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Cover: Dorsal view of Mantis Shrimp *Cloridina ichneumon* (Fabricius, 1798) & *Gonodactylus demanii* (Henderson, 1893). © Fisheries Research Station, Junagadh Agricultural University, Sikka.

INTRODUCTION

Human-made structures often disconnect and fragment the habitat of wildlife animals, negatively impacting their survival and potentially leading species to local extirpation (Rudolphi et al. 2014; Warner et al. 2021). Electric poles, a power line element, are one of the human-made facilities that can be deadly to various animal species. A power line can cause immediate death by electrocution or serious injuries when touched simultaneously with another non-electric current object or a wire with a different voltage (Kumar & Kumar 2015; Schulze et al. 2016). Although bird electrocutions are well documented and studied (Loss et al. 2014; Pérez-García et al. 2017), arboreal mammal species such as primates are also especially vulnerable given their high accessibility to the power lines (Moore et al. 2014; Kumar & Kumar 2015; Katsis et al. 2018).

Considering electrocutions of primates, several long-term studies reported that 32 to 40% of them eventually died after an electric shock from a power line (*Macaca mulatta*: Kumar & Kumar 2015; *Alouatta guariba clamitans*: Lokschin et al. 2007; *Semnopithecus vetulus vetulus*: Roscoe et al. 2013). The most extended study from 1998 to 2019 in Kenya found 73% of the death is due to electrocution in four monkey species (Cunneyworth & Slade 2021). In addition, electrocution was the reason for 36% of deaths observed in Hanuman langurs in Jodhpur, India (*Semnopithecus entellus entellus*; Ram et al. 2015) and 16% of four primate species in Kenya (*Colobus angolensis palliatus*, *Cercopithecus mitis albogularis*, *Chlorocebus pygerythrus hilgerti*, & *Papio cynocephalus cynocephalus*: Cunneyworth et al. 2021). These results suggest that electrocution contributes highly to mortality in primates, especially in urban areas where humans and wildlife co-exist.

Java is the most heavily populated island of Indonesia with more than 140 million people while also hosting various wildlife habitats. Due to the continued deforestation in Java, less than 10% of forests remain, and the remnant is also heavily fragmented (Nijman 2004, 2013). Gunung Halimun-Salak National Park (GHSNP) has the largest remaining forest blocks in Java and it is the host to high biodiversity (MacKinnon & MacKinnon 1986). These areas can provide ecological services not only to wildlife but also to humans. However, throughout the year, with the increasing growth rate of the human population, infrastructure like roads and power lines are traversing areas close to the conservation area and could cause negative effect on wildlife.

The Javan Gibbon *Hylobates moloch* is an 'Endangered'

primate and the main threats are deforestation and hunting for pet trade (Nijman 2020). While around 4,000 Javan Gibbons are left in the wild, GHSNP holds between 900 and 1,221, the largest remaining wild population (Nijman 2004; Supriatna 2006). Similar to other gibbon species, Javan Gibbons are highly arboreal, spending most of their time in the canopies (Cheyne 2011). As a result of their movement through brachiation, gibbons are at high risk of electrocution when electric poles are installed in their habitats. Several electrocution of gibbons have been reported in the media (The Wildlife Trade Monitoring Group 2020; The Straits Times 2019; Zon Pann Pwint 2019), but rarely in the scientific literature (Talukdar et al. 2018). In this study, we report and describe three cases of electrocuted wild Javan Gibbons in 2011, 2015, and 2021 at the edge of the forest close to GHSNP.

METHODS

Study site

The Javan Gibbon is one of the three key species of GHSNP, along with Javan Leopards *Panthera pardus melas* and Javan Hawks *Nisaetus bartelsi*. In addition to Javan Gibbons, the endemic Javan Lutung *Trachypithecus mauritius* and the endangered Javan Surili *Presbytis comata* are also found in the National Park. While GHSNP supports one of the largest Javan Gibbon populations, their habitats are still fragmented due to deforestation and human facilities (Smith et al. 2017). The field site in Citalahab is also located on the edge of primary forests and is surrounded by tea plantations and rice paddies (Yi et al. 2020).

Study subject

The Javan Gibbon Research & Conservation Project (JGRCP) began in 2007 in Citalahab area in GHSNP (-6.739167 S, 106.530000 E), with a focus on behavior and ecology of wild Javan Gibbons (Kim et al. 2012; Ham et al. 2017; Oktaviani et al. 2018; Yi et al. 2020; Jang et al. 2021). The home ranges of the gibbon groups that are regularly followed by the research team are located along the tea plantation, separated by a one-lane dirt road. We expect a similar habitat shared with human facilities for other gibbon groups in GHSNP. Given the long-term research going on in the area, local people are aware of Javan Gibbons and therefore direct threats towards the gibbons are relatively low compared to other habitats.

Data collection

The observations of electrocuted Javan Gibbons were

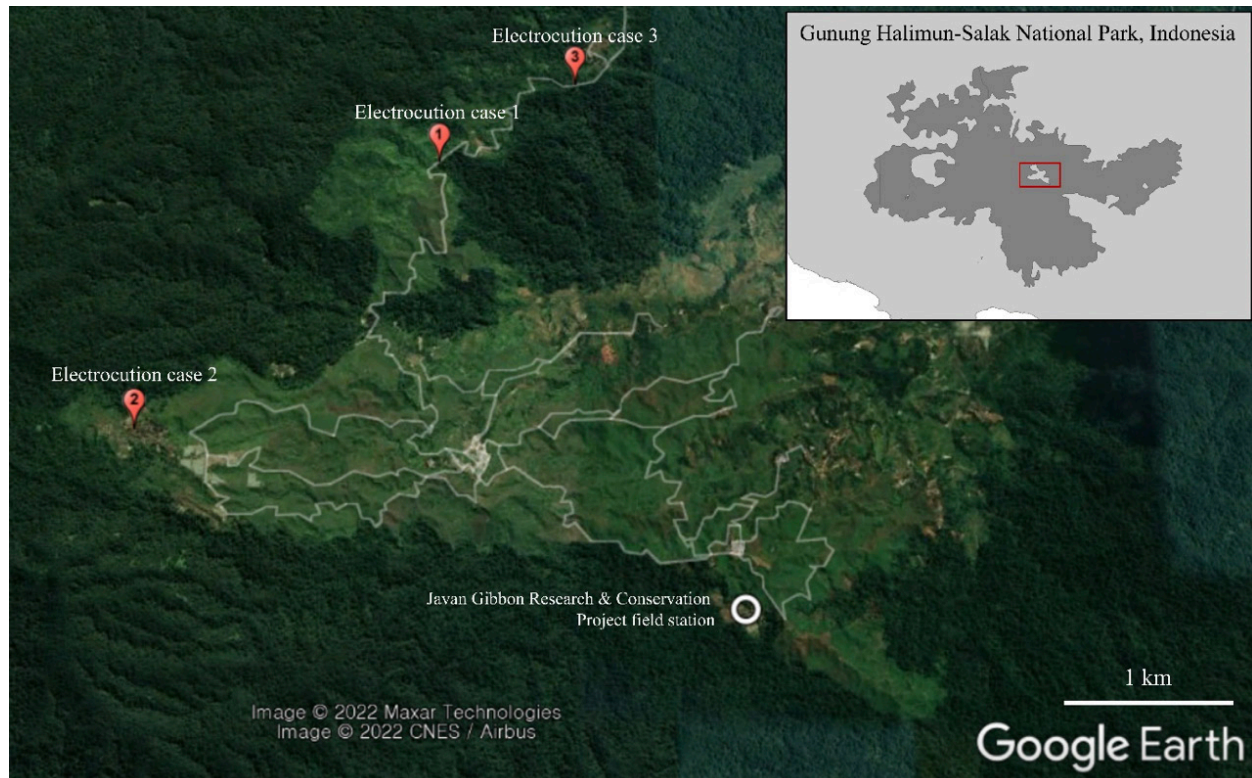


Image 1. The location of three electrocuted gibbons and the Javan Gibbon Research and Conservation Project field station on the map.

opportunistic, temporarily matching within the frame of the long-term research project. We collected the date, location and context of the electrocution events.

RESULTS

We observed three cases of electrocution of Javan Gibbons on power lines over the 15 years of long-term research along the road and the tea plantation adjacent to GHSNP (Image 1).

Case 1

22 February 2011: We found a dead gibbon holding a power line at Malani area (-6.710944, 106.512500). The individual had died a few days prior (pers. com. Cikaniki Research Station) and it was collected before 25 February 2011. The GHSNP staff witnessed the electrocution at the edge between forest and tea plantation. The gibbon jumped and held on to the power line unexpectedly because of a falling tree behind and was electrocuted. The dead gibbon was stuck to the power line until the GHSNP staff requested the national electricity company to turn the power off a few days later (Image 2). There was not much flesh left on the body and its head was missing after

falling to the ground probably due to the electrocution and decomposition. Because of the bad condition, the GHSNP staff buried the gibbon body directly and we could not obtain further information. We suspect the dead gibbon was an adult male from the body size.

Case 2

23 March 2015: A local resident found an electrocuted gibbon close to Malani area (-6.727778, 106.493889), and suspected that human disturbance made the gibbon to jump onto the power line. The electrocuted gibbon's face and left arm which held the power line were damaged. No other gibbons were observed around at the time of electrocution. For necropsy, the body was delivered to LIPI (Indonesian Institute of Sciences) in Bogor. The individual was an adult male, with a body length of 530 mm and a weight of 5.5 kg (Image 3). Later, the specimen was deposited at the GHSNP headquarter in Kabandungan area as education material.

Case 3

13 December 2021: A local resident found an electrocuted gibbon close to Ciwalen (-6.705809, 106.521170). The right side, especially the arm and flank, of the dead gibbon were seriously damaged probably

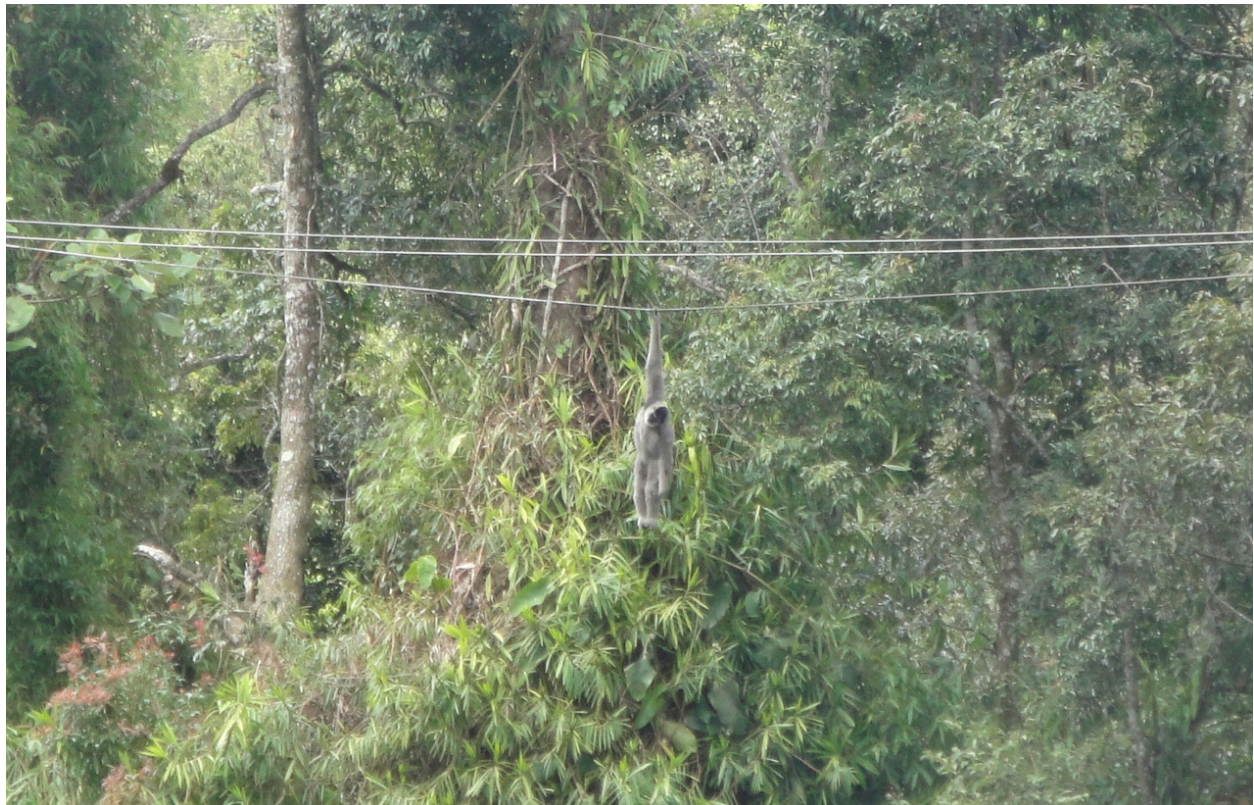


Image 2. A Javan Gibbon *Hylobates moloch* electrocuted on a power line around Malani area (-6.710944, 106.512500) close to Gunung Halimun Salak National Park (22 February 2011). © Soojung Ham.

when touching the power lines. The residents buried the dead body close to the road. From the pictures taken by the resident, we assume the dead gibbon was an adult male.

Power line installed in the region

The voltage running through the power line is above 20 kv for main, 20 kv for medium, 220 v for low voltage. The number of wires is: three phases and three wires for medium, three phases and four wires for low voltage. All cables are horizontally arranged. Therefore, the gibbons likely held medium voltage (20 kv) cables. There is an insulator in the medium cable, however, the insulation strength is only up to 6 kv, and holding it for more than a few seconds will break the insulator and lead to death.

DISCUSSION

In this study, we described three cases of electrocution of Endangered Javan Gibbons on electric power lines along with their natural habitat. These observations highlight the effect of power lines on highly arboreal species such as Javan Gibbons. Given that these data are

obtained opportunistically, there may be more actual number of electrocution cases in more remote and uninhabited areas. At the study site, some of the power lines pass along the road and inside forest patches. As a result, its presence can be a great threat to the wildlife in the forest, mainly for birds and arboreal mammals. Thus, we suspect similar but unreported cases of Javan Gibbon, or other wildlife injury or death, caused by electrocution in the study area.

While arboreal species have relatively low chances to be hit by vehicles (roadkill), power lines are easily reachable for them. Among primates in general, mortality resulting from electrocution seems to be higher in arboreal than in terrestrial species (Al-Razi et al. 2019; Cunneyworth & Slade 2021). While previous reports on primate electrocution are mostly from urban areas (Printes 1999; Goulart et al. 2010; Corrêa et al. 2018; Pereira et al. 2020), our cases indicate that power lines can cause fatality in forested areas as well. Moreover, along with the cases reported in this study, three more electrocuted gibbons were found outside the protected areas in the last four years: two cases from Gunung Gelap Garut, Cisewu between January and February 2022 (-7.370986, 107.497615; pers. com. Sigit



Image 3. A male adult Javan Gibbon *Hylobates moloch* electrocuted on a power line around Malani area (-6.727778, 106.493889) close to Gunung Halimun Salak National Park (23 March 2015). Pictures of the whole body (left), the face (top right), and the injury on the left arm due to the electrocution (bottom right). The body was collected by Muhammad Nur. © Mia Clarissa Dewi.

Ibrahim, The Aspinall Foundation, Indonesia) and one case in 2018 from Lengkong, South Sukabumi (-7.127500, 106.687222). This suggests that the endangered Javan Gibbons suffers from power line mediated electrocution both in urban and forested areas.

People living in the study site were previously isolated because there was no electricity and mobile signal before electric poles were set up in 2011–2012. Despite the benefits of offering electricity to the local community, the cases reported in the study highlight that the increase in human facilities, especially in the areas surrounding protected areas, has negative effects on wildlife. A recent study of population viability analysis revealed that Javan Gibbons might go extinct within the next 100 years if existing threats such as hunting and deforestation remain the same (Smith et al. 2017). Electrocution caused by power lines may hasten this trend. Therefore, mapping the priority areas to apply mitigation measures will be an urgent step to decrease the threats. Furthermore, a typical conservation approach to preserve Javan Gibbon populations, the distribution of power lines should be considered a relevant determinant of possible mortality risk.

With the cases reported in our study, we conclude

that the installation of human infrastructures such as electric poles needs to take into account conservation management practices. First, power line installations should practically avoid the habitats of Javan Gibbons according to the mitigation hierarchy, and should follow the application of wildlife standards (Kiesecker et al. 2010). Then, mitigation efforts such as insulation or burial of electric cables, artificial canopy bridges will help lower the mortality of the species (Janss & Ferrer 1999; Katsis et al. 2018). In Sri Lanka, the electrocution cases of the Toque Macaques *Macaca sinica* significantly dropped from 18 to zero after the installation of shields on electric poles (Dittus 2020). Given the cost of mitigation efforts, it is critically important to understand habitat use and the ranging behaviors of species as well as to investigate and prioritize mitigation in high-risk areas, for instance where power lines pass along the forests. For example, mitigating actions are spatially prioritized based on the systematical analyses of spatial occurrence of electrocution in five primate species between 1998 and 2016 (Katsis et al. 2015). Wildlife Javan Gibbon electrocution mortality in areas close to GHSNP must be promptly and appropriately addressed through monitoring and conservation management practices.

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