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With the 'spider's web effect' and UV-absorbing material against bird-death on transparent and reflecting panes

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Abstract

Every year there are millions of collisions between birds and transparent or reflecting glass panes. Previous methods of protection are ineffective because they do not prevent birds from colliding with windows or they are unacceptable from the esthetical point of view. As birds can see ultraviolet (UV) light very well, it could be useful to stain glass panes 'bird-coloured' with pattern of transparent UV-absorbing material which could warn the birds against colliding with the pane. Web spiders protect their webs by the same effect against destruction by birds. That's why we call it 'spider's web effect'. Power supply systems, windmills and airports will become safer, too. These patterns for men are invisible, because they can't see UV-light. Therefore we suggest to do experiments to protect birds based on the 'spider's web effect'.

Zusammenfassung

Jährlich verunglücken Millionen von Vögeln an transparenten oder spiegelnden Glasflächen. Die bisherigen Schutzmöglichkeiten wirken nicht befriedigend oder sie sind ästhetisch nicht akzeptabel. Da Vögel sehr gut Ultraviolett (UV)-Licht sehen, könnten solche Scheiben mit Mustern aus transparenten UV-Absorbern "vogelbunt" gefärbt werden und so die Vögel vor Kollisionen warnen. Mit dem gleichen Effekt schützen Radnetzspinnen ihre Netze vor Zerstörung durch Vögel, daher nennen wir es "Spinnennetz-Effekt". Auch Stromnetze, Windmühlen und Flughäfen könnten so sicherer gemacht werden. Für Menschen sind diese Muster unsichtbar, weil sie UV-Licht nicht sehen können. Deshalb schlagen wir Untersuchungen vor, Vögel mit dem "Spinnennetz-Effekt" zu schützen.

1. A question for nature conservancy, animal protection, technology and architecture

Every attentive observer knows bird-death caused by transparent or reflecting surfaces of windows, winter gardens, greenhouses, bus stops, passageways, facades or facilities for noise- and those for wind-protection. Even birds which survive the collision for the moment often die later because of inner injuries. A lot of species are concerned. According to OTTO (1994) the following 60 species were found in the rediscovery file of ringed birds of the Hiddensee ornithological station:

Barn owl	Greenfinch
Bearded tit	Grey wagtail
Blackbird	Hawfinch
Blackcap	Hawk
Black-headed gull	Hedge sparrow
Black redstart	Jay bird
Blue tit	Kestrel
Brambling	Kingfisher
Bullfinch	Lapwing
Chaffinch	Linnet
Coal tit	Long-eared owl
Common buzzard	Magpie
Common gull	Marsh tit
Crested tit	Marsh warbler
Dipper	Moorhen
Garden warbler	Nuthatch
Garganey	Oyster catcher
Goldcrest	Penduline tit
Great reed warbler	Pied flycatcher
Great tit	Red-backed shrike

Redpoll	Stock dove
Redstart	Swallow
Reed warbler	Swift
Ring ouzel	Teal
Robin	Tree creeper
Sand martin	Wagtail
Short-toed tree creeper	White stork
Song trush	Willow warbler
Sparrowhawk	Wood warbler
Spotted woodpecker	Yellowhammer

Herewith this list is by no means complete, because not all species are ringed. This fact is also shown by other authors and our own experience. Other victims are e. g. collered turtle dove, crossbill, cuckoo, fieldfare, golden oriole, goldfinch, green woodpecker, house sparrow, meadow pipit, siskin, starling, tree sparrow, woodcock and wren. The total number of the bird species affected might be at least 80 - only in Germany. KLEM (1989) found specimens of 225 different species killed in accidents in the USA and Canada. This means 25 % of the stock of all bird-species there.

The exact number of birds died through transparent and reflecting panes is unknown, but spot checks and estimated numbers do exist and show a horribly high number. For the USA KLEM (1979) estimated the number of bird-deaths to be at least 97.6 millions a year. It could be ten times more because of the high number of undetected cases. The number of bird-deaths in Europe should be on the same scale. Therefore we face a huge problem.

Surveys made with 51 owners of buildings, mostly detached houses, but also kindergartens, public schools and companies, show that bird-death on windows is commonly known and that suggestions for practicable solutions meet with general approval. That’s the reason why nature conservancy and animal protection as well as technology and architecture are asked to find solutions. We should design transparent and reflecting surfaces that are harmless to birds as well as to humans.

2. Why do collisions happen and how could we prevent them?

It’s presumed that birds cannot discern transparent panes and that birds are deluded by reflections. There is no effect of learning (KLEM 1989). Especially coated glass can reflect the surroundings in front of it almost perfectly. On slide-photographs You are hardly able to tell the difference between the original and the reflected image (BUER 1996). Under these circumstances and if birds view in a way similar to ours, collisions are inevitable.

Effective precautions should make transparent and reflecting surfaces identifiable for birds as an obstacle. Measures known up to now are summarised in the leaflets ‘Merkblatt zur Verhütung von Vogelverlusten an Glas’, Deutscher Bund für Vogelschutz (OTTO 1994) and ‘Vogelkiller Glas’ (Tips zum Vogelschutz, Schweizerische Vogelwarte und Schweizer Vogelschutz SVS-BirdLife Schweiz). The best-working solutions mentioned there are narrow, vertical strips of cloth, fixed on the outside of windows with distances of about 5 to 10 cm or similar sticker strips. Covering the windows with nettings has the same positive effects. Widespread, raptor-shaped, black or white stickers are nearly completely useless. Red reflecting film seems to be better. All of these precautions have in common that they reduce the transparency of glass, spoil aesthetics and therefore are refused frequently.

3. The viewing physiology of birds as a new approach to solve this problem

We can possibly avoid this conflict of aims, if we work with markings, which are visible to birds but invisible to humans. As birds can see UV-light, UV-absorbing markings, which are transparent and colourless for our eyes, should be suitable for warning birds of collisions. These markings would be invisible to humans, because humans cannot view UV.

We can see light with wavelengths between ca. 400 nm and 750 nm. This range contains the rainbow colours violet, blue, green, yellow, orange and red. Our eyes are especially sensitive at the wavelengths of 440 nm, 530 nm and 590 nm. We perceive them as blue, green and red. We can find three specialised cone-types in our retina for these three wavelengths. Light with wavelengths below 400 nm is absorbed by our eye lens and by protection pigments in our eyes. Therefore it's invisible to us.

Birds can additionally view ultraviolet light (UV). In accordance to this, they have a fourth cone-type in their retina, which reacts especially to UV-light. The eyes of the pekin robin (*Leiothrix lutea*) which is very well trainable, are especially sensitive at 370 nm (UV), 460 nm (blue), 530 nm (green) and at 620 nm (red) (BURKHARDT & MAIER 1989).

UV-vision was first discovered with the white-vented violet-ear (HUTH & BURKHARDT 1972) and then with doves (WRIGHT 1972), which are especially sensitive between 325 nm and 360 nm (KREITHEN & EISNER 1978). Examinations with zebra finches have shown, that changing only one amino acid, serin instead of cystein, is enough to transform the violet light receptors into UV receptors (look up BRENNICKE 2000). Therefore in the biology of evolution it's only a small step towards UV-viewing. Thus BURKHARDT (1989) mentions 30 species from 6 orders for which UV-vision is proved. In 1992 he comes to the conclusion: 'Nowadays we have to presume that birds perceive the ultraviolet range of daylight as a separate quality of colour.'

For our problem it is especially remarkable that *Leiothrix lutea* reacts five times more sensitive to UV-light with a wavelength of 380 nm than to green light with 530 nm (BURKHARDT & MAIER 1989) and even 30 times (!) more sensitive to this UV-light than to red light with a wavelength of 620 nm (BURKHARDT 1992). The widespread opinion that birds see red especially well because of red fruits eaten by birds and red blooms visited by birds has to be supplemented: Birds view UV even better!

Bird feathers reflect or absorb UV-light in a specific way, which depends upon species and sex (BURKHARDT 1989). The dimorphism of sexes of the great hornbill is visible to human eyes, but it becomes more obvious in UV-light (BURKHARDT 1989). The red chest feathers of male bullfinches reflect UV-light considerably. Superficially seen, both sexes of blue tits and many other bird species seem to be identical for our eyes. This should lead to chaotical conditions when these birds search for mates. But in UV-light the dimorphism of sexes becomes strikingly visible with blue tits as well. Male specimen can be identified at a glance (ANDERSSON et. al. 1998, HUNT et. al. 1997, GUILFORD & HARVEY 1998). For zebra finches distinctive marks visible in UV are important for the choice of a sexual partner, too (BENETT et. al. 1996, HUNT et. al. 1997). Kestrels (*Falco tinnunculus*) use UV-reception for hunting. Urine and faeces of mice reflect UV near 340 nm. Because mice soil their passways with their excrements, kestrels can make out from high in the air if the passways are used and if it's worth rattling over the area. The rough-legged buzzard (*Buteo lagopus*) uses UV-reflection of mice excrements for hunting, too (VITALA et. al. 1995). For our considerations it's important that only the contrast between the UV-reflection of the excrements and the UV-absorption of the surrounding area makes the passways visible for raptors.

On the whole birds use their UV-ability for searching for food, for identifying members of their own and of different species and for finding sexual partners. Therefore it is of basic importance for survival and it must work reliably even under poor conditions. UV-absorbing material should be discerned by birds accordingly well.

The intensity of UV-radiation is fluctuating strongly near the ground. It depends upon geographical latitude, altitude, season, time of day and vegetation. In winter, in high latitudes, under cloudy sky, below trees and in the morning- and evening-hours UV-radiation is rather low. Nevertheless birds should also be able to discern this dim UV-light because of the surprisingly high UV-sensitivity of bird eyes.

4. The 'spider's web effect'

According to EISNER & NOWICKI (1983) the webs of web spiders are avoided by birds and thus protected against destruction. So their webs should be visible to approaching birds (OTTO 1994). It's proved that the webs are not only passive catching devices but owing to UV-reflection they actively lure insects which can also discern UV-light (WICKELGREN 1989, FOELIX 1992). Simultaneously, the UV-reflection of the spider's threads protects the web against the destruction by birds which can discern

UV especially well. In this way birds, additionally, protect their plumage from tiresome, sticky threads. Primordial weaver spiders build their gossamer only for the protection of their eggs. Interestingly enough, these gossamers don't reflect UV-light, which is equivalent to a camouflage against hungry birds. In the course of their phylogeny web spiders must have apparently solved the problem of birds colliding with their webs by UV-reflection of their web threads. This phenomenon was also assumed by KLEM (1989).

But in our opinion the web threads can certainly only attract attention because the background of the web absorbs UV-light. Window glass actually reflects UV as well, even though only poorly. Above all, this reflection is on the whole surface and without a contrast with UV-absorbing areas. Consequently it's not identifiable for birds. A pattern on the glass surface, made of UV-absorbing material, which is transparent and colourless for our eyes, should be suitable for warning birds because of the spider's web effect.

5. Birds see colours without UV-A-light

If we want to protect birds from collisions with glass surfaces by using the spider's web effect, we have to consider the differences in the viewing physiology between humans and birds. While our retina has three colour-capable cones, which are each for blue, green and red; birds have a fourth cone-type for UV-light (BURKHARDT 1989, the same 1992, FINGER & BURKHARDT 1993). Humans see uncoloured white or grey, when our three cone-types are stimulated simultaneously by light with the spectral composition and with the same energy density as daylight. In analogy to this and in accordance with BURKHARDT (1992) birds should as well have the impression of seeing uncoloured, white or grey, but only if their UV-sensitive cones are stimulated, additionally.

Humans see colours, when only one or two of our three cone-types are stimulated. Similarly birds should view an object as coloured ('bird-coloured'), if only one, two or three of their four cone-types are stimulated. If e. g. the one of the four cone-types is not stimulated, which is responsible for UV-light, birds see a colour. The question, which colour the birds may see, will perhaps never be answered for us.

The berries of the white cohosh (*Actea alba*) are white for us, because they reflect daylight completely. They, additionally, reflect UN-light, which is irrelevant for us. But in the bird's eyes this UV-light also stimulates the fourth, UV-sensitive cone-type. And only thereby birds see these berries in pure white ('bird-white'). The berries of the mistletoe (*Viscum album*) are white for humans, too. But they absorb UV-light, which is irrelevant for us again. But in a bird's eye the fourth cone-type, which is responsible for UV, is not stimulated thereby. That's why birds don't see the berries of the mistletoe in 'white' but 'coloured' (BURKHARDT 1992).

6. UV-A stains obstacles coloured for birds

UV-light has wavelengths between 100 nm and 380 nm. Short-waved UV-light below 200 nm spreads only in vacuum. UV-A reaches from 315 nm to 380 nm, UV-B from 280 nm to 315 nm and UV-C from 200 nm to 280 nm. UV-B damages the DNA, causes sunburn and skin-cancer, UV-C attacks the DNA and proteins. That makes vision below 300 nm improbable. Additionally, the spectral energy density of daylight, which is important for vision, increases rapidly above 300 nm, and reaches its maximum at 490 nm. In fact the UV-responsible cones of doves have their highest sensitivity at 325 nm and 360 nm (WRIGHT 1972) and those of the pekin robin at 370 nm (BURKHARDT & MAIER 1989). That's why it's presumably enough, if surfaces show UV-A-absorbing patterns so that birds can see them coloured.

For transparent, colourless surfaces the result is that they are only invisible to us if they are permeable for daylight which means for blue, green and red light. If they absorbed e. g. red, the surfaces would appear in the complementary colours green and blue, so turquoise. The question if they let through UV-light or absorb it is without interest for our vision. That's different with birds. For them a transparent surface is only invisible, if it's permeable for blue, green, red and ultraviolet light. If, for instance, the UV-share of daylight was absorbed, for birds the surface would have to appear in the complementary colours and therefore coloured ('bird-coloured'). In the situation of a bird a reflecting surface reflects the surrounding area in front of it true to life only if it reflects not only the light visible to humans but, additionally, UV-A-light. That's the case at least with some of the usual window panes. Collisions are the consequence. If reflecting surfaces absorbed UV-A in patterns, it wouldn't be visible to humans. In comparison with this birds would discern such patterns on the panes as bird-coloured and would be warned.

For these reasons stripes, web-structures and other patterns, which are put on transparent or reflecting panes for the prevention of collisions, should absorb UV-A-light to be visible to birds as an obstacle. If the materials which are used for the production of these patterns are transparent and colourless for us, they stay invisible to human beings. We presume that thus we can use the spider's web effect, the evolutionary invention of web spiders, for the protection of birds.

7. Suggestions for materials and technologies of UV-absorption

Transparent materials which absorb UV-A can be put on glass surfaces as sticker films, varnishes or sprays. Also felt-tips ('bird-protection-pens') should be suitable. UV-absorbing additives in window-polishes, which remain on the surface after cleaning, would be especially handy. After the usual cleaning we also have the opportunity to spray them on the surfaces like graffiti using so-called 'bird-protection-sprays'. But also the effect of the precautions which have been usual until now, like silhouettes, stripes and webs, could be improved with the help of UV-absorbing substances.

We could apply this material to the inner surfaces of double- or multi-pane-glass during the manufacturing process in the factory, as we already do it with other layers for heat insulation. In such 'bird-protection-glass' the layer would be kept away from the influence of weather or window cleaning. So-called museum-glass with UV-protection and glass with vaporised metal-layers could also be suitable. The synthetic material which is used for customary UV-protective-goggles instead of real glass, absorbs UV effectively. A further approach would be electrically conductive panes whose optical characteristics can possibly be controlled in a specific mode, so that they show patterns in the UV-light which scare off birds. The thickness of a glass pane influences the degree of reflection and absorption of photons. The cause for this phenomenon are effects of the quantum-electric-dynamics (FEYNMAN 1992). We might find an especially elegant approach for a solution here. The UV-reflection of ripe sloes is caused by white frost, which in this case consists of diminutive scales of wax on its surface (BURKHARDT 1992). Therefore waxes and nanoparticulars must be examined, too. We can buy special UV-protection-varnishes on the market, also for the protection of works of art. The furniture polish 'Poliboy' uses avocado oil as an UV-protection. 'Frosch' furniture spray, made by Erdal-Rex also provides UV-protection. As kestrels are able to discern the excrements of mice because of a UV-contrast and use this phenomenon for hunting, there must be UV-active substances in the excrements which are visible to a kestrel's eye at least.

'Tinosorb™FR' is a product of the Ciba Specialty Chemicals Inc. in Basel. It's an UV-absorbing substance for the protection of the human skin and makes cotton-fabrics nearly impermeable for UV. On the German market it's available as a washing powder called 'Frosch UV-Schutz-Waschpulver'. The company of 3M has developed a clear 'scratch-protection-film' against vandalism on glass panes of public means of transport. It's sticked on the surfaces by an acrylate-glue, which contains an UV-absorbing ingredient. If required, it can be removed without remains. Actually, this material already fulfils our imaginations of a bird-protection-film.

So called fluorochromes, which absorb visible wavelengths and emit UV-A, could be useful as well. This effect would be an special advantage with only weak natural UV-irradiation. Fluorochromes, emitting in the visible range of wavelength, are already usual ingredients in washing powders today and cause the 'gleaming white' in the black light of discotheques.

Carotinols and flavonols are widespread in plants and are used by them as a guide for bloom visitors and as protection pigments against violent UV-radiation. Carotinol pigments reflect UV, flavonols in comparison absorb strongly in UV. Carotinols are fat-soluble, flavonols are water-soluble. Both mark the way in blooms towards the location of the nectar for nectar-searching insects, e. g. in *Rudbeckia hirsuta*, the black-eyed susan (THOMSON et. al. 1972). Further examples are well-known in the genuses of *Helianthus*, *Eriophyllum*, *Bidens* and *Oenothera*. In *Coronilla* and *Potentilla* UV-absorbers of the group of the flavonol-glysodides which are colourless themselves were found (survey in HARBORNE 1995). Butterflies can discern UV very well. The female caterpillars of the common blue butterfly (*Polyommatus icarus*) take flavonols from the blooms of their forage plants, e. g. from *Lotus corniculatus*, *Trifolium repens* and *Medicago sativa* into their body, deposited as patterns in their wings. These patterns, only visible in UV-light, make them more attractive for males (BURKHARDT 2000).

DNA absorbs UV-light. Under a UV-microscope the DNA in the nucleus of cells appears dark. By this absorption photo products are produced, which link up neighbouring thyminbases in the line and thereby the DNA can be damaged. Pollen are male DNA-packages, which should be transferred to female blooms. For this reason they have to be protected against UV-light for a longer period of time. This is especially important for wind-flowering plants like conifers, whose pollen are exposed to UV-radiation when flying free in sunny, high-pressure weather. Additionally, the exines of the sporoderme contain the extremely durable and robust sporopollinine. This polymerisate of carotinols and carotinolesters absorbs UV and protects the DNA in the sexual cells of the pollen-grain in this way (STRASSBURGER 1998). Following our own experiences, it's interesting as well that on windows, which were covered in pinus-pollen and dust, there were no collisions of birds any more.

Suntan lotions should be another treasure trove for UV-absorbing material. Those are to protect the DNA of human skin cells primarily against UV-B light and therefore prevent sunburn and skin cancer. Usual are for instance 4-MBC (4-methylbenzyliden--Campher), benzophenon-3, homomethyl-salicinate, octyl-methoxycinnamicacidester and octyl-dimethyl-p-aminobenzoeacid.

Along with passive UV-absorbers also active systems for windmills, aeroplanes and airfields to scare off birds, which emit UV in a suitable mode, should be taken into consideration. UV-lamps and corresponding filters respectively are customary but according to our knowledge they have not yet been examined with regard to the protection of birds or aeroplanes.

Whatever material may appear suitable, it has to be especially durable or it has to be applied easily on the glass panes again after cleaning. Wind, rain, fog, moistness, dryness, sunlight during the day, heat, coldness, emissions and cleansers in steady alternation form an aggressive mixture. In the ideal case these materials should attain the lifespan of windows.

8. Considerations and suggestions for examinations

Spider's web effect, UV-absorbing material and the special viewing-physiology of birds are a new approach of thinking. Unfortunately, we can deduce what birds see and what therefore could warn them of collisions only indirectly. Anyway we face many open questions waiting for clarification, e. g.: How strong must the contrasts in the UV-A-range of light be to be conspicuous for birds? Therefore there is no way to avoid careful laboratory tests with trained birds and careful field tests over sufficient periods of time. Only in this way can we understand in the end, if and how we can use the UV-vision of birds to avoid collisions with transparent and reflecting surfaces.

8.1 Laboratory experiments

Sheet-glass panes can absorb, reflect or let pass through UV-light. In most cases, sheet-glass panes show a mixture of these properties. This depends upon the wave-length of UV and the quality of the glass. The actual value of the customary materials of windows and facades (e. g. glass, acrylic, etc.) has to be measured first, because the UV-absorption of the applied protection patterns must be in a sufficient contrast for birds. Here the range around 380 nm in UV-A would be especially interesting, because it's discerned by birds very intensively.

Afterwards the materials mentioned above and possibly other substances and methods should be checked with regard to their UV-properties and if they are technically suitable.

As a next step experiments with tamed birds could follow. They would have to show if and which UV-contrast is discerned by a bird and which patterns are effective. For this we could possibly use the optomotor reflex or tests with panes, which are equipped with piezoelectric sensors for acceleration.

8.2 Field experiments

Field experiments are the acid test, just because in a laboratory we have to restrict the number of examined bird species to one or few. Field experiments should last one whole year at least, because the frequency of collisions also depends upon the season.

A point of essential significance will be how to detect the collisions. As the collisions are not always deadly or not always deadly at once and predators like to serve themselves from the victims, regular inspections are not precise enough for a quantitative evaluation and, additionally, very laborious. But nevertheless they are indispensable, because they are the only way to detect the spectrum of concerned species.

Sensors detecting vibrations should be suitable for the quantitative and, in a restricted way, also for the qualitative analysis of collisions. According to LERCH (2001) we could employ piezoelectric sensors for acceleration connected to an electronic wiring for the evaluation, which could be developed without great efforts. Such sensors could be fixed on experimental panes and automatically detect every collision including the date, the time of day and the intensity. It's conceivable to retrieve its data centrally.

9. Commercial usability

The protection of nature and of animals have extended their importance globally in the recent decades. This is also shown by the interest of the media, by the rising number of members of relevant environmental societies and world-wide acting organisations, by the activities of the UNO, by the programmes of political parties, by the further development of legislation (in Germany even up to the constitutionary level). If we could succeed in transferring the spider's web effect to glass panes and if our method should be effective, we could reckon with a broad attention by the media, by relevant environmental organisations and organisations for the protection of animals and although by politics. This would match a free and especially effective advertising campaign.

In addition, the experience shows that the protection of the environment and animals always makes progress, if it's possible to earn money and create jobs at the same time. The remarkable revenue from donation for the protection of the environment and of animals proves that people are willing to invest money. Especially if it's about the protection of birds, people are generous. Allegedly the Germans spend over 50 millions Euro only for bird seed in the winter (SCHMIDT & WOLFF 1985).

Effective, transparent and colourless bird-protection-markings eliminate the conflict between architecture and bird-protection. So the opportunities for the application of glass are extended, for instance with facilities for noise-protection, passageways, winter gardens and the passive use of solar energy.

No thermo-cracks any more: Dark markings like the usual black silhouettes of raptors warm up in sunlight faster than the surrounding glass. Therefore we have to face thermal tension between the sticker and the pane, which could lead to thermo-cracks. With transparent and colourless material we can get rid of this dilemma in the future.

From our own conversations we know, that people would like to spend one or another Euro for each glass pane to stop the misery of bird-death. For instance in Do-it-Yourself-superstores black silhouettes of raptors (Werga, ∅ 20 cm) are sold in packs of three for 3.50 Euro, though they hardly help. In the area of the former Federal Republic there were 12.8 millions of residential buildings in 1995. Every year new ones are built; in 1993 the number was 235’679 and, additionally, 59'219 non-residential buildings, which means office buildings, buildings for agricultural use, factories, workshops, studios, hotels, restaurants, etc. (STATISTISCHES JAHRBUCH F. D. BUNDESREPUBLIK DEUTSCHLAND 1995). Therefore we deal with low costs for the modernisation per pane but with a remarkable market-volume.

‘Bird-protection-glass’ can be quite a new market-share for the producers of sheet-panes. They already had best commercial experience with the protection of the environment and with the protection of the nature as well. The production of environmentally friendly glass for windows with heat shields, like double- or multi-pane--glass, layers and fillings with gases have meanwhile become fundamental columns of business. In Germany 11 million m^2 sheet-glass were produced only in 1999. Bird-protection-glass can be a new push for this trend.

After all, bird-death on overhead cables is an unsolved problem. For years it has caused serious conflicts between animal conservationists and power suppliers. Actually securing facilities against deadly short-circuits with pylones are usual, but primarily big birds still collide with the conducting wires, because they are obviously not realised by the animals. Our method offers a completely new approach here, too.

Another old problem is the protection of vineyards and orchards against hungry birds. Webs can hurt birds and other animals and small cannon shots get on the nerves of residents and innocent strollers. Silent UV-light of a suitable wavelength e. g. in form of flashes should at least be worth a try.

A rather new terrible nuisance is bird-death at wind power stations. Here the advantages of regenerative generation of energy are in a conflict with the disadvantages for the protection of birds. Wind-energy parks on the mainland and increasingly offshore as well are especially dangerous. Ornithologists already talk about ‘crane-chaffcutters’. Therefore the opposition against those facilities grows, which causes delays and foilings. Furthermore, the degree of effectiveness of dirty rotors is lowered about 50 % especially with lucrative high wind speeds. UV-patterns on the wings or active UV-emissions would probably be helpful here as well.

Not only birds suffer from bird-death on aeroplanes, especially in the areas of airports, but also security is influenced. Here we can also imagine to use the distinct UV-ability of birds to alleviate the problem. Besides passive UV-absorbers we have to think of active UV-systems to scare off birds on aeroplanes and at airports as well.

Considerable interest might also exist in exporting the new technology to other European countries or to the USA. That’s already proved by publications about the topic of bird-death on panes, written by American authors and by activities of organisations for the protection of birds there. Furthermore the protection of birds is an important issue in many other countries and therefore an interesting field for business.

Naturally, realistic estimations first of all depend upon how efficient the new method against bird-death on panes will be and how high the costs of production will be. With a high efficiency and with costs usual at the moment, we assume the turnover for the modernisation of transparent and reflecting panes to be in the two-digit--million-Euro-sphere. The turnover-push should turn out much higher for those producers who enter competition with new bird-protection-glass and therefore do not only aim at the known market but at new fields of application. In any case, this modern technology would also be commercially interesting.

The many millions of our feathered friends, which die on transparent or reflecting panes every year, should be worth a serious examination. With the spider’s web effect and the special viewing physiology of birds we can possibly find another way to reconcile nature and technology.

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