfield boundary .An airport authority or military base has little or no control over matters outside its territory. Usually it is extremely difficult to implement recommendations to reduce known bird hazards. Progress is slow in altering community land because of a wide variety of organizational, legal, financial, or political reasons. Certain land use practices must be examined in preparing comprehensive plans and bird control programs. Scientists and technicians working with birds have the necessary knowledge to identify problems with land use which will aid in planning for the future. To appreciate the problems created by land use, we must examine a few uses found near airports [Davidson *et al.*, 1971].

Air traffic in South Africa is increasing and it is essential to ensure that international air safety standards are maintained at South African airports. Little has been done in the past to co-ordinate the management of bird related safety risks at South African airports. In order to improve the situation, the Airports Company South Africa (ACSA) has entered into a unique strategic partnership with the Endangered Wildlife Trust (EWT), a nongovernmental organisation committed to the conservation of southern Africa's biodiversity, to establish and operate an integrated national bird control program. The aim of the project is to minimise bird strikes and other interactions between wildlife and airport facilities at ACSA airports by applying environmentally-sensitive management techniques. [Froneman, 2000].

Airport staff is involved in the monitoring of bird strikes and bird populations on or near airports in order to gain a better understanding of population dynamics. Emphasis is placed on proactive bird control measures involving ecological solutions such as habitat management. However, during the establishment phase of habitat alterations, more re-active bird control measures are used to scare birds away from high-risk areas on the airfield. During its first year of operation the project has made significant progress. One hundred and forty eight bird strikes were reported from 13

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airports across the country. The data recorded have helped to narrow the problem down to specific species and to prioritise actions through analysing bird strike rates for the different airports. In addition to refining the reporting system the project currently focuses on establishing appropriate environmentally sensitive bird control measures [Anderson and Kok, 1991].

Wildlife control committees have been established at ACSA airports and they form the basis of an improved bird strike reporting and bird control monitoring programme. The formation of a South African Airport Wildlife Working Group under the auspices of the partnership is envisaged to share information from a national and international level with all stakeholders.

The study comprised gathering and analysis of international literature and publications on bird control, in order to obtain an overview of bird control at airports.

II. Habitat Modification

All birds need food, cover (including shelter, safety, places to nest, rest and roost) and water to survive. Design and management of the airport habitat in such a way that these elements are eliminated or minimised (aimed at the locally most hazardous species), will reduce the local population of birds [Blokpoel, 1976, and Project Mainport en Milieu, 1993]. Habitat modification should be aimed at the problem species. Because habitat modification will not only affect the target birds, but also other bird species and animals, it is not highly selective. It is also important not to create circumstances that are attractive to other species. Habitat modification is considered to be a very effective and enduring way of preventing the presence of birds. Measures should be based on ecological research of the airport area and its surroundings; every airport offers a unique situation. Continued and properly specialised maintenance of vegetation and water is an important condition to success [Desoky, 2014 and Godsey, 1997].

III. Model Aircraft

Remote-controlled model aircraft, shaped in the silhouette of a bird of prey, have been tested with success (on gulls in the Netherlands, on Dunlin in Canada). The small aircraft are flown across or towards the target birds by remote control, in such a way that a raptor is imitated. Tests in France showed that shape, colour and noise of the model did not influence results, but that the way the model was piloted was most important [Stenman, 1990]. Maneuvering the aircraft is said to be difficult, especially in windy circumstances and in busy aviation traffic. There is no information on habituation [Grote, 1994 and Burney, 1999].

IV. People Vehicle

Slow arm weaving has been tried successfully on gulls, perhaps because the movement imitates the flight of a large raptor (e.g. White-tailed Eagle) [Kuyk, 1981]. There will be many variations on this theme, such as imitation wings fixed on a vehicle etc. However, little information was found in literature. The mere presence of people or the bird patrol vehicle is enough to scare away some species. Persons holding shotguns (or even models) are successful, especial ly where hunting is common practice. In some cases it is noted that habituation to this way of visual scaring is much less than to other dispersal techniques [Stenman,1990].

V. Mylar-Tape

In agriculture, mylar tape is used as a ‘scarecrow’ to keep birds out of crops. Twisted strands tied to sticks move in the wind and flash in the sun, and they appear to have a frightening effect. Fences of Mylar tape are also used in agriculture. Although the use of Mylar-tape is mentioned in relation to bird control, no examples of use at airports were found [Cleary, 1998].

VI. Eye Spots

With eye spots on flags, balloons or doors no positive results are obtained. There may be an initial reaction, but birds get used to them very quickly .Eye spots on aircraft (e.g. engine spinner) are studied with various outcome: negative [Godsey, 1997] to a 20% reduction of bird strike [Stenman, 1990].

VII. Lights

Various types of light source (search, rotating, flashing, laser or strobe lights) are tried and/or used, sometimes in combination with mirror systems [Godsey, 1997]. Flashing (‘anti -collision’) lights are commonly used on aircraft; birds are better able to detect an approaching plane and avoid it. Flashing lights are also used on bird patrol vehicles. The flashing frequency should be less than 100/sec. Search lights have shown to have some effect in darkness. A strong light beam can scare gulls at a distance up to 800 m. Tests have indicated that blue light may be more effective than other colours, perhaps due to a higher sensitivity of the bird’s visual senses to ‘blue’ wavelengths. Fixed strobe lights have been successful inside buildings, but they are not practical outside. Laser is considered not very successful, although there have been good results with a portable helium -neon laser in France [Kuyk, 1981and Stenman, 1990]. However, test results also showed that the required laser intensity would be dangerous to animals and man [Blokpoel, 1976]. It has been concluded that the approach-lights alongside landing-strips reduce bird strike (during day light) by 50%.

Probably, they improve a bird's timely detection of an approaching plane [Thorpe, 1996]. Care should be taken with the use of lights, because migrating passerines are known to be attracted by lights at night. Especially during falls, increased numbers of passerines have been recorded at or around lighthouses, lightships or illuminated large industrial areas along the coast.

VIII. Resource Protection

Resource protection comprises all activities that make areas inaccessible or less attractive to birds. Apart from food, cover and water, airports often offer relative 'quiet' conditions, because there is little disturbance apart from engine noise. This is attractive to birds and can be an important factor in their presence [Project Mainport en Milieu, 1993 and World Top 50 Airports, 1998]. Resource protection measures include 'passive' (e.g. wires across ponds, spikes on ledges) and 'active' (harassment with chemical, audio or visual means) methods, hereafter called exclusion and repellents respectively [National Wildlife Research Centre, 1999]. The success of active harassment depends not only on the methods and bird species, but also on the shape the target birds are in. When breeding, tired or hungry, gulls for example are harder to chase away. Also, the availability of alternative sites for birds in the vicinity determines the success [MacKinnon, 1996]. This may be especially important in case of an island in sea. Due to the adaptive abilities of birds, habituation to repellent techniques is a serious problem in bird control [Bird Strike Committee Canada and Bird Strike Committee USA, 1999; Godsey, 1997 and Kuyk, 1981.], Similar methods used at different airports may yield completely different or even contradictory results. Therefore, it is nearly impossible to judge effectiveness of most visual and audio repellents from experiences. At many airports, the effectiveness of repellents is assessed by testing in the field [MacKinnon, 1997].

IX. Exclusion

Access to attractive areas can be denied or discouraged by using physical barriers. Such barriers are mainly used for buildings and for open water, but also for landfills. Buildings are used by birds as roosting (or even breeding) sites, for example Starling and pigeons on ledges or in hangers, gulls on open water or on rooftops. Favoured areas, such as ledges, setbacks and flat surfaces can be closed off with netting, screening, spikes, wires or sticky substances (the latter only having a temporary effect). On flat ledges, metal strips can be applied with an angle greater than 45o. Using curtains of heavy plastic sheets will prevent the use of openings or doorways; making a ceiling with nets or cloth will prevent birds to roost under roofs or shelters [Blokpoel, 1976 and Cleary, 1998]. Water bodies such as ponds or lakes can be made inaccessible with wire systems. The grid of the wire system depends on the target species. For gulls, a grid of 6 x 6 meters proved to be useful, for waterfowl a smaller grid (3 x 3 meters) is needed. Exclusion of water is also possible with nets [Cleary and Dolbeer, 2000]. Exclusion of landfills as a food source (mainly important for gulls) is best done by daily covering of the waste. Wire systems have also been successfully used on landfills. Waste sites at meat- or fish-processing industries should also be carefully covered. Gulls appear to use several feeding sites spread out over a large area. It is therefore important to take measures at all potential feeding grounds in wider surroundings than just the close vicinity. Large, horizontal nets have been described by [Kuyk, 1981] as a means of keeping birds away from airport fields. However, such nets make maintenance of the terrain difficult. Experiments have been conducted with heated surfaces, based on the assumption that gulls prefer warm surfaces for roosting or loafing. No positive results were obtained [Blokpoel, 1976].

X. Audio Repellents

Birds can (temporarily) be chased away with sounds by using pyrotechnics, propane gas cannons or bioacoustics. In general, loud noise itself does not seem to bother birds [Blokpoel, 1976]. Experience with and a result of audio repellents varies greatly between countries [Stenman, 1990].

a) Pyrotechnics

Pyrotechnics are noise producing devices such as scare cartridges, shell crackers, fireworks, alarm pistols, shotguns and electronic alarms (the latter being little used). They are often effective, easy and safe to use and are thus widely used, nearly always in combination with bioacoustics, visual scaring or shooting. Additional development of smoke is occasionally used. Flares are not widely used but tend to have a good effect [Blokpoel, 1976; Klaver, 1999 and Stenman, 1990]. Apart from the audio effect of the explosion, there is also a visual effect of light and smoke. Flares are normally fired from a Very pistol. At Schiphol, the Very flares have been replaced by shell crackers that do not leave debris (dangerous on runways). The effect of shell crackers varies, due to habituation. Birds can be dispersed in a desired direction by carefully locating the sound source or firing in a certain direction (cartridges) [Cleary and Godsey, 1997]. Sirens on vehicles are used with some success. Automatic noise generators along runways are used successfully on Lapwing, gulls and pigeons [Jonkers and Spaans, 1997].

b) Gas cannons

Propane, carbid or acethylene gas cannons are less widely used, probably because habituation can occur comparatively quickly. They can be very effective

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on gulls, waterfowl and other game birds (the latter being hunted and associating the noise with danger), especially when used when (migrating) birds come in to feed or roost. Frequent relocation, varying the frequency of detonations and combination with other harassment techniques will prevent habituation and improve the effect [Blokpoel, 1976 and Godsey, 1997].

c) Bioacoustics

Bioacoustics work through broadcasting of pre-recorded bird distress calls. These calls are specific to a bird species, although Godsey mentions that non-specific distress calls are the most effective [Godsey, 1997]. Experiments with synthesised versions of calls have been successful as well. The birds will interpret the calls as an alarm signal and fly away, perhaps enhanced by group behaviour. However, other responses, such as flying towards the source to check out the 'danger', have been reported, creating a potential momentary hazard (gulls, Corvids. Distress tapes are (preferably) played from a sound system on a vehicle, producing 90 to 100 decibel. Fixed systems have proved to become ineffective in time in several countries. After the birds have been identified and the tape is selected, the birds are approached to a minimum of 100 to 200 meters (depending on the local situation) and the call is played for a short interval (15 to 20 seconds, to prevent habituation). In the Netherlands, an automatic randomising system is used to broadcast distress calls. Gulls, starlings and crows can be dispersed with distress calls. Not all species react to bioacoustics (Lapwing, Oystercatcher and Starling appear to be difficult); several calls may be tried. The response may also depend on the birds' behaviour or state (hungry, tired or breeding birds showing less response) [Blokpoel, 1976]. In practice, bioacoustics are very often used in combination with other measures to prevent habituation. Combinations with pyrotechnics, hunting or incidental killing provide good results in many countries [Stenman, 1990]. In Britain, the main problem species react to their distress calls. Before using distress calls, investigations are needed into the problem species, their calls, the circumstances in which the calls should be used, the required quality and equipment and the best way of reinforcement.

d) Ultra-sound, infra-sound, radar

These sound sources are generally regarded as not effective in scaring birds. Tests at various locations and under various circumstances have, in some cases, provided contradictory results. However, there is no hard proof for any positive effect .Generally, ultra-sound (using very high frequencies) has appeared to be unsuccessful in chasing away birds [Blokpoel, 1976 and Godsey, 1997]. The hearing range of birds is assumed to be narrower than the human range (proven for Pigeon, House Sparrow and Starling), so sounds inaudible to humans are inaudible to birds [Cleary and Dolbeer, 2000]. Moreover, ultrasound requires much power and quickly loses strength with distance. Contrastingly, one record of successful use of ultrasound was found in literature: at Venice airport in Italy ultra-sonic equipment has reportedly been used with success on gulls.

The experimental circumstances in which these results were obtained are not mentioned [Stenman, 1990]. According to some sources, birds species may be sensitive to infra-sound (low frequency) and use it for navigation. The same may be true for modulated radar, as several observations indicate. According to other sources, however, radar does not seem useful for scaring birds [Kuyk, 1981]. Studies are underway to test this possibility [Cleary, 1998]. The noise of aircraft engines is being studied to determine if certain frequencies are suitable for scaring birds. There may be overlap in frequencies between engine noise and distress calls. Studies to investigate these subjects are currently underway [MacKinnon, 1996].

XI. Visual Repellents

a) Carcasses or models of dead birds

This method of agricultural origin is widely practised, with varying results. Dead birds 'wear out' quickly; their use can be extended by conservation with formaldehyde. Plastic models (dummies) or mounted specimens are more durable, but the effect seems to less compared to carcasses. Incidentally, problems with animals or birds of prey, attracted to carcasses, occur [Kuyk, 1981 and Stenman, 1990]. At Schiphol, many experiment with both mounted or model gulls have been conducted [Blokpoel, 1976]. Various gull reactions, ranging from virtually no effect to a very strong reaction, have been noted. Posture and placing of the model appear to be important factors. Sitting or standing models do not deter gulls. Lying birds, with or without spread out wings, provoke a reaction similar to distress calls; flying towards the model, circling and flying away. The frightening effect may last 1 –3 months [Kuyk, 1981]; other sources report effectiveness lasting only one to a few days [Stenman, 1990]. Birds may settle down again within 50 meters of the dead bird. Models hung up are more frightening than when laying on the ground, probably because of the additional movement [Blokpoel, 1976]. Especially a nodding head-tail movement has been successful [Kuyk, 1981 and Stenman, 1990].

b) Falconry

The results with falconry vary in practice. Success of falconry depends on many factors; more analysis is needed to establish the effectiveness under various circumstances [.Several species of falcon (Peregrine, Gyr, Lanner or Saker Falcon or Merlin) and Eurasian Goshawk can be trained effectively for bird dispersal at airports. Not only low altitude hunting flights

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but also high altitude patrolling flights of raptors are successful in chasing away birds. An advantage is that the falcon is less vulnerable than when hunting. In this respect, falcons are more useful than goshawks, because the latter preferably uses fast low altitude flight [Dolbeer, 1998].

Falconry was or is practised in some countries with good results (e.g. Scotland, Canada [Blokpoel, 1976], Spain [Dolbeer, 1998]). At JFK Airport, falconry was tested to supplement (and eventually replace) the gull-shooting programme. Peregrine, Peregrine x Gyr falcon-hybrid and Harris' hawk were flown, typically in flights simulating hunting. Gulls will react mainly with formation flight [Lovell, 1997]. Additional pyrotechnics and distress calls were used. During overlap of shooting and falconry, less gulls were shot. When shooting was stopped and falconry was continued (received positively by public and media), there was, however, no significant reduction of bird strikes compared to the period prior to shooting. In other cases, falconry did not appear to be (cost) effective after testing. In the Netherlands, falconry was tested at Schiphol airport, in combination with model aircraft. It was used at Vliegbasis Leeuwarden until 1974 [Stenman, 1990]. An advantage is that habituation does not occur, because a real danger is involved. However, there are several limitations: training and maintenance is difficult, a full-time team is required, the birds can only be flown during daylight and good weather and fl ying is not possible just after feeding or during moult [Blokpoel, 1976; Godsey, 1997 and Kuyk, 1981]. In many cases, falconry was abandoned because of these limitations. When considering use or testing of falconry, the local situation and limitations should be taken into account.

XII. Killing

Population management aimed on an actual reduction of the total numbers of a bird species (other than on a local scale) implies that the killing rate must be higher than the natural death rate. Most target species tend to be very numerous or the numbers are increasing (e.g. gulls, waterfowl, Starling), so killing will show little effect in terms of numbers, unless practised on a very large scale. However, it has shown to be effective at local breeding colonies. Killing great numbers of birds is, apart from difficult an expensive, generally not an acceptable control method. Moreover, it may have an adverse effect. Decreasing numbers result in less competition between the surviving birds for resources, so the remaining population may well be 'healthier' [Cleary and Dolbeer, 2000]. In the Netherlands, population management at gull colonies is hardly practised, also because gulls generally do not cause many problems in the breeding season [Kuyk, 1981].In the case that birds are an acute danger, killing or capturing is used to immediately eliminate the threat. This method is widely used, often as a 'last option' in bird control [Klaver, 1999 and Stenman, 1990]. Captured birds are either relocated (birds of prey) or killed. There are various methods for killing or capturing which will be discussed below. The use will depend on the local situation, the applicable regulations and on social or political aspects. Killing individual birds as a reinforcement of repellent techniques is widely used and has proved to avoid habituation and to stimulate the scaring effect. This is mainly done by shooting. Leaving a carcass after shooting has proved to be very effective, the effect lasting 24 hours. However, care should be taken not to leave carcasses on or close to runways because they may attract predators or scavenging birds, or the carcass may itself be ingested in engines of passing planes. Lethal means of population management are shooting, lethal trapping, poisoning and destroying of eggs or nests. One example of introduction of predators was found. Relevant methods are discussed below.

XIII. Shooting

Shooting eliminates the target bird, frightens the rest of the flock and reinforces other repellent techniques. Surviving birds will be scared by the noise and the death of one bird, and will associate this with the other repellents. It can be very effective; at JFK International Airport for instance, bird strike was reduced to 90% by shooting gulls flying over the airport. These birds were mainly Laughing gulls, originating from an expanding breeding colony nearby; during a six year shooting period, 52,235 gulls were killed [Dolbeer, 1998]. Observations indicated that shot local breeders were replaced by birds immigrating from other (expanding) colonies [MacKinnon, 1997]. Apart from the disadvantage of killing many birds, shooting is expensive and demands a lot of effort. Professional use of fire arms, study of regulations and notification of local authorities are important aspects of this control method [Cleary and Dolbeer, 2000]. For waterfowl, hunting is a good way of reducing the local population as well as repelling ducks or geese [Dolbeer and Bucknall, 1994]. Gulls tend to learn very quickly and will soon react to approaching vehicles or people by keeping a safe distance; out of shooting range (this behaviour causes the reinforcing effect of shooting on harassment). Thus, shooting gulls may soon become very difficult, unless it is practised on birds flying overhead on a sleeping or feeding fly route [Dolbeer, 1998 and Kuyk, 1981]. Occasional shooting of individual birds is practised in many countries, depending on the applicable regulations. In the Netherlands, shooting at civil airports is only used as reinforcement of the usual techniques and to reduce the number of hazardous breeding species (Oystercatcher, Lapwing, Grey Heron,Pheasant).

XIV. Trapping

Lethal traps are little used. An (American) example is a snap trap for woodpeckers damaging utility poles [Cleary, 1998]. Woodpeckers are generally not a problem species on airfields. Eurasian species of woodpecker are not likely to use poles and are rare around airports because of the lack of trees.

XV. Destruction of Eggs and Nests

Nearby breeding populations of waterfowl or gulls can be a problem. Breeding of gulls can be discouraged by removing their eggs and nests. As soon as clutches are complete, all eggs and nests should be removed from the colony every two to three weeks, continuing until all breeding efforts stop. Another possibility is to spray the eggs with an emulsion of oil in water containing 10% formaldehyde. The eggs will die of without decomposition (which may induce laying of a second clutch). [Kelly, 1999] mentions that this method is only workable in smaller colonies, although it was used effectively at a large Herring Gull colony near the airport of C openhagen [Stenman, 1990 and Inoue, (1999).]. Egg-shaking is also used. Shaking should start after the clutch is complete and breeding begins. When incubating is already progressed, shaking loses its effect. To determine the state of incubation, the flotation test is suitable. Eggs and nests should not be destroyed after shaking before another period of incubation have gone by (three weeks for waterfowl). After that period, birds will generally not attempt to re-nest [Dolbeer, 1995].

XVI. Predators

In the United States, Herring Gull colonies on small islands have been eliminated by introduction of fox and racoons within 2–4 years (predation of both birds and eggs). However, these predators were not able to survive without additional feeding. In contrast to colonies, the presence of predators at gull-roosts does not appear to be effective, because roosting birds will fly sooner than breeding birds. To prevent escape of predators and colonisation of adjacent terrain, areas where predators are introduced should be completely fenced of. In practice, this will be very difficult (except on islands). A general problem with introduction of predators is that they themselves have to be controlled, in order to maintain a certain population density. Also, the predators themselves may pose a strike risk to aircraft [Kuyk, 1981].

XVII. Chemical Capture

Chemical capture works by feeding target birds with bait treated with a sedative or immobilising toxicant, after which the birds can be captured. Recommended baits are corn (for groups of pigeons or waterfowl) and bread (individual birds). Alpha chloralose (A -C), for example, is used in the United States and on Herring Gulls in Denmark (here, however, in a lethal dose) [Stenman, 1990]. Birds become capturable within 30 to 90 minutes, recovery occurs within 8 to 24 hours. Pre-baiting is necessary to ensure the success of this method.

XVIII. Chemical Repellents

In the Netherlands, amongst other countries, chemical repellents are not used nor are experiments conducted. A number of chemical repellents are currently used in the United States and Australia [Cleary, 1998 and Stenman, 1990]. In many cases, experiments with chemicals to harass birds (mainly tried on gulls) have often been unsuccessful and if it was, a combination with other techniques was necessary to chase birds away [Kuyk, 1981 and Stenman, 1990]. Having a moderate climate with a lot of rain, chemicals are not expected to be successful in the Netherlands [Kuyk, 1981]. The use of potentially toxic chemicals may also have legal (and ethical) complications. Consequently, testing and use of chemicals as bird repellents is not recommended.

a) *Reta*

In Israel, surface spraying with Reta (aluminium ammonium sulphate) caused a decrease in the number of gulls; but the gulls did not disappear completely until this was combined with other measures. Although the gulls seemed to have become more uneasy and more susceptible to sounds, the use of Reta was not considered a sufficient method. In several other countries (Denmark, Switzerland, France), tests with Reta failed to produce good results [Kuyk, 1981 and Stenman, 1990].

b) *Polybutene*

The chemical repellents discussed below are registered in the United States. For keeping birds of roosting surfaces, a number of repellents containing polybutene or polyisobutylene are available. They are applied to the favoured surfaces inliquid or paste form and make birds feel uncomfortable when they land. In order to displace the birds effectively, all potential surfaces should be treated. Application should be repeated every half a year or year, but much more often if the surfaces are very dirty. Examples are Bird Stop, Roost-no-more, Bird-X, 4-The Birds, all of them non-toxic [Stenman, 1990].

c) *Methyl anthranilate*

Methyl anthranilate is the non-toxic active compound in ReJeX -iT, to which birds have a strong aversion. It is applied on golf courses, landfills, standing water and temporary pools to keep away gulls, waterfowl or Starling [Cleary and Dolbeer, 2000]. Although the effectiveness of methyl anthranilate has been demonstrated on several bird species (Ring-billed gull, Mallard [.Dolbeer *et al.* 1993]), experiments on (captive) Canada geese foraging on turf showed no evidence that ReJeX -iT was effective as a grazing repellent. It may be more effective in higher doses and on wild Canada geese, particularly in combination with other forms of harassment. The effectiveness mayalso depend on the surface that is being protected; food demands higher concentrations of methyl anthranilate than water, for instance [Belant et al. 1996 and Dolbeer *et al.* 1993].

d) Naphthalene

This repellent, working on the sense of smell, was tested at airfields in the United Kingdom. It was applied to the field as 'moth balls'. Results were contradictory [Blokpoel, 1976].

e) Aminopyridine

Avitrol is an example of a toxic repellent. Bait (preferably grain) is treated with Avitrol and subsequently eaten by the target birds. They react on the active compound (4-aminopyridine) with distress behaviour, in turn frightening other birds in the vicinity. A sufficient dose will be lethal; by using limited amounts of bait, a flock of birds can be chased away with minimum mortality [Cleary and. Dolbeer, 2000].

XIX. Poisoning

For poisoning target birds, oral and contact toxicants are used, a.o. in the United States (they are not used in the Netherlands [Lensink and Dirksen 1999]. Experience with toxicants mainly has an agricultural background, but they are also used at airports. Oral toxicants are applied by baiting, contact toxicant by treating perches. They require a careful study of the target birds' behaviour, favoured sites, carefully designed pre-baiting, careful handling and controlling of toxicant and bai t. Pre-baiting is the determining factor for success. Location and timing of pre-baiting should be adjusted to the birds' feeding behaviour and daily routine, and should be conducted for two to three weeks before applying the toxicant. The bait should be of good quality and of fine, uniform structure (higher surface-volume ratio). It should not be applied before it is made sure that only target birds feed on the bait. Unused bait and dead birds should be properly removed An example of an oral toxicant (registered in the United States) is 3-chloro-p-toluidine hydrochloride, that is a.o. used for gulls at colonies to reduce predation of nearby nesting colonies of other species. It metabolises quickly, the metabolites are not toxic and there is no secondary toxicity to animals eating killed birds. An example of a contact toxicant (registered in the United States) is fenthion ('Rid-a-Bird' perches). It is used for Starling, pigeons and sparrows and applied on or in (farm) buildings, power plants, bridges etc. Secondary toxicity occurs so dead birds should be properly removed. It is not recommended to use perches outside building because non target birds may become a victim [Cleary, 1998]. There is an example of successful application of a strong sleeping drug in a gull colony in New Zealand, after which many birds were captured [Kuyk, 1981].

XX. Developing a Bird Control Program in Airports

In general, It is clear that the design of a bird control program should be proceeded by a study of ecology and behaviour of problem birds at the local and regional level. Preferably, the results will be taken into account when locating and designing a new airport. The first step towards effective bird control is answering the question why the birds are (or will be) attracted to the airport. The answer will be provided by identifying to what extent the environment offers food, cover and water. This implicates knowledge about the ecology of the target birds (and, possibly, their prey), the features of the environment and land use activities in the vicinity [MacKinnon, 1997 and Godsey, 1997] also stresses the importance of learning about local bird activities, through conducting bird surveys. These surveys should include weather conditions, species, location, flying and other activities and possible attractants. [Cleary, 1998] mentions questions that should be answered next:

1. Which bird species are causing the damage?
2. What are the birds doing that make it necessary to control them or their damage? The answer to this question will, to a large extent, determine the control methods used.
3. What is the legal status of the problem birds?
4. What are the daily movement patterns of the birds between their feeding, loafing and roosting areas? When are they most vulnerable in their movement cycles?
5. What effective and legal control methods are available?
6. How selective are these control methods? The object is to control only the target birds, not all birds in the area.
7. How much will it cost to apply the selected control methods (also in relation to the costs of the damage)?
8. How does the public feel about the birds, their damage and the control implications?

A number of these questions may be of less relevance, when compared to the risks involved (for instance, the legal status of birds or the public feeling). Bird control measures (and their costs) should be compared to an assessment of the risks to safety. Several authors stress the fact that, apart from control techniques, monitoring of bird strike is a very important way of gathering information, assessing risks and

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developing bird control measures fit to the local situation. It is suspected that many strike events remain unreported. Reporting bird strike is being strongly promoted by the several bird strike committees [Bird Strike Committee USA, 1999 and National Wildlife Research Centre, 1999].Using this information will facilitate the assessment and modelling of the risk of bird strike [Bird Strike Committee USA, 1999]. A guideline for developing a wildlife management plan is under preparation.

Special attention should be paid to bird hazards from the start. An island at sea will always constitute a strong attraction to many birds. The attraction can be influenced by design, habitat manipulation and exclusion and repellent or dispersal techniques, be it only partly. In order to provide sufficient safe conditions for aviation, bird control should be very strict, for instance including absolute zero-tolerance policy towards (breeding) gulls and Cormorants. However, migrating or sheltering birds can hardly be controlled by bird control measures. An adequate observation and warning system may be necessary. Especially during migration and winter, bird hazards can well be such that flight operations may have to be intermitted.

Zoning around an airport at sea takes a rather different perspective compared to airports inland. Restrictions on 'land' use do not seem to apply, however, certain activities, like commercial fishing, require special attention. Large numbers of gulls may follow fishing boats, usually flying at low altitude and is very useful as a sheltered look -out for approaching boats.

At night, an airport-island at sea will also be an island of light. Whereas special lights have been used for repelling birds, they will rather attract birds at sea (whether flashing or not), especially nocturnally migrating passerines. Vegetation management requires special attention, because the island will start off with bare sand. Sand dunes are dynamic and will shift rapidly under the windy circumstances. Measures will be needed to keep runways and hard surface free of sand, and vegetation will be the most important. In coastal areas, grass ('Helmgras') is generally used. However, Herring, Black-backed and Common gulls use this habitat when breeding in dunes. Pioneervegetations on flat coastal sands are generally scanty and short, thus being attractive as

Roosting and loafing habitat. Creating a closed grass vegetation will be very difficult Thorn scrub ('Duindoorn') grows well in this habitat and may be an alternative, despite its attraction to migrating passerines (for cover and berries). These small migrants are generally not abundant out at sea (except in the occasion of a fall), they tend to stick to cover and do not fly around much, thus being less hazardous than roosting gulls. Audio and visual repellents that have proven to be effective should be tested in the field situation. Depending on test results, techniques may be adjusted or altered. Chemical repellents may be tested as well, although legal or environmental concerns may arise. Moreover, many chemicals have proven to be unsuccessful and may be especially so in the wet and windy circumstances on an island.

a) Recommendations of Bird Control in Egyptian Airports

A number of measures can be mentioned as being important and/or potentially useful. These are:

1. design and management of lay-out, vegetation and other terrain on the airport
2. management of fresh water (drainage, rain)
3. handling of potential food sources and waste disposal
4. regulations for commercial fishing around the airport
5. exclusion measures
6. continuous bird patrol
7. pyrotechnics and bioacoustics
8. shooting
9. discouragement and destruction of breeding attempts (zero tolerance)

With respect to the rather unique situation of an airport, several aspects will require more research. Also, other aspects deserve interest that are usually not or less relevant in the case of an airport inland. A number of aspects can be mentioned in this respect (some of which are already subject to current studies):

1. preferred distance from the coast with respect to migration patterns and attracting coastal birds
2. behavior of birds (gulls) at and around Egypt
3. sea-migration patterns around Egypt
4. effects of creating nearby Egypt attractive to birds, to keep them away from the airport island
5. design of the Egypt with respect to birds migrating across the sea
6. field tests on the development of (preferred) vegetation under coastal conditions
7. minimising the creation of sheltered bays or lagoons
8. exclusion measures along shores, buildings and at sheltered sites on and around Egypt

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