Long-term bird abundance in a threatened grassland ecosystem: an assessment using daily bird lists

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Abstract:

Open Natural Ecosystems (ONEs), such as topical grasslands, are among the most threatened habitats on Earth today. The long-term monitoring of ONEs is an important research domain that is essential for understanding anthropogenic impacts and facilitating conservation action. Using a simple day-listing method over a 12-year period, we studied bird abundance in a central Indian grassland-agriculture mosaic experiencing several land-use changes. Our results indicate that some grassland species (such as the Great Indian Bustard *Ardeotis nigriceps*) show steep declines during the study period, while woodland species (such as the Small Minivet *Pericrocotus cinnamomeus* show highly fluctuating populations with no discernable trend. Daily listing also reveals distinct seasonal patterns, and we discuss the Great Indian Bustard and Eurasian Marsh Harrier *Circus aeruginosus* as examples. Our study highlights the utility of consistent checklist surveys to monitor abundance trends of bird communities within a changing landscape.

Introduction:

Grasslands are one of the most threatened ecosystems on Earth today, a condition they share with other open natural ecosystems (ONEs) (Madhusudan and Vanak 2021). Their favourable topographic features and fertile soils have made grassland habitats the most extensively modified ecosystem by humans (Henwood 1998). These modifications and the resulting fragmentation has led to increased habitat heterogeneity and can severely threaten native grassland species (Punjabi et al. 2013).

Local bird communities are good indicators of ecosystem health and functioning (Gregory and van Strien 2010). Consequently, the study of bird communities can be useful in habitat assessment and conservation planning of a region. Grassland birds are often specialised to (or have a preference for) open habitats. Specialised species, such as the Red-necked Falcon *Falco chicquera* (Ali 1990), show a high degree of physiological and behavioural adaptation to the grassland habitat. For example, many grassland specialist birds are ground-nesting and build small nests, which are camouflaged using grasses and reeds to avoid nest predation (Fogarty et al. 2017). Several species are affected by habitat features, such as vegetation density and openness of habitat, and also by anthropogenic effects, such as degree of livestock grazing (Cheung et al. 2009).

The specialisation of grassland species makes them vulnerable to land-use changes (Kher and Dutta 2021). Consequently, grassland bird communities face a considerable threat from anthropogenic change. Despite this, there is inadequate funding, research, and conservation effort focussed on grasslands (Madhusudan and Vanak 2021). Although many grassland birds are known to be negatively affected by disturbances, low-intensity agro-pastoral lands can, in some

cases, supplement protected areas in conserving grassland bird species and communities (Dutta and Jhala 2014; Kher and Dutta 2021). In India, protected grasslands are mostly very small (<50 km^2), and tend to be surrounded by a mosaic of small farms and grazing lands (Madhusudan and Vanak 2021). In a study in western Rajasthan, protected grasslands were the best habitat for dietary specialist and grassland specialist species, but adjoining grazing and fallow lands supported comparable densities of generalist bird species (Kher and Dutta 2021).

Here, we use a simple checklist method to study trends in bird abundances within the grasslands of Nannaj, Maharashtra, India — a region with a complex interplay between biodiversity conservation and economic interests (Narwade and Rahmani 2020). Our decade-long study reveals several interesting population trends within the regional bird community. We also compare local patterns of species in the Nannaj grasslands with their national and global species trends. Lastly, we explore the real-world applicability of a simple methodology performed by an individual observer consistently over time.

Study area and its current land use distribution:

We documented birds within a study area bounded by the five villages of Vadala, Akolekati, Karamba, Mardi and Narotewadi, and centred around Nannaj village (17.836 °N, 75.851 °E) in the Solapur district of Maharashtra. The annual precipitation in the region is less than 750 mm, and the semi-arid climate has a distinct seasonality; long, intense summers (March-June) are followed by a rainy season (monsoon; July-October), after which the winter season (November-February) leads back into the summer (Krishna et al. 2016).

Figure 1: (*inset*) The location of the study area within a larger map of the Indian subcontinent; **(*main*)** The study area (shaded darker) is roughly a polygon with its vertices being at adjoining villages. Lighter shades of brown (in the centre) show grassland habitats within the Great Indian Bustard Sanctuary, while the darker and greener patches show agricultural lands.

The study area, much like the larger landscape, is an evolving mosaic of protected native grasslands, afforested woodland plots, communal and private grazing lands, urban settlements, and agricultural land (Punjabi et al. 2013; Krishna et al. 2016; Narwade and Rahmani 2020). Among the main crops grown in the region are jowar and groundnut. Most farmers also own cattle, which are often allowed to graze freely in the grasslands. Our study area encompasses parts of the Great Indian Bustard Sanctuary, a protected area created to conserve the region's

native grasslands and especially the critically endangered Great Indian Bustard (*Ardeotis nigriceps*), locally known as *Maldhok*.

Methods:

All field data were collected by SM, who, from 2009 to 2020, maintained a daily bird attendance register containing commonly seen and easily identifiable species found in the study area (**Table 2**). There are 199 bird species recorded in Nannaj on the eBird Database (Sullivan et al. 2009; eBird 2021). Of these, we began by monitoring 40 bird species in 2009, and added a further 7 species in 2013. For each of the species on the master list, SM used a physical register to mark those seen through the course of a day, while carrying out his usual routine, with no fixed route being followed. The study area depicted in Figure 1 shows the region SM typically covered as part of his daily activities. Only birds observed within the study area were included in the dataset.

The bird attendance register was filled at the end of each day by putting a tickmark against all species that were seen or heard during the course of that day. Species that were not seen or heard were marked with an 'X' mark, representing a non-detection. If the identification was uncertain, the species was recorded as undetected for the day. This routine was repeated whenever SM conducted fieldwork within the area; therefore, it mostly excluded Sundays and public holidays.

Analysis:

To analyse the collected data, the handwritten registers were digitised into a spreadsheet (row-column) format. Subsequently, the data were analysed using the following packages in R (R Development Core Team 2013) — dplyR for data handling (Wickham et al. 2019); lubridate

for handling dates (Grolemund and Wickham 2011); and ggplot2 for data visualisation (Wickham 2016).

We did not have information on the number of individuals that were seen by SM. Rather, we had data on simple presence and absence (more accurately, detection and non-detection). Assuming that the probability of detection rises asymptotically with the number of individuals, we calculated and used the *reporting rate* (the fraction of day lists containing a species in a given time period) as an index of population density.

For resident species, we calculated monthly reporting rates and then averaged across months to arrive at an annual reporting rate. Winter migrants are absent during the summer at Nannaj, and for these species, we used only the months with reporting rate above 0.05, thereby excluding months where the species was largely or completely absent. From the annual reporting rates, for each species we calculated an *abundance index* for each year, which was the reporting rate of the species for that year relative to the reporting rate for the starting year, 2009 (or 2013, for the 7 species added later). The Black Redstart was recorded only sporadically and hence removed from any further analyses.

To examine trends over years, the median annual relative change in the abundance index over 2017-2020 and the entire study period (2009-2020) was calculated to estimate short-term and long-term trends, respectively. For example, if the abundance indices of a species in four consecutive years was 1, 0.8, 0.4 and 0.5, then, the inter-annual change between years would be -0.2, -0.4 and 0.1. The trend in abundance index in this example is the median of the inter-annual changes over time, i.e., -0.2. Species showing a trend (as calculated in this manner) below -0.025

were termed *declining*; above 0.025 were termed *increasing*; and between -0.025 and 0.025 were termed *stable* (or more precisely, neither increasing nor decreasing). We selected this threshold because a species declining at 0.025 per year, compounded over 12 years, declines by roughly 25% (precisely speaking, 26.2%) over the entire study period. A diagrammatic representation of our methods is shown below.

For species that were monitored from 2013 onwards, the long-term changes in abundance index was calculated separately between 2013 and 2020.

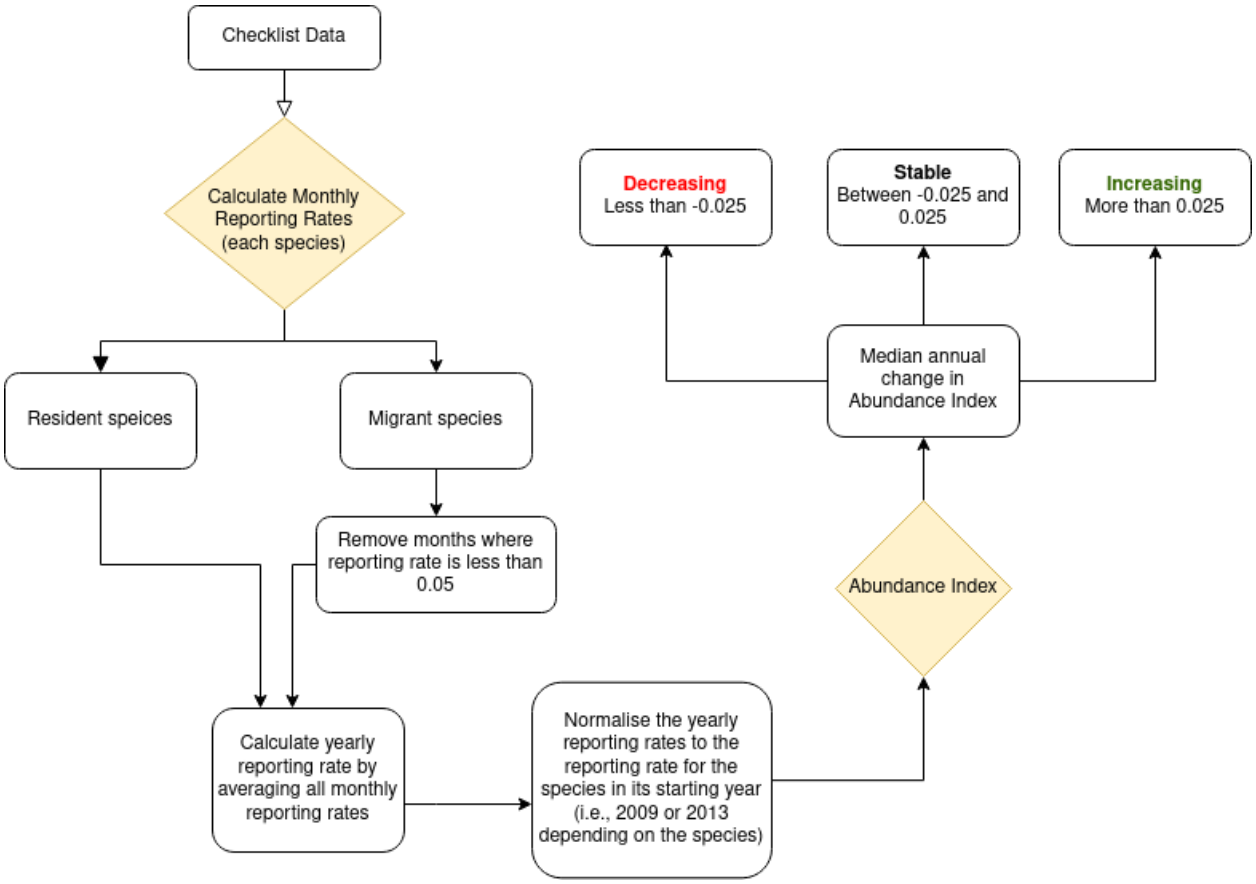


Figure 2: A schematic representation of the analysis pipeline.

In addition to examining annual trends, we also investigated seasonal changes in bird abundances for select species, by calculating reporting rates for each month, averaged across years. The

confidence intervals are 95% CIs calculated using the Aggresti-Coull method (Agresti and Coull 1998).

To understand how trends might differ among different kinds of species, we classified species into different habitat specialisation guilds. This classification was based largely on the *State of India's Birds* report (SoIB 2020), supplemented with information from *The Book of Indian Birds* (Ali 1990), and the *Birds of the World* database (Billerman et al. 2022). Definitions for each habitat guild are described in Table 1. To examine the change in the abundance index for a guild as a whole, we calculated the abundance index of each species in each year, and then averaged the abundance index for each year across all the species in that guild.

Table 1: Description and example species of each guild in the study

Habitat Specialisation (Guild)	Description	Example
Generalist species	Species that are associated with a wide range of habitats and exhibit adaptability in habitat requirements	Red-wattled Lapwing, Red-vented Bulbul
Grassland species	Species that are closely, but not exclusively, associated with open/grassland habitats. These species occur mostly in grassland habitats, but are also found in other habitat types.	Red-necked Falcon, Great Indian Bustard
Woodland or Scrub species	Species that are closely but not exclusively associated with shrub and woodland habitats. These species mostly inhabit shrub/woodland habitats, but are also found in lower abundances in other habitat types to a lesser degree.	Coppersmith Barbet, Small Minivet
Human Commensal	Species that can withstand high degrees of urbanisation and that thrive in urban settlements	Feral Pigeon, House Crow

We used these estimates to ask three broad questions:

1. How did the abundance index of habitat guilds change over the study period?
2. Within each guild, how did the species-level abundance index change over time?
3. Within a single species, can we observe seasonal changes/patterns in reporting rates?

The annual trend graphs presented here contain a shaded region depicting one standard error from the means, calculated using the monthly proportions that each year's abundance index is calculated from. A key assumption we make is that, within a species, there is no change in the average detectability over the study period.

Results

We monitored 47 bird species, including seven migratory species, in 3714 days of survey over 12 years. The mean abundance index of the bird community as a whole fluctuates from year to year but does not show any clear long-term trend **(Figure 3)**.

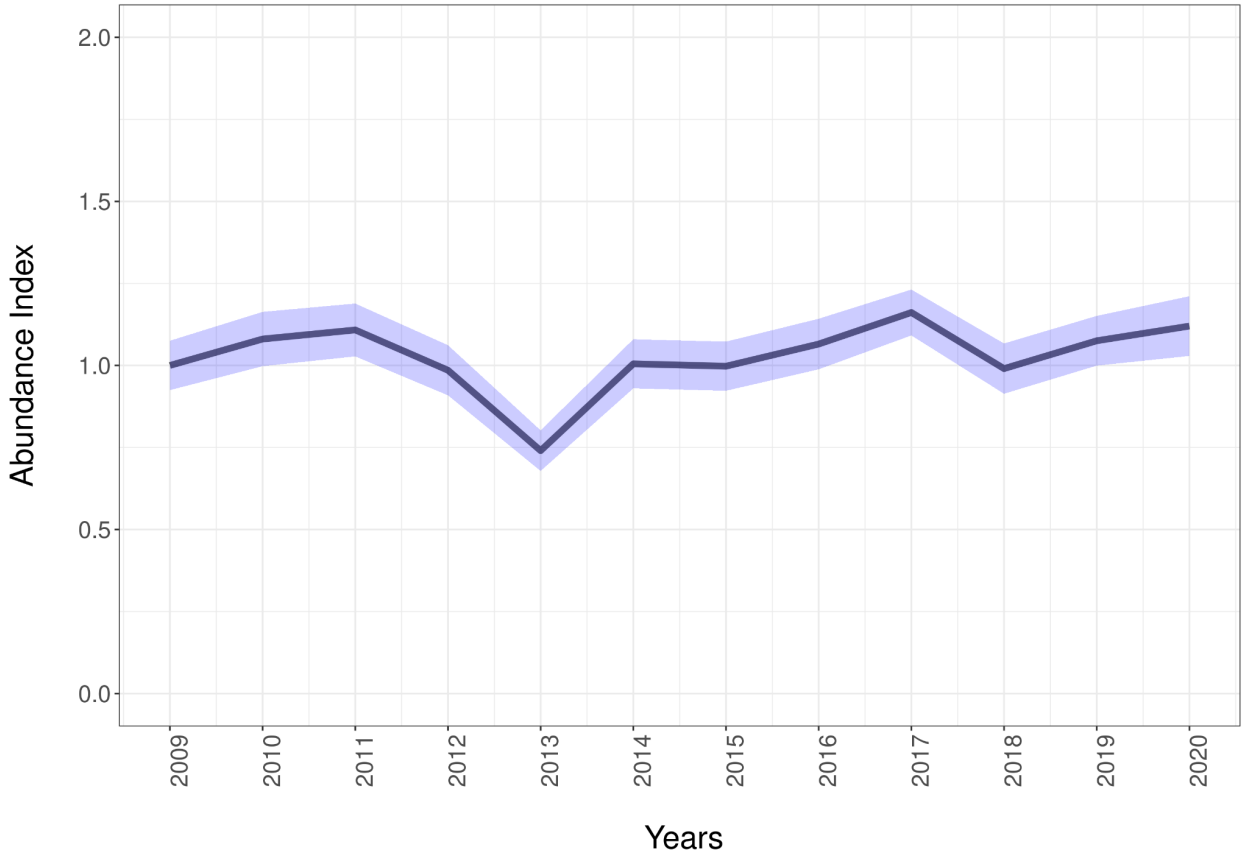


Figure 3: Overall trend in bird abundances throughout the study period, from 2009-2020. The annual abundance index for the overall community is calculated as the mean of the abundance indices for all resident bird species which have been studied from 2009. The shaded region shows the standard error around the mean, which is calculated from the abundance indices of the constituent species.

Table 2 shows a summary of species-wise classifications and results. All species names used are from the *Birds of the World* database (Billerman et al. 2022), as used in EBird (Sullivan et al. 2009). The overall average annual change in abundance index is 0.01 over the long term and -0.013 over the short term, implying a rough community-level stability in abundances.

Table 2: Guild-wise classification, short-term trend (between 2017-2020), long-term trend (between 2009-2020) and national trends (as published in the State of India's Birds (SoIB) report) of commonly seen and easily detected bird species at Nannaj. Species in red are winter migrants at Nannaj, while those in *italics* have been monitored only since 2013. For species that were monitored from 2013 onwards, the long-term changes in abundance index were calculated with 2013 rather than 2009 as baseline year.

Species	Habitat specialisation	IUCN Status (2022)	Median annual short-term change in Abundance Index	Median annual long-term change in Abundance Index	Short-term Trend	Long-term Trend	SoIB trend
Asian Koel	Generalist	Least Concern	0.017	0.077	Stable	Increasing	Moderate increase
Bay-backed Shrike	Generalist	Least Concern	0.057	0.01	Increasing	Stable	Moderate decline
Baya Weaver	Generalist	Least Concern	-0.003	-0.003	Stable	Stable	Stable
Black Drongo	Generalist	Least Concern	0.131	0.005	Increasing	Stable	Stable
Brahminy Starling	Generalist	Least Concern	-0.057	-0.022	Decreasing	Stable	Stable
Eurasian Collared Dove	Generalist	Least Concern	0.003	0.055	Stable	Increasing	Stable
Eurasian Kestrel	Generalist	Least Concern	-0.382	-0.117	Decreasing	Decreasing	Moderate decline
Eurasian Marsh Harrier	Generalist	Least Concern	-0.068	-0.059	Decreasing	Decreasing	Stable
Great Grey Shrike	Generalist	Least Concern	0.014	0.014	Stable	Stable	Strong decline
Greater Coucal	Generalist	Least Concern	-0.011	-0.011	Stable	Stable	Stable
Green Bee-eater	Generalist	Least Concern	-0.062	0.056	Decreasing	Increasing	Stable
Indian Grey Hornbill	Generalist	Least Concern	0.133	0.133	Increasing	Increasing	Uncertain
Indian Peafowl	Generalist	Least Concern	-0.161	0.29	Decreasing	Increasing	Strong increase
Indian Pond Heron	Generalist	Least Concern	-0.033	-0.033	Decreasing	Decreasing	Stable
Indian Robin	Generalist	Least Concern	0.101	-0.004	Increasing	Stable	Stable
Indian Roller	Generalist	Least Concern	0.023	0.024	Stable	Stable	Stable
Indian Silverbill	Generalist	Least Concern	0.185	-0.027	Increasing	Decreasing	Stable
Large Grey Babbler	Generalist	Least Concern	0.002	0.002	Stable	Stable	Stable

Laughing Dove	Generalist	Least Concern	0.105	0.066	Increasing	Increasing	Stable
Long-tailed Shrike	Generalist	Least Concern	0.137	0.137	Increasing	Increasing	Stable
Red-vented Bulbul	Generalist	Least Concern	-0.003	-0.003	Stable	Stable	Stable
Red-wattled Lapwing	Generalist	Least Concern	-0.156	0.256	Decreasing	Increasing	Stable
Short-eared Owl	Generalist	Least Concern	-0.095	-0.083	Decreasing	Decreasing	Data deficient
Short-toed Snake Eagle	Generalist	Least Concern	-0.215	-0.099	Decreasing	Decreasing	Strong decline
Siberian Stonechat	Generalist	Least Concern	-0.16	-0.04	Decreasing	Decreasing	Uncertain
Ashy-crowned Sparrow Lark	Grassland	Least Concern	0.05	0.002	Increasing	Stable	Moderate decline
Black-winged Kite	Grassland	Least Concern	-0.089	-0.036	Decreasing	Decreasing	Stable
Chestnut-bellied Sandgrouse	Grassland	Least Concern	-0.112	-0.013	Decreasing	Stable	Moderate decline
Eurasian Hoopoe	Grassland	Least Concern	-0.291	-0.097	Decreasing	Decreasing	Moderate decline
Grey Francolin	Grassland	Least Concern	0.058	0.029	Increasing	Increasing	Stable
Great Indian Bustard	Grassland	Critically Endangered	-0.016	-0.063	Stable	Decreasing	Strong decline
Indian Courser	Grassland	Least Concern	-0.28	0.089	Decreasing	Increasing	Moderate decline
Montagu's Harrier	Grassland	Least Concern	0.081	-0.034	Increasing	Decreasing	Moderate decline
Painted Francolin	Grassland	Least Concern	-0.096	-0.039	Decreasing	Decreasing	Uncertain
Pallid Harrier	Grassland	Near Threatened	-0.015	-0.015	Stable	Stable	Moderate decline
Red-necked Falcon	Grassland	Near Threatened	-0.233	-0.071	Decreasing	Decreasing	Strong decline
Yellow-wattled Lapwing	Grassland	Least Concern	-0.063	0.109	Decreasing	Increasing	Moderate decline
Common Myna	Human commensals	Least Concern	0.104	-0.009	Increasing	Stable	Stable
House Crow	Human commensals	Least Concern	0.108	-0.023	Increasing	Stable	Moderate increase
House Sparrow	Human commensals	Least Concern	0.061	-0.014	Increasing	Stable	Stable
Feral Pigeon	Human commensals	Least Concern	0.081	0.149	Increasing	Increasing	Strong increase
Bonelli's Eagle	Woodland or Scrub	Least Concern	-0.523	0.05	Decreasing	Increasing	Uncertain
Common	Woodland or	Least	-0.76	-0.044	Decreasing	Decreasing	Moderate decline

Hawk Cuckoo	Scrub	Concern					
Coppersmith Barbet	Woodland or Scrub	Least Concern	0.224	0.194	Increasing	Increasing	Stable
Painted Sandgrouse	Woodland or Scrub	Least Concern	0*	0*	NA*	NA*	Data deficient
Small Minivet	Woodland or Scrub	Least Concern	-0.257	0.221	Decreasing	Increasing	Strong decline

**The short-term and long-term median annual trend for Painted Sandgrouse was 'stable' because the median change was zero (because its abundance index had gone to zero since 2017). In reality, there is no discernable trend for this species.*

Guild-wise trends across the study period indicate that abundance indices of various habitat guilds in the region have been largely stable (**Figure 4**), with human commensals and woodland/scrub species showing guild-level increases in their abundance indices in recent years.

Among grassland species, small-bodied and relatively generalist species (such as the Ashy-crowned Sparrow Lark *Eremopterix griseus;* **Figure 5A**) showed somewhat stable population trends. Meanwhile, there is much variation among specialist species, with some species (such as the Great Indian Bustard and Red-necked Falcon) showing strong, consistent declines throughout the study period **(Figure 5B)**.

Generalist species, on the whole, had stable or increasing population trends over time **(Figure 6A-D)**. However, species such as the Eurasian Marsh Harrier showed considerable declines over time.

Woodland/scrub species (such as the Small Minivet *Pericrocotus cinnamomeus*) showed highly fluctuating populations over time, with no clear long-term trends, while the Painted Sandgrouse *Pterocles indicus*, a species of scrub habitat, appears to have experienced considerable decline in recent years **(Figure 7)**.

Human commensals, which are often found inhabiting urban and human-modified landscapes (such as the Common Myna, House Crow and House Sparrow) have been remarkably stable, while another commensal, the Feral Pigeon, has increased dramatically (**Figure 8)**.

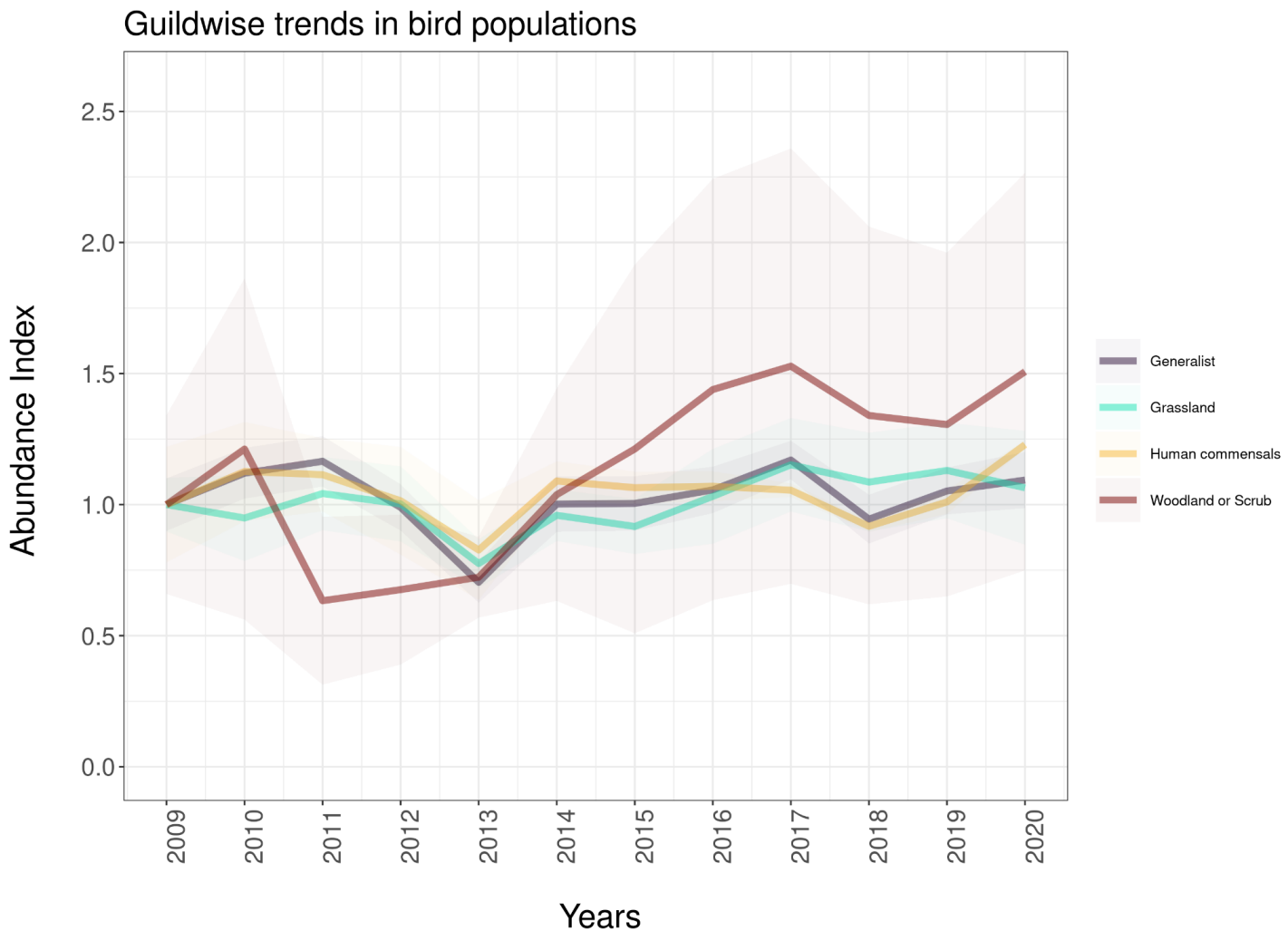
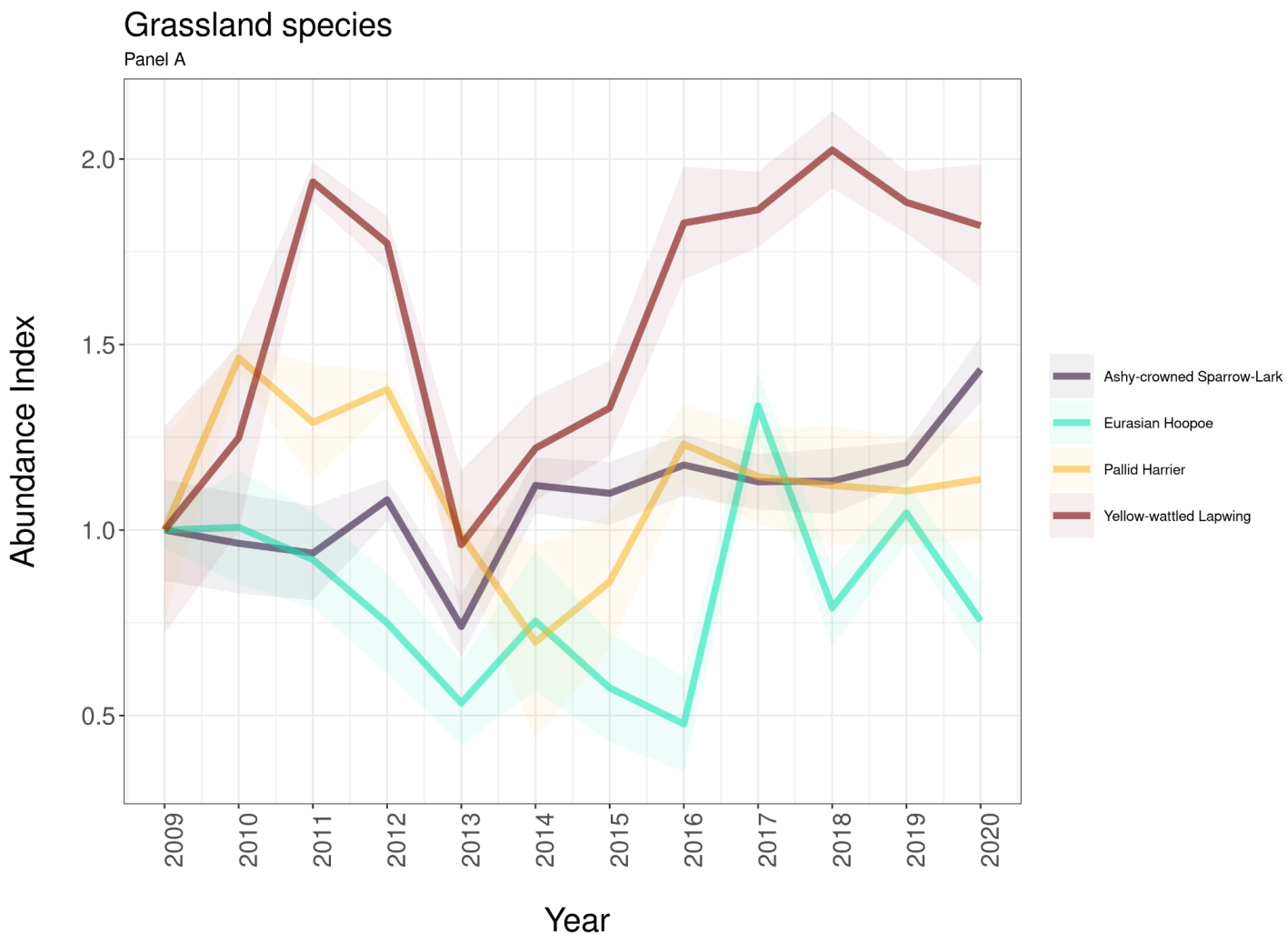


Figure 4: Guild-wise trends of the abundance index across the study period (2009-2020). The shaded region represents standard error around the mean.


Grassland species
Panel A
Abundance Index
2.0
1.5
1.0
0.5
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Year
Ashy-crowned Sparrow-Lark
Eurasian Hoopoe
Pallid Harrier
Yellow-wattled Lapwing

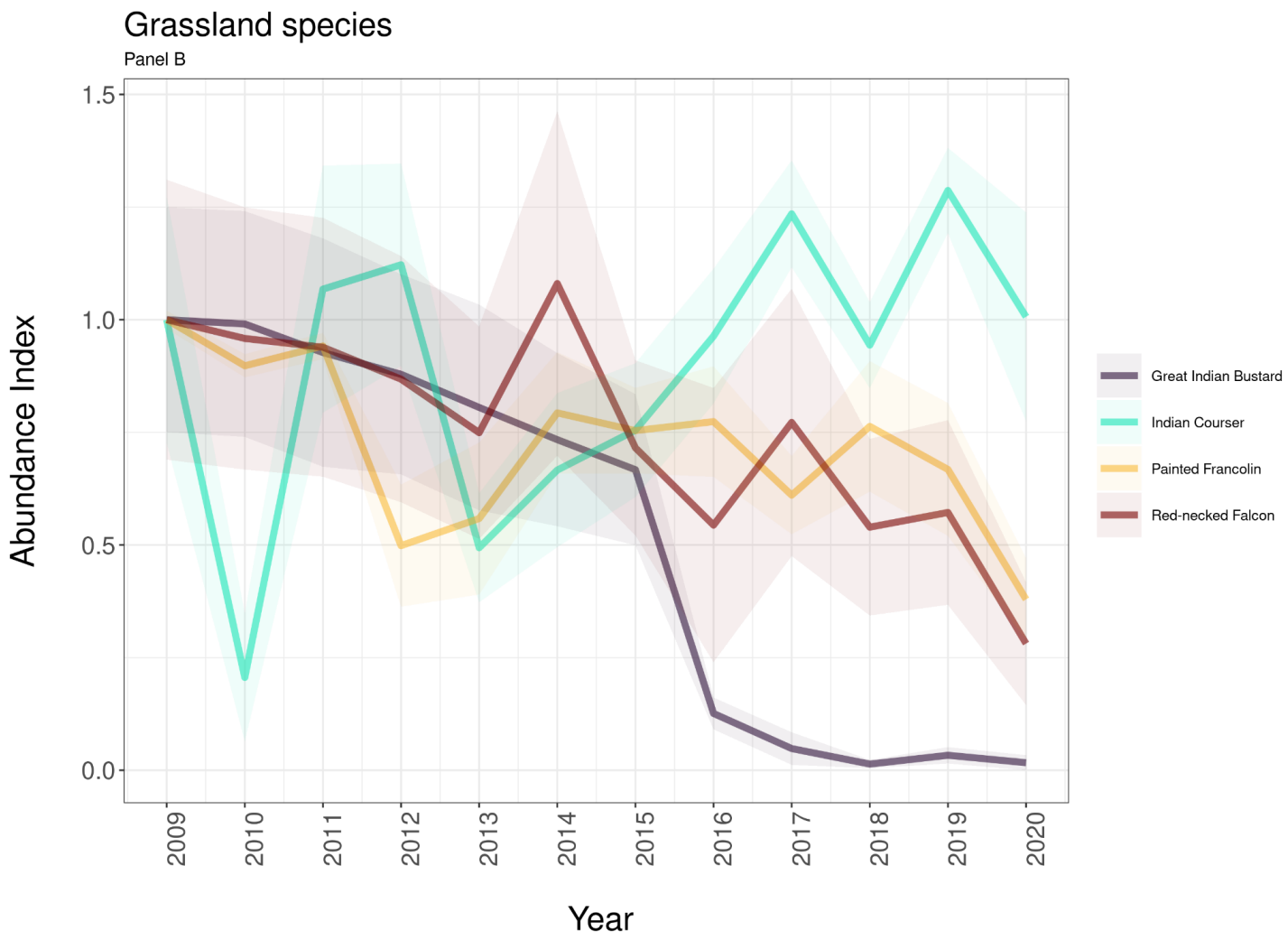
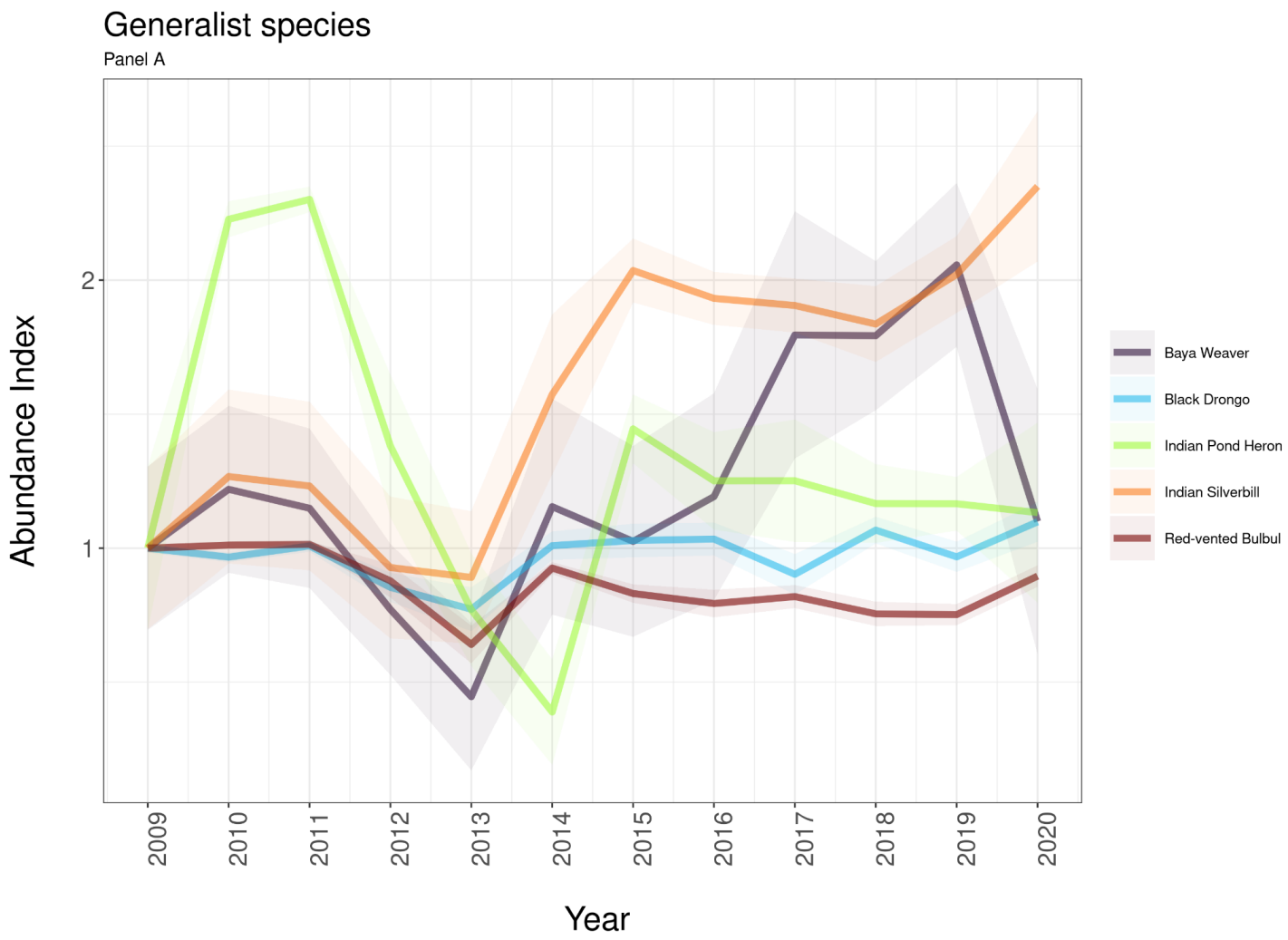
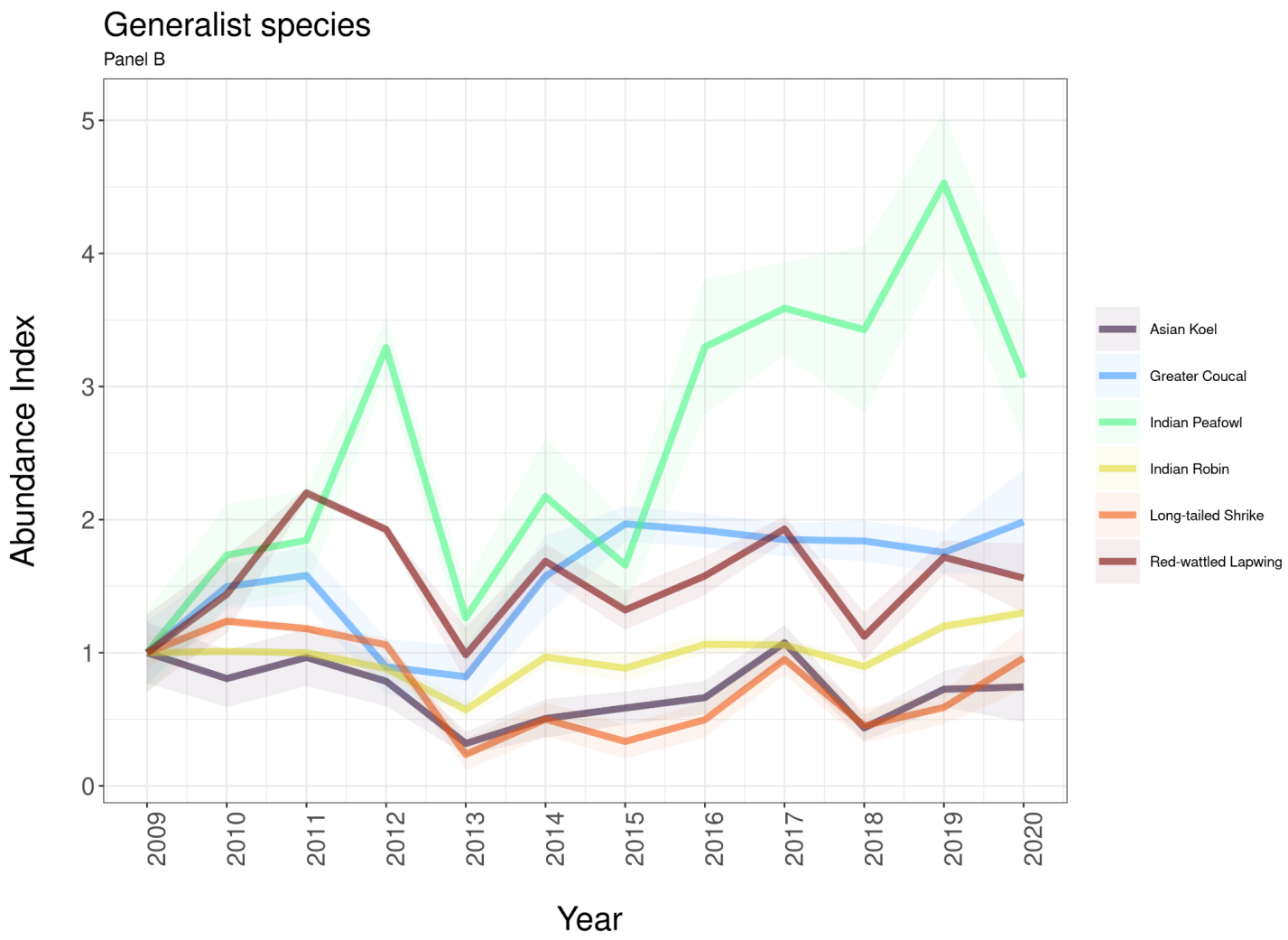
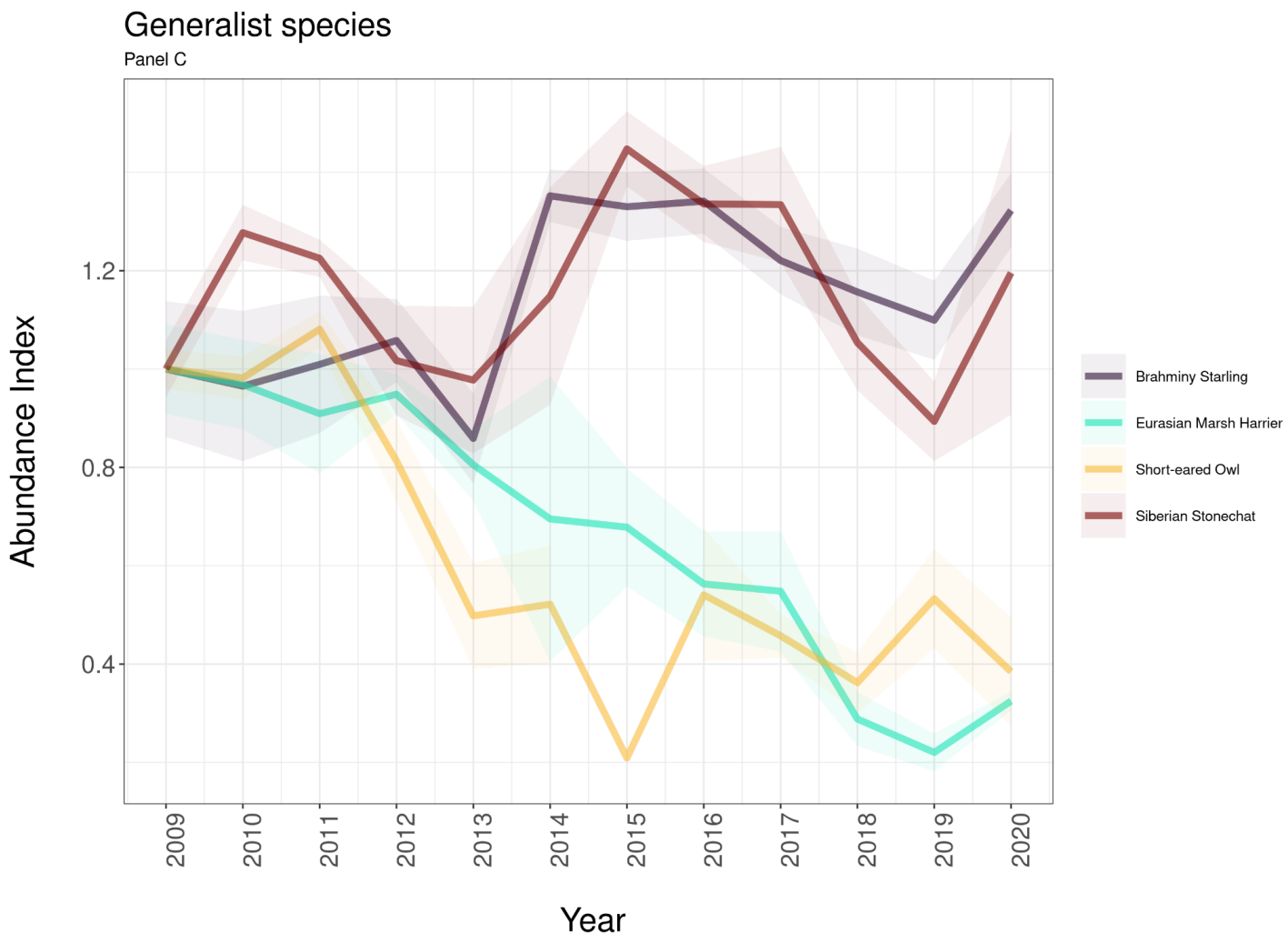


Figure 5 (Panel A & B): Trends in the abundance indices of grassland species across the study period (2009-2020). The eight species are split among two panels for clearer visualisation. The shaded region represents standard error around the mean.


Generalist species
Panel A
Abundance Index
2
1
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Year
Baya Weaver
Black Drongo
Indian Pond Heron
Indian Silverbill
Red-vented Bulbul


Generalist species
Panel B
Abundance Index
0
1
2
3
4
5
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Year
Asian Koel
Greater Coucal
Indian Peafowl
Indian Robin
Long-tailed Shrike
Red-wattled Lapwing


Generalist species
Panel C
Abundance Index
1.2
0.8
0.4
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Year
Brahminy Starling
Eurasian Marsh Harrier
Short-eared Owl
Siberian Stonechat

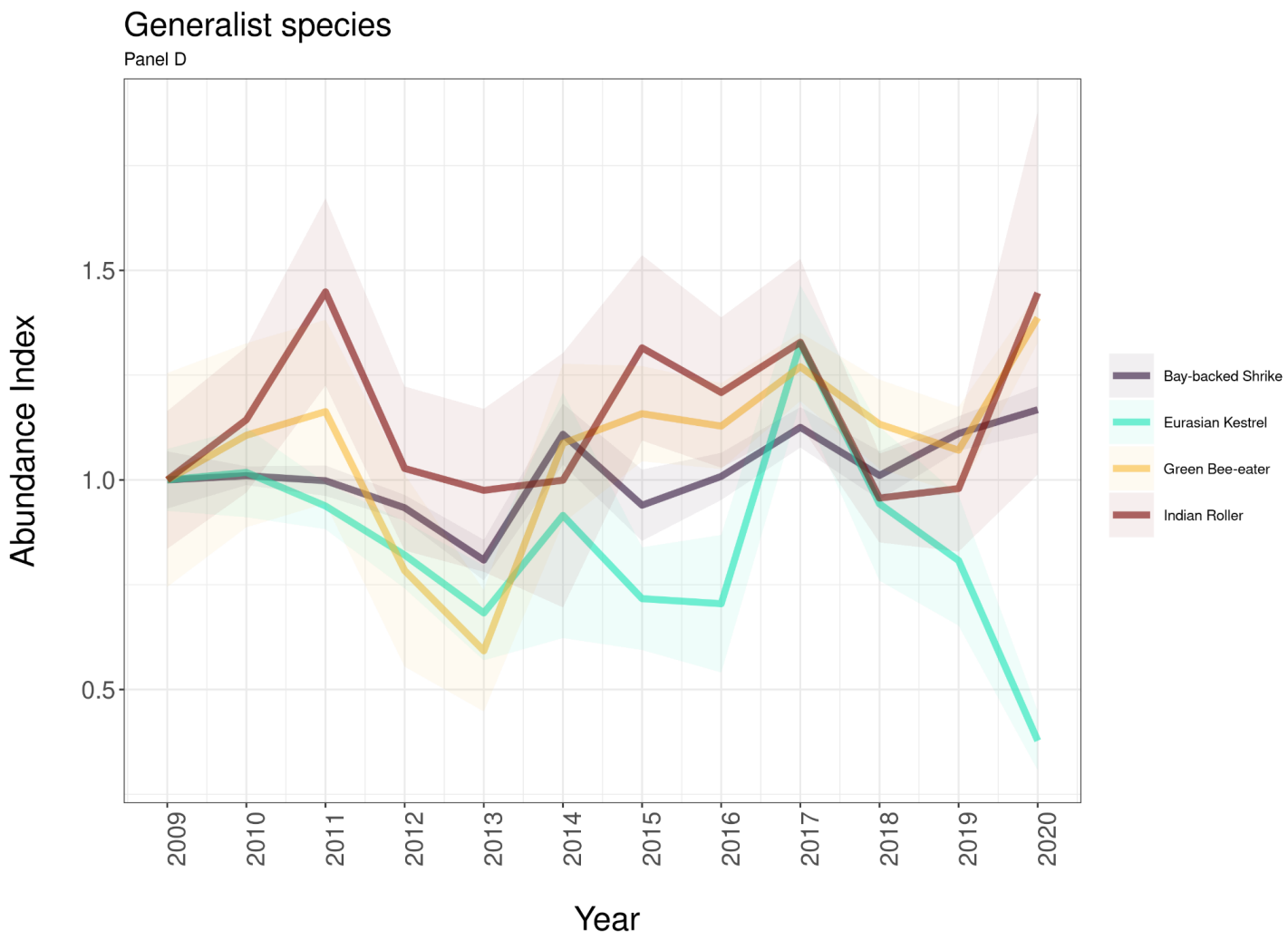


Figure 6 (Panel A to D): Trends in the abundance indices of generalist species across the study period (2009-2020). The 22 species are divided into four panels for clearer visualisation. The shaded region represents standard error around the mean.

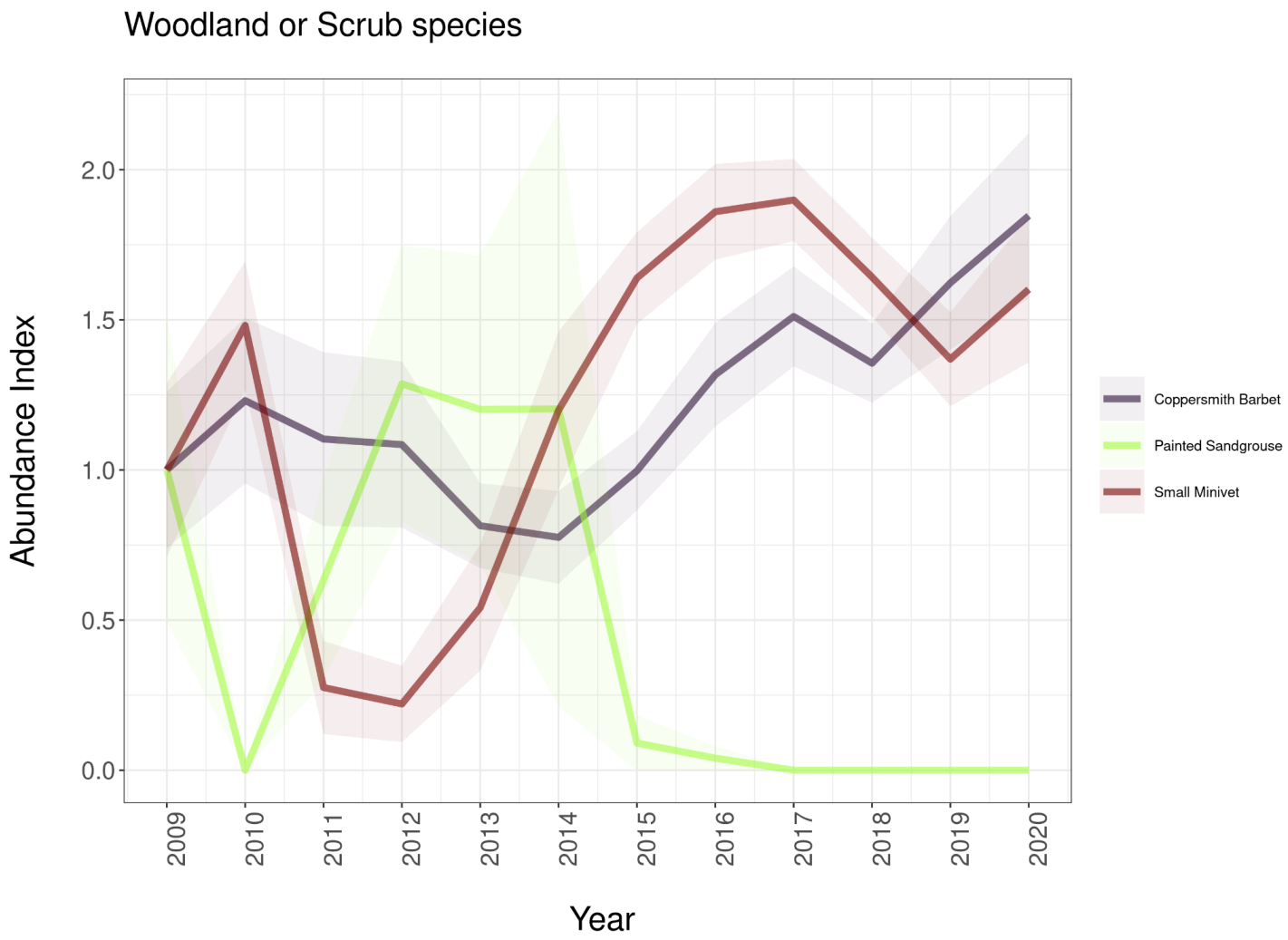


Figure 7: Trends in the abundance indices of woodland/scrub species across the study period (2009-2020). The shaded region represents standard error around the mean.

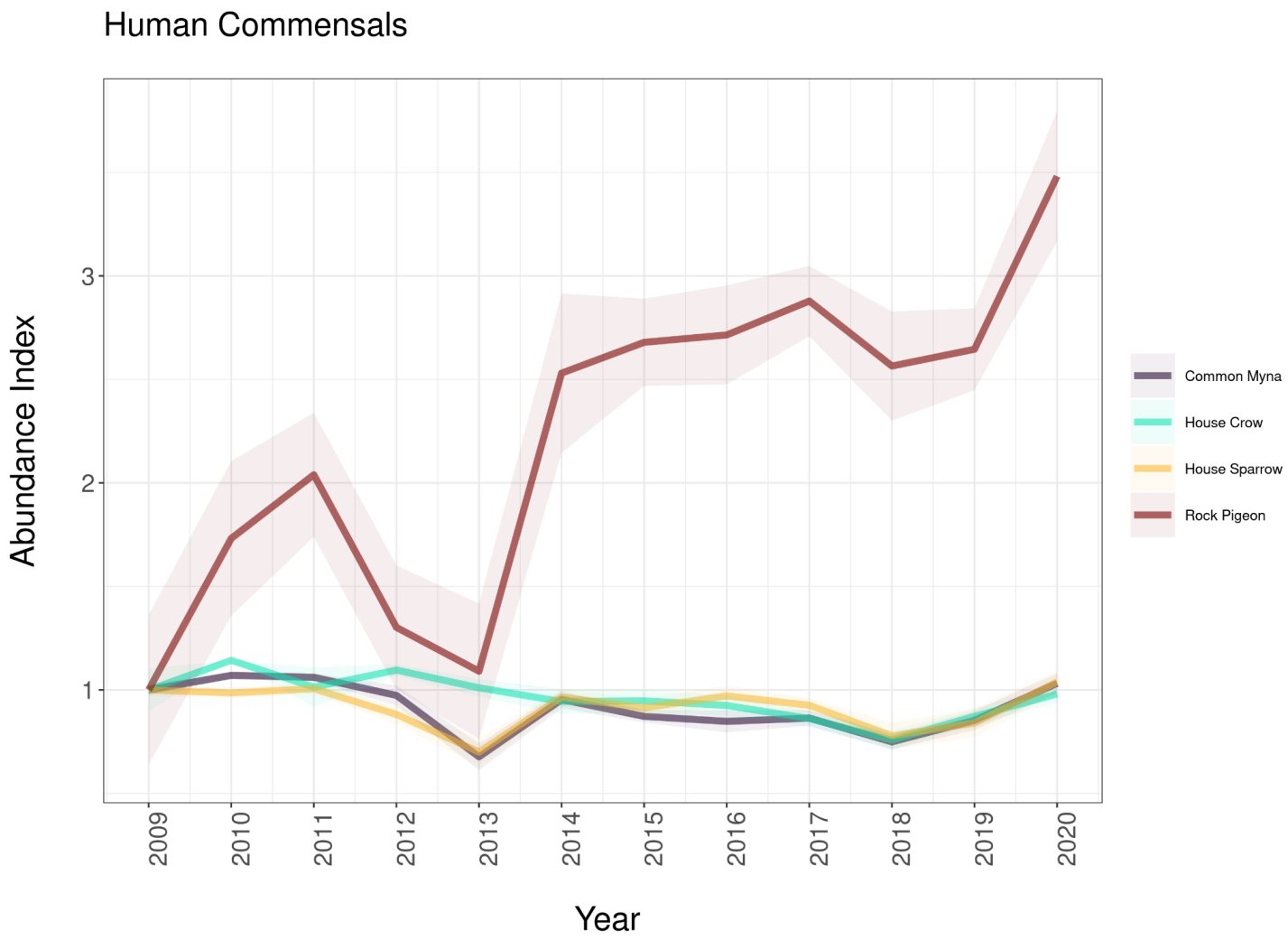


Figure 8: Trends in the abundance indices of human commensal species across the study period (2009-2020). The shaded region represents standard error around the mean.

Studying seasonal trends in bird populations:

To investigate what can be learnt from this dataset about seasonal trends, we examine two species - (a) Eurasian Marsh Harrier, a migratory raptor that travels over long distances between central Asia and the Indian subcontinent; and (b) the Great Indian Bustard, a grassland-specialist and flagship species that shows seasonal local movements.

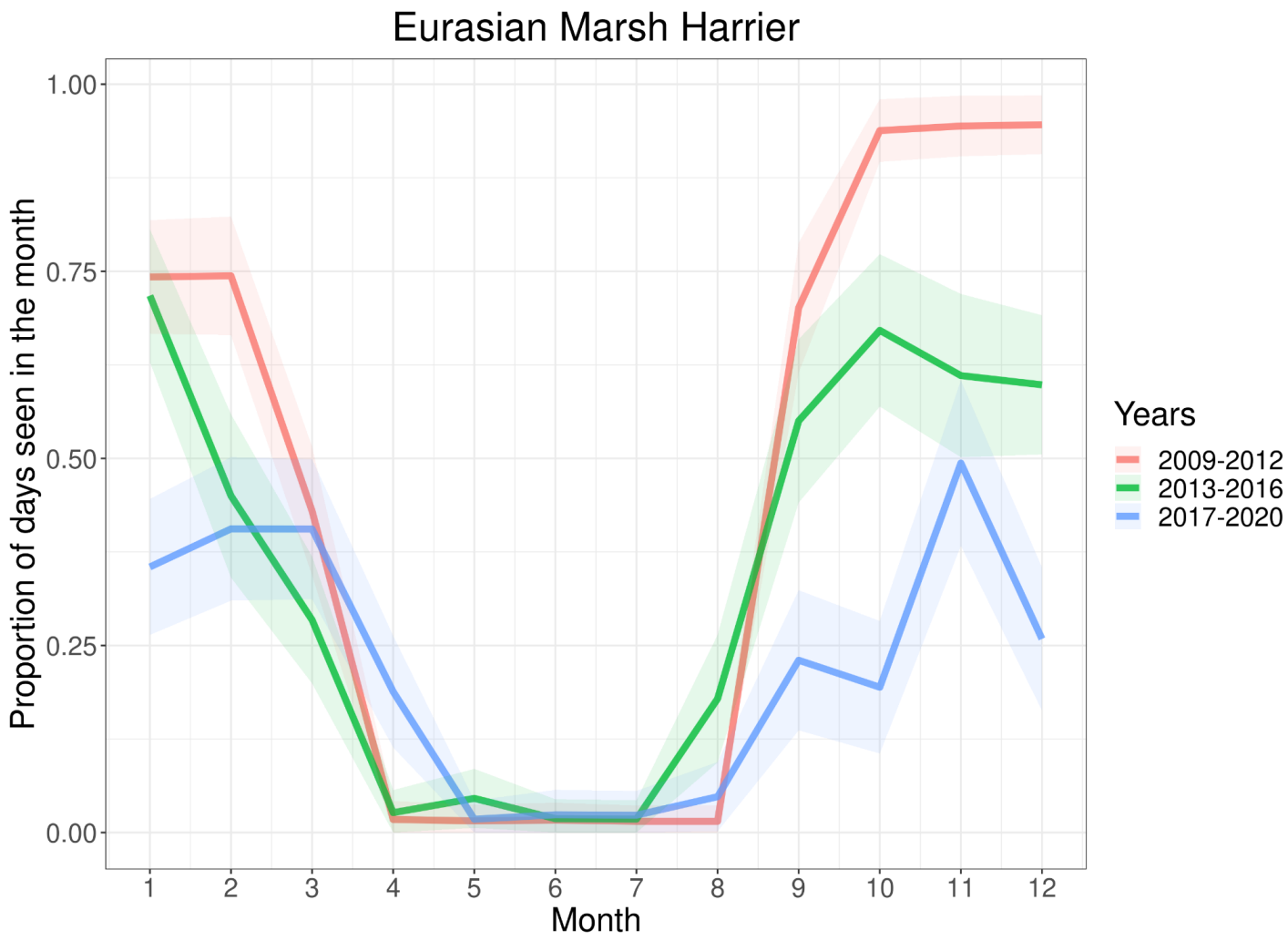


Figure 9: Monthly trends in abundance indices of the Eurasian Marsh Harrier throughout the study period, with every four years grouped together for clearer visualisation. This is a species with a preference for open habitats. There is an evident decline in winter reporting rates in each consecutive four-year period.

India is one of the largest wintering grounds for harriers in the world. As the only raptors in the world that nest on the ground, harriers are adapted to living in open landscapes such as grassland-marsh mosaics. Furthermore, as one of the top predators in the grassland food chain, harriers can serve as an indicator of ecosystem health (Verma 1996).

The Eurasian Marsh Harrier is a common, widespread winter visitor to India. It is often found in a mosaic of marshland, agricultural fields and grassy plains. Throughout our study, we see a steady decline in winter reporting rates of this species (Figure 10). This trend is consistent with other long-term studies of roost counts (Ganesh and Prashanth 2018).

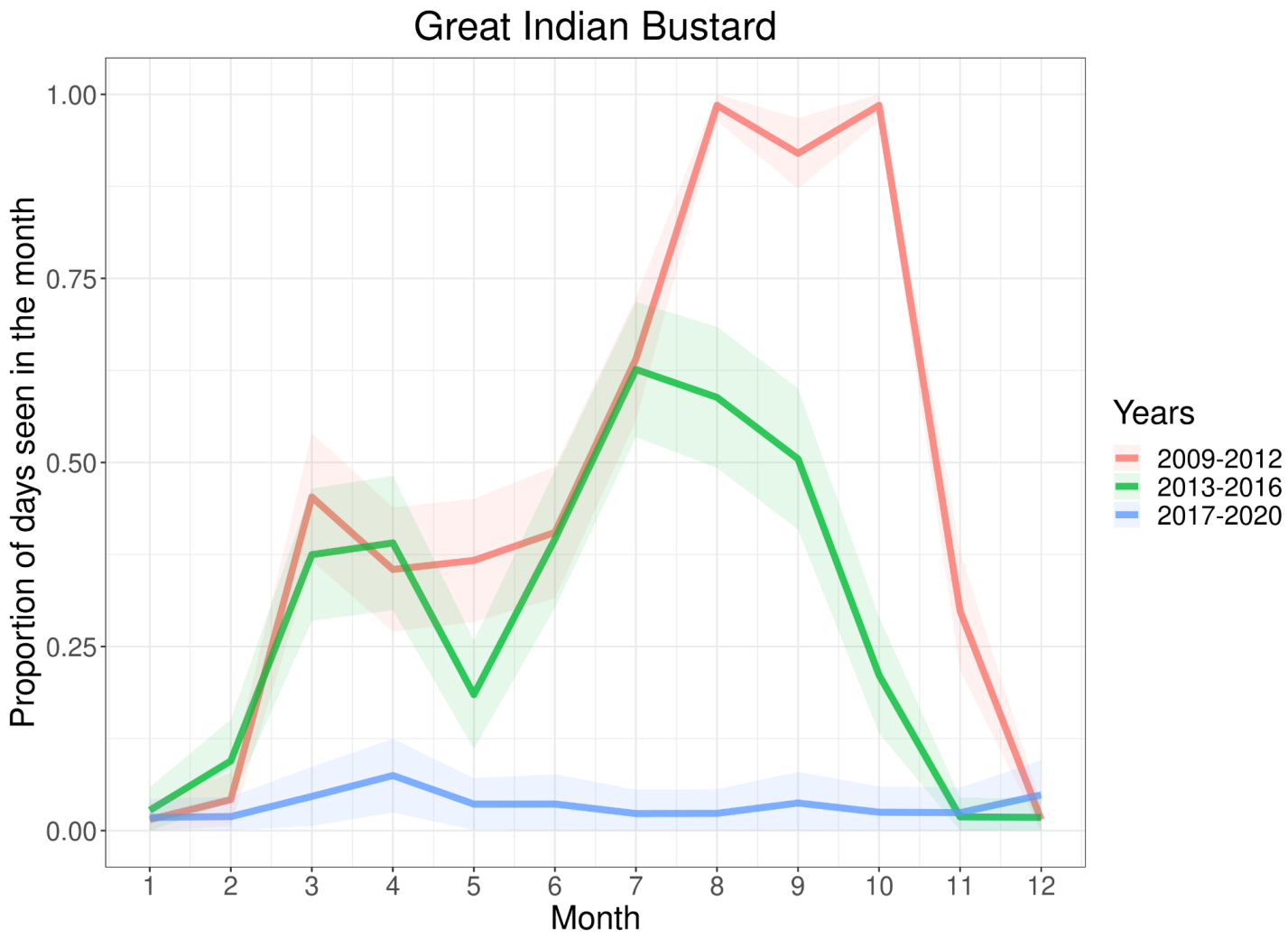


Figure 10: Monthly trends in reporting rates of the Great Indian Bustard throughout the study period, with every four years grouped together for clarity in visualisation. There is a clear seasonality to the bustard activity within the study area, suggesting the existence of local movements. In recent years, reports of the species have fallen to near zero.

The Great Indian Bustard, despite its steady decline in its reporting rate, showed seasonality in its detection in our study region, with its local population being highest during the months of July to November. In recent years, we were unable to discern any seasonality due to the extremely low number of sightings of this declining species.

Discussion:

Our study used a simple checklist procedure to monitor bird abundance over 12 years. This method can be implemented by anyone with a basic knowledge of bird identification, without the need for intensive training in more sophisticated protocols. While quick and easy, such a procedure is not suited for monitoring population densities with differential detectability taken into account. For this, more protocols like distance-based transects or point counts are needed. Its simplicity, however, makes the checklist method a widely implementable procedure to examine general trends.

Despite changes in land use within the study area, including increasing urbanisation and extensive agricultural expansion in the region (Narwade and Rahmani 2020), many species show no discernible trends in abundance index over the study period. This suggests that the region is supporting the extant populations of species. An important caveat to acknowledge is that the reporting rates are not the same as actual population densities, although we assume monotonically related.

A handful of sensitive species, however, mostly grassland specialists with larger body-sizes, show steady declines (Figure 5B), possibly due to the loss of native grassland habitat

(Madhusudan and Vanak 2021). Among human commensal species, Feral Pigeon shows a tremendous increase while Common Myna, House Crow and House Sparrow are roughly steady (Figure 8). Below, we take a closer look at the trends in selected groups and species.

A. Grassland species

Grassland species showed differential trends over time. Small-bodied grassland-generalists such as the Ashy-crowned Sparrow Lark increased (Figure 5A). The Yellow-wattled Lapwing *Vanellus malabaricus*, a species with a high affinity for grassland habitats (Sethi et al. 2010), also shows a moderate increase in abundance index (Figure 5A). This is in contrast to its steadily declining national population (SoIB 2020), and indicates the potential of the Nannaj grasslands in conserving this increasingly threatened species. Along similar lines, specialists like the Indian Courser *Cursorius coromandelicus* showed increases in their abundance indices (Figure 5B), in stark contrast to their national trends that show strong population declines (SoIB 2020).

Most alarmingly, some grassland specialists such as the enigmatic Great Indian Bustard and the Red-necked Falcon experienced drastic reductions in their abundances (Figure 5B). Among grassland generalist species, the Eurasian Hoopoe and Painted Francolin *Francolinus pictus* also showed varying degrees of population decline (Figure 5A-B). For these species, the local trends in our study area were consistent with national trends (SoIB 2020).

Great Indian Bustard

Once widely distributed in Indian semi-arid grasslands, the Great Indian Bustard is now restricted to fragmented pockets of open habitats, with a steadily decreasing population (Dutta et al. 2011). Our results, consistent with previous studies (Dutta et al., 2011; Narwade & Rahmani,

2020; Varghese et al., 2016) and national population trends, show that bustard abundance in the region has declined during the study period (Figure 5B). Their numbers have reached historic lows and the species is nearing local extinction. Satellite studies have revealed that the suitable habitat in the Nannaj-Mardi region is extremely fragmented, with relatively small patches of grasslands remaining (Varghese et al. 2016).

Until 2016, the Great Indian Bustard showed distinct seasonality in the study area, being more frequently observed between June/July and October/November (Fig 10). Subsequently, its abundances have been too low to discern seasonality. It is likely that the seasonal appearance of the bird reflects seasonality in the abundance of its prey: locusts, grasshoppers, beetles, frogs, bird eggs, small snakes and mice (Hume and Marshall 1879; Bhushan and Rahmani 1992; Patil et al. 2013), although this has not been examined specifically in our study area. SM notes that the breeding season for the bustard at Nannaj lasted from July/August to December each year, as evidenced by the presence of active nests and chicks during these months.

B. Generalist and human commensal species

On the whole, generalist species showed stable or increasing trends in their abundance indices (Figure 6A-D). Most species showed stable abundances, albeit with considerable fluctuation, over our 12-year study period. Generalists, by virtue of their ability to survive in varied environments, are likely less sensitive to changes in the landscape (Bowler et al. 2019; Callaghan et al. 2019).

A few species such as the Short-eared Owl and Eurasian Marsh Harrier (Figure 6C), however, witnessed declines over time. These species are known to have a preference for more open

habitats (Ali 1990), which are shrinking and increasingly fragmented at Nannaj (Varghese et al. 2016).

Indian Peafowl:

The Indian Peafowl (*Pavo cristatus*) is a generalist species that underwent considerable increases in our study period (Figure 6B). Peafowl, a species known to feed within agricultural lands and regularly cause crop loss (Paranjpe and Dange 2020), is likely benefiting from recent agricultural expansions within the study region. However, peafowl increases at Nannaj are less dramatic than at the national level (SoIB 2020; Jose V and Nameer 2020).

C. Woodland species

Woodland species, like the Coppersmith Barbet *Psilopogon haemacephalus* and Small Minivet *Pericrocotus cinnamomeus* show increases in their abundance indices over time (Figure 7), possibly resulting from land-use changes in the region (Narwade and Rahmani 2020).

D. Human commensals

Our expectation was that increased urbanisation in recent years would result in an increase of all human commensal species over time, similar to their national trends (SoIB 2020). However, over the course of our whole study period, it is only the Feral Pigeon that shows considerable increases in its abundance index. The other human commensal species (Common Myna, House Crow and House Sparrow) show a relatively stable long-term trend in the study region.

Feral Pigeon:

The feral Pigeon (*Columba livia*) has undergone a dramatic increase in its abundance worldwide, closely correlated with increasing human density and urbanisation (Jokimäki and Suhonen 1998). Much of its recent population increase can be attributed to the increase in human population and activity, the pigeon's ability to exploit diverse food sources in an urban setting and reduced predation pressures within urban environments (Stukenholtz et al. 2019).

Consistent with national and worldwide trends (Stukenholtz et al. 2019; SoIB 2020), our data shows rising Feral Pigeon populations within our study area (Figure 8), at a smaller geographic scale.

Conclusion

Our study applies a simple checklist method and resultant dataset to understand changes in species abundances at a local scale. Despite not estimating absolute population numbers while taking into account variation among species in detectability, checklist-based methods can provide important information on broad trends and provide early warnings of changes in population trends, especially if one can assume constant within-species detectability over time. Of course, monitoring alone cannot diagnose causes of changes in abundance: but its results can trigger more detailed work towards that end.

The power of this method is its huge potential to involve a larger community of people in the practice of ecological monitoring. This includes birdwatchers (or other enthusiasts), Forest Department staff, nature guides, ecotourism outfits, college students, and many more. Daily bird lists (or lists of specific duration in a consistent location) can enable citizen scientists to understand their neighbourhood ecosystems, Protected Area managers to monitor their lands, and

ecotourism resorts to build a detailed seasonal picture for their clients. Online platforms, such as eBird, make it easy to record, store and visualise the collected data. Simple online tools for summarising and visualising the information collected would enable a more diverse set of people to take up this activity. We look forward to a day when thousands of individuals across India keep track of the birds of their localities using simple, repeatable protocols such as that described here.

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