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NEW PRECAUTIONARY STUDIES AND RESULTS FOR REDUCING BIRD CAUSED FAULTS IN OVER HEAD LINES

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Abstract: Studies for the prevention of bird-induced malfunctions have been examined in the literature. In studies in the literature, some precautions have been taken to prevent birds from being placed in undesirable dangerous spots on conductors and poles. It has been observed that some of the measures are efficient and some are inefficient. In this direction, a number of measures have been taken to Turkish Transmission Network.When evaluated in terms of the number of individuals and wing spans in Türkiye, storks and seagulls are expected to cause the most malfunctions in OHLs. However, it has been observed that the habitats of seagulls are generally near the sea. It has been observed that storks use OHLs and poles on their migration routes, nesting and resting. It has been determined to the degree that storks are mostly responsible for bird-related malfunctions. Turkish Electricity Transmission Corporation has taken various measures to reduce bird-related faults in OHLs. Sheet galvanized metal assembly was carried out in May 2019. Sheet plates are mounted horizontally (flat) on the middle phase console of the poles. As a result of the studies, it was observed that although horizontally mounted galvanized sheets did not prevent nesting, the number of openings of bird-borne OHLs decreased by a minimum of 63 percent and a maximum of 100 percent.

Keywords: Overhead lines, birds electrocution, birds trip, anti - bird measures

INTRODUCTION

Türkiye, being situated among different climate zones and encompassing various geographical regions, is one of the richest countries in terms of biodiversity. Generally, the life cycle of birds is divided into three main phases: breeding, wintering, and migration. During the wintering period, birds engage in feeding and survival efforts and can spread across large areas. The migration period is when the maximum dispersal occurs. The breeding period is the most selective phase in terms of choosing a region compared to other periods [1].

OHLs are one of the main sources of bird mortality. Some species, commonly use electric poles for nesting. Birds and their nests can cause electrical faults. In Europe, the number of White Storks using electric poles for nesting is increasing [2]. The primary reasons for birds using electric poles as nests are their elevation, providing safety from ground predators, and offering a good vantage point. Additionally, the probability of using electric poles as nests is higher when they are close to significant food sources, such as agricultural areas, wetlands, and landfills. Storks select poles within 2 km or less of landfills as roosting sites during the post-breeding and wintering seasons [3].

When a bird or nest debris comes between two phases of conductors, it creates a short circuit, resulting in current flow. This is called a phase-to-phase short-circuit fault, and the bird is likely to die. This fault current is detected by distance protection relays. The reclosing function operates, and if the fault current persists, the line goes into definite tripping. If a bird touches a phase and grounded equipment, or if nest debris remains between the phase conductor and grounded equipment, a fault current occurs. This is called a phase-to-ground short-circuit fault, and the bird is likely to die [4]. Similarly, the reclosing function operates, and if the fault current persists, the line goes into definite tripping. Electrical shocks are always fatal accidents, and birds cannot learn from this experience [5].

Observations of birds colliding with overhead lines [6] are not new. The phenomenon of birds colliding with telegraph wires, resulting in their death, was first documented in 1876 by Coues, a naturalist in the United States [7]. Principal component analysis has been applied to wing morphologies, and statistically independent dimensions and wing ratios have been derived. Additionally, major bird groups are categorized into six main aerodynamic performance-based categories: weak fliers, water birds, diving birds, soaring at sea, aerial hunters, and thermal soarers. “Water birds” and “diving birds” have high wing loading, and many species of waterfowl are frequently recorded as collision victims [8,9].

For small birds such as sparrows (Passer Domesticus), starlings (Sturnus Vulgaris), and thrushes (Turdus Spp.),

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passing in a flock over high-voltage power lines or when several flocks take off simultaneously, it has been observed that a current can pass through them, causing a short circuit [8]. Larger birds with larger wing spans and longer bodies increase the likelihood of causing a fault by coming into contact with multiple OHLs or any part of the electrical infrastructure simultaneously.

The exact calculation of the number of birds killed by electric shock in Türkiye and globally is not possible. However, some studies in Canada and the United States provide statistical data estimating an annually 25.6 million bird deaths in Canada and 175 million bird deaths in the United States [10]. Birds nesting on OHL's poles with high and horizontal conductors are at high risk of electric shock [3]. Clusters of storks nesting in such locations in Spain have recorded high rates of electric shock and faults each year [11]. In a study conducted in Portugal, the most common causes of 3367 electrical faults recorded between 2001 and 2018 were lightning (29.3%), followed by birds (25.3%), forest fires (16.2%), fog and pollution (9.7%), and other causes (19.4%). White storks constituted the majority of bird-related faults (99.7% of bird-related faults) [12].

Species frequently affected by electric shock include storks (Ciconiiformes), birds of prey (Falconiformes), owls (Strigiformes), and passerine birds (Passeriformes) [8].

Table I: Information on some bird species [13].

Bird Species	Location Status	Behavior Type	Size Range
Storks (Ciconiiformes)	Both migratory and resident	Landing on lines, nesting on poles	55 cm (Black Stork) - 57 cm (White stork)
Falconidae (Falconiformes)	Both migratory and resident	Landing on poles and lines	20 cm (Kes-trel) - 40cm (Saker falcon)
Passerine birds (Passeriformes)	Both migratory and resident	Landing on poles and lines	5 cm (Great tit) - 45 cm (Black Crow)
Owls (Strigiformes)	Both migratory and resident	Landing on poles and lines	16 cm (Eurasian scops owl) - 48 cm (Puhu)

Bird pecking is one of the causes of deterioration in composite insulators. Due to bird pecking, the components of the polymer parts are damaged. Such damages to the insulators lead to problems reducing the efficiency and reliability of insulators pecked by birds [14].

To prevent faults caused by roosting birds on power transmission lines, two types of precautions can be taken. The first is to minimize damage by protecting the equipment, and the second is to use a method that prevents birds from perching [15]. The methods to be used should be planned according to the type of equipment. Indeed, in cases where the problematic surface is narrow, bird perching can be prevented with simple solutions. In cases where the roosting area of birds is wide, the key consideration in preventive measures is the optimization of cost and benefit. Türkiye is located along the main migration route of birds [16, 17], and an example of this migration route is shown in Figure 2. Moreover, due to providing habitat for many birds during breeding and wintering periods, interactions between birds and the transmission system are observed in many parts of the country. Wetlands, agricultural areas, and landfills are attractive habitats for birds. Especially OHLs near landfills are common perching points used by birds. Although it is anticipated that the problem will be addressed with the start of closed re-establishment of landfills nationwide, the slow construction process due to high construction costs indicates that birds will continue to use landfills as feeding areas in the long term.

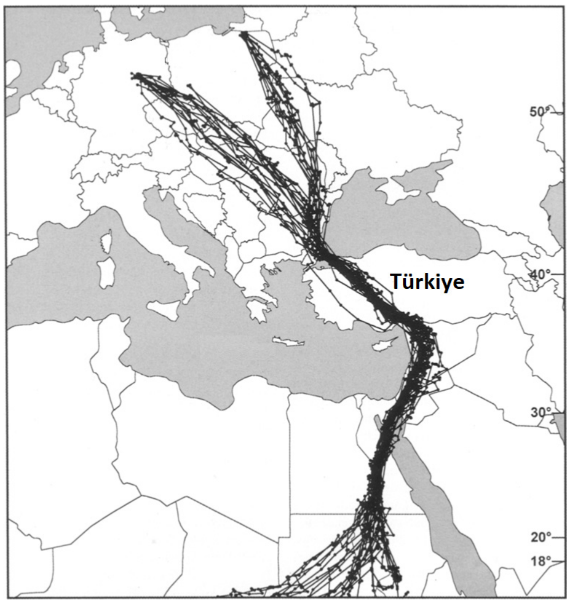

Figure 2: Reflection of the route followed by 23 white storks carrying GPS on Türkiye [18].

Bird droppings adversely affect the proper functioning of insulators. Since bird droppings are fluid, it flows between the phase conductor and grounded equipment. Due to the chemical structure of the droppings (which allows them to conduct electricity), they create an unwanted conductive layer on the insulator surface. The flowing droppings on the insulator surface ruin its insulation properties, leading to phase-to-ground faults. In Türkiye, during humid and foggy spring months, bird droppings that accumulate on poles become fluid, creating a path for current flow from the conductor to the pole. These faults are recorded as the most frequently occurring type of fault. This study will examine the precautions taken for phase-to-ground short-circuit faults caused by bird droppings in the electricity transmission system in Türkiye, as well as the results and efficiency of these precautions.

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1. MATERIALS AND METHODS

Information related to faults occurring in OHLs is recorded by the Turkish electricity operator, the TEİAŞ. TEİAŞ is responsible for the construction and maintenance of transmission lines at the 154kV and 400kV voltage levels in the country. As of December 2023, TEİAŞ operates 25,176 km of OHLs at the 400kV level and 47,558 km at the 154kV level. In this study, using TEİAŞ's database, the causes of faults recorded between 2019 and 2023 were examined, with a focus on bird-related faults. OHL faults, obtained based on field inspections and weather data, are attributed to 36 different causes. Bird-related faults are categorized under "Bird Activity," including bird-related pollution, bird nests, and bird collisions, totaling three categories. Detailed information, including geographical location, date, and time, is recorded for each fault. Additionally, the fault index number per 100 km, among the recorded fault data, is crucial for examining and evaluating the effectiveness of precautions taken against bird-related faults.

During the installation process, sheet metal materials must comply with TS EN 10346 standards and have a minimum thickness of 1.5 mm. As shown in Figure 3, in the 154 kV OHL, the mid-phases are installed at below the bracket, while the corner phases are installed inclined towards the upper part of the bracket. In rainy weather, an incline will be provided to prevent bird droppings accumulated on the plate from flowing onto the insulator. During plate installations, care must be taken not to damage the galvanization of the pole. Therefore, the plates will be connected using galvanized steel wires through the connection holes (a distance of 30 cm between connection points at each corner).

Figure 3: (a) Installation on the console end of the pole; (b) Installation on 3 phases of the pole

The data has been collected from various regions in Türkiye, which serves as the main migration route for birds. The source of our data is TEİAŞ, a corporation with regional directorates. Faults are identified and confirmed on-site by regional maintenance personnel through visual inspections, helicopter flights, and lidar-based checks. The personnel classify faults based on their characteristics and record them in the system.

In the study of bird-related faults, geographical location information from the recording system has been utilized. Observations have shown that dead birds and traces of droppings can stay on insulators for an long period. In some cases, it has been observed that bird droppings are washed away by rain, leaving behind traces of arc on the insulators and pole bodies.

2. RESULTS

Between 2019 and 2024, the most common cause of recorded faults in the power transmission lines was lightning (20%), followed by birds (18%), fog and pollution (17%), and 33 other sub-causes (55%). A total of 2645 faults were attributed to birds, with the majority being caused by migrating stork flocks. White Storks were observed to be the primary contributors to bird-related faults. From January 2019 to December 2024, a total of 2645 faults caused by birds occurred in the Turkish transmission network. This value represents more than 18% of the total fault count. Table II provides details on bird-related faults. Among all faults caused by birds, 1852 faults occurred on the 154kV lines, constituting 77% of the total bird-related faults. On the 400kV lines, 552 faults occurred, accounting for 22% of the total faults. Figure 4 displays bird-related faults on the map of Türkiye as red dots. Bird-related faults were more severe in 2020, reaching 617 faults, making up over 20% of the total fault count for the year. In the last years, with the implementation of precaution to combat birds and an increase in operational and maintenance management at various units, bird-related faults have shown a decreasing trend, falling below 300 in total fault count.

Table I: Distribution of bird-related faults in Türkiye by years

Years	Total bird faults	Bird fault index (faults/year/100 km of line)
2019	512	2.8
2020	617	3.3
2021	555	2.9
2022	412	2.0
2023	294	2.0
2024	255	1.9
Total	2645	1.6

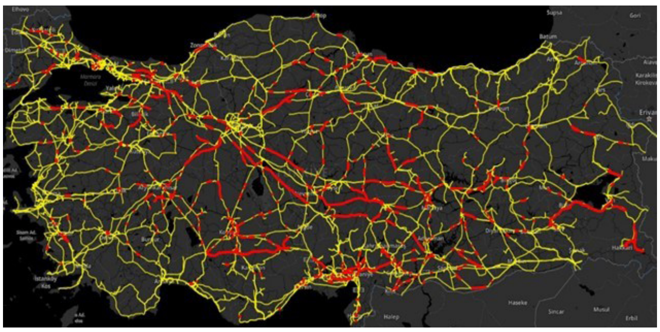

Figure 4: Locations of bird-related faults on the map of Türkiye

In Figure 5, the monthly distribution of faults caused by birds on OHLs from January 2019 to December 2024 is displayed. The number of faults shows an increasing trend from February to May. The fault counts peak in May and August, coinciding with increased bird activity. From August onward, there is a declining trend. The obtained graph aligns well with the pattern of bird migration.

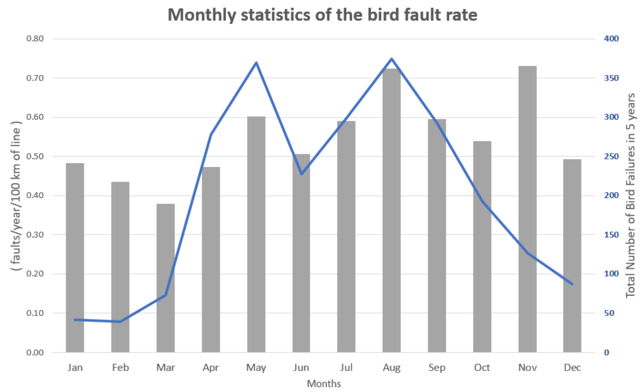

Figure 5: Failure rate and average number of failures per 100 km line caused by birds in the TEİAŞ network by months in the period 2019-2024

In Figure 6, faults caused by birds have been analyzed in hourly intervals from January 2019 to December 2024. The faults predominantly occur in the early hours of the morning. However, it has been observed that faults can occur at any time during the day. The number of faults is highest from 4 AM to 5 AM. This difference in the hourly distribution is closely related to the habits of birds. Birds that use OHLs typically begin digesting their food at night and defecate before flying in the morning. The occurrences of faults on the lines parallel the moments when birds defecate.

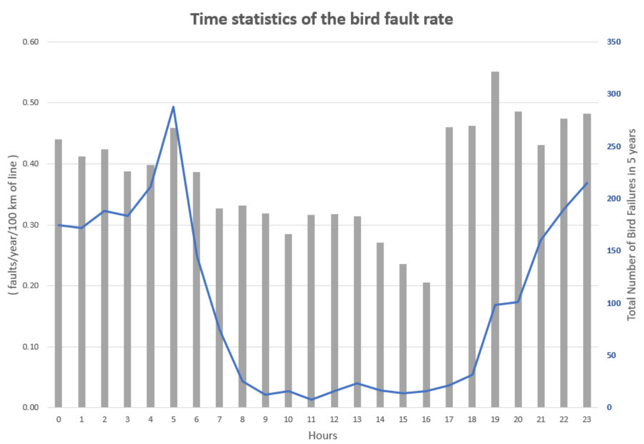

Figure 6: Failure rate and average number of failures per 100 km line caused by birds in the TEİAŞ network according to hours in the period 2019-2024

The OHL with the highest number of bird-related faults in the Turkish electricity system is the 400 kV Elgün - Hilvan OHL, as shown in Figure 7. Information regarding the fault clearing counts before and after the installation of sheet metal shields is presented in Table III. This OHL, with a length of 92.74 km, is generally located over agricultural areas. The fault zone has been confirmed through observations conducted in the region with high bird density. Significant bird droppings have been observed on the poles during the inspections. The installation of sheet metal shields on this line was carried out on December 11, 2022. As a result of the installation, the number of faults has significantly decreased.

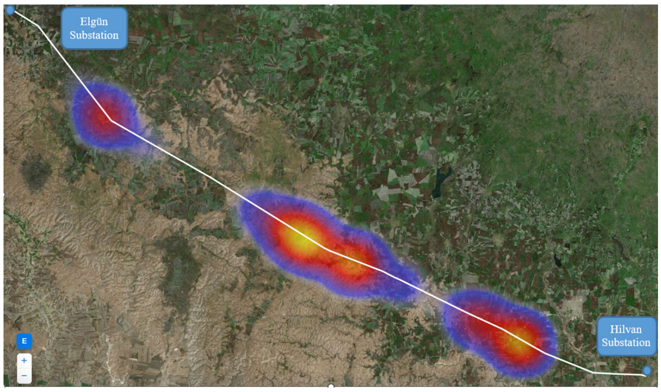

Figure 7: 400 kV Elgün – Hilvan OHL fault intensity map

Table III: 400 kV Elgün – Hilvan OHL fault distribution by years.

Years	Total bird faults	Bird fault index (faults/year/100 km of line)
2019	24	25,9
2020	27	29,2
2021	15	16,2
2022	9	9,7
2023	1	1,1
2024	0	0
Total	76	12,3

The installation studies have not been limited to a specific region but have generally covered maintenance zones for power transmission lines throughout Türkiye. Despite bird-related faults occurring nationwide, some regions are much less affected. In the OHL where faults occurred, the locations of the faults were identified by relays, and sheet metal shield installations were carried out on the poles corresponding to those locations. Many regions have implemented sheet metal shield installations. In an assessment study, it was inquired how many OHLs received sheet metal shield installations in 14 different regions. The total number of faults before sheet metal shield installation and the number of faults after the installation were collected for these OHLs. Additionally, in Table IV below, the percentage reduction in faults is calculated.

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Tablo IV: Decreases in the number of faults with assemly made in TEİAŞ regions.

Area	Number of lines assem-bled	Fault before assambly	Faults after installation	Percentage of decrease (%)
1	7	40	1	97,5
2	20	41	3	92,68
3	2	10	0	100,00
4	16	139	54	61,15
5	34	126	53	57,94
6	45	633	209	66,98
7	22	232	93	59,91
8	10	196	29	85,20
9	8	32	7	78,13
10	1	7	1	85,71
11	30	157	57	63,69
12	7	203	17	91,63
13	9	47	9	80,85
14	6	39	6	84,62

3. DISCUSSION

This study highlights the significant issue of bird-relateed OHL faults in Türkiye. To address this problem, precaution to reduce birds perching on OHLs have been deemed necessary. These precautions also emphasize the importance of designing OHLs to prevent birds from colliding with them. Additionally, precautions have been suggested to prevent the nests made by birds on OHLs from causing faults.

An increase in faults caused by birds has been observed during migration periods. It is understood that birds using our country for wintering during other periods contribute to these faults. Changes in bird migrations and settlements have been observed due to climate change. The construction of dams in our country, breaking the harsh continental climate conditions in some regions, has led to an increase in stork populations during winters. The expansion of irrigated agriculture, landfill areas, and climate warming have been observed to reduce the necessity for birds to migrate.

Although the detection of faults caused by birds and the harm birds suffer from OHLs have been known in Türkiye for years, insufficient infrastructure has prevented the necessary attention to be given to this issue. In recent years, increased awareness has led the TEİAŞ to develop important projects for both wildlife conservation and reducing the number of faults in OHLs. Initially, plastic anti-perching devices, 20 cm in length, were installed on OHLs to prevent birds from perching, but it was later realized that these had no effective. A plan was made to prevent bird droppings from reaching the lines, and the idea of installing sheet metal shields was unanimously agreed upon. Positive results were obtained from these studies.

Significant progress has been observed in the OHL with the highest number of fault records in the Turkish electricity system as a result of the installations, as given in Table 3. In Table 4, there have been significant reductions in the number of faults in many regions as a result of sheet metal shield installations. The reason for the decrease in some regions remaining around 60% is the excessive bird density and birds perching on the poles where installations have been done, subsequently moving to other poles without installations. It is believed that as the number of installations on poles increases, the number of faults will decrease further.

4. CONCLUSION

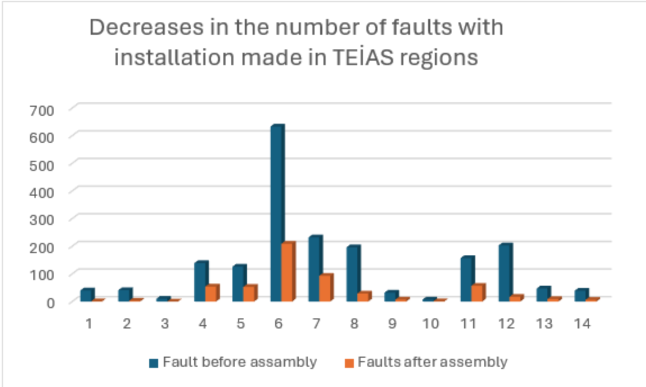

Figure 8: Decreases in the number of faults

This study examines the results of a project aimed at reducing bird-induced faults on OHLs. The conducted research represents the initial findings of a national-scale and long-term project. The study reveals that white storks are the primary culprits behind bird-related faults. The use of OHLs by storks is generally attributed to their nature. The project developed to decrease short-circuit faults resulting from storks and other birds excreting on insulators has proven to be beneficial in significantly reducing faults. According to observed results and field investigations, storks are found to use OHLs only during migration and for nesting purposes. As our country is located on the main migration route, many birds stay in our country both during the breeding season in summer and continuously during winter. Due to their continuous presence, birds use OHLs as nests, causing various faults during nest construction. Efforts should be made to design these nests in a way that minimizes potential faults. Research and the development of new designs in the future are crucial for minimizing the impact of birds on OHLs, ensuring the sustainability of the natural balance.

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BIOGRAPHY

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