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Protecting birds from power lines focusing on countries of Danube/Carpathian region



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CONTENTS

PREAMBLE

Electric power is still regarded to be a benefit for humankind, but it is also turning to be a threat for wildlife. Transmission and distribution electricity grids are expanding rapidly worldwide, with significant negative impacts on biodiversity and, in particular, on birds. In particular, above-ground power lines still continue to increase in number as well as in area covered. Depending on the type of construction used power poles and power lines may cause fatal injuries for birds. This is particularly true for large birds such as raptors, storks, herons etc. Collisions and electrocutions are still an important, continuing mortality factor of several species of birds, despite to a number of compensatory measures realised worldwide.

The routes of Eurasian migratory birds specifically are concentrated in those regions around the world which at the same time have erected the most elaborate grid of electric power lines. We therefore are called upon to acknowledge the responsibility of the States located in Central and Eastern Europe to minimise the potential risks for many critically endangered bird species. Only in countries of Central and Eastern Europe, including Czech Republic, Hungary, Slovakia, Poland are found as many as 42 bird species as listed in Appendices I and II of the Bonn Convention, that are threatened due bird strikes with medium voltage power lines. Altogether 22 species are already classified as critically endangered by injuries due to electrocution in Central and Eastern Europe (Haas et al, 2005).

Main focus of this publication is concentrated on primary countries of interest situated in Danube/Carpathian region of Europe; specifically: Czech Republic, Hungary, Poland, Romania, Slovakia and Ukraine. Other countries of interest include: Austria, Bulgaria, Bosnia and Herzegovina, Croatia, Germany, Montenegro, Serbia, Slovenia.

Our publication is focusing on discussing problems related to birds and power lines in the Danube/Carpathian region.

1. INTRODUCTION

Around the world, the availability of electricity has become a part of the standard of living. The transport of electricity from the power plants to the users is mainly via above-ground power lines. World-wide, this „wiring“ of the landscapes continues to increase and to advance even into the most remote parts of the inhabited continents. Most powerlines constructed so far pose fatal risks for birds and significantly affect the habitats of large birds (in their breeding, staging and wintering areas) (Haas et al., 2005). Powerlines and other wire infrastructures have been identified as a mortality source for birds for more than 130 years (Derouaux et al., 2012). Bird mortality from interaction with power lines and other electric-utility structures has been documented for over 380 species of birds, with critically endangered and threatened species among those. Some bird species that are active in the vicinity of power lines are more susceptible to collision and electrocution risk than others. Interactions between birds and power lines are a complex mixture of biological, environmental, and engineering factors (APLIC, 2012). Power lines that span water bodies plus 100 meters radius and/or in SPA Natura 2000 sites represent the first priority for the implementation of the protection measures (Ferrer, 2012).

Power lines are only one of numerous anthropogenic causes of bird collision mortality. Others include tall buildings, windows, vehicles, communication towers, airplanes, and wind turbines (Erickson et al., 2005).

Above-ground powerlines pose three main risks or perils to birds (Haas et al., 2005):

- **risk of electrocution:** birds sitting on power poles and/or conducting cables are killed if they cause short circuits (short circuit between phases, or short-to-ground).
- **risk of collision:** in flight, birds can collide into the cables of powerlines, because the cables are difficult to perceive as obstacles.
- **risks and loss of habitat quality in staging and wintering areas:** mainly when aboveground powerlines cut across open landscapes and habitats (wetlands, steppe, etc.).

The risk of power lines for birds is still an underestimated reason of mortality in some countries or areas and the data are either missing or absolutely insufficient. The birds vs. power line issue is dealt within a large number of reports and publications from various European countries. From some countries, only sporadic data were recorded by local experts and wide public. In many countries (such as Germany, Czech Republic, Slovakia, Hungary, Bulgaria) within the Danube/Carpathian region, different methods, efforts and solution for bird safety are under study and under monitoring of efficiency of proper mitigation measures (line marking, insulation of medium voltage poles etc.). But also, in many countries has just got attention recently (Serbia, Romania and Croatia) and the realisation of proper mitigation actions are just developing.

All primary countries of interest situated in Danube/Carpathian region of Europe; specifically: Czech Republic, Hungary, Poland, Romania, Slovakia and Ukraine will be discussed and presented in detail within individual sections of document. For other countries of interest, including: Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Germany, Montenegro, Serbia, and Slovenia, is the bird vs. power line issue following:

In **Austria** one of the first ever successful examples of placing high voltage cables underground has been implemented (Raab et al., 2012). The above mentioned approach rapidly reduced mortality of great bustards (*Otis tarda*) in their West-Pannonian range and consequently contributed to increase of the population, along with implementation of marking of powerlines against collisions in great bustard areas.

In **Bulgaria** also some conservation measures have been already realised: a plan to insulate all powerlines crossing territories of some threatened species of raptors was announced in 2004 and in the period between September-December 2004, altogether 139.3 km of power lines and a total of 1418 electric poles of different designs were under field survey. As a result, 105 bird carcasses representing 22 species were detected. Electrocution was suspected for 77.1% (n=81) of the detected carcasses, while 22.9% (n=24) were suspected power line collisions. Recently, many other projects are following this topic and mitigation measures are adopted by responsible electric companies.

In **Croatia** guidelines for protection of birds from electrocution ware enforced already in 2004. Nest carriers are installed for nests placed at poles of powerlines and nest transfer for that nests is secured. Implementation of anti-electrocution measures has been realised at some powerlines in Croatia.

In **Germany** since 2009 the § 41 of the Federal Nature Protection Law states that newly erected power poles must be constructed such that birds will not be electrocuted . The VDE application rule from 2011 (VDE-AR-N 4210-11) is binding for energy supply companies. On the basis of data obtained in Germany a detailed databases of criticality of bird losses due to electrocution and / or collision with powerlines for the different families of bird species has been developed (Bernotat & Dierscheke, 2016): The catalogue of technical solutions for bird safety on medium-voltage power poles was already set up by German experts for an international initiative, that was accepted by the states of the Bonn Convention in September 2002.

In **Serbia** there were guidelines and law enforcement for powerlines under preparation already in 2004 and conservation activities included installation of nest carriers for the saker falcon (*Falco cherrug*) as well as a study „Safe nest for White Storks“ has been prepared and implemented. In Serbia also a very limited monitoring of electrocution has been recently started in Northern part of the country (Vojvodina Province) where 4 medium-voltage lines with a total length of 12 km has been checked in detail. These data are the first systematically collected data in Serbia so far, and besides that an opportunistic data collection on collisions and electrocutions in the whole of Serbia has been started in 2018.

In **Slovenia** a brochure on bird safety has been prepared. As a conservation measure against electrocution a distance between poles has been increased, but still this approach can not provide protection for birds with large body size. In Slovenia, the transmission system operator (Elektro-Slovenija, d.o.o.) and a nature conservation NGO (DOPPS – BirdLife Slovenija) collaborated on planning and installing bird-friendly transmission power lines.

In **Montenegro** dangerous powerlines are still being used and in **Bosnia and Herzegovina** also newly built powerlines are still posing a risk for birds. For this last three countries the data are either missing or absolutely insufficient.

Aim of this document is joining of approach for countries of the Danube/Carpathian region, to define best practice in elimination electrocution and collisions and address methods which appeared to be ineffective. A prepared document will provide answers on questions raised in individual chapters and from questionnaire prepared by NGO Raptor Protection of Slovakia in frame of the LIFE13 NAT/SK/001272 – LIFE ENERGY project. Subsequently, numerous studies were to leave no doubt as to the alarming scale under certain circumstances of the problem of bird deaths on power lines within Danube/Carpathian region.

2. ELECTRIC POWERLINES

Electric power transmission is the movement of electrical energy from a generating site (power plant, wind turbines etc.) to an electrical substation (transformers reduce the voltage to a lower level) via transmission and distribution power line network to the end customers (Fig. 1).

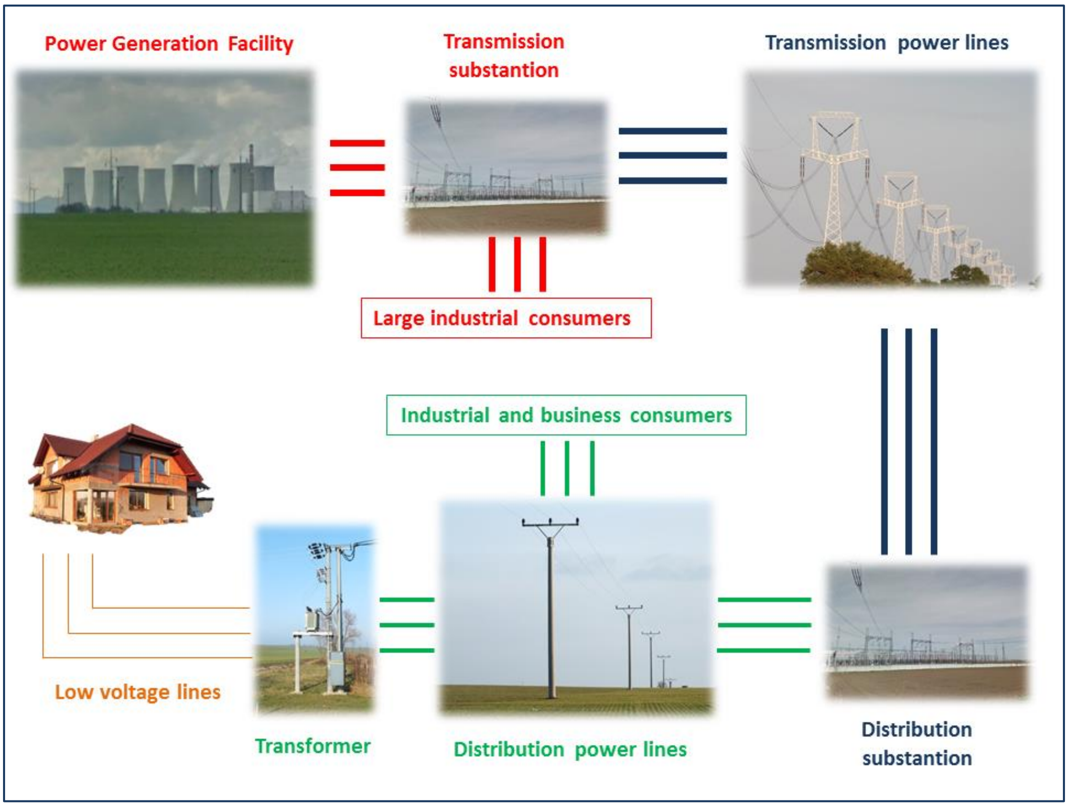

Fig.1 Schematic of the electric power system from the generation facility to the customer

Power lines are rated and categorized, in part, by the level of electrical voltage they carry. In European circumstances powerlines are mostly referred to three basic categories: high voltage, medium voltage and low voltage (Annex 1).

- **High-voltage powerlines (50 – 400 kV)**

High-voltage powerlines, or “transmission lines” carry electricity at high voltages from generating facilities to substations where voltage is reduced. High voltage power lines are in use in all main primary countries of interest.

Transmission lines transport energy from large production centres (thermal, hydroelectric and nuclear power stations, or from renewable sources) to the main centres of consumption (e.g. cities and heavy industry) and to substations, which feed the energy into the distribution lines and thence onto the smaller centres of demand. Even to the most uninitiated in the subject, the differences in the different types of lines are apparent. Transmission lines (Fig. 2) loop between large towers or pylons, over 25 m high, that, aside from the conductors, often have another cable on top – known as groundwires or earth wires – that protect conductors by earthing pylons in the event of being hit by lightning.

Fig. 2 400 kV transmission power line

Due to voltages they carry, these types of lines have long chains of insulators and normally three conductors per circuit, although it is not unusual for lines to carry more than one circuit (double or even triple circuits) (Ferrer, 2012). The large distances between wires generally prevent electrocution risk for birds.

- **Medium-voltage powerlines (15 – 50 kV)**

Medium-voltage powerlines, or "distribution lines" deliver electricity to individual consumers at lower voltages (Bernardino et al., 2018). The pylons on distribution lines are much smaller than those used on transmission lines and are normally only 8-12 m high (Fig. 3). They are made, depending on the country, of metal, concrete or wood mainly as central mast – with metal crossarms (Ferrer, 2012) and in many variations of type and positions of consoles, insulators and exposed jumper wires. In some countries and by some electric utility companies, the whole medium-voltage power network has been laid underground. However, world-wide the majority are still aboveground powerlines. Often, the conductor cables are attached via relatively short insulators to poles constructed of conducting material.

Fig. 3 22 kV distribution power line

- **Low-voltage powerlines (220-380 V)**

In a number of countries is used for connection between a residential or small commercial customer and the utility. Often, low-voltage supply lines use well insulated cables, directly attached to support poles. Collision risk are minimised, because the well-visible black cables replace a number of conductor wires. On low-voltage overhead powerlines, the risk of electrocution is low, because of the relatively low voltage and the high electric resistance of birds (Fig. 4).

Fig. 4 Low voltage power line in one black cable design

- **Other wire constructions**

Overhead powerlines of the railways transmit power at typically 10,000 V to 15,000 V (Fig.5). This corresponds to the medium-voltage range of the electric utility companies, and similar aspects of bird safety must be taken into consideration. Also the railroads use different construction types: beside bird-safe solutions, also „killer poles“ are in use. These different types can be found next to each other. In the past, these dangerous powerlines received little attention (Haas et al., 2005).

Fig. 5 Electric railway power lines

2.1 Energy companies and voltages of powerlines in primary countries of interest

- **Czech Republic**: High voltage power lines: 400 kV, 220 kV, 110 kV,
  Medium voltage power lines: 35 kV, 22 kV
  Low voltage power lines 230/400 V

Split of competencies of power companies is geographic. ČEPS, a.s. - 400 kV a 220 kV, partly 110 kV on the whole territory of the CZ. Rep. ČEZ Distribuce, a. s. - 110 kV and less voltage lines: regions - Plzeňský, Karlovarský, Ústecký, Středočeský, Liberecký, Královéhradecký, Pardubický, Olomoucký (with the exception of the district Prostějov town) and Moravskoslezský region, partly region Zlínský – only the district Vsetín town and region Vysočina – only the district Havlíčkův Brod town. E.ON Distribuce, a. s. - 110 kV and less voltage lines: regions - Jihočeský, Vysočina (with the exception of the district Havlíčkův Brod town), Jihomoravský, Zlínský (with the exception of the district Vsetín town) PRE distribuce,

a. s. - 110 kV and less voltage lines: the capital Prague and the town Roztoky nad Vltavou (comment: Czech Republic is administratively divided into 14 regions and 76 districts).

- **Hungary**: High voltage power lines: 750 kV, 400 kV, 220 kV, 120 kV,
  Medium voltage power lines: 35 kV, 22 kV, 1 kV
  Low voltage power lines 230/400 V

Split of competencies of power companies is geographic. North East –company ELMŰ-ÉMÁSZ managing power lines: 120 kV, 22 kV, 230/400 V; West and East – company E.ON Hungária managing power lines: 120 kV, 22 kV, 230/400V; South-East – company NKM managing power lines: 120 kV, 22 kV, 230/400 V; Countrywide – company MAVIR (Hungarian Transmission System Operator Company Ltd.) – 120 kV (several sections), but mostly 220 kV and 400 kV power lines, with one section of 750 kV power line in Eastern Hungary.

- **Poland**: High voltage power lines: 400 kV, 220 kV, 110 kV, 60 kV
  Medium voltage power lines: 30 kV, 15 kV, 6 kV
  Low voltage power lines 230/400 V

Split of competencies of power companies is geographic. Polskie Sieci Elektroenergetyczne S.A. (PSE) is a transmission system operator. Energa company is Poland's third largest distribution network operator serving North and Central Poland, with the other major distributors being. PGE Polska Grupa Energetyczna S.A. (PGE SA or PGE Group) is a state-owned public power company and the largest power producing company in Poland. Enea is a power industry company based in Poznań and is the fourth largest energy group in Poland.

- **Romania**: High voltage power lines: 400 kV, 220 kV, 110 kV, 60 kV
  Medium voltage power lines: 20 kV, 15 kV
  Low voltage power lines 230/400 V

Split of competencies of power companies is geographic. Transelectrica - very-high and high voltage power line grid in Romania, the high, medium and low voltage lines are geographically split among different companies: ENEL ENERGIE, ENEL ENERGIE MUNTENIA, EON ENERGIE ROMANIA, CEZ VANZARE, ELECTRICA FURNIZARE.

- **Slovakia:** High voltage power lines: 400 kV, 220 kV, 110 kV,
  Medium voltage power lines: 22 kV
  Low voltage power lines 230/400 V

Split of competencies of electric companies is geographic. Western part of Slovakia – company ZSD, a.s. manages power lines: 110 kV, 22 kV, 230/400 V; Central part of Slovakia – company SSE-D, a.s. manages power lines: 110 kV, 22 kV, 230/400V; Eastern Slovakia – company VSD, a.s., manages power lines: 110 kV, 22 kV, 230/400 V. Countrywide - company SEPS, a.s. – 110 kV (several sections), but mostly 220 kV and 400 kV power lines.

- **Ukraine:** High voltage power lines: 750 kV, 400 kV, 350 kV, 220 kV, 110 kV

  Medium voltage power lines: 35 kV, 10 kV

  Low voltage power lines 220 V

Power lines 220-750 kV belong to National power company „Ukrenergo“, 110 kV and less – „Ukrenergo“ and regional power companies and other owners. Distribution system operators consists of 44 enterprises.

3. LEGISLATION – OVERVIEW OF EXISTING LAW AND METHODICAL ACTIONS

Three main international treaties address the conservation of birds of prey in Europe: the 1979 Convention on the Conservation of Migratory Species of Wild Animals (known as the ’Bonn Convention’), 1999 African-Eurasian Waterbird Agreement (AEWA) and the 1979 Convention on the Conservation of European Wildlife and Natural Habitats (known as the ‘Bern Convention’). Within the EU, the Birds Directive (Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds) also establishes a general system of bird species protection (Stroud, 2004).

Guidelines on the conflict between birds and power lines have been published before, most notably the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention) published detailed guidelines to be implemented for the protection of birds on medium voltage power lines, based on Haas et al. (2005), and the Bern Convention Standing Committee in 2004 adopted Recommendation No. 110 on minimising adverse effects of above ground power lines. Furthermore, in 2002 CMS/COP 7 adopted a resolution (No. 7.4 “Electrocution of Migratory Birds”), which called on Parties and Non-parties to implement technical and legislative measures to mitigate the electrocution of birds on power lines, based on guidelines published in a brochure by NABU (German BirdLife partner), which is a precursor of Haas et al. (2005). Also for North America, extensive practical guidelines are available, published by APLIC (1994, 2006, 2012).

Guidelines for mitigating conflict between migratory birds and electricity power grids has been prepared and adopted in 2011 by the AEWA and CMS (Bonn) Conventions, the report has been prepared by Prinsen et al. (2011). The report presents the available information (including references to other reviews) on the topic from the wider area of the African-Eurasian region. These documents summarise the latest technical standards on electrocution mitigation and review and present guidelines to mitigate collision risk for birds, a topic that received less attention in both the guidelines of the Bern Convention and the 2002 CMS Resolution 7.4.

The Position statement of BirdLife International „On the risks to birds from electricity transmission facilities“ and how to minimise any such adverse effects has been prepared by Rybanič in 2007, derived from materials prepared by NABU, presented by Haas et al. (2005) and by Haas & Nipkow (2005). The Position statement defines main adverse impacts of powerlines on birds, appeals on urgency to address and minimize the on-going worldwide threat to birds from electrocution, collision and loss of habitat availability due to electricity transmission facilities.

After years of bilateral negotiations between stakeholders, all three utility companies in Hungary, the Ministry of Environment and Water (MEW), and MME/BirdLife Hungary signed the ‘Accessible Sky’ agreement in 2008. They pledged full cooperation in all aspects to efficiently reduce electrocution and collision problems. The Coordination Committee of the agreement became the most important forum of problem solving. It convenes at least twice a year to discuss plans, implementation and monitoring. Both reactive and proactive actions are undertaken with the announced goal to retrofit all dangerous lines before 2020.

Also in Hungary, the Budapest Declaration on bird protection and power lines has been adopted by the conference ‘Power lines and bird mortality in Europe’ (Budapest, 13 April 2011). The declaration called on all interested parties to jointly undertake a programme of follow up actions leading to effective minimisation of the power line induced bird mortality across the European continent and beyond.

Another national and international initiatives (The Renewables Grid Initiative, The Energy & Biodiversity initiative) are implemented by adopting the technical standards, development for safety of power lines, planning, anti-collision measures and minimize harm to biodiversity and also by supporting environmental and nature conservation projects (The LIFE+ programme).

Fortunately, many types of electric lines will be removed with the continuing technical progress. In many countries, overhead telephone and telegraph lines will continue to disappear. In addition favorable trends can be reported from the low-voltage and medium voltage networks of some utility companies, which have made the step to change from above-ground powerlines to under-ground powerlines (Haas et al., 2005).

3.1 Analysis of situation in main priority countries for Danube/Carpathian region

All priority countries are contracting parties of Bern Convention, Bonn Convention, CITES and AEWA.

- **Czech Republic**: According to Act no. 114/1992 Coll., on nature and landscape protection, natural and juridical persons must act in such a way to avoid excessive death and injuries to animals, which can be prevented by technically and economically available measures (also in the energy sector that is explicitly mentioned). If this is not done by the person alone, the use of such measures can be ordered (in practice, such a “command” is very rare). In the above-mentioned methodological Guidelines and methodological Guidelines (VĚSTNÍK MINISTERSTVA ŽIVOTNÍHO PROSTŘEDÍ ČR, 2016) prepared by Ministry of the Environment of the Czech Republic, distributors undertook to include in their technical requirements for components providers only components safe for birds. The safety of components is evaluated by a written opinion of the Nature Conservation Agency of the Czech Republic. E.ON Distribuce, a. s. fulfills the commitment given by the Guidelines, ČEZ Distribuce, a. s. still only partially.

- **Hungary:** electricity supply; protecting users. According to 96 § subsection (da) of section (1), the licensing office is obliged to withdraw the license if the licensee is unable to meet his obligations or the electricity company is responsible for security of supply, life, health, plant and property security, operating in a seriously endangered environment. So far, the problems have always been solved after mutual communication, either by upgrading constructions to prevent electrocutions or installing diverters on power lines to prevent collisions. Since 2017, implementation of bird friendly retrofitting mitigation or reconstruction works the Electric Companies are considering the protection of birds from the preparing the plans at the very beginning to prevent collisions and electrocution. The good relationship, cooperation built with the Electric Companies is far more effective, useful and important than the obligations set by the law, however in some cases (large scale mortality of protected species, or planning old scheme solutions on distribution power lines) the 91/2007. (IV.26.) Government Decree should be and will be used to hinder further incidents. All of the companies do have internal guidelines how to proceed in case of electrocutions, eventually they have clearly defined ways how to handle with certain type of constructions or which bird diverters to use for which occasion etc. These guidelines are updated regularly. BirdLife Hungary was also working with their partners on internal guideline for nature conservation authorities and National Park Directorates based on recent results of KFO survey and modeling of geometry and scaling of new bird friendly pylon head structures on the distribution power line system. As a result of decade-long cooperation, the Hungarian Ornithological and Nature Conservation Society (MME / BirdLife Hungary) signed the 'Accessible Sky' agreement with the Ministry of Environment and Water, and relevant electricity companies in Hungary on 26 February 2008. The objective of the agreement is to provide a long-term solution to the problem of bird electrocution. Under this agreement, MME produced a map in 2008 showing key areas of conflict between power lines and bird populations in Hungary.

- **Poland**: Bird species are protected by the Ramsar, Bonn and Bern Conventions, as well as by Polish nature protection law. Today, the fundamental legal measure concerning wildlife protection in Poland is the Wildlife Conservation Act of April 16, 2004 (Journal of Laws, No. 92, item 880), whereas the protective status of individual species is determined by the related order of the Minister of the Environment of September 28, 2004, on wild animal species subject to protection (Journal of Laws, No. 220, item 2237) (Dolata, 2006).

- **Romania**: Regarding the implementation of "Nature 2000" Network, Romanian legislation transposed the provisions of the two Directives through Government Emergency Ordinance No. 57/2007 on the regime of protected natural habitats, conservation of natural habitats of flora and fauna approved with amendments by Law No. 49/2011, the Minister Order No. 2387/2011 on the establishment of protected natural area regime for the sites of community importance and by Decision No. 971/2011 regarding the declaration of Special protection areas as integrant parts of the European ecological network „Nature 2000" in Romania (Ministry of Environment and Forests). Electric companies do have internal protocol how to proceed in case of electrocutions. All the incidents are internal reported and organised in a database. The electric companies have their own prioritization of problematic electric lines. They try to solve the situations in the locations with most of the incidents that caused power failures.

- **Slovakia**: In the Law 543/2002 Coll. on conservation of nature and landscape it is written: § 4 (4) Everyone building or planning an aerial power line, is requested to use a technical solution that is preventing electrocution of birds. (5) If a proven electrocution takes place on a powerline or telecommunication devices, authority of nature conservancy can decide that the administrator must undertake technical measures to prevent electrocution of birds. So far, the problems have always been solved after mutual communication, either by upgrading constructions to prevent electrocutions or installing diverters on power lines to prevent collisions. Since implementation of the LIFE Energy project all Electric Companies in Slovakia are considering the protection of birds even when preparing the plans at the very beginning to prevent collisions and electrocution. The good relationship, cooperation and trust that was built with the Electric Companies is far more effective, useful and important than the obligations set by the law. Also very good cooperation was strengthened with the State Nature Conservancy of the Slovak Republic. Some electric companies do have internal guidelines (the Eastern Slovakia Electricity Company issued an internal technical norm called: 'Construction and amendment of aerial 22kV power lines with respect to bird protection.') how to proceed in case of electrocutions, eventually they have clearly defined ways how to handle with certain type of constructions or which bird diverters to use for which occasion etc. These guidelines are updated regularly based on recent results.

- **Ukraine**: The Law "On the Nature Conservation Fund of Ukraine", No. 2456-12 of 16 June 1992, provides the main basis and instruments for the protection and conservation of wild flora and fauna habitats in Ukraine. Moreover, Ukraine is a Party to the Bern Convention on the Protection of Wild Flora and Fauna and Natural Habitats in Europe, the CITES Convention on the International Trade in Endangered Species of Wild Flora and Fauna and the Bonn Convention on Migrating Wildlife Species. Methodology recommendations are developed by Ukrainian Society for the Protection of Birds (USPB) and some ornithologists (Andryushchenko 2014, Ponomarenko, 2015; 2016; 2017; 2018), but not as official guidelines. Electric companies do have internal protocol/norm how to proceed in case of bird electrocution and collisions.

4. BIRDS VS. POWER LINES

The unexpected effects of the development of powerlines on birds – both transmission and distribution lines – was probably first noticed in the United States of America. A number of publications in the period 1950-1970 began to warn of what was to become one of the most serious conservation problems resulting from human activity for many threatened species of birds. The relevance to bird conservation of bird deaths on power lines began to be studied in various European countries at the end of the 1970s by Scott et al. (1972) in Great Britain, Renssen (1975) in the Netherlands, Haas (1970) in Germany and Bijjleveld & Goeldin (1976) in France were the first authors to document the death of birds through electrocution and collision. The numbers speak for themselves: 700 dead birds per kilometer per year found in a wetland in the Netherlands (Heijnis, 1980), over one million birds killed per year in France (Faure 1988), a further million of birds per year colliding with power lines in the Netherlands (Renssen 1975), and 586 white storks (*Ciconia ciconia*) killed in West Germany over a period of 40 years (Fiedler & Wissner, 1980), the most important cause of death in this species during this period.

Since then, the number of publications on the interaction between birds and power lines has increased rapidly in Europe (Ferrer & Janss, 1999; Karyakin et al., 2009; Raab et al., 2012; (Derouaux et al., 2012; Demeter et al., 2018 etc.).

Above-ground powerlines pose three main risks or perils to birds (Haas et al., 2005):

• **risk of electrocution:** birds sitting on power poles and / or conducting cables are killed if they cause short circuits (short circuit between phases, or short-to-ground). In particular, „bad engineering“ practised on medium-voltage power pole constructions has resulted in an enormous risk for numerous medium-sized and large birds, which use power poles as perching, roosting, and even nesting sites. Many species of large birds suffer heavy losses and are strongly decimated by electrocution. Some species are even threatened by extinction.

• **risk of collision:** in flight, birds can collide into the cables of powerlines, because the cables are difficult to perceive as obstacles. In most cases the impact of collision leads to immediate death or to fatal injuries and mutilations, which cannot be survived.

• **risks and loss of habitat quality in staging and wintering areas:** mainly when aboveground powerlines cut across open landscapes and habitats (wetlands, steppe, etc.).

5. ELECTROCUTION

Electrocution on power lines is a major threat to many bird species across the world, in particular endangered species such birds of prey, which show the greatest incidence of electrocution. Consoles of power pylons represent a very attractive place for birds in the open country. If the neighborhood is not nearby vegetation, such an elevated seating place provides predators in particular a suitable point for observing prey and if necessary defense of the territory. In many cases, electric pylons and consoles are a risk to abutting species. Avian death can occur either by (1) short – circuit (a bird’s wings bridge the gap between energized wires with different voltages and electricity flows through its body causing severe and often fatal burns and paralysis) or by (2) ground-fault that occur bird’s body itself and a grounded part of metal structure (Fig. 6).

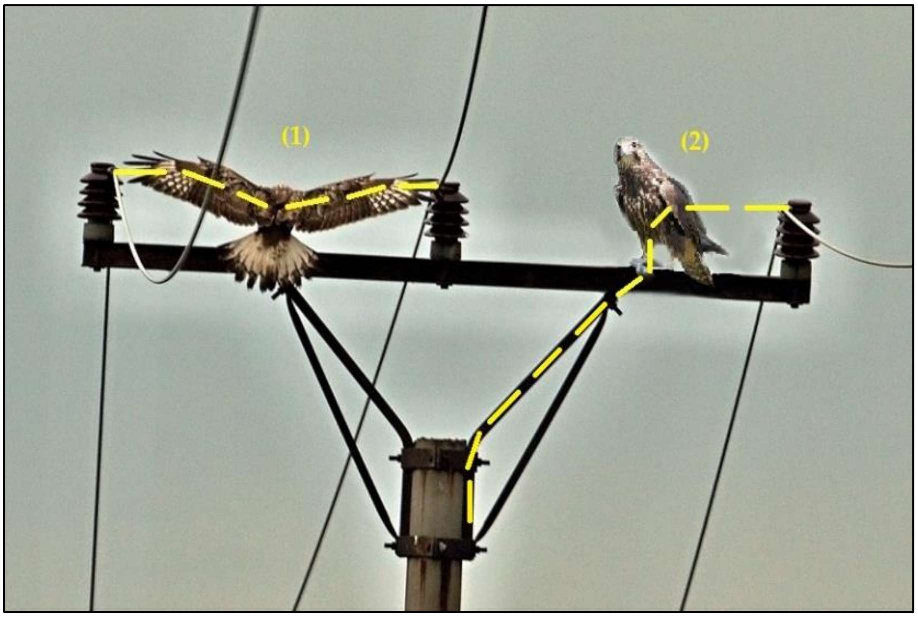

Fig. 6 Typical reasons of electrocution on medium voltage pole

Large bird species are significantly vulnerable to electrocution, because of their size (Fig. 7.) Energized hardware, such as transformers, can be especially hazardous, even to small birds, as they contain numerous, closely-spaced energized parts. The risk of the individual abutting significantly increases with an increase in body proportions. Endangered species are particularly medium to large bird species such as the saker falcon (*Falco cherrug*), imperial eagle (*Aquila heliaca*), and common buzzard (*Buteo buteo*). They are among the most frequent victims of electrocution, especially in areas with the highest appearance in farmland and nearby grassland. They offer increased concentrations of field hamsters, small rodents and other main dietary sources of predators. On the electric poles more species can be found, for example storks, herons, owls.

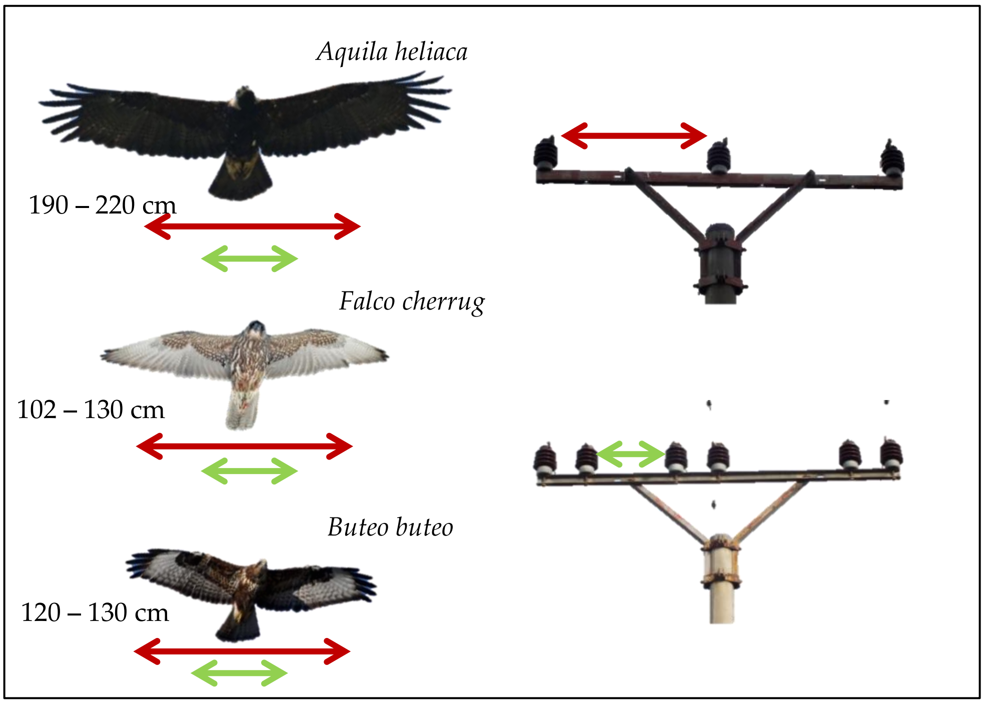

Fig. 7 Wingspan of large species in comparison to dimension of most common utility poles of medium-voltage power lines

The killing of an individual after abutment on the console is not only due to the electric shock, but also due to the several meter fall from the pylon. Typical symptoms of deceased individuals are burns to the feathers, legs and their claws are held in a convulsive pose, large necrotic areas on the limbs, skull fractures (Fig. 8).

Fig. 8 Typical signs of electrocutions

Given the distance between pylons and the size of the gap between conductors and the length of the insulators, electrocutions are only frequent on power lines with voltages below 45 kV. Electrocution occurs above all in medium-to-large birds that habitually perch on top of pylons. Unfortunately, this description corresponds perfectly with birds of prey, which, moreover, are generally scarce and in many cases at risk of extinction.

As the most threatened groups of birds by electrocution were defined diurnal birds of prey/raptors, specifically eagles, hawks, vultures, kites; falcons; storks and corvids (*Corvidae*) (Haas et al., 2005; Ferrer, 2012; Bahat, 2010; Gadziev, 2013; Prinsen et al., 2011) included in reports from various parts of Europe, Asia, North America. Additional species were reported to die from electrocution in Bulgaria by Demerdziev (2009): *Circaetus gallicus*, *Coracias garrulus*, *Corvidae* (5 species), *Sturnus vulgaris*, *Turdus merula*, undetermined *Passeriformes*.

In most Danube/Carpathian countries among most frequently effected species (Fig. 9) occurred the common buzzard (*Buteo buteo*), as the most often electrocuted raptor species in the region; in some countries also the white stork (*Ciconia ciconia*) – in Czech Republic, Hungary and Poland as well as in Romania. Common kestrel (*Falco tinnunculus*) was often reported from Czech Republic, Hungary and Romania, also common crow (*Corvus corone cornix*) and magpie (*Pica pica*) are being frequently electrocuted. Victims of electrocution include in Romania also some rare raptor species as long-legged buzzard (*Buteo rufinus*).

Fig. 9 Electrocuted common buzzard (A), common crows (B), magpie (C), white stork (D)

Electrocution is a worldwide problem, documented first in a number of earlier and more recent reports from USA (Miller & Lehman, 1981; APLIC 2006; Dwyer et al. 2015), in different parts of Europe (Haas, 1980, 2005; Demerdziev et al., 2009; Ferrer et al. 1991; Samushenko et al., 2012), as well as from different countries in Asia, as e. g. Israel, Mongolia, Saudi Arabia or Dagestan (Bahat, 2008; Shobrak, 2012; Gadziev, 2013).

In Slovakia the problem of electrocution was identified in 1980, since when a number of meetings took place with the power lines providers. The first bird diverter was designed by RPS around 1990 (plastic „combs“ to keep birds away from perching on poles) and was installed in 1993 in Mala Fatra mountains (Párnica – Zázrivá). The regular monitoring has started about this time around. In Hungary the problem was identified in the late 1970s, early 1980s, in the Hortobágy when many of storks and some raptors were found electrocuted. Meetings were organized with the power line companies and first steps took place to develop a crossarm cover insulator. The first type of such an insulator was designed by MME in 1991 (plastic cover to hinder electrocution while birds are sitting on poles) and was installed in large numbers (50 000 pylons covered) countrywide. Regularly national surveys started in 2004 by MME. In Romania the problem has been identified from 1995.

5.1 Methods of data gathering and evaluation

It is very difficult to estimate the total number of large birds lost by electrocution. Monitoring is difficult, because large birds have a large range where they can die and large dead birds are quickly taken away by raptors, foxes, badgers. It was not until banding programs and the analysis of ring recoveries, respectively the monitoring of birds fitted with radio transmitters, revealed the disastrous toll due to electrocution (Haas et al., 2005).

Some groups of species may be more affected than others and within these groups some species may be particularly prone to die on pylons. In general, susceptibility of a species to this kind of accident depends on its behaviour (e. g. use of pylons as perches or for nesting) and its size, as large birds are more likely to be electrocuted. The study areas should be chosen with focus on the presence of distribution lines, where the risk is much higher and are located in natural areas of great ornithological interest.

In field surveys it is recommended to review all types of poles (wooden, concrete, steel poles) of distribution lines. If surveying distribution lines, it is recommended to have in mind, that certain number of electrocuted birds is removed below the pylons by scavengers, thus reducing amount of detected bird corpses (Ferrer, 2012).

Because factors that affect the search efficiency, scavenger rate, accessibility of terrain, *etc*., vary greatly between study locations, it is not possible to present a method that is applicable in all situations and study outlines may need to be developed on a case-by-case basis. Nevertheless, the following topics are of importance to consider and incorporate in such a study protocol in order to make studies more comparable (Prinsen et al., 2011).

- **Spatial and temporal coverage**

- an observer should be able to find medium sized birds in terrain with low vegetation within a radius of 10-15 meters around him.
- the terrain is surveyed preferably on foot, in specific conditions, large open flat areas, can be surveyed by slowly mowing field car under/close to the power line.
- search radius of 5 meters around poles is suffice – almost all victims of electrocution are located close to the base of pole.
- for small bird is recommended intensity of twice weekly or once a week, for large birds fortnightly searches may be sufficient.
- width of surveyed area= medium voltage (10-20 meters on each side), for high voltage 50 meters on each side is recommended. One observer will survey first one side along the line (e.g. the 10-20/50 m on the right side), and then returned to the starting point surveying the other side (10-20/50 m band on the left side). To move in zigzag line is recommended only due to high vegetation.

- **What is necessary to note?**

- position of carcass – GPS coordinates
- bird species, age, sex
- distance from the power lines, if the carcass is far from the base of pole
- reason of death
- signs of injuries – burn marks/holes on feathers, wings, body
- condition of body decomposition, to determine approximately the time period of death = a) fresh carcass, b) the carcass is decomposing, c) only skulls, bones are present
- effect of scavengers = a) the carcass lies on the original location of death; b) the carcass was removed from original location of death, but is still presence close to the line; c) the carcass is missing (only feather are presence, fox/another scavenger excrements are present)

- photodocumentation – photo of carcass, photo of position of carcass towards the pole, photo of all injuries.

Note: It is necessary to check not only the area under the power line, but also in a distance up to 100 m from the power line on each side. It is because the birds after collisions often move by themselves or are moved by a predator. All volunteers/field assistants should be trained by expert staff via theoretical and practical trainings to ensure proper data collection in the same expert quality.

The most frequent victims of electrocution in countries of Danube/Carpathian region are for individual countries the following:

- **Czech Republic:** *Buteo buteo, Pica pica, Falco tinnunculus.* Source: results of the project „Monitoring of the avian mortality due to transmission line electrocution and collision“ (one-time monitoring was carried out in 2015-2016, 1/10 of the total length of high voltage lines was monitored)
- **Hungary:** *Buteo buteo, Falco tinnunculus, Ciconia ciconia.* The results from a national survey carried out yearly by MME and National Park Directorates in the frame of MME's KFO project (Monitoring of Medium voltage power lines), long term knowledge from the field, reported deaths from electrocutions.
- **Poland:** common buzzard (N=46), white stork (N=21), magpie (N=15) - source: inventory by Lublin Society for the Prot. of Birds (data come from just 2 visits on some 510 km of different types of power lines in Lublin region, in summer 2015)
- **Romania:** *Sturnus vulgaris, Ciconia ciconia, Falco tinnunculus.* Based on personal observations.
- **Slovakia:** *Buteo buteo, Pica pica, Corvus cornix.* The results from a survey carried out within the LIFE Energy project, long term knowledge from the field, reported deaths from electrocutions.
- **Ukraine:** white stork, other birds of prey. Among rare species: *Buteo rufinus.*

Power line configurations in many countries around the Danube/Carpathian region are similar so concerns identified in Slovakia, Poland and Hungary etc. may occur regionally.

5.2 Most dangerous types of powerlines and their risks to birds

The following describes the most widely used types of power poles, their potential risk and steps towards mitigation. The safety of the installations depends primarily on: - how insulators are attached to the poles and the actual space between the exposed jumper wires and other energized and grounded parts.

- **Medium risk -** power poles with upright insulators. They are most common utility poles of medium-voltage power lines The gap between the cables and the crossarm is small especially for large bird species (Fig. 10).

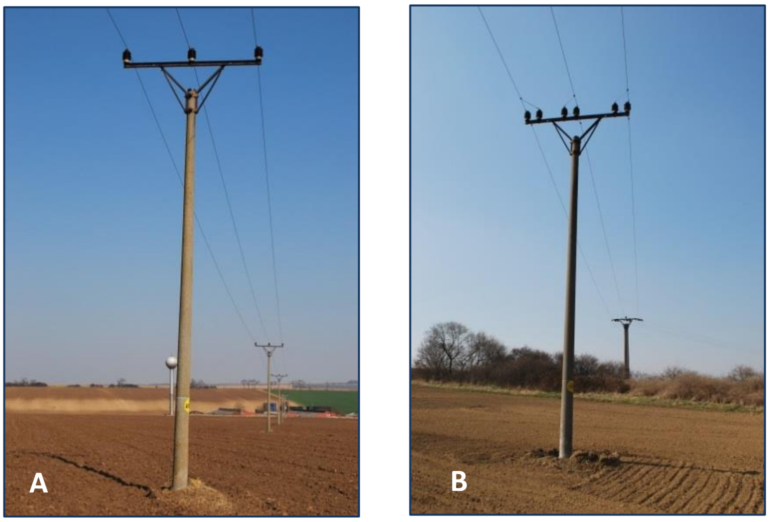

Fig. 10 Electric poles with a single (A)/ pair (B) of support insulators in vertical position on console

- **High risk -** metal cross arms poles, generally complex constructions and poles with a different combination of exposed jumper wires locations (Fig. 11 A), mostly when on a top of the (B), transformer stations (C) and switch towers (D).

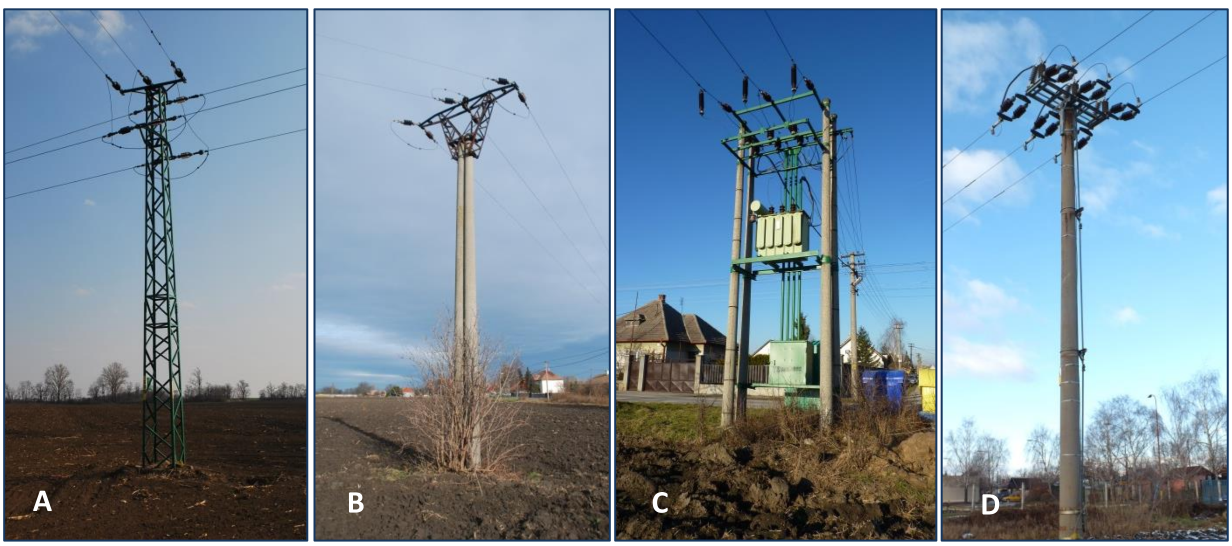

Fig. 11 Electric poles of the highest risk of electrocution

The most dangerous types of constructions due to electrocutions are in the Danube/Carpathian countries the following: metal cross arms poles, poles with a different combination of exposed jumper wires locations (Fig. 12), mostly when on a top of the console (Fig. 13) (Slovakia); mostly different tension, switch and transformer poles with metal cross arms, metal lattice poles (Hungary); relatively truss poles of the high voltage lines with a branch, entirely concrete poles with metallic horizontal console and with three or two times three „supporting“ insulators (Czech Republic); medium voltage lines, transformation stations (Romania) and 10 kV poles, usually the most dangerous are that with wires at different levels close to each other (Ukraine).

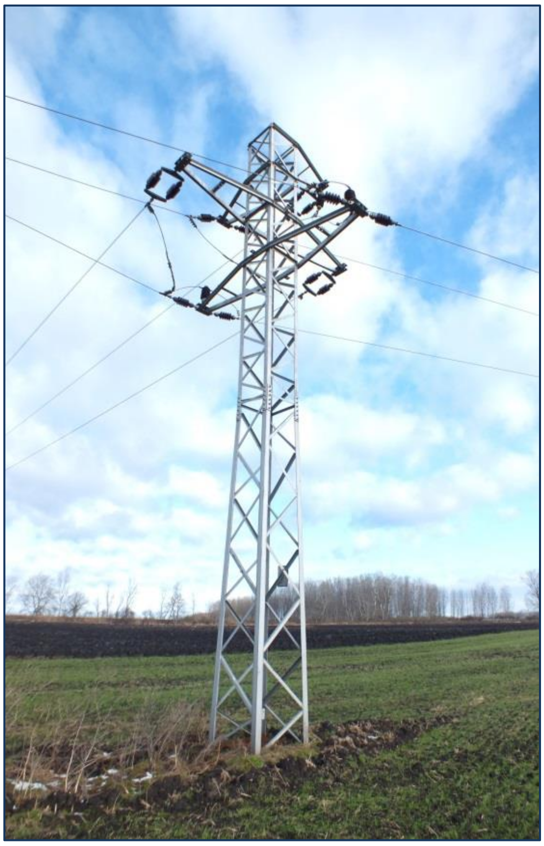

Fig. 12 Metal cross arms with a different jumper combination of support insulators and exposed jumper wires

Fig. 13 Electric pole with exposed wire on the top of the console

5.3 Measures to eliminate electrocution

There are many types of effective solutions (Annex 2) of insulations of poles of medium-voltage power lines such as: plastic hood, silicon tubes, long rod insulators, plastic insulators covering the metal console etc. The best solutions are those, which allows the birds to securely perch on poles.

The list of non-effective solutions to mitigate electrocutions in the Danube/Carpathian region:

In **Czech Republic** none of following measures were tested but their use on power lines revealed their inappropriateness as a protective measure. Measure „Racks“ - negatives: short lifetime, damaged racks are more dangerous than missing protection (same as in Fig. 17). Measure „Bench“ – negatives: not frequently used, a bench occupies space on a console and birds which - despite of the bench - sit on the console are more threatened than without bench (Fig. 14). Because of wrong installation or damage, the plastic belt (used in „Delta Variant con-sole type“) (Fig. 15a – good status, Fig. 15b – damaged status) and plastic covers on the insulators top (Fig. 16a – good status, 16b – damaged status) lose their function.

Fig. 14 A bench – that means a threat for birds

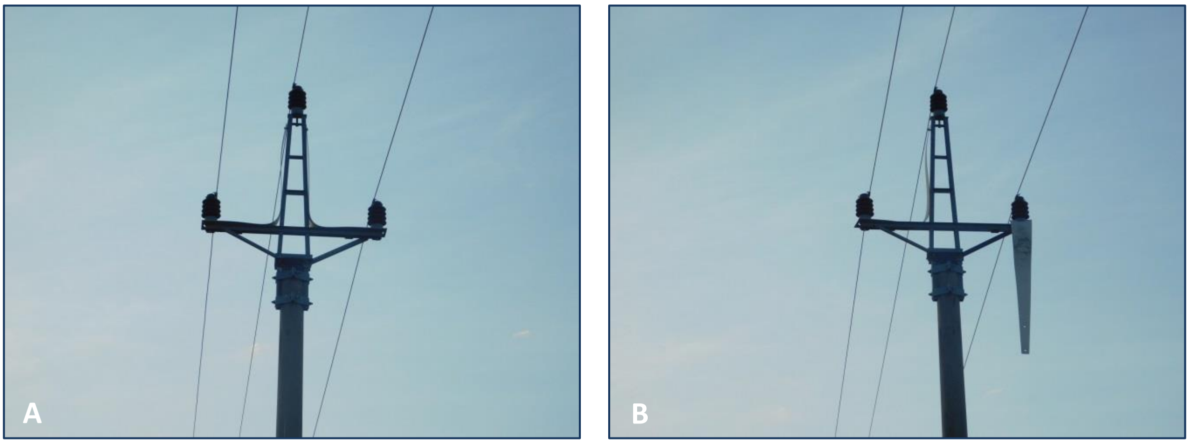

Fig. 15 Delta variant of console – good status (A) and (B) damaged status

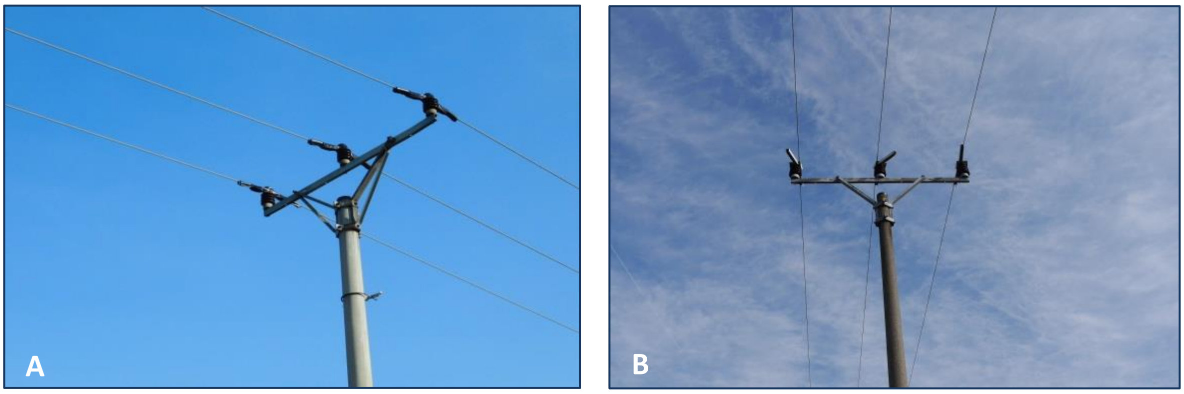

Fig. 16 Plastic covers on insulator top – good status (A) and (B) damaged status

In **Hungary** a number of different experience has arisen. Regarding to new data, any crossarm cover insulator (green and orange) or plastic phase coverts and various types of plastic insulators which allow birds to perch safely on the console (black ones), or other products installed as retrofitting mitigation on the poles. The plastic products could be attached the wrong way to the crossarms and insulators, ignoring the recommendations and have a short lifetime. After any retrofitting mitigation methods power line companies never pay enough attention to regular maintenance or replacements of missing elements/kits.

In **Slovakia** plastic „combs“ in different colors (green, black) (Fig. 17), as well as other products installed in a wrong way or installed in a way without respect to recommendations turned out to be inefficient (Fig. 18).

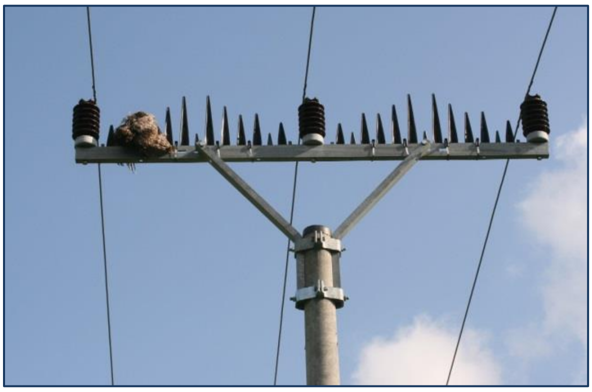

Fig. 17 Inefficient protection by plastic combs

Fig. 18 Wrong installation of products

In **Ukraine** some bird-protecting tools had been developed, they were installed on a few power lines (Ponomarenko, 2015; 2016; 2017; 2018), but results of their functioning have not been received yet.

The data for other priority countries (**Romania** and **Poland**) are missing.

The list of effective solutions to mitigate electrocutions in the Danube/Carpathian region:

The most effective measure in **Czech Republic**: „Pařát console type“ with a perch (perch length 120 cm, diameter 5 cm) or „Delta Variant console type“ with a perch (perch length 120 cm, diameter 5 cm): the shape of console discourages birds from sitting down and at the same time, perch offers place to sit. That is why there is a bird motivation to use a perch on these consoles. A study realised in years 2011-2012 evaluated results of that testing (Škorpíková et al., 2012). The new technical solution consisted of a bar with a perch below the console, allowing safe landing for the birds (Fig. 19). The monitoring of this solution at 4 selected powerlines in different parts of the Czech Republic has shown, that perches were frequently used by Common Bussards with a high protective value and results indicate, that positive effect will be also for other raptors typically using poles as perches: Black Kite, Red Kite, Rough-legged Bussard, etc.). Despite of that, species as magpie, common crow used perches only with low frequency. In case of these two species the perches were evaluated as useless, in common kestrel positive effect of the perch was not possible to prove. Overall evaluation of the perch was positive and only 10 % of tested common buzzards performed risky behaviour, the rest of birds was protected against electrocution due to using the perch.

Fig. 19 Console „Pařát“ with a perch

In **Hungary** the most effective solution appears to be a complete change of the pylon head construction for the new, bird friendly scaled type with well geometry (see pictures of bird friendly pylon head structures used and tested in Hungary). Switch poles could be changed to closed types filled with gas. To branch poles could be attached a new perching frame generating a safe sitting and landing surface for birds.

From **Poland** are missing data on most effective protective measures, as there is no general evaluation. Removal of dangerous parts of installation can usually help in most cases, but regularly gathered data are missing. In **Romania** underwater cables and cable insulations have been recommended as effective solutions. In **Ukraine** no testing has been done yet, even if some measures already have been developed (Ponomarenko, 2015; 2016; 2017; 2018).

In **Slovakia** the most effective solution appears to be a complete change of the construction for the new type – so called Antibird (Fig. 20a) Then also phase covers and various types of plastic insulators which allow birds to perch safely on the console or do not allow the birds to perch on the construction at all. Antibird is effective thanks to the shape of the console (45° angle of the arms). In the years 2006 - 2007 three new elements were tested that proved to be the most appropriate type, they are still used today and are called "Tooth" - insulators, which allows the birds to securely engage the bracket column (Fig. 20b). New type of insulation with telescopic parts was developed for 22 kV power lines, to eliminate the distance between the products and support insulators (Fig. 20c).

Fig. 20 Effective solutions of bird protection in Slovakia

6. COLLISIONS

Collisions of birds in electrical lines represent a significant mortality factor of several species. Such clashes at high speed have fatal consequences for birds. Frequently they can be observed in areas where the power line crosses foraging and nesting habitats used by birds and can occur equally with transmission and distribution lines. A particular problem occurs when there is frequent movement of a large flock among the habitats, or if such conduct is perpendicular to the main migration routes.

Collisions of birds are relevant to the main cause – the flying individual is unable to register such an obstacle ahead. Problems of collisions into power lines can be generally based on factors of origin divided into four categories, including biological, topographical, meteorological and technical perspective. Among the biological factors include the physiology of the birds vision, style and speed of flight behavior during hunting season, mating, and nesting. Topographic factors include the amount of lead above the ground and the nature of the relief. Significant contributions to the collisions are meteorological factors such as wind power surges and bad weather reducing visibility lines. Technical factors include the height of pylons and power lines, horizontal and vertical segmentation lines and the presence of a earth (ground) wires on the top of the transmission voltage pylons, which is almost "invisible" for the birds. Data from many studies indicate that up to 80% of collisions occur with the ground wire.

Bird casualties due to collision with above-ground powerlines can happen to any species of bird, capable of flight. There are differences between habitats: on grassland there are 113 collisions/km/year; on agricultural land 58 collisions/km/year, and near river crossings 489 collisions/km/year (Erikson et al., 2005).

The technical installations of the powerline can also take damage from bird accidents: collisions can cause conductor cables to sever or to strike together. Short-circuits to ground can damage insulators and switches. Bird accidents can lead to outages and economic damages (Haas et al., 2005).

In case of collision accidents, birds crash at high flight speed into cables or wires. The resulting injuries such as broken bones, wings, legs and shoulder bones, wounds (Fig. 21) vary widely and are comparable to traumata caused by collisions with cars.

Fig. 21 Typical injuries due to collisions with the wires detected on bird carcasses

6.1 Methods of data gathering and evaluation

Methods of data gathering (for identification of range of problem) are the same as for electrocution field survey and follow the same principles of field survey, data collection, methodology and data evaluation. It is necessary to check not only the area under the power line, but also in a distance up to 100 m from the power line on each side. It is because the birds after collisions often move by themselves or are moved by a predator. All volunteers/field assistants should be trained by expert staff via theoretical and practical trainings to ensure proper data collection in the same expert quality.

Methods of data gathering, to identify the bird reactions on non-marked and marked power lines are specific and following principles:

Monitoring run twice for the monitored day. (A) Morning – it starts 0,5 hour before dawn, while it continues for another 1,5 hours after sunrise. (B) Evening - monitoring starts 1,5 hours before dusk and continues for 0,5 hour after sunset. In given time period, the light conditions are insufficient and birds are most active at the same time, hence there is a high risk of collision. Total minimum monitoring time is 4 hours/day. If repeated reactions of birds to power lines are detected during a monitoring day, then the monitoring goes on for all day. The goal is to capture as many bird's reactions as possible either on power lines with installed diverters or those without them.

One person monitors power lines in the 500 meters range of sections. Two persons carry out monitoring of sections longer than 500 meters, if the power line changes direction significantly or it is divided by a barrier (horizon, vegetation etc.).

For each monitored power line, a special form is needed, with following data:

- location (ID), observer, sheet number, GPS device ID number,
- date and time of monitoring,
- observed time of sunrise and sunset
- biotope, vegetation close to the monitored section
- weather, wind direction and intensity
- notes of the observers – it is appropriate to include field findings that are relevant for evaluation of results and subsequent monitoring.

The responses protocol (following the guidelines from APLIC, 2012) consists of 9 choices for various reactions of a bird individual to power line and record of a reaction zone from the power line, in which the reaction of bird is detected. The monitoring methodology is the same for both marked and unmarked section, that follows section with installed diverters or is located in its close proximity (same site specific conditions). Each section of marked or unmarked power line is divided into individual sections according to line spans, in order to precisely locate the birds' flights over the line. Part of the monitoring is also tracking of deaths under line, video and photo documentation of flights, reactions, deaths.

In **Slovakia** deaths from collisions had been located sporadically, but first more extensive results were found out in the year 2010 in SPA Ondavská rovina. The results proved the need of a systematic approach, therefore we have been regularly monitoring collisions since 2014. A project LIFE Energy has started, its duration is planned for 5 years period (2014-2019). Project is focused on collisions of birds with 22 kV and 110 kV power lines. First there is a need to identify most dangerous types of powerlines for collisions (e. g. in Slovakia 22 kV and 110 kV powerlines) as well as to identify most dangerous sites with high collision rate. In Slovakia in frame of project LIFE13 NAT/SK/001272 a complex methodology for monitoring of these powerlines has been identified during period May 2016 – May 2019 and results will be evaluated at the end of the process.

In **Hungary** deaths from collisions had been located sporadically. First extensive survey and results were found out in the frame of the LIFE project titled „Conservation of *Otis tarda* in Hungary” between 2004-2008 mainly in Kiskunság National Park Directorate. The results proved the need of using bird diverters in bustard habitats on the wires increasing visibility and focusing on building underground cable system instead of existing power lines.

In **Romania** collisions started to be regularly monitored since 1996. The data from other priority countries (**Poland, Czech Republic** and **Ukraine**) are missing.

6.2 Bird species in risk

Collision susceptibility may be influenced by flight behaviour. Gregarious species are generally thought to be more vulnerable than species with solitary habits (APLIC, 2012; Drewitt and Langston, 2008). On the basis of published data groups of birds the most often and most seriously threatened by collisions in various parts of the world include pelicans, storks, cranes, grouses (*Tertaonidae*), rails, gallinules, coots (*Rallidae*), bustards, waders (*Charadriidae* + *Scolopacidae*) (Haas et al., 2005). Larger, heavy-bodied birds with short wing spans and poorer vision are more susceptible to collisions than smaller, light-weight birds with relatively large wing spans, agility and good vision (APLIC, 2012).

Birds on migration and during stopovers remain in a certain area only for a limited time, therefore they are under higher risk to collide with obstacles than the resident birds. Especially in case of rare species, collision losses can represent an additional, substantial mortality factor. For species that are rare or endangered, the loss of a few or even one individual may impact a local population or the overall population's viability. Biologically significant risk from collisions and electrocutions may occur in a population that is so small that the loss of a few individuals may impact local, rare, or endangered populations (Crowder, 2000). For some species, this meant a double loss: first, the loss of the adult that collided with the line or is electrocuted, and second, the loss of the young, which rarely fledge after one parent is lost because both parents must forage extensively to feed them.

The most frequent victims of collisions in countries of Danube/Carpathian region are for individual countries the following:

- **Slovakia**: *Cygnus olor*, *Anas platyrhynchos*, *Ardea alba/ Egretta alba*, *Ardea cinerea.* The results from a survey carried out within the LIFE Energy project, long term knowledge from the field, reported deaths from collisions (Fig. 22).
- **Hungary***: Grus grus*, *Otis tarda*, *Ardea cinerea*. The results from a surveys carried out by MME and National Park Directorates („KFO" = Monitoring of Medium voltage power lines), long term knowledge from the field, reported deaths from collisions.
- **Czech Republic**: *Anas platyrhynchos*, *Turdus merula*, *Columba sp*. Source: results of the project „Monitoring of the avian mortality due to transmission line electrocution and collision"

(one-time monitoring was carried out in 2015-2016, 1/10 of the total length of high voltage lines was monitored). Generally, the most common victim of collision is *Cygnus olor* – this fact is influenced by the size and the visibility of this species.

- **Poland**: no sufficient data.
- **Romania**: *Cygnus olor*, *Anser albifrons*, *Ciconia ciconia*. Data based on personal observations.
- **Ukraine**: Bird species composition significantly vary depend on place of power lines installing (Andryushchenko et. all., 2017; Bronskov, 2017). On Kerch peninsula the species composition is: Gull sp. – 17%, *Corvidae* sp. – 17%, *Melanocorypha calandra* – 13% (Andryushchenko et. al., 2002), in general on the Crimea peninsula: *Larus cachinnans* - 18%, *Philomachus pugnax* - 10%, *Corvus monedula* - 9% (Andryushchenko et. al., 2012). Among rare species: *Oxyura leucocephala*, great bustard (Andryushchenko et. all., 2002; 2014; Bronskov et. all., 2016).

Fig. 22 The most frequently effected bird species by collisions in Slovakia: (A) *Cygnus olor*, (B) *Phasianus colchicus*, (C) *Anas platyrhynchos*, (D) *Turdus merula*

6.3 Types of powerlines that constitute risk for birds

The most dangerous types of high-voltage powerlines in the Danube/Carpathian countries in regard to collisions: In **Czech Republic** there is still a lack of to answer this question. Up to now, the phenomenon of collisions has not been credibly studied and evaluated. It seems that the position of particular component is more important than its technical parameters. The results of the project „Monitoring of the avian mortality due to transmission line electrocution and collision“ revealed that mortality due to collisions is an area factor, that is often overlooked (f.e. for „small passerines“). It is necessary to emphasize that the above mentioned project was focused on high voltage lines. Extra-high voltage lines – from the view of collisions - have not been systematically studied.

The most dangerous types of power lines do not correlate with constructions of the lattice tower types in **Hungary** (high voltage power lines) or pole types on medium voltage system. More important is the location of the power line sections, whether they crosses important bird habitats/breeding areas or main migration routes. Even a single barbed wire fence could cause a mortality in an unfavorable location. For 120 kV, 220 kV, 400 kV power lines the most risk is associated with optical cables, and ground wires (the highest ones), which are also the thinnest ones. Data from filed survey of BirdLife Hungary and National Park Directorates.

In **Romania** the most dangerous types of powerlines turned out to be the medium voltage lines in Danube Delta Biosphere Reserve, because there are very short segments of high voltage lines only. Wire Fences and mirror windows turned out also seriously dangerous. In **Slovakia** more important than the voltage is location of the construction regarding to habitats inhabited by birds or to main migration routes. For constructions of 110 kV, 220 kV, 400 kV, the most risk is associated with optical ground wires, especially the highest one, which is the thinnest.

On the basis of experience gained in **Ukraine** pylons with wires on different levels, as well as a lot of wires on small space, high concentration of wires and location of the construction regarding to habitats inhabited by birds or to main migration routes turned out to be the most dangerous. For **Poland** are no sufficient data available.

6.4 Measures to eliminate collisions

Even if collisions could not be eliminated, still they can be reduced by proper measures. Engineers and biologists can reduce collisions by (APLIC, 2012):

- Line marking to increase the visibility of the line.
- Managing surrounding land to influence bird use.
- Removing the shield wire if lightning is not an issue or if lightning arresters can be used instead.

- Increasing the diameter or changing the configuration of wires when a line is being rebuilt.
- Rerouting the line if all other attempts have been exhausted and when populations are significantly impacted.
- Burying the lines if feasible and warranted.

Once infrastructure exists, line modification in various forms is the other known approach, and is the most widely used (APLIC, 1994; Hunting, 2002; Crowder & Rhodes, 2001; Drewitt & Langston, 2008). Line modification can take several forms, which can be broadly divided into those measures that make power lines present less of an ‘obstacle’ for birds to collide with, those that keep birds away from the power line and those that make the power line more visible (Prinsen et al., 2011).

- **Line design or configuration–less of an ‘obstacle’ to flying birds (Prinsen et al. 2011)**

Birds are believed to collide most often with the earth or shield wire (the thinnest wire at the top of the power line structure (Fig. 23). Removing this wire or designing power lines from the outset without this wire is therefore a potential collision mitigation measure However, since these wires are used to protect the infrastructure from lightning, this is unlikely to be a widely used measure unless a viable alternative for lightning protection is developed (APLIC, 2012).

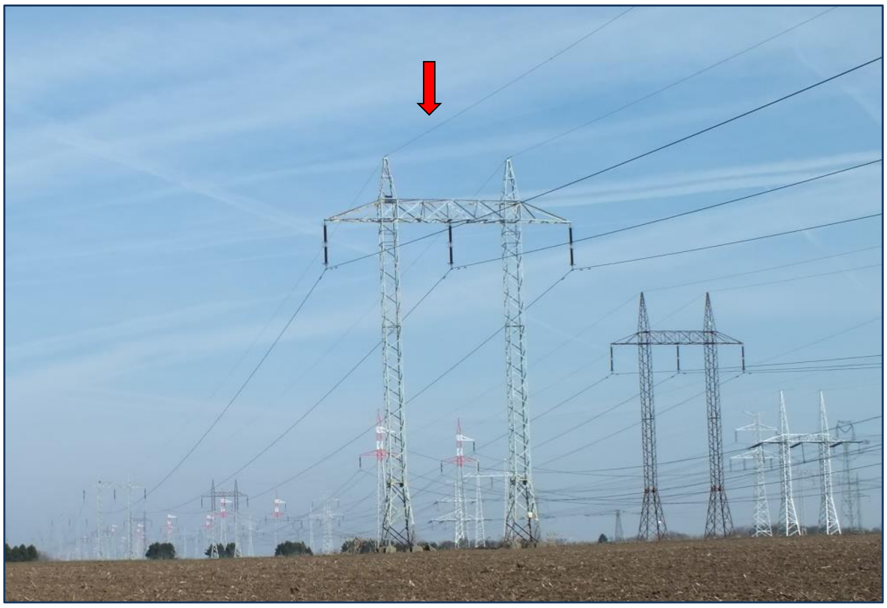

Fig. 23 The thinnest (shield) wire on the top of the power lines is almost invisible for birds

- **Line marking – making lines more visible to birds (Prinsen et al. 2011)**

Line marking is one of the best solution, how to make the cables more visible to birds in flight. It has become the preferred mitigation option worldwide. A wide range of potential line marking devices (Annex 3) has evolved over the years, including: spheres, swinging plates, spiral vibration dampers, strips, SWAN-FLIGHT diverters, Firefly Bird diverters, bird flappers, aerial marker spheres, ribbons, tapes, flags, fishing floats, aviation balls, crossed bands (Fig. 24).

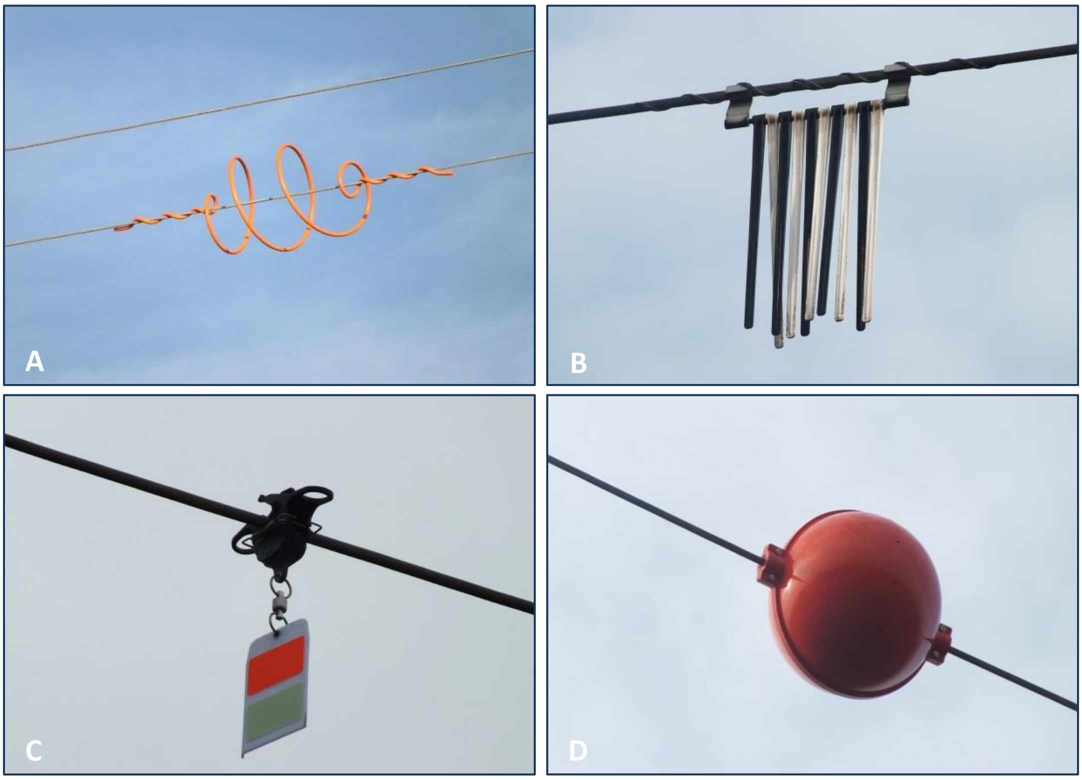

Fig. 24 The example of most used line marking devices: (A) SWAN-FLIGHT Diverter (B) RIBE lamellas, (C) FireFly Bird protection, (D) Aerial Marker Balls

There is a large amount of literature available on efficiency of such marking devices in mitigating collision mortality, some examples from the African-Eurasian Flyways region are presented in the AEWA/CMS International Review on Bird-Power Line Interactions (Prinsen et al., 2011). Barrientos et al. (2011), reviewing 21 wire marking studies, similarly conclude that wire marking reduced bird mortality by 55-94%. Spacing recommendations vary depending on species considerations, environmental conditions, line location, and engineering specifications (e.g., wind and ice loading, conductor size, and the presence or absence of the shield wire). In general, intervals of 5 to 30 m (16 to 98 ft) have been most commonly used and recommended for all markers (APLIC, 2012). The various types of line marking devices require different installation techniques: from the ground, bucket truck, boat, , or other means. Some devices can be attached by hand and others need to be attached by a hot stick (Fig. 25).

Fig. 25 The most used installation techniques of line marking: (A) bucket truck and (B) hot-stick

Power lines that are higher or over a water body (e.g., rivers, lakes, etc.) can be difficult to access and require more costly installation methods, such as a boat, line trolley helicopter, drone or special devices (Fig. 26).

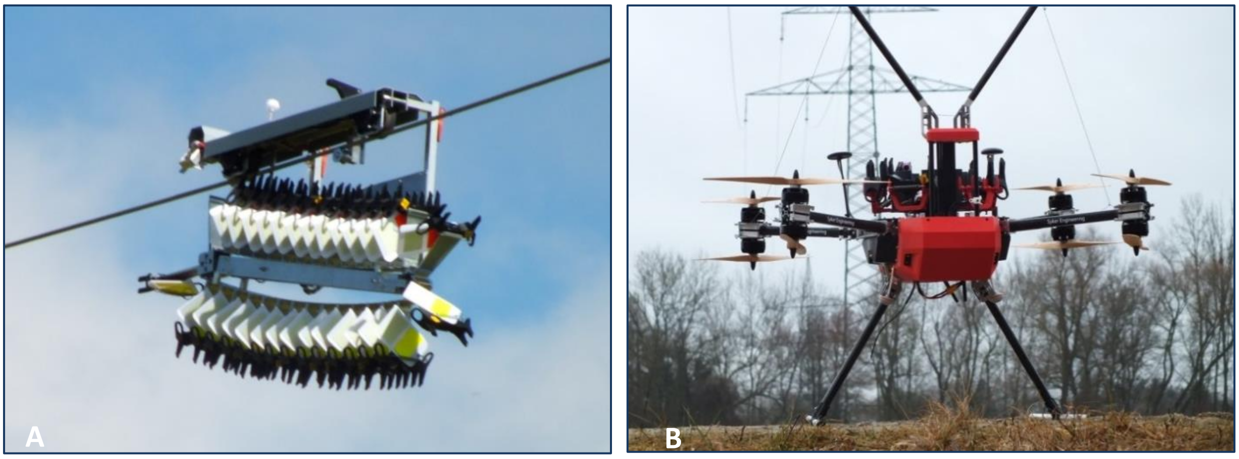

Fig. 26 Special device (A) and drone (B) for installation of FireFly Bird diverters

Recommended properties of marking devices are: motion of the device or its parts, reflectivity, contrasting colors, and enhances the visibility of the line and glowing for up to 6 hours after sunset. Buried power lines may be a solution to bird collisions in some instances, but can cost about 60,000 euro/1 km of medium-voltage power lines and 650,000 euro/1km for high-voltage power lines.

The following mitigation measures turned out to be ineffective in some of the Danube/Carpathian countries:

In **Czech Republic** none of the protective measures were tested. Only sections of a few power lines are refitted with protective measures. Their efficiency was not studied. In the center of Prague, tram trolley on 7 bridges over the river Vltava were refitted by diverters FireFlies. They should prevent collisions of seagulls, ducks, cormorants and pigeons. However, these diverters are inefficient to prevent swans from collisions with tram trolley.

In **Hungary** any systematical testing has not been realised, however static spiral bird diverters used by MAVIR seemed to be too rigid / brittle and UV-sensitive and thus we documented a lot of missing diverters after some years. A vibrating FireFly diverter had also a period with high rate of amortization, but newest type seems to be sufficient, and could be fitted to the wires by drones, thus reducing the trailing damage and collateral costs.

In **Slovakia** so far, testing have not been performed systematically. Results from the long term monitoring are not available yet. Bird diverters have been installed on multiple power line sections only recently, under the LIFE Energy project.

In **Ukraine** some bird-protecting tools, they were installed on a few power lines (Ponomarenko, 2015; 2016; 2017; 2018), but results of their functioning have not been received yet. The data from **Poland** and **Romania** are missing.

Analysis of the threat in primary countries of interest situated in Danube/Carpathian region of Europe, with focus on organisations dealing with the topic and way of division of responsibilities:

- **Czech Republic:** Nature Conservation Agency of the Czech Republic (an expert body of the Ministry of the Environment) – issues expert opinions about safety of particular components of the transmission system (e.g. console) for birds, negotiates about methodological approach and new technical solutions with the Ministry of Industry and Trade and with the providers of transmission net, it also asserts using bird-safe components in the transmission net, is an advisor for other nature conservation authorities, organizes monitoring of power lines. Czech Society for Ornithology (NGO) and its regional offices – collects data, identifies dangerous power lines, negotiates with providers of transmission net and asserts using bird-safe components, asserts securing the most dangerous poles and power lines sections, cooperates with NCA and the Ministry of Environment and participates in evaluation of the safety of transmission net components for birds, coacts on methodological and conceptual materials preparation Czech Union for Nature Conservation (NGO) – as the „umbrella organization“ of rescue stations in the CR it ensures especially collecting data and sometimes participates in asserting bird-safe components. Distributors have a legal obligation to ensure bird protection on power lines till 2024. This fact motivates them to cooperate - but there is no penalty if they do not keep limit of 2024. Hence, it devalues the function of this time limit. Another motivation of companies is to obtain a positive image in the eyes of the public. In 2016, the Ministry of the Environment issued Guidelines for bird protection against electrocutions. The Guidelines are binding upon nature conservation authorities. Distributors collaborated on these guidelines and they should keep the rules given by them. The organization ČSO cooperates with the company E.ON ČR, a. s., on the basis of term contracts.

Research: Hlaváč V. et al., 2017: Na sloupech elektrického vedení hynou stále desetitisíce dravců. Ochrana přírody 2: 7-9

Hlaváč V. et al., 2013: Ochrana ptáků na linkách vysokého napětí, Ochrana přírody 5/2012

- **Hungary:** BirdLife Hungary (MME) coordinates the field surveys of KFO project (Monitoring of Medium voltage power lines) and cooperates with producers of products for birds protection from electrocution and collisions. National Park Directorates are dealing with collisions, monitoring the victims and preparing a heat map of relevant sections of transmission power lines for MAVIR. MME is also preparing plans for implementation of various solutions to eliminate the risks. Main steps of these works were 2 conferences organised in years 2008 and 2011 with attendance of power line companies, Ministry of Environment and MME BirdLife Hungary within the framework of the Accessible Sky Agreement. Noteworthy result of the conference held in 2011 was the so-called „Budapest Declaration“, which includes a call on the European Institutions (Commission and Parliament) and national governments to maintain high levels of implementation of the EU's environmental acquis including the Birds and the Habitats Directives and relevant international legislation through the application at national or regional level of effective legal, administrative, technical or other requisite measures for: 1) minimisation of the negative impacts of power lines on the natural environment and wild birds and 2) ensuring a system of general protection of wild birds, as required by the Birds Directive, and 3) ensuring that such considerations are incorporated in the assessment of investment projects such as the electricity 'Projects of European Interest' that will be advanced through the follow-up of the EU's Energy Infrastructure Package. The Budapest Declaration also includes a call on all interested parties to jointly undertake a programme of follow up actions leading to effective minimisation of the power line induced bird mortality across the European continent and beyond and a framework of preparatory, planning and standard verification actions, as well as mitigation actions towards reduction of the threat of electrocution and collisions with powerlines from 2016 onward. Important achievement of the declaration was to ensure that new and fully reconstructed power line sections are safe for birds by design and that priority power lines in term of bird conservation/distribution and the most dangerous pole types in all lines are retrofitted/changed to bird-friendly lines and pole types.

Projects aiming any reconstructions, underground cabling, retrofitting mitigation or increasing visibility in case of collisions: LIFE02 NAT/H/008627, LIFE04 NAT/H/000109, LIFE04 NAT/H/000116, LIFE05 NAT/A/000077, LIFE05 NAT/H/000117, LIFE05 NAT/H/000122, LIFE06 NAT/H/000096, LIFE06 NAT/H/000104, LIFE07 NAT/H/000322, LIFE09 NAT/AT/000225, LIFE15 NAT/AT/000834

- **Poland:** There is no organization dealing with the topics on regular basis. In general national and regional nature conservation authorities are responsible, esp. when it comes to EIA. NGOs are involved sporadically and act if there is a local problem (raptors in Lublin area - LTO, White Storks in E i NE Poland - TP Bocian, PTOP, etc). Powerline operators react only from case to case, only if formally urged by nature conservation authorities.

Research:

http://ochronaprzyrody.gdos.gov.pl/files/artykuly/5499/Wplyw_lini_na_ptaki_04_04_2014.pdf

http://ochronaprzyrody.gdos.gov.pl/files/artykuly/5499/Wplyw_lini_na_ptaki_04_04_2014.pdf

http://www.iop.krakow.pl/pobierz-publikacje,595

www.kp.org.pl/pp/pdf2/PP_XXIV_3_Pakula.pdf

- **Romania:** MILVUS GROUP, ROS (BirdLife Romania).

Mutual agreements between DDBRA and electric companies has been reached.

Research:

http://milvus.ro/en/?s=electrocutare,

http://milvus.ro/en/putem-face-ceva/8581,

https://sor.ro/ro/noutati/-O-statistica-sumbra-100-000-de-pasari-mor-electrocutate-anual-in-Romania.html

- **Slovakia:** Raptor Protection of Slovakia (RPS) coordinates the field survey and cooperates with producers of products for birds protection from electrocution and collisions. Also prepares plans for implementation of various solutions to eliminate the risks. Before the solutions are implemented, they are discussed with State Nature Conservancy of the Slovak Republic and Energy Supply Companies in Slovakia. Often there are mutual memoranda. However, energy companies do have a responsible approach which makes cooperation easier, for instance a joint participation on projects such as LIFE Energy. Last but not least, it is also Act 543/2002 Coll. about Conservation of Nature and Landscape. It imposes an obligation to prevent bird mortality on managers of power lines. In case it happens, they have to take actions to prevent it from happening again in future.

The problem of electrocution was identified in about 1980. In 1993, the insulation of the first section of 22 kV lines in Malá Fatra occurred. The element was called "ridge barrier" limiting abutting birds on the console line. This type of barrier, however, appeared to be insufficient. Birds, despite installations, tried to abut and again there was a fatal shock. Later followed the testing and development of new structures and components. In the years 2006 - 2007 three new elements were tested that proved to be the most appropriate type, they are still used today and are called "Tooth" - insulators, which allows the birds (in contrast to the first type) to securely engage the bracket column. They also use elements that overlap the electrical conductors and insulate electric poles. In **Slovakia** deaths from collisions had been located sporadically, but first more extensive results were found out in the year 2010 in CHUV Ondavská rovina. The results proved the need of a systematic approach, therefore we have been regularly monitoring collisions since 2014. A project LIFE Energy has started, its duration is planned for 5 years period (2014-2019). Project is focused on collisions of birds with 22 kV and 110 kV power lines. First there is a need to identify most dangerous types of powerlines for collisions (e. g. in Slovakia 22 kV and 110 kV powerlines) as well as to identify most dangerous sites with high collision rate. In Slovakia in frame of project LIFE13 NAT/SK/001272 a complex methodology for monitoring of these powerlines has been identified during period May 2016 – May 2019 and results will be evaluated at the end of the process.

Project LIFE Energy - http://www.lifeenergia.sk/index.php/en/

- **Ukraine:** Ukrainian Society for the Protection of Birds developed a recommendations in order to prevent bird collisions and electrocutions. From time to time some power lines companies asks for justifying the construction of power lines. Among them Shmalhausen Institute of

Zoology NAS of Ukraine, Azov-Black Sea Ornithological Station, and Ukrainian Society for the Protection of Birds.

Co-operation is being realised usually by the agreement.

Research:

Ponomarenko O.L. (Пономаренко О. Л. Біологічне обґрунтування «Оцінка впливу ліній електропередач 330 кВ ТОВ «Юрокейп Юкрейн 1» на орнітофауну в межах території біля ріки Молочна, Мелітопольского р-ну Запорізької обл. та розробка заходів по запобіганню можливості загибелі птахів і внаслідок цього аварійних відключень на лініях електропередач». Дніпро – 2018. 12 с.)

7. FINAL EVALUATION AND RECOMMENDATIONS

We live in a time when a life without electricity is hard to imagine. Electricity has become a part of our daily necessity, such as drinking water. The fact that we turn on a light or appliance whenever needed, we see as automatic as to use a tap for drinking water. Electrification meant the construction of a constantly expanding network of overhead electrical power lines that provide electricity transmission to users. At that time no one thought of what a risk they would be to the country, they also pose threats to birds - along with other obstacles in open country, such as road and air traffic, and high-rise buildings.

Overhead power lines are an important factor significantly influencing the life of birds. For species that are rare or endangered, the loss of a few or even one individual may impact a local population or the overall population's viability. Biologically significant risk from collisions and electrocutions may occur in a population that is so small that the loss of a few individuals may impact local, rare, or endangered populations (Crowder, 2000).The attitude between birds and networks of overhead electrical power lines has two levels. The first is electrocution in abutment birds on the console of power pylons, and other is collisions with the overhead electrical power lines. The prior actions should be focused on power lines that span water bodies plus 100 meters radius and/or in SPA Natura 2000 sites represent the first priority for the implementation of the protection measures (Ferrer, 2012). The most dangerous types of constructions due to electrocutions are in the Danube/Carpathian countries tare metal cross arms poles, poles with a different combination of exposed jumper wires locations. There are many types of effective solutions of insulations of poles of medium-voltage power lines such as: plastic hood, silicon tubes, long rod insulators, plastic insulators covering the metal console etc. The best solutions are those, which allow the birds to securely perch on poles.

The most dangerous types of power lines do not correlate with constructions of the lattice tower type or pole types on medium voltage system. More important is the location of the power line sections, whether they cross important bird habitats/breeding areas or main migration routes. Line marking is one of the best solution, how to make the cables more visible to birds in flight. It has become the preferred mitigation option worldwide (Frost, 2008).

Recommended properties of marking devices are: motion of the device or its parts, reflectivity, contrasting colors, and enhances the visibility of the line and glowing for up to 6 hours after sunset. Buried power lines may be a solution to bird collisions in some instances, but can cost about 10 times more that the line marking.

Even if collisions and electrocution could not be eliminated, still they can be reduced by proper measures.

Risk reduction options include (APLIC, 2012; Haas et al., 2005):

- Line placement that takes migratory patterns and high bird-use areas into account.
- Line orientation that considers biological and environmental factors such as bird flight paths, prevailing winds, and topographical features.
- Line configuration that reduces vertical spread of lines, clusters multiple lines in the same right-of-way (ROW), increases the visibility of lines, and/or decreases the span length if such options are feasible.
- Line marking to increase the visibility of the line.
- Burying lines if feasible and warranted.

From **Slovakia** final recommendations include in the following: in the case of collisions, it is appropriate to proceed in accordance with the "Risk Assessment Methodology for Potential Bird Deaths Caused by Collision with Power Lines", produced by RPS. Thanks to that knowledge we are able to focus time and money to those power lines sections, which are the most risk-bearing for collisions. From **Hungary** the proper planning of bird friendly pylon head structures on medium voltage power lines could be evaluated by the previously cited guideline: Solt et al. (2015): Bird-friendly construction principles - Overview of planning medium voltage bird-friendly overhead structures, and head sizing. Risk assessment of existing and newly constructed mid-voltage power line pylons / overhead structures in terms of electrocution of wild bird species. Guideline of BirdLife Position statement on Power lines and Grid development in the European Union - BirdLife Task Force November 2015 (Annex guideline). A detailed planning procedure were first demonstrated in Solt Szabolcs, Szügyi Kálmán, Horváth Éva és Horváth Márton (2013): Középfeszültségű hálózatok fejszerkezeteinek madárbarát méretezése. MAVIR Madárvédelmi Konferencia, Budapest, 2013. március 6. (Presentation in Hungarian), and in english in Márton Horváth, Szabolcs Solt, András Kovács, Károly Nagy, Ferenc Papp, Kálmán Szügyi, János Bagyura, Iván Demeter, Éva Horváth and Gergő Halmos (2014): Birds and powerlines: the problem, experiences and future directions for solution in Hungary. 11. June 2014. Birds and powerlines Conference, Sofia, Bulgaria (Presentation). These models are planned in the near future to be published in an international journal.

The recommended experience from **Czech Republic** would be the proven construction for the 22 kV line – "Pařát console type" with a perch. The effectiveness of RIBE lamellas marking in **Germany** has been proven in a study at the river Elbe (Jödicke et. al, 2018).

„Best practice“ experience from **Romania** includes underwater cables that use to cross some of the Danube arms. Best practice experience from **Ukraine** includes their methodical approaches to the assessment of the impact of air power transmission lines on birds (Andryushchenko, 2014), as well as Recommendations to prevent death of birds because of collisions and electrocutions (USPB, 2002).

The risk of power lines for birds is still an underestimated reason of mortality in some countries or areas and the data are either missing or absolutely insufficient and only sporadic data are still available from local experts and wide public.

In general a systematic approach and standardized monitoring on transnational level will enable to invest into the real effective measures and focus on areas with the highest priority. When only the most risky lines are treated and most effective solutions are applied more birds will be prevented from collisions and electrocution. Sharing of expert knowledge will ensure the better cooperation in bird vs. power line issue within the responsible authorities and stakeholders.

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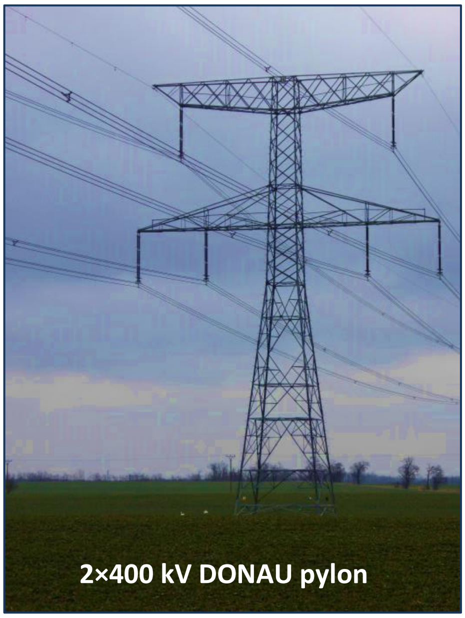
ANNEXES

Annex 1 – Examples of electric power line constructions

(A) High voltage power lines



Pylons of 400 kV power lines in Slovakia

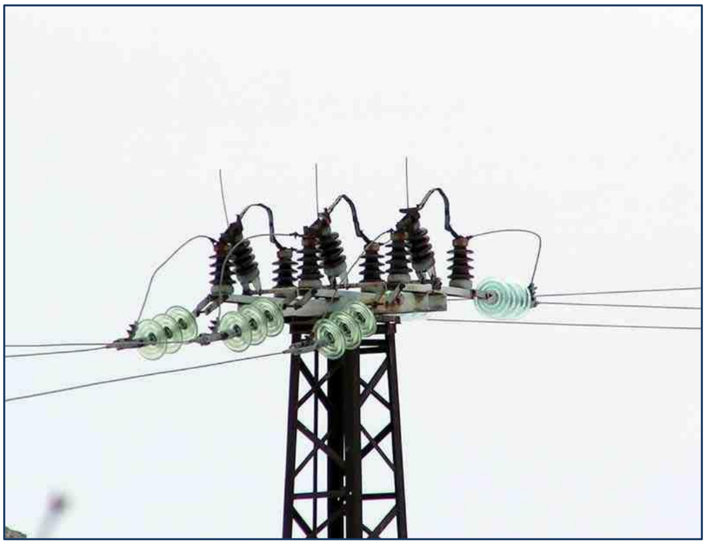
Pylons of 2x400 kV power lines in Hungary (A) and 750 kV in Hungary and in Ukraine (B)

Pylons of 220 kV power line in Slovakia

Pylons of 2x110 kV lines in Slovakia

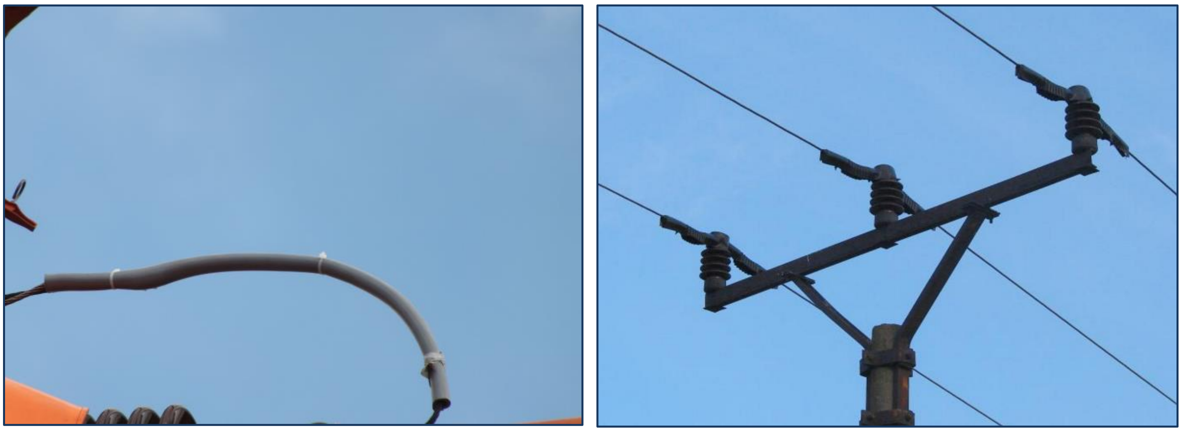
(B) Medium voltage power lines - examples

Utility poles of 22 kV line in Slovakia



Pin type pylons and switch tower in Bulgaria. Photo: Svetoslav Spasov

Annex 2 - Another effective solutions of insulations of poles of medium-voltage power lines



Silicone cover of jumper wire and plastic hood on support insulator in Slovakia

Console cover and plastic black hood on support insulator in Hungary

Annex 3 – Power lines marked with different types of bird flight diverters


FireFly Bird protection


SWAN-FLIGHT Diverter


Aerial Marker Balls in Austria


Aerial Marker Balls in Slovakia


Bird Mark Afterglow


RIBE lamellas