

# Population trend of Lesser Adjutant (*Leptoptilos javanicus*) in Muar, Johor using eBird data

Nur Athirah Fauzi<sup>1</sup>, Kaviarasu Munian<sup>2,3</sup>, and Nor Atiqah Norazlimi<sup>1,3\*</sup>

<sup>1</sup>Department of Technology and Natural Resources, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia (Pagoh Campus), Hab Pendidikan Tinggi Pagoh, KM1, 84600 Panchor, Johor, Malaysia

<sup>2</sup>Zoology Branch, Forest Biodiversity Division, Forest Research Institute Malaysia (FRIM), 52109 Kepong, Selangor, Malaysia

<sup>3</sup>Environmental Management and Conservation Research Unit (eNCORE), Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia (Pagoh Campus), Hab Pendidikan Tinggi Pagoh, KM1, 84600 Panchor, Johor, Malaysia

**Abstract.** The Lesser Adjutant (*Leptoptilos javanicus*) is a globally vulnerable stork species that is sporadically distributed in south and southeast Asia. In Malaysia, even though the population shows a gradual decline, the species population status in 2004-2006 is considered stable. However, the recent population status of the species is yet to be documented and is in question. Hence, we used data from the citizen science project, eBird to assess the population trend of Lesser Adjutants over 20 years in two selected sites in Muar, Johor. The population of Lesser Adjutants in Pantai Leka reduced over time while the population in Sungai Balang paddy field was likewise. The paddy field might become an alternate choice for the species due to developments and disturbances along the Pantai Leka shore. Most of the coastal mangrove forests in Muar have been degraded caused by the expansion of coconut and oil palm plantations; these remaining two valuable habitats need to be conserved. We discussed the population trends of Lesser Adjutant in two study sites and recommendations to conserve the species and its habitats.

## 1 Introduction

Approximately 40% of bird populations worldwide are currently facing a decline [1], with waterbirds being particularly affected. Anthropogenic modifications of coastal areas and habitat loss have been identified as major contributors to the decline of waterbird populations globally [2]. It is crucial to conduct continuous biomonitoring in habitats that have been highly jeopardized.

The proliferation of data collected by citizen science projects provides a valuable resource for biological monitoring activities [3-4]. These projects excel at filling information gaps, covering a wide range of habitats spatially and temporally compared to conventional monitoring methods [5-6]. One such citizen science project is eBird, a global online database

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\* Corresponding author: [atiqah@uthm.edu.my](mailto:atiqah@uthm.edu.my)

where data has been contributed by observers with varying levels of ornithological expertise [7-8]. eBird holds one of the largest global databases on birds and has been instrumental in species distribution modeling and numerous contemporary studies [8-10].

Malaysia is known as one of the vital passages for migratory and resident waterbirds, providing grounds for resting and feeding [11]. However, recent expansions in agriculture, land reclamations, and pollution along the West Coast of Johor have raised concerns about the coastal environment in Peninsular Malaysia. The Asian Waterbird Census, conducted in collaboration with the Malaysian Nature Society (MNS) and the Department of Wildlife and National Parks (DWNP) since 1999, covers vast habitats of major water bodies in Peninsular Malaysia [12]. This long-term census serves as a valuable baseline dataset to observe changes in population size and formulate effective management and conservation strategies, especially for threatened waterbirds like the Lesser Adjutant (*Leptoptilos javanicus*).

The Lesser Adjutant is currently one of the globally threatened storks, ranging from India, south through Myanmar and Thailand to Laos, Cambodia, Vietnam, and Peninsular Malaysia, to the Greater Sundas including Sumatra, Kalimantan, Java, and Bali (Indonesia), Sabah, and Sarawak (Malaysia) and Brunei. There are unconfirmed records from Bhutan, and it occurs as a vagrant east of Bali in the Lesser Sunda Islands (Nusa Tenggara), Indonesia [13]. Currently, the species is classified as Vulnerable under the IUCN Red List of Threatened Species [14]. In Peninsular Malaysia, the species can be observed along the west coastal zone, including Matang Forest Reserve and Kuala Gula Bird Sanctuary in Perak, Kuala Selangor Reserve in Selangor, the West Coast of Johor, and a few locations on the east coast of Pahang [15].

In recent years, the number of Lesser Adjutants in Peninsular Malaysia has remained stable. Still, it is believed that the population is facing a decline due to anthropogenic factors, especially in selected study sites. Hence, this study aims to investigate the trend of Lesser Adjutants in Pantai Leka and nearby paddy fields of Sungai Balang, Johor, utilizing data contributed by citizen observers recorded in the eBird database.

## 2 Materials and Methods

### 2.1 Study areas



**Fig. 1.** The study areas in Pantai Leka and Sungai Balang paddy fields, Muar, Johor.

Two study sites, namely Pantai Leka (1°56'59.92"N, 102°37'55.75"E) and Sungai Balang paddy field (1°52'48.89"N, 102°45'22.95"E), located in Muar were selected to investigate the population trend of Lesser Adjutants over 20 years (see Figure 1). Pantai Leka, situated approximately 20 kilometers from the city of Muar, Johor, is known for being one of the

crucial fish landing sites in Muar and a popular tourist destination. Mangrove forests primarily surround this area and feature various man-made structures, including cemented pavements and buildings. In addition to its tourist appeal, Pantai Leka serves as the primary docking point for local fishermen to offload their catches before distribution to local markets.

Sungai Balang paddy field, located about 17 kilometers from Pantai Leka, Muar, Johor, is predominantly cultivated by local farmers. Local settlements and adjacent oil palm plantations encircle this agricultural area.

## **2.2 Data collection and filtering**

eBird offers free access to its data through customizable file downloads. A request was submitted on eBird website (<https://ebird.org/data/download>) along with a brief abstract explaining how the data would be utilized. The eBird basic dataset, specifically filtered to include only the observation data of Lesser Adjutants in Malaysia, was downloaded with approval from the eBird administrator [16] (downloaded on August 10, 2021). The data was provided in spreadsheet format and Microsoft Excel (2019) was used for processing.

The eBird basic dataset encompasses all validated observations from the checklists entered into eBird, along with associated covariates pertaining to location and effort [8]. Further filtration was applied to isolate observations of Lesser Adjutants within Pantai Leka and Sungai Balang paddy fields in Muar, Johor, Malaysia. While many broader studies utilizing eBird data focus on effort-based checklists, typically with short distances and durations starting in the early morning hours (e.g., [9-10]), in this study, we included checklists from all five primary protocol types. This decision was made due to the significant contribution of data from historical and casual Observation protocol types, which encompass both complete and incomplete observations. Given that the study's emphasis was on Lesser Adjutants in Pantai Leka and Sungai Balang paddy fields, single species observations, often labeled as incomplete, were also incorporated.

Although eBird was launched in 2002, users have been able to submit checklists from earlier years. Consequently, lists prior to 2001 were excluded to focus on the most recent 20 years of data.

## **2.3 Statistical analysis of population trends**

All statistical analyses were conducted using Paleontological Statistics software (PAST) [17] and data sorting software such as Microsoft Excel (2019). The frequency of occurrence of Lesser Adjutants in both sites was calculated using the observation counts retrieved from the eBird Basic Dataset (EBD). The frequency of occurrence ( $f$ ) was determined by dividing the number of observation counts (total number of individuals observed per year) by the 20 years (2001-2020). Polynomial regression was employed for each site using the frequency of occurrence of Lesser Adjutants each year to illustrate the population trend in Pantai Leka and Sungai Balang Paddy Field. Additionally, the annual percentage change of the population, relative to the base year of 2001, was computed. In cases of missing data for certain years, it was assumed that the population remained unchanged during those periods.

# **3 Results and Discussion**

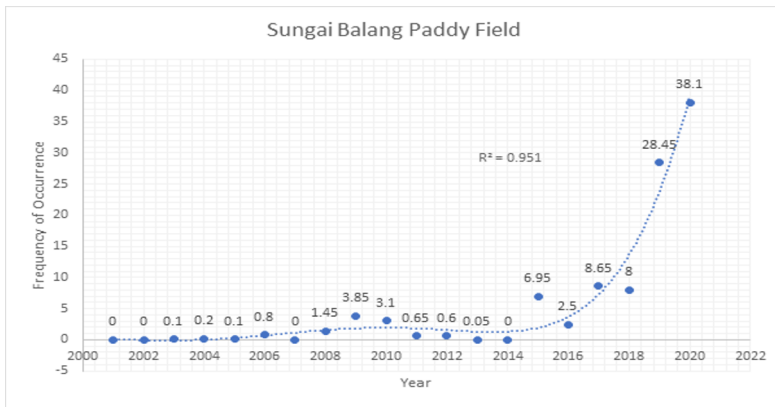
## **3.1 Results**

From 2001 to 2020, a total of 219 observations of Lesser Adjutants were submitted to eBird in Pantai Leka and Sungai Balang paddy fields, involving an average of two observers per

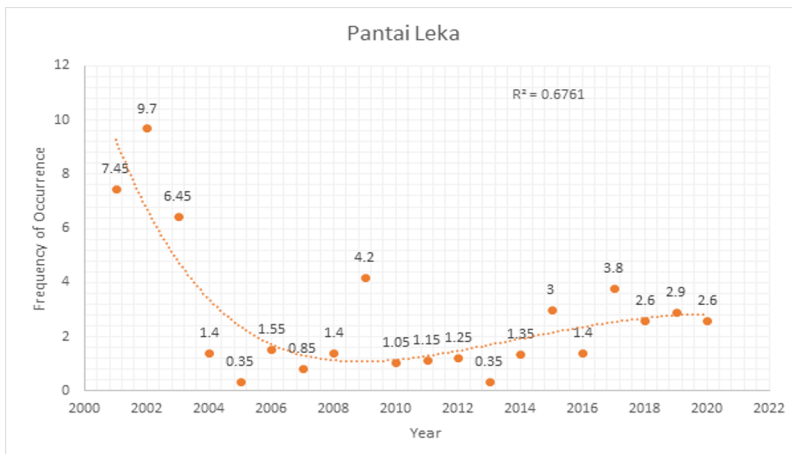
observation event. Among these, 2,146 observation counts (count of individuals) of Lesser Adjutants were recorded in the Sungai Balang paddy field, while 758 observation counts were recorded in Pantai Leka between 2001 and 2020. The frequency of occurrence for both sites was calculated, and a fifth-order polynomial regression fit was generated to illustrate the population trend of Lesser Adjutants over the 20 years. Based on the polynomial regression fit, Sungai Balang showed an  $R^2$  value of 0.95, while Pantai Leka exhibited an  $R^2$  value of 0.67

The frequency of occurrence of Lesser Adjutants in Sungai Balang exhibited subtle fluctuations but generally remained below 4.0 in the first 14 years (2001 to 2014). Notably, zero observations were recorded in 2001, 2002, 2007, and 2014 (Figure 2). However, from 2016 to 2020, there was a significant increase of 92.8% in frequency.

In contrast, the occurrence of Lesser Adjutants in Pantai Leka saw its highest frequency in the initial two years (2001 and 2002) before experiencing a sharp decline of 31.3% by 2005 (Figure 3). The frequency steadily decreased from 2005 to 2008. However, in 2008, there was a slight increase, followed by a spike of 200% in 2009 (Table 1) before experiencing another drop in the subsequent year. Nevertheless, the trend appeared to stabilize with moderate fluctuations in population observed between 2012 and 2020.



**Fig. 2.** Population trend of Lesser Adjutant in Sungai Balang paddy field from 2001 to 2020



**Fig. 3.** Population trend of Lesser Adjutants in Pantai Leka from 2001 to 2020

**Table 1.** The percentage change of Lesser Adjutant in the Sungai Balang paddy field and Pantai Leka is relatively based on the year 2001

Year	Sungai Balang (% change from 2001)	Pantai Leka (% change from 2001)
2001	n/a	0
2002	n/a	0.3
2003	0	-0.34
2004	1.0	-0.78
2005	-0.5	-0.75
2006	7.0	3.43
2007	-1.0	-0.45
2008	n/a	0.65
2009	1.67	2.0
2010	-0.19	-0.75
2011	-0.79	0.1
2012	-0.08	0.09
2013	-0.92	-0.72
2014	-1.0	2.86
2015	n/a	1.22
2016	-0.64	-0.53
2017	2.46	1.71
2018	-0.08	-0.32
2019	2.56	0.12
2020	0.34	-0.10

n/a: not available

### 3.2 Discussion

Based on the observed trend, it is evident that the populations of Lesser Adjutants in both Pantai Leka and Sungai Balang paddy fields exhibited significant variations. Over 20 years, as recorded by citizen observers, the trend of Lesser Adjutants showed a decline in Pantai Leka, while visits of the targeted species steadily increased in the Sungai Balang paddy field. Several factors may have contributed to the shift in habitat preference for Lesser Adjutants between Pantai Leka and Sungai Balang in Muar, Johor.

The jetty at Pantai Leka, also known as Parit Jawa Jetty, has served as a vital fishing dock for local fishermen since the 1980s. However, the heightened boat traffic within the narrow river estuary adjacent to the mudflat area of Pantai Leka has become a potential source of disturbance for the Lesser Adjutant population. Additionally, the noise generated by engine-powered boats exacerbates this disturbance, potentially altering the behavior of the species. This behavioral shift can be observed in responses to disturbances, such as flushing during foraging, which may ultimately impact their overall fitness [18-19]. Previous studies by [20] have reported that waterbird species tend to avoid locations with frequent sources of disturbance, often seeking alternative areas. It has also been noted that prolonged exposure to disturbances can lead to nesting and reproductive failures, affecting species at the population level [21-23]. The long-term ecological impact on the population of Lesser Adjutants in Pantai Leka has only become apparent in recent years, starting from 2004, as it

is believed that the species had been exposed to disturbances for an extended period prior to the census.

Frequent disturbances could lead to significant energetic consequences for Lesser Adjutants in Pantai Leka. Consequently, individuals with poorer physical conditions, unable to adapt to the changes, may choose to seek alternative habitats, such as Sungai Balang paddy field. According to optimal foraging theory, animals select foraging patches that allow them to minimize costs and maximize energy intake efficiency [24-25]. However, non-breeding individuals are less likely to return to their original location following a disturbance. In contrast, breeding individuals typically return to their original nesting sites, situated in mangrove trees, to care for their young. This could explain why the occurrence of Lesser Adjutants in Pantai Leka remained relatively high compared to Sungai Balang paddy field between 2005 and 2014, as breeding parents alternated between flying to Sungai Balang paddy field to forage and returning to Pantai Leka to attend to their young.

Despite being dominated by a single crop, the paddy field is recognized as the second most preferred habitat for waterbirds after mudflats [26]. The prey assemblage in paddy fields, consisting of polychaetes, crustaceans, aquatic insects, and fish, closely mirrors that of mudflat ground, providing ample sustenance for numerous carnivorous waterbird species, including the Lesser Adjutant. A previous study also noted that a few individuals of Lesser Adjutant were observed feeding on snakes and rodents in paddy fields in Pekan, Pahang [27]. Furthermore, compared to coastal habitats affected by tidal currents, paddy fields offer uninterrupted accessibility for foraging throughout the day.

Public databases like eBird should be approached with caution, as they may introduce biases and yield alternate conclusions. The application of other avian databases by citizens was typically restricted to broad-scale inquiries and rarely employed to address small-scale questions (e.g., bird abundance or distribution at specific sites, specific land management projects) [28-29]. Utilizing citizen science data for fine spatial scale studies is often susceptible to spatial and temporal biases, primarily due to weaknesses in data integrity [30]. However, eBird was designed with protocols to mitigate issues related to data quality, and thus, the use of the eBird database should not be limited to large spatial-scale studies. To maintain high data quality, a quality control filter has been implemented in eBird's data entry process, ensuring accurate submission of all required protocol information. Entries are required to detail effort information, including the duration spent searching for birds, number of observers, start time, and distance traveled, allowing analysts to account for variations and biases in the observation process [8, 31].

Through careful processing and analysis of the data, the eBird database has demonstrated its capacity to provide high-quality bird observation data, covering global areas year-round. While eBird has gained popularity worldwide, particularly in North America, its applications in Malaysia remain relatively low. The effectiveness of citizen science data heavily relies on the substantial participation of observers [32]. Therefore, a limited number of participants results in fewer observations, leading to unfortunate gaps and the potential for inaccurate statistics and information for further analysis. However, based on the basic dataset retrieved from eBird, the number of participants among birders and volunteers involved in the annual waterbird census in Malaysia has steadily increased over the years. Regardless, eBird data enable us to capture long-term population trends for bird species, both those with substantial changes in abundance over time and those that remain relatively stable. Thus, in the future, the eBird dataset can be considered a valuable addition to monitoring bird populations in Malaysia.

The globally vulnerable Lesser Adjutant once formed the largest congregation in Parit Jawa, particularly in Pantai Leka, as reported by the Asian Waterbird Census [12, 33] and became an emblematic symbol for Parit Jawa [34]. However, the population trend has markedly declined over time due to habitat degradation and disturbances driven by human

activities. [35] Also noted is that residents and regular birders in Pantai Leka believe that the decline in the species population is caused by coastal erosion resulting from land reclamation. While the current population of the species in Pantai Leka is deemed stable, conservation efforts are imperative to preserve the coastal habitat, as it serves as a significant nesting site for the Lesser Adjutant while simultaneously minimizing disturbances to the species.

Similarly, the population of Lesser Adjutants in the Sungai Balang paddy field appears to have thrived in recent years, establishing itself as an alternative foraging and roosting ground for the species. Recent observations by birders and volunteers during the waterbird census have demonstrated that the paddy field can accommodate not only resident waterbird species year-round but also migratory species during their respective seasons. As one of the crucial sites for waterbird species, it is essential to ensure that the current landscape habitat remains unaltered and is not subjected to future land-use changes, especially given its proximity to oil palm plantations. Furthermore, farmers should be encouraged to minimize the use of inorganic fertilizers and pesticides to ensure the long-term survival of the species population. Despite both sites being included in the southwest Johor Coast Important Bird Area (IBA), they lack legal protection due to their proximity to local residential areas. Therefore, special conservation efforts by residents, as well as relevant government and non-governmental agencies, are essential.

## 4 Conclusion

This study marks the initial endeavor to infer the population trend of Lesser Adjutants in Pantai Leka and Sungai Balang paddy fields in Muar using the citizen science eBird database. The results reported herein suggest that both sites hold equal significance as primary habitats for the Lesser Adjutant population in Muar, Johor. While the presence of Lesser Adjutants is notably high in the Sungai Balang paddy field, Pantai Leka remains crucial for the species, particularly for nesting purposes. The data on species occurrence and abundance from eBird, employed in this study, effectively portrayed the population trend of Lesser Adjutants in both sites. Extensive participation from both professional and non-professional observers ensures the sustained availability of data on species populations, thereby enhancing our capacity to comprehend and address ecological issues through citizen science databases.

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Lesser Adjutant on mudflats near mangrove areas of Pantai Leka searching for prey



The Lesser Adjutant searching for its prey on mudflat during flood tide in Pantai Leka

