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Effects of Fireworks on Birds – A critical Overview

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A critical overview of the effects of fireworks is provided based on observations of 133 fireworks with 272 documented species-reactions. The occasion for this study arose from individual observations which hinted at such effects, but whose meaning nevertheless could not be assessed due to the lack of a general overview. The observations were compiled using internet and database research as well as surveys among birdwatchers. These were then subjected to critical evaluation in order to determine the likelihood that such effects were the result of fireworks.

70% of the observations came from Germany (primarily chance observations), 18% from the United States of America (to a high extent from planned observation and monitoring) and the remainder came from the Netherlands, Switzerland, Austria and a few other countries. In the portion from Germany, observations came from almost all of the German states – though the southern states of Germany are somewhat underrepresented.

The observations are divided among 88 taxa (species or higher taxa) from different taxonomic or ecological groups (waterbirds s.s., cormorants, geese, Lari families, big wading birds, birds of prey, owls, gamebirds, oscine families and woodpeckers, crows and pigeons). The three most prominent species were the greylag goose, the white stork and the common crane.

Traditionally, fireworks are lit to celebrate the new year, national holidays or large events – though there is an increase in private use (including association celebrations) or for commercial purposes. National firework traditions also vary greatly. In Germany, the legal basis for fireworks is regulated by the “Erste Verordnung zum Sprengstoffgesetz” (1. SprengV, First Ordinance to the Explosives Act).

Disturbance - stimuli and general effects

Lighting fireworks in the environment of wildlife represents a human-caused disturbance stimulus, which – depending on the type of firework, exposure, distance and time of year as well as the species-specific and individual sensitivities of the exposed species – can have varying disturbance effects. Birds react to the visual stimuli (flash and light “storms”) as well as to the acoustic stimuli (muffled to loud bangs, shrill whistling sounds, etc.) of fireworks.

For some reactions, visual stimuli played only a minor role, particularly at greater distances when noise from the fireworks could barely be heard. However, even at shorter distances, a primarily visual stimulus (for example, signal rocket) can cause reactions up to physical flight. The main effect here though is the surprise effect caused by the sudden flash and light “storm”, which is different than a meteorological storm that birds can detect beforehand due to its slow approach and the drop in air pressure.

Unlike continuous noise, which birds often get habituated to, the acoustic stimuli of fireworks often produced strong reactions and even panic. In 21 cases, the disturbances were primarily acoustic in nature (compared to 4 cases in which the disturbances were primarily visual). This matches observations that sonic booms and other sudden noise events often lead to startle reactions – though waterbirds apparently react more sensitively than birds of prey and mammals. Strengthened reactions were also observed during hunting season, so that one can assume – at least in part – that the birds associate the disturbances with hunting.

The manner in which birds are disturbed by pulsating bass, sonic booms and deterrents using pulse detonation technology make it very likely that birds perceive even the pressure waves from firework explosions as a disturbance stimulus and find this unpleasant and perhaps even painful. This perception may occur via the paratympanic organ in the inner ear or via the air sacs. Habituation to the pulse detonation technology apparently does not occur– which matches the observation of no habituation to fireworks.

Disturbance stimuli must cross a stimulus threshold before they lead to a reaction. The stimulus threshold is species-specific (e.g. physiology, ecology, adaptation to predation, etc.) and individually determined (e.g. learning through experience, habituation, etc.), thus leading to more tempered or heightened reactions. However, it seems to be questionable, whether the stimuli created by fireworks represent adequate disturbance stimuli sufficient for expedient biological reactions or whether these are not simply achieved as a result of their high-threshold nature and surprise effect. The simultaneous appearance of various types of stimulus from one and the same source of disturbances (summation) or of identical types of stimulus from different sources (cumulation) have an increased negative effect according to other authors.

A series of similar disturbance stimuli and an increase in the rate of disturbances led to sensitizing and, thus, stronger disturbing effects. Repeated disturbances often led to increased evasion and even to complete abandonment of the area. Typically, the individual and species count sank.

The intensity of the disturbance stimulus determines if it crosses the stimulus threshold: This essentially depends on the height, the volume, and the distance of the fireworks as well as on their perceptibility at the place of disturbance. Shielding structures reduce the strength of the reaction, while reflecting (buildings, dunes, hills, etc.) or sound-carrying structures (water surface) increase it. The height and volume of the fireworks of course depend on the type of fireworks. Large fireworks reach greater elevations, use larger explosive charges, and thus achieve greater intensity as well as create greater disturbance effects. On average, small fireworks or German New Year's fireworks (Silvesterfeuerwerke) had an effect about 5 times as far as firecrackers or bangers, while large fireworks had an effect twice as far as small fireworks or German new year's fireworks.

It cannot be demonstrated with certainty that birds of prey are less susceptible to disturbance than other birds. Single observations, however, seem to support this. Beyond this, the disturbance effects from fireworks were significantly stronger in open country than in the woods. It remained, however, unclear if this is due to the ecologically-determined higher sensitivity of the species in open land or if the open land increases the intensity of the disturbance. Birds that breed in colonies were more sensitive to disturbances during breeding season than the other species studied. All species groups were less affected during winter, presumably because they are in their energy-saving mode.

Direct damage, disturbance effects and consequential damage

Intentional or unintentional direct hits on birds by firework materials have only been documented on rare occasion. Only in individual cases has it seemed sufficiently clear that fireworks were the clear cause of the bird's death or injury. Several case studies and entries in internet discussion forums indicate that such occurrences take place more often than usually thought. In particular, one must assume that intentional targeting with fireworks occurs often. In individual cases, the killing or burning of the animal have been proven. The incidence of hearing damage as result seems unlikely due to the special anatomy of bird's ears. There is no information concerning other damage due to explosion pressure, eye damage or damage by residues of combustion.

Typically, a disturbance stimulus leads the bird to stop its behavior up to that point and instead brings it to a state of vigilance or causes further disturbing effects. However, this is not always an outward reaction. The few studies available on this topic prove physiological reactions (e.g. increased heart rate, hormone release, and other metabolic reactions) and that fireworks cause a stress for the bird, even if they show not a larger reaction (bodily activity, flight, etc.). For partridges, just being woken up at night causes them to use about 5% more of their energy. For a griffon vulture, the heart rate increases from 50 to 170 beats per minute – something which ordinarily only occurs at maximum physical strain.

For the simplest and weakest cases, outward signs of anxiety and fear involve changes in body posture. There is ample proof of increased vigilance (noticing, protecting, etc.), warning cries and contact calls (often emitted in flight), backward head motions, running around, hopping back and forth nervously, sitting down or ducking, motions caused by fear (wincing) and intentional movements. There are no case studies involving possible further reactions such as shaking due to fear or displacement activities.

Flight was the most documented phenomenon, and, where possible, a distinction was made between "normal flight" and panic. Due to lowered visibility at night, fleeing birds were often only heard and species that do not call as much were not noticed. Flight because of fireworks does also not only mean the animals flew away. Many species or individuals fled by flying, running or swimming into protective bank vegetation or to areas far off. This is particularly true for non-flying individual animals or young birds that have not yet learned to fly. In extreme cases, these young birds jumped or fell out of the nest (e.g. storks, heron). Flight also contains within it the danger of aftereffects, meaning that the birds hurt or exhaust themselves; in particular, young birds that have not yet learned to fly become easy prey for predators, have accidents or get lost completely.

The greatest danger comes from the aftereffects of a panic, which comprises a third of all documented flights. Compared to other disturbance effects, flocking birds react more often by taking flight and panicking than the remaining species groups, particularly geese and cranes. After panics, the complete or partial count of birds then returned less often than after "normal flight", and the length of the absence and anxiety was longer. The percentage reduction was on average longer, and 9 of the 10 documented fatalities were attributable to panics. Wayward birds were found at distances of up to 15 km away.

Seagulls and crows, which are flocking birds too, tend to first fly upwards to gain a literal overview of the situation without initially demonstrating full departure flight tendencies.

New Year’s Eve fireworks are an exception since they occur over a large area. In the Netherlands during such fireworks, weather radar calculates peak density values of up to 100,000 cm^2/km^2. That corresponds to 666, 2000, and 9090 birds scared off per km^2 in the goose, duck, and small bird size categories, respectively. The birds also flew up to greater heights (as much as 500 meters) than they flew during their normal daily flights. Densely populated areas (in other words, where there are lots of fireworks) in some cases were completely abandoned.

As a result of flight or panic, birds can become disoriented (due to poor visibility, night, fog, etc.), fly into obstacles (buildings, power lines, trees, etc.) and injure themselves or even die. Here, again, it is the flocking birds that are particularly at risk. Single cases have been documented with up to 5,000 fatalities. There is also evidence of white storks being injured or dying as a result of fireworks.

Reproductive success also may be reduced as a result of flight. There are case studies in which the nest was given up or the adult birds returned to the nest so late that the unprotected brood fell victim to weather conditions or predators. The brood can also be damaged during flight, such as when eggs or young are unintentionally pushed out of the nest or crushed in the nest. For cormorants, the loss of young was up to 30 times higher and up to 83% of its total nest loss was determined to have occurred on the night of the fireworks; for heron, the loss of young was much less pronounced. The mortality risk for young birds also then increases when contact with the parental flock – within whose structure the acquisition of food, social behavior and traditions (e.g. roosting sites during migration) are taught – is lost during flight. Observations of these were made among waterbirds and cranes.

Independent of these short-term effects, flight decreases the fitness of individual birds, thus weakening them and making them more susceptible illness or parasites. Due to the loss of time and habitat – that undoubtedly arise as a result of flight –, they also lose sleep for recovering and time for feeding in order to regain energy. The scale of the forced change of place becomes clear when examining those that return after flight or panic: Only in 10% of cases (of 182) did the frightened birds completely return, in 59% of cases they did so partially, and in 30% of cases they did not return at all. This inevitably leads to a deterioration of the animal’s energy balance since flying (for geese) consumes about ten times more energy than dietary intake and about twenty times more energy than the basal metabolic rate; changes of location of up to 15 km were observed as were climbs to higher than usual elevations. But the stress alone causes an increase in energy needs. The additional energy expense was calculated into the needs for a day stage on a crane’s flight towards France. In such times with high energy needs and a simultaneously poor food supply situation, this can lead to an emergency situation that is life threatening.

There are, as of yet, no studies on the effects of fireworks on the population. While individual fireworks in many cases have a negligible impact on populations, the use of extensive fireworks across a wide area, such as is the case on New Year’s Eve in densely populated Central Europe, can lead to population losses. The results of this overview demonstrate that, in varying ways, fireworks increase the risk of mortality for individual birds and, thus, the death rate of the bird population. For populations with an unstable conservation status, negative trend or small population size as well as for sensitive species types (birds that flock or breed in colonies), the conservation status can worsen.

Conclusions

Conclusions and possible consequences are briefly sketched for the handling of fireworks in Germany. The “Bundesnaturschutzgesetz” (German Federal Nature Conservation Act) and “Tierschutzgesetz” (Animal Welfare Act) must be consistently applied in cases where animals are intentionally killed or injured. Despite considerable unknowns regarding the dimensions of the damage for small birds, for the present it is assumed that no regular, significant disturbance by fireworks occurs to common and widespread species. Minimum distances from nest locations are specified for species that are rare or endangered as well as for species that are more sensitive to disturbances and breed in colonies.

For resting areas of international importance, no more than 1% of the area may be affected by fireworks; for areas of regional or national importance, this may be no more than 10% of the area. A minimum distance of 1000 meters is also to be maintained around areas for flocking birds – regardless of the protection status of the species and the area. Particularly for sensitive species, such as the crane, an increased minimum distance of 2000 meters is to be maintained. If reflecting structures exist around the resting areas (e.g. buildings, hills, cliffs and dunes) or if water or other sound-carrying surfaces exist between the resting area and the launching area for the fireworks, the minimum distance must be doubled – and the same applies during hunting season. Power lines must not run within a radius of 1000 meters from the resting area and the launching area for the fireworks.

When approving fireworks, the spacial and temporal effects of the firework display on the environment must be considered. The time interval between 2 firework displays at the same site must be at least 4 weeks, and the physical distance between 2 firework displays on the same day must be at least 10 kilometers. Authorities could increase control of fireworks by implementing regulatory measures (e.g. in national parks and bird conservation areas as well as in the area of bird breeding colonies and bird roosting sites). Extremely loud explosion effects (flash crackers, etc.) and percussive charges along water, along the coast, near protected areas, breeding colonies and roosting sites must be eliminated.

The effectiveness of the measures must be monitored through random spot-checks and then improved as necessary. It must be noted here that simple before and after counts are not sufficient. In every case, the counts must be combined with observations during the fireworks and, as possibilities permit, supported by technical means (night vision devices, video recordings, photography, camera traps, etc.).