# WHAT EFFECT DO AIRPLANES HAVE ON BIRDS? – A SUMMARY

Norbert Kempf and Ommo Hüppop,
Institute for Ornithological Research, Helgoland Ornithological Station

No one will expect this short question to produce an equally short and simple answer. The diversity of animal species and individual situations results in a wealth of barely classifiable and predictable responses. Outside in wild a lot of individual events can be observed that often appear contradictory. And opinions on the implications of a conflict between protection of birds and air traffic are correspondingly divergent. Representatives of authorities and associations nevertheless frequently expect a decision that is brief and unequivocal as possible. Attempts are often made to quantify and predict the effects of air traffic on birds in expert appraisals. The plethora of local individual situations and the different approaches to studies lead to results that are barely comparable with each other or generally capable of extrapolation.

Against this background, the results widely scattered in publications and the "grey literature" (appraisals, dissertations etc.) have been compiled and their variability and identifiable universally applicable correlations have been presented. In this article, an earlier publication (Kempf & Hüppop 1998) has been partly updated and summarized on the basis of new developments and findings.

## Why do birds react at all to flying objects?

Almost all species of bird have to live with the threat of dangerous predators swooping on them out of the sky. The fastest possible escape flight as soon as a predator appears is the only sensible reaction in many cases. In the process, mistakes may also occur, so that birds respond to the sudden approach of animals that are essentially harmless by suddenly flying off.

Airplanes can also prompt birds to take flight, even though the aircraft do not appear as predators. In experiments on birds with different dummies, it was found that escape flight reactions are the natural response to all flying objects. Fear of dummies used many times quickly subsided, but not their attentiveness towards them. Individual features of the flying object, such as shape, size, angular speed etc., are of differing significance as trigger mechanisms. But since wild animals react to enemies according to a complex system, virtually no useful rules can be derived from this for air traffic.

## What kinds of reaction occur?

When an airplane appears, all possible levels of excitation are described in birds, from outwardly non-visible physiological reactions to protection, ducking, increased calling activity, restless pacing back and forth, running away, flying off and returning to the same place or a place close by, flying off and leaving the area, right through to panic-like flight reactions.

In addition, during the breeding period, various predatory species of bird repeatedly carry out **pseudo-attacks** and also genuine attacks on gliders, hang-gliders and paragliders. Curlews sometimes launch vicious attacks on model aeroplanes that fly over their breeding grounds, which can also lead to accidents.

Waterfowl which take to the air because of an airplane usually stay in the air for one to three minutes, but sometimes also considerably longer. After this, it takes some time before the birds calm down again and resume their previous activity.

Using modern electronic instruments, it is possible to measure the heart rate of brooding birds. Measurements show that these birds often react to the appearance of airplanes with a marked **increase in heart rate**, in other words they become nervous, even if no outward reaction is visible.

It thus becomes clear that the loss of time immediately associated with taking flight is not the only effect of an airplane on birds which has to be taken into account.

**What are the effects of these reactions?**

A crucial question that needs to be answered is the extent to which effects can be anticipated on individual life expectancy, reproduction rate and ultimately on population size.

- First of all, any reaction leads to **changes in energy conversion.** In species which fly a lot (e.g. swallows) the energy conversion during flight increases only to three times the base energy conversion, in poor flyers or at high speeds (e.g. in ducks) it sometimes increases to more than 20 times the base figure. In the case of escape and attack flights of e.g. waders of wet meadows, it has to be assumed that the energy consumption corresponds to twelve times the base energy conversion. Even when there is no outwardly visible excitation, the heart rate may show a fifteen-fold increase and energy consumption may at least treble even without physical activity.
- In resting snow geese, it has been found that the **time of food intake during** the day may be reduced by up to 51 % if they are disturbed. Brent geese which are frightened every 30 minutes by aircraft or people must spend 30 % more time feeding compared with birds of the same species in less intensely disturbed areas. When the period of daylight and other resources are limited, it is not always possible to compensate for such loss of time.

Disturbances can thus influence the time and energy budget of birds and hence, for example, the ability to lay down fat reserves for migration and breeding. In many species there is documentary evidence to indicate that breeding success depends on the available energy reserves at the start of the breeding periods. Birds try to make up for the energy deficits that come from constant disturbances by feeding at different times of the day, by feeding at the expense of other activities, e.g. preening, by increased feeding rates or by increased risk taking. Even if it is hardly possible to provide any direct evidence in methodological terms, it becomes clear that individual life expectancy and reproductive capacity may be impaired.

Disturbances can also lead directly to expulsion and thus loss of territory for certain species of bird. In geese, a rate of more than two disturbances an hour can lead to a decrease in the bird population in the area concerned. Breeding birds may for example be driven to the edge of their territory or out of their territory altogether by aircraft, which has obvious consequences for feeding and breeding success. In some cases, breeding areas are abandoned altogether for this reason. Many bird species in Central Europe have been reduced to small scattered populations as the result of a deterioration and decrease in habitat. Thus even the slightest additional damage can lead to further decreases.

## Which birds react to airplanes?

- Most reports on disturbances by aircraft concern ducks and waders (plovers). Geese are particularly sensitive to airplanes. Aircraft disturbances are especially striking in those places where the birds gather in **large *swarms***, in our case especially in the area of the Wadden Sea.
- In the literature, negative effects of aircraft **at breeding time** are documented in particular for meadow-breeding waders (including curlews, godwits and lapwings) in relation to model aircraft. Flight reactions of breeding lapwings to powered airplanes have also been documented. In the case of breeding waders (Limicolae), however, air traffic with powered airplanes – in contrast to model aircraft – and low-flying ultralight aircraft (up to 1994, see UL article) – lead more rarely to visible reactions.

The fact that the interests of meadow birds and air sports in particular often come into conflict is explained by their matching “habitat preferences”: expansive, open and as far as possible unwooded areas that are remote from residential districts and are or can be extensively used.

Apart from ducks and waders, disturbed reactions to flight activities have been reported for other waterfowl, great bustards, black grouse, various predatory birds and crows. Particular sensitivity to aircraft is shown by breeding colonies, especially those of larger bird species. For colonies of terns, gannets, guillemots and pelicans, almost complete breeding failure has been documented following just a few aircraft fly-overs.

The group of smaller song-birds has hardly been studied. Apart from in two reports on a military jet exercise and an air display, where some small birds reacted with panic-like flight movements, we did not find any reports in the literature about corresponding behavioral impairments. However, the reactions of small birds are difficult to observe. We know from our own observations that starlings at least frequently take flight in response to airplanes. In wine-growing regions, airplanes are used to drive away starlings.

## How do birds respond to different types of aircraft?

Most studies on the effects of **model aircraft** are primarily concerned with meadow-breeding waders during the breeding season.

- In an area that has already been used by model aircraft enthusiasts for 17 years, lapwings reacted in two-thirds of fly-overs with protection-seeking behavior (in 50 % of cases as a result of powered airplanes), and sometimes also with escape reactions. A strong reaction was found when several sources of disturbance occurred in combination.
- A newly arrived female lapwing showed substantially greater anxiety than the well-established birds. Even if the meadow birds in this study region appeared to have grown accustomed to the model aircraft to a certain extent, the flying of model aircraft still frequently led to disturbances, especially in combination with people and dogs running

around.

- One author measured escape distances from model aircraft of 150 - 250 m for meadow-breeding waders in the breeding area, and 300 - 450 m for resting birds. On three occasions he observed that breeding lapwings were driven from their nests by model aircraft. The escape distances were in the range 130-200 m. As long as the aircraft flying continued, the birds did not return to their nests.
- In studies on curlews in Southern Germany, losses of egg clutches were detected on several occasions as a result of flying model aircraft. The birds evacuated the areas completely or partly during model aircraft flying and often did not return for the whole day. Young curlews hatched more frequently in areas with no aircraft flying activity than in those where model aircraft were flown.
- After a model aircraft site was set up, the curlew population in Isarmoos fell from a maximum of 15 to 3 - 4 pairs of birds. The short-eared owl, Montagu's harrier, snipe and corncrake all migrated away from the area. Since the habitat was progressively worsening at the same time, however, it is not possible to identify the factor that was ultimately responsible for this migration.
- In almost every large curlew breeding area in the southern region of the Upper Rhine there is at least one site used for flying model aircraft. The illustrates the potentially grave consequences of this type of aerial sports.
- One author studied the propensity of model aircraft for perpetually frightening off birds. Remote-controlled model aircraft resulted in a marked frightening effect on almost all groups of birds. Geese reacted most strongly. It was observed that the main advantage of this frightening technique was that no acclimatization effects occurred. Other authors also assume that acclimatization to model aircraft is hardly possible.

It is worth noting that **hang-gliders and paragliders** can induce greater anxiety in chamois goats and ibexes than other aircraft, including helicopters. In some cases, these animals respond with panic-like flight reactions and no longer appear in the same area again for the rest of the day. A corresponding effect in birds has only once been documented, and this was in black grouse. In the aerial sports regions of Oberallgäu, no decline was observed in any members of the grouse family. In the few direct encounters that were observed, black grouse did not flee.

Larger predatory birds may feel disturbed in their area by hang-gliders and paragliders , and pilots even have to expect attacks. The abandonment of breeding grounds or breeding losses appear to be occurring from time to time by golden eagles as a result of disturbances by aerial sports enthusiasts, although it is difficult to provide any direct evidence of a link.

Reports on the marked negative effects of **ultralight aircraft** are essentially attributable to the low-flying practices (at a maximum height of 150 m) that were required by law until 1994.

- There is evidence to show that, on the landing area of Reichelsheim, Hessen, a small brood of black-tailed godwits (over half the population in Hessen) and curlews died out in the 80s as a result of ultralight aircraft activities. On active flying weekends, the district hunting system of the birds broke up. The many years of air traffic with other aircraft apparently had no negative impact.
- The numbers of resting and foraging Bewick's swans in an area of the Dutch delta region declined from 1400 - 4300 in the period from 1986 to 88 to a few individual

birds in 1989 after a take-off and landing strip for ultralight aircraft was installed nearby and had been in operation for a year.

With the flying laws that have also been in place for ultralight aircraft since 1994 (e.g. minimum flying altitude of 600 m above the ground on cross country flights) and in view of the type of construction of modern ultralight aircraft, their effect on wild birds today can probably be regarded as similar to that of powered airplanes.

With normal **glider** operations, disturbing effects on birds are hardly to be expected: Except at take-off and landing, the thermal-dependent gliders mostly fly at a great height. In the literature there are few specific data on the reactions of birds to gliders/motor gliders.

- The flight pattern of gliders with large wing-spans and a slowly gliding flight movement at what is usually a great height does however seem to fit the generalized pattern of an airborne enemy. In a study on breeding and resting birds in the Wadden Sea, the disturbing effect of motor gliders was considerably greater than that of powered airplanes.
- The scarcity of gliders would also seem to play a role here: the only registered motor glider on the Wangeraage during the period of the study triggered the strongest and longest-lasting reaction of all. As soon as the motor glider came into view, all the birds resting on the salt flats – even the usually unruffled gulls and oyster catchers – took to the air, making calling sounds as they circled the area for a long time.
- In the case of black grouse in an aviary used to reintroduce birds into the wild, panic-like flight reactions were observed with the direct approach flight and fly-over of gliders and motor gliders – much more often than in the case of fly-overs by fighter jets.
- Flight reactions of goats to gliders have been reported from the Alps.

The effects of **powered airplanes** on birds have been reported in particular from the Wadden Sea.

- On various East Frisian islands, resting birds showed a reaction to direct aircraft fly-overs in 50 – 90 % of cases. Resting birds reacted more by taking to the air (57 % of reactions) than breeding birds (22 %) (see "What other parameters influence the reaction?"). While there no marked differences were seen in the effects of aircraft flying at low and medium altitude, there was overall a discernible tendency for higher-flying aircraft to cause less of a disturbance than lower-flying aircraft. In a study on the impact of human disturbance on Brent geese, aircraft or helicopters were the cause of geese taking to the air in 26 % of all cases. While helicopters had the greatest impact, the reactions to airplanes were only slightly weaker. No clear difference was discernible between the impact of aircraft fly-overs at altitudes above or below 150 m.
- In a study on the factors disturbing birds at a high-tide sanctuary in the Dutch Wadden Sea, airplanes and walkers were found to be by far the most importance causes of reactions.
- According to a literature review on the disturbing effects on waders in the Dutch Wadden Sea, airplanes were among the most disruptive factors in the Wadden Sea. The authors presented a model which can be used to calculate the area affected by a disruptive object. This model is based on data relating to escape flight distance, the distance within which birds interrupt their search for food, and the time it takes for the

various disturbing effects to disappear again. In the case of oyster catchers, the affected area for a mud-flats hiker walking at a speed of 3.6 km/h is 20 ha and for an airplane flying at an altitude of 150 m over the mud-flats 15,000 ha. This large area is produced with a 1000 m breadth of impact to the right and left, a speed of 150 km/h and a duration of 30 minutes.

- A group of authors observed the flight of breeding meadow birds from powered airplanes in many cases – both at low altitudes (50 - 100 m) and also at very high altitudes (in some cases then very long protection-seeking behaviour). Powered airplanes induced protection-seeking behaviour in half of cases, and model aircraft in about two-thirds of cases.

In terms of the intensity of the impact which they have on birds, powered airplanes lie between helicopters and jet fighters which are used comparatively little, if at all, in air sports. The disturbing effect of military jet fighters on birds is often less than one would expect in view of their rather unpleasant effects for humans. By contrast, almost all authors come to the conclusion that, of all aircraft, helicopters most frequently lead to reactions in birds and at the same time to the strongest disturbance reactions.

Systematic studies on the effect of **free balloons** on animals do not appear to have been carried out to date. In 1996, the Society of Wildlife Biology in Munich (*Wildbiologische Gesellschaft München*) carried out an extensive survey of experiences on this subject among balloonists, hunters, farmers, nature lovers, biologists and others. In many respects, the evaluation suggests a situation similar to that with other flying devices: most balloon rides are carried out without any discernibly negative consequences for animals. To some degree, many different species of bird and mammal show reactions of fear towards free balloons (flying at low altitude). Through a combination with the burner, which may ignite precisely when the animal is already in a state of nervous tension, panic flight reactions are possible with dramatic consequences for the individuals concerned. However, the effects of silent gas balloons is no less marked.

The latest example of an unfortunate incident: a pair of sea eagles which had nested in the Segeberg district for the first time in 2000 suffered enormous disturbance from a landing hot-air balloon, whereupon they abandoned their brood.

**What other parameters influence the reaction?**

Since the visual faculties of birds tend to be essentially far better developed than their auditory faculties, they respond less to noise than is generally assumed. Silent flying objects can induce reactions similar in intensity to those induced by noisy aircraft. However, visually comparable loud airplanes on average induce more and stronger reactions in birds than quiet ones.

- In breeding bald-headed eagles in North America, the parameter of noise (in contrast to distance or duration of visibility) played no role in disturbances caused by aircraft.
- In a study on a colony of terns, it was not until jet noise reached 90 and 95 dB (A) that two and four percent, respectively, of the birds took to the air, and a further four percent showed a fright reaction.
- With motorized model aeroplanes, it is above all the irregular changes of volume and frequency that play an important part in the disturbance effect.

There are more conclusive findings on the influence of **flight altitude** than there are on the influence of noise volume, but these findings are rarely based on measured altitude data.

- In one expert appraisal on military air traffic, the altitude of helicopters was calculated from distance with reference to land markings and from the angle. The frequency of bird reactions was clearly dependent on the altitude of the helicopters (at 50 – 80 m there was a reaction in 83 % of cases, at 120 - 150 m in 56 % and at 200 - 300 m in 27 %). But strong reactions were still induced even at greater altitudes. This is confirmed by various other authors.
- Brent geese in Alaska reacted in 68 % of cases to airplanes flying at altitudes lower than 610 m and in 33 % to higher flying aircraft (altitude calculation via land markings, experimental fly-overs and listing into radio communications).
- In two literature reviews for the Wadden Sea, it is concluded in the summary that effects on birds are very marked at altitudes below 500 m (1700 ft) and decrease substantially above this altitude.

The disruptive effect of an airplane depends on the **lateral distance** of the fly-over.

- In various studies, the frequency and intensity of the reaction decreased in inverse proportion to the lateral distance. From 700 to 1000 m upwards, no birds took to the air.
- Geese, however, flew off up to a lateral distance of 1.5 km. The first unrest at the approach of an aircraft occurred on average at a distance of 2.6 km.

In general, it can be said that an airplane travelling at high speed in a straight trajectory has less impact on birds than a slow airplane flying in a curved trajectory.

A stronger reaction is often observed in combination with several sources of disturbance **(stimulus summation)**. Such a situation frequently occurs precisely in those places where air sports attract spectators: flying model aircraft, flying sites for hang-gliders and paragliders and also in areas around airfields, day-tripping activities, people walking and dogs off the leash can cause additional disturbances. The stress caused by people seeking relaxation produces stronger and longer-lasting reactions to airplanes in birds than are seen at times when there are no such leisure activities. Conversely, air traffic, even if it does not cause birds to take to the air, can lead to a substantial increase in the distance of the animals' escape flight from humans.

Some **stimulus-independent factors** also affect the reaction of a bird. For example, breeding birds are inhibited from leaving the nest and for this reason alone react differently to disturbances. The willingness of parent birds to take risks may increase in the course of the day or with advancing incubation and rearing of chicks. Weather and season can also play a role. During the wing moulting period, when they are incapable of flight, ducks show substantially greater sensitivity in their reactions to airplanes than at other times. Birds in relatively large swarms tend more towards escape flight reactions than groups of a few individuals. In mixed groups, species may influence each other in their reactions. In the Wadden Sea, the birds are substantially more sensitive before high tide than after high tide.

**Do birds become accustomed to air traffic?**

Almost all authors report on habituation effects. It would seem that the frequency and above all the regularity with which an airplane flies past have a decisive influence on the reactions of birds. This is especially striking during military exercises or in the vicinity of airfields, where bird species that are regarded as sensitive can also be found.

- The same bird species which developed a certain tolerance to air traffic on Wadden Sea islands that have an airfield showed considerable flight reactions to comparable fly-overs on Mellum, where there is no airfield in the vicinity.
- Rare types of aircraft in a certain area also produce conspicuously strong reactions.

These correlations provide an explanation for the different results, e.g. with regard to critical flight altitudes, in the various studies or for unusual observations that contradict the results of most other studies.

But there are limits to the capacity for habituation. The uneven and unpredictable movements of model airplanes and to a certain degree also of gliders, hang gliders and low-flying trikes do not generally allow any habituation. In sensitive species (e.g. resting curlews or Brent geese) even regular air traffic does not lead to a greater degree of tolerance. At least some bird species or individuals react to heavy air traffic by leaving the area, and no habituation takes place. If only insensitive birds are then observed, there is a tendency for this to be confused with habituation.

**Demands of nature conservation**

- Many authors recommend **maximum possible flight altitudes** for airplanes to avoid disturbances of birds or mammals. The minimum altitude figures here range between 150 and 750 m. Most experts recommend a flight altitude of at least 500 m.
- In various projects, there was also seen to be a need for an **adequate lateral distance.** Depending on the sensitivity of the animals studied, this minimum distance ranges from one to eight kilometres (for helicopters).
- In several studies, authors demand that air traffic keep to routes and certain areas. A separation into **areas with regular traffic and areas free of air traffic** on the one hand facilitate habituation and on the other effective protect the rest of the landscape.
- In addition to this proposal not to fly over areas with especially sensitive and threatened species, **seasonal or day-time restrictions of air traffic** are recommended where there are specific or local problems. Examples of this are to set flight shows on a date in late summer or not to fly over ice-free places of refuge for waterfowl during periods of frost.

The original article Kempf, N. & O. Hüppop (1998): "Wie wirken Flugzeuge auf Vögel? - Eine bewertende Übersicht" in *Naturschutz und Landschaftsplanung* 30, (l), pp.17 - 28, is based on a review of 161 publications and expert reports. These also list the citations of these studies, which are not given in this short summary.

Dr. Ommo Hüppop, 48, biologist, studied zoology, general botany, hydrobiology and fishing sciences and obtained his doctorate at the University of Hamburg. Since 1988 Director of the Island Station of the Institute or Ornithological Research, “Vogelwarte Helgoland”. Main areas of work: ecology of seabirds and coastal birds, bird migration research, effects of human activities on birds {fishing, disturbances, offshore wind energy plants)

Norbert Kempf, 45, biologist, worked mostly on the North Sea and Baltic Sea since 1983. Main areas of work: ornithological studies, effects of human activities on animals, aerial registration of animal populations, appraisal of nature conservation conflicts