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Research on New Artificial-Guided Bird Prevention Device Based on Bird Damage Characteristics

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Abstract. Aiming at the operation safety for transmission lines in east Inner Mongolia seriously threatened by bird-caused damage in transmission and transformation equipment, according to the analysis of the law of bird activities in east Inner Mongolia , it is found that 463 species of birds are exist in east Inner Mongolia, and the bird damages are mainly caused by larger birds. Through the application effect of existing anti-bird measures, it is found that the current bird-repelling anti-bird measures can reduce the number of bird damages. However, the actual application effect of the anti-bird measures is still limited based on the operational data. Therefore, the guided improvement measures based on the artificial bird guide are proposed, and the corresponding models are made. The comparison with several existing bird-prevention measures is carried out and the test show that the combination of bird thorn of anti-bird measures prevention and the bird guides have a better effect. It is expected that the research can provide reference for the bird disease prevention and control work for east Inner Mongolia Power Grid.

1. Introduction

Due to the continuous improvement of the ecological environment and the increasing human awareness of environmental protection, the bird populations and ranges are increasing in east Inner Mongolia. At the same time, the east Inner Mongolia is located in the migration area of Eurasian migratory birds. This seasonal bird damage fault covers a large area and causes serious damage, which poses a great threat to the safe and stable operation of the east Inner Mongolia Power Grid. Therefore, it is of great significance to grasp the rules of birds' habits, to analyze the types and characteristics of bird damage faults, to count the practical application effect of existing anti-bird measures and to put forward reasonable anti-bird measures [1-3]. At present, some domestic experts have carried out relevant studies on the characteristics of transmission line bird damage and the corresponding anti-bird measures [4-5]. However, the existing literature lacks observation and analysis of the bird habits around transmission lines, studies on the application of existing anti-bird measures, and studies on the improvement of overall anti-bird measures of the transmission lines.

In this paper, the behaviour of birds around transmission lines in east Inner Mongolia was observed and investigated, and the birds causing bird damage were classified and sorted out. Then this paper made statistical analysis on the characteristics of bird damage fault data of the east Inner Mongolia Power Grid in the past five years, and studied the practical application effect of the existing anti-bird measures. In view of the limited effect of the existing anti-bird measures on 500 kV tower lines, a new type of artificial-guided anti-bird device was designed, which can provide reference and guidance for strengthening the anti-bird work of transmission lines in the east Inner Mongolia Power Grid.

2. Bird habits in east Inner Mongolia

Located in the northeast of Inner Mongolia autonomous region, the landform the east Inner Mongolia is dominated by plateaus, and there are various environments such as mountains, hills, plains and wetlands. The climate is changeable and generally belongs to temperate continental monsoon climate area, and the vegetation types are dominated by forest, grassland and desert. The complex and diverse natural environment breeds abundant bird resources. At present, 467 species of birds are recorded in eastern Mongolia, belonging to 19 orders, 66 families, 206 genera [5]. The east Inner Mongolia region is located on several migration corridor of birds so the region is an important breeding and resting place for migratory birds. The main areas of nesting and activities of birds in east Inner Mongolia are located in the western Hulunbuir, Eastern Xing'an League, central and Western Tongliao City and Northern Chifeng City. There are many important 220kV and 500kV voltage transmission lines in these areas, and they are also the areas where the migration paths and activities of birds are most concentrated every year.

Most of the birds which are easy to nest and lay eggs on power lines or towers in east Inner Mongolia live in forest, grassland and wetland terrain structures, as shown in table Ⅰ. There are mainly two kinds of damages caused by birds on Power Grid in east Inner Mongolia. The first one is that the material of bird's nest falls between the cross arm and the wire, which will cause the line tripping fault. The second one is the flashover caused by bird droppings with large size, large variety, large number and low flying altitude.

Table 1. Birds are prone to cause damage on transmission line or tower.

Birds	Active landform
White stork	grassland, wetland
Oriental white stork	grassland, wetland
Magpies	urban area, forest
Crows	urban area, forest
Eagles	desert, grassland

3. Statistical analysis of fault characteristics of bird damage in east Inner Mongolia

According to statistics, 82 bird-related faults occurred on 220 kV and above voltage level transmission lines in east Inner Mongolia Power Grid from 2013 to December 2017, as shown in figure Ⅰ.

3.1. Seasonality of bird-caused tripping fault

Figure 2 shows the monthly distribution curve of bird-caused tripping faults in east Inner Mongolia Power Grid. The peak periods of bird-caused tripping faults occurred in March-April and August-October, in which April was the month with the largest number of bird damage, accounting for 14.6%.

The migration time of large migratory birds in east Inner Mongolia is mainly from march to April and from August to October. This is because about half a million large and medium-sized migratory birds pass through or reside in this region every year. In March, the region just entered the spring. A large number of birds build their nests on the poles and towers. While in August-October, a large number of migratory birds inhabit the poles and towers in the east Inner Mongolia. In addition, the autumn crops maturity in the region, and there is a greater risk of tripping due to large feed of birds in farmland.

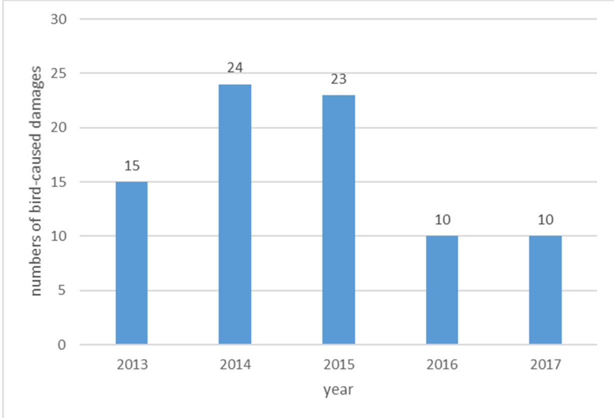

Figure 1. Statistics on the numbers of bird-caused damages occurred in east Inner Mongolia Power Grid.

3.2. Time-course of bird-caused tripping fault in one day

Figure 3 shows the time period statistics of bird-caused damages in east Inner Mongolia Power Grid. Most bird damages occur from 20 p.m. to 7 a.m. and peak at 4-5 a.m.

The main reasons for this phenomenon are as follows: birds migrate at night in east Inner Mongolia, and frost condensation often occurs at night due to high humidity, which is easy to cause the insulator strings flashover along the surface because of the formation of bird droppings conductive liquid. At the same time, many large birds in east Inner Mongolia will have a defecation before taking off in the morning, which may cause flashover in the gap of the guano passage.

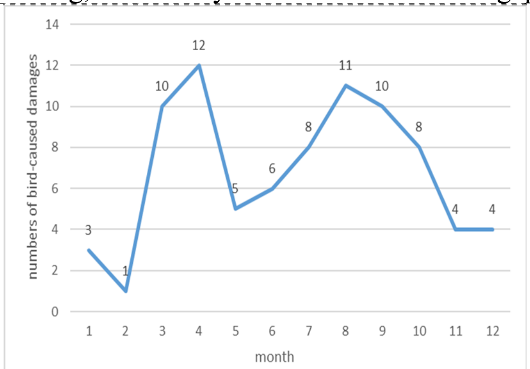

Figure 2. Month distribution of the bird-caused damages in east Inner Mongolia Power Grid.

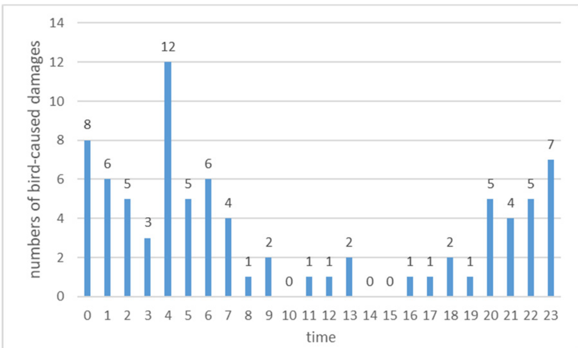

Figure 3. Time period statistics of bird-caused damages.

3.3. Surrounding terrain and landform of bird-caused tripping fault

The statistics of bird damages in various terrains in east Inner Mongolia in the past 5 years are shown in table Ⅱ. As can be seen from the data in the table, the terrain of transmission lines with bird damage faults in east Inner Mongolia is mainly on flat ground, accounting for 81.7% of the total number of faults. The main reason is that the grasslands in the area account for a relatively high proportion, which makes it easier for birds to perch and nest on towers of such terrain.

Table 2. Numbers of bird- caused damages in various terrains.

Terrain	Flat ground	Hill	Mountain
Numbers	67	10	5

Table 3. Numbers of bird- caused damages in various landforms.

Landform	Wetland	Grassland	Farmland	Desert
Numbers	4	52	20	6

The statistics of bird damages in various landforms in east Inner Mongolia in the past 5 years are shown in table Ⅲ. It can be seen from the table that the most bird-caused faults occur in the grassland landform of east Inner Mongolia, accounting for 63.4%, followed by farmland, accounting for 24.4%. The reason for this phenomenon is that there are vast grasslands in east Inner Mongolia, where raptors have abundant food sources, so the activities of large birds in this region are relatively frequent. Farmland can also provide food for some birds.

4. Study on improvement of anti-bird measures

4.1. Application of anti-bird measures in east Inner Mongolia

At present, the anti-bird measures adopted by east Inner Mongolia Power Grid mainly include anti-bird sting, anti-bird cover, windmill bird repeller, etc. Through statistical analysis of anti-bird measures for lines and towers with bird-caused damage in past five years, it is found that the main anti-bird measures of the transmission line of east Inner Mongolia Power Grid were anti- bird stings from 2013 to 2015. In the three years, 62 bird damage faults occurred on lines and towers, 56 anti-bird stings were installed, 10 anti-bird cover s were installed, and 8 windmill repeller were installed. In the past two years, east Inner Mongolia power grid has carried out the rectification of anti-bird measures such as installing more anti-bird stings, using the anti-bird cover with a larger radius, and replacing the damaged windmill bird repeller, etc., which resulted in a significant decrease in the number of bird-caused faults in the two years from 2016 to 2017. In 2016 and 2017, there were 10 bird tripping accidents, down from 23 in 2015.

However, bird-caused tripping fault ranks second among all tripping accidents in east Inner Mongolia Power Grid, next only to lightning disaster. In particular, although the number of anti-bird measures has increased a lot in 500 kV lines, there are still five accidents in 2016-2017, which seriously threatened the safe operation of the Power Grid. This indicates that the application effect of the existing anti-bird measures is limited, and the corresponding anti-bird improvement measures need to be proposed according to the structural characteristics of bird damage fault lines and the characteristics of the surrounding environment.

4.2. New artificial-guided bird prevention device

The data characteristics of 5 bird-caused tripping faults of 500 kV transmission lines in east Inner Mongolia Power Grid in recent two years are analysed:

1) Environmental analysis: The tower area of the bird damage fault line is located in the plain terrain, and the surrounding vegetation is mainly grassland, trees and farmland. There are rivers or fish ponds and other water sources within 3 km of the fault lines and tower. There are many fish and shrimp in the rivers, and the surrounding surface vegetation is lush, attracting large birds to gather here for roosting and foraging.

2) Bird activity analysis: The whole cross arm of the line and tower with bird damage fault is covered with anti-bird stings, so small birds such as sparrows and crows cannot gather on the cross arm to inhabit in large numbers. Line tower is located in the plain, there are no other tall trees or buildings around it, and large birds have the characteristics of "high" habits. So it can be observed that a small number of large birds landed in the gap of anti-bird sting on one leg, and some of them landed on overhead ground line brackets or overhead ground lines, which poses a certain threat to the safe operation of the line.

3) Fault type analysis: A large number of bird droppings were found on towers and cross arms of bird-damaged fault lines, and obvious discharge points were found at grading rings of side phase composite insulators and cross arm angle steels. Due to the large insulation distance of the side phase,

it can be judged that the air gap between the short cross arm and the grading rings of the insulator hanging point was punctured, causing tripping accident.

It is found that the existing anti-bird measures can effectively prevent sparrows, magpies and other small birds from gathering at the tower cross arm if they meet the requirements of large number and large coverage area, thus effectively playing the role of bird prevention to a certain extent. However, the surrounding environment of 500 kV transmission lines can attract large birds to gather and inhabit, and the existing bird prevention measures have limited effect on these large birds. Figure 4 is the model and physical diagram of 500 kV compact tower.

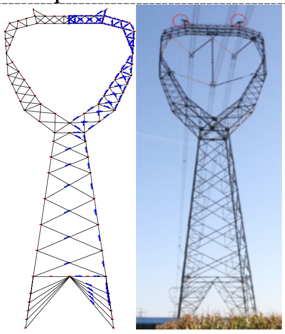

Figure 4. 500kV compact tower model and physical graph.
（The red marked are large birds stay region）

In this paper, a new type of artificial-guided bird prevention device is designed for the structural characteristics of 500 kV compact towers in east Inner Mongolia. The idea of active bird guidance is adopted to make large birds stay away from the transmission line conductors and insulators. Thus, the overall bird prevention level of 500 kV transmission lines can be further improved. Figure 5 is the design drawing and effect drawing of the new artificial-guided bird prevention device. The design principle is as follows:

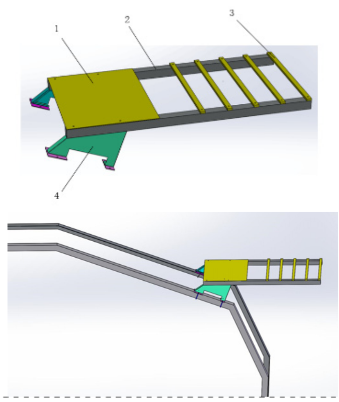

Figure 5. Design drawing of a new artificial-guided bird prevention device.

Figure 6. Artificial bird guide device physical graph

1) In order not to affect the insulation performance of the entire transmission line tower, the artificial-guided bird prevention device adopts epoxy resin material with good insulation performance and corrosion resistance as the main part of the whole device. The connecting parts are made of stainless steel, which can ensure the stability and safety of the device.

2) The device is designed to be installed at the side cross arm of 500 kV compact tower. Because the side cross arm spacing is inclined at 21°, the horizontal angle between the device and the cross arm is also designed at 21°, which makes the main body of the device extend along the horizontal direction. It is beneficial for large birds to stay on it.

3) Since large birds do not nest in groups, generally 3-4 birds gather together, so the whole device designed 5 epoxy resin supports for roosting. The four sides of the bracket are polished, and the width of the bracket is not more than 5 cm, on which is convenient for large birds to land.

4) An epoxy resin board is installed directly above the device to prevent bird droppings from falling on the insulator sub-area below the side cross arm during the flight. The bird guide bracket part of the device is outside the range of insulator area, which can ensure that the range of bird activity is far away from the line conductor and insulator area. The physical diagram of the whole device is shown in Figure 6.

4.3. Comparative experiment on the effect of anti-bird measures

In order to study the actual effect of different anti-bird measures, a comparative experiment was designed to analyse the effect of different anti-bird measures. The experimental design idea are as follows:

1) Firstly, five anti-bird measures, including anti-bird sting, anti-bird cover, windmill bird repeller, ultrasonic bird repellent, and newly designed artificial-guided bird prevention device, were divided into five groups. Among them, the anti-bird cover and artificial-guided bird prevention device were scaled up in proportion. Then they were placed in the forest environment where the birds were active frequently and were not affected by each other. Each anti-bird device was equipped with a small tower model and three clean composite insulators. In order to facilitate manual feeding, the size and height of the simulated cross arm should not exceed 1.5m, and 10kV composite insulator was selected as the insulator. In order to facilitate manual feeding, the size and height of the simulated cross arm should not exceed 1.5m, and 10kV composite insulator was selected as the insulator.

2) The three insulators of each group were vertically suspended below the cross arm and the anti-bird measure device was placed above the cross arm. The experiment started in May, when the birds were more active, and the period was 3 months. Bird feeding was delivered once a week at the corner steel joint of each group, attracting birds to move around the cross arm.

3) After 3 months, the distribution of bird droppings on the cross arm, composite insulator and anti-bird device of each group were photographed on the spot, and then the bird prevention effect of different anti-bird devices was analyzed.

Five sets of field photos of devices in figure 7 show that:

1) Anti-bird sting: three traces of bird droppings were found on the cross arm, and five traces of bird droppings were found on the insulator.

2) Windmill bird repeller: two traces of bird droppings were found on the cross arm, and four traces of bird droppings were found on the insulator.

3) Anti-bird cover: two traces of bird droppings were found on the cross arm, no trace of bird droppings was found on the insulator, and five traces of bird droppings were found on anti-bird cover.

4) Ultrasonic bird repellent: one trace of bird droppings on the cross arm, no trace of bird droppings on the insulator.

5) Artificial-guided bird prevention device: one trace of bird droppings was found on the cross arm, one trace of bird droppings was found on the insulator, and four traces of bird droppings were found on the artificial-guided bird prevention device.

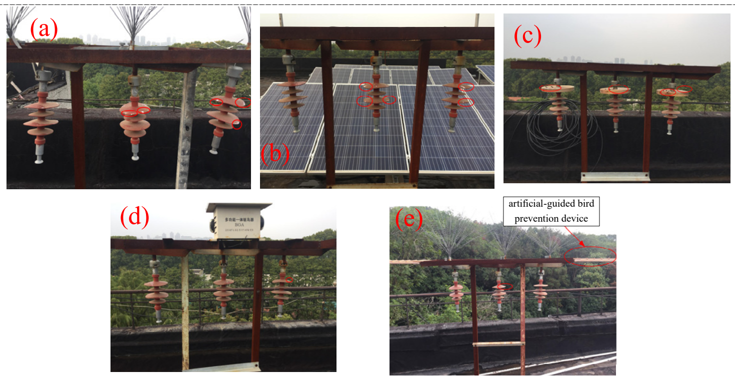

Figure 7. Anti-bird effect comparison experiment scene graph.（The red part are white bird droppings.）
a) anti-bird sting
b) windmill bird repeller
c) anti-bird cover
d) ultrasonic bird repellent
e)artificial-guided bird prevention device

According to the above experimental phenomena, the analysis is as follows:

1) Ultrasound bird repellent device has two measures to drive birds, sound wave and ultrasonic wave at the same time. Because of the least trace of bird droppings was found, it shows that birds move less frequently on it and the effect of ultrasound bird repellent is the best. It can be found that after 3 months of outdoor test, the main body of the device has obvious rust marks, although the solar charging is normal, but the sound volume has signs of weakening. The overall electrical performance of the device will affect the anti-bird effect under long-term operation.

2) There are many traces of bird droppings in anti-bird sting and windmill bird repeller devices, which can be explained that these devices may have some effect in the initial stage, but in the long run, the adaptability of birds to the environment will reduce the bird prevention effect of such devices.

3) There are many traces of bird droppings on anti-bird cover, but there are no bird droppings on the insulator due to the shielding effect of the cover. This shows that the anti-bird cover can effectively prevent the accumulation of bird droppings on insulators in the practical lines. However, it is difficult to install bird shield in practice, and a large amount of bird droppings accumulated on the anti-bird cover will cause a large number of inclination in rainy days, which threatens the safety of transmission line.

4) Artificial-guided bird prevention device is equipped with anti-bird stings on the cross arm. According to the photos, only one trace of bird droppings was observed on the cross arm and insulator, while four traces were found on the artificial-guided bird prevention device. It can be explained that birds often stay on artificial-guided bird prevention device. By comparing the experiment phenomena on the insulator with anti-bird sting, it shows that the artificial-guided bird prevention device combined with anti-bird device for driving birds can effectively reduce the number of birds' activities on the cross arm.

5. Conclusion

1) Bird damage in east Inner Mongolia has obvious regional, topographic and geomorphological characteristics. The main areas of birds nesting and activities are located in the western Hulunbuir, Eastern Xing'an League, central and Western Tongliao City and Northern Chifeng City. Bird damage areas are concentrated and related to the migration paths of migratory bird. Birds in east Inner Mongolia which are prone to cause flashover failure of bird droppings are generally large birds. They are active in wetlands, grasslands and other terrain, often flying at low altitudes, with a large number of species and flying speed.

2) Bird damage faults in the east Inner Mongolian Power Grid mainly occur in March-April and August-October each year, mainly at 20:00 to 7:00. Bird wading failures are mainly caused by the flashover of bird droppings from large birds, which like to move around grasslands.

3) The existing anti-bird measures of east Inner Mongolian Power Grid have achieved certain results after the rectification work in 2015, but the practical application effect is limited. In view of the serious tripping fault caused by large birds in the 500kV lines of east Inner Mongolian Power Grid, a new type artificial-guided bird prevention device is designed. The experiment proves that the combination of the new type of artificial-guided bird prevention device with anti-bird device for driving birds has a good bird prevention effect.

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