A Preliminary Project Proposal for Annual Cycle Modelling of Landbird Migration in South Asia

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Flyways and Migratory Landbirds

Some 20% of bird species are migratory, and face conservation challenges distributed over multiple, discontinuous geographical regions [1, 2]. Global migration 'flyways', linking species' seasonal distributions, are the conceptual cornerstone of multi-national initiatives for the conservation of migratory birds [3, 4]. Flyways were originally defined — and are best studied for — the conservation of migratory waterbirds; onsequently, terrestrial migratory species are often not associated with migration along flyways. This means that landbirds are rarely included in conservation plans centering on flyways and waterbird habitats, despite facing significant threats [3, 4, 5, 6, 7].

Landbird Migration and the Indian Subcontinent

The Indian subcontinent (hereafter, India, or 'the subcontinent') is a region of special importance for bird migration and conservation, spanning the Central Asian and East Asian (waterbird) flyways. India also hosts a number of migratory landbirds [8], including passerines such as the common rosefinch (*Carpodacus erythrinus*) and paddyfield warbler (*Acrocephalus agricola*) [7, 9, 10], and several raptors [11], which migrate along a potential 'Indo-European' flyway [7, IEF]. A smaller number of mostly passage migrants also arrive from areas traditionally considered part of the East Asian

flyway (EAF), *en route* to Africa [5, 6]. Within the subcontinent, some 50 landbird species migrate up to 3,000 km between their Himalayan breeding ranges and southern wintering grounds (see *Supplementary Material*), forming a potential 'Indian subcontinental flyway' (ISF). Adequately quantifying landbird migrations into and within India, and protecting their subcontinental habitats, then, is key to sustaining the populations and migratory routes of a number of terrestrial birds.

Challenges to Migratory Landbird Conservation in India

A primary challenge to conservation is that landbird migrations into and within the subcontinent are known only at coarse, limited spatial scales [*but see*: 12]. For instance, it has only recently been shown that common rosefinches, which winter across western and southern India, likely originate in two distinct breeding regions — eastern Europe, and the Himalayan foothills [7, 8]. Such knowledge gaps could lead to species being classified as only 'local' migrants in an Indian context.

The lack of recognition and consequently, awareness, of the long-distance, trans-national migrations of landbirds affects conservation policy. The Convention on the Conservation of Migratory Species (CMS), and especially its regional agreement, the Central Asian Flyway Action Plan (CAF Plan), does not refer to landbirds or their habitats [13]. Further, the CAF may be a subset of the larger IEF, or overlap significantly with it — and this might make a more comprehensive, landbird focused framework necessary for effective conservation.

Tracking the full annual cycle of species could help reveal where they are most at risk, where conservation actions are most necessary, and thus which states should be working together [*see e.g.* 14, 15]. These arguments apply to the conservation of local migrants *within* the subcontinent as well, at the level of the Indian states. Specifically, mapping landbird migrations into and within India could help assess:

1. Which species are long-distance migrants, local migrants, or both, and which administrative areas they connect.

2. How the CAF relates to the larger IEF, and whether the CAF is a sufficient paradigm for understanding landbird migration into India.

3. Whether local and long-distance migrants overlap on their migratory routes within the subcontinent, and the environmental drivers of overlap.

4. Whether protected areas under national and international agreements targeting waterbirds (e.g. Ramsar sites), are sufficient to protect migrant landbirds while in the region.

Annual Cycle Modelling Along the IEF-CAF

Extensive individual tracking of migrant landbirds travelling along the IEF-CAF has only recently begun, and does not cover most species. In the absence of this data, modelling species' annual cycles from citizen science observations, in relation with environmental predictors, can help fill knowledge gaps for migratory species, and inform conservation actions [16, 17, 18]. The widespread use of eBird by Indian birdwatchers between 2015 and 2020 could make similar efforts possible in an Indian context [8]. Using existing eBird data from the Indian subcontinent and from the breeding ranges of IEF-CAF migrants, it may be possible to quantify the annual cycle of terrestrial migratory birds using the AdaSTEM approach. Such an effort could help better understand and define terrestrial bird flyways, determine priority areas for landbird conservation in the subcontinent, and suggest a more comprehensive trans-national landbird protection agreement [*see:* 19].

What This Project Proposes

Here we propose a project focusing on landbirds that are known to be winter migrants into or within India. This project has a dual focus:

1. Filling existing knowledge gaps on the migratory routes and wintering areas of landbirds wintering in the subcontinent.

2. Assessing the existing flyway concepts as a basis for the protection of migrant landbirds.

Specifically, we propose:

1. To model the full annual cycle of Indian subcontinent wintering migratory landbirds using citizen science data [16, 18]. This should help

define and better understand which India-wintering landbird populations are comprised of long-distance migrants, local migrants, or a mixture of the two.

2. To determine which species travel along a potential IEF, and how this flwyay overlaps in its Asian stages with the CAF: are all IEF species also CAF species?

3. To model the environmental drivers of flyway routes and especially their overlap: can a resource maximising, or wind-support maximising strategy predict flyway routes, common to multiple species [*see:* 7]?

4. To examine the overlap between areas of importance predicted from modelling species winter abundances, and the existing protected areas (PA) network in the subcontinent: are PAs and current conservation agreements sufficient to protect migrant landbirds?

Candidate Species

A list of candidate species, focused on passerines, may be found in the supplementary material. We chose species based on their migratory status classification in the State of India's Birds report [8], and include observation counts in India (NB: These counts are taken from the eBird India data used in another project). We further classified species by their potential routes into the subcontinent. Species may appear on two lists, as some populations are resident in the subcontinent as well as long-distance migrants along the CAF or IEF.

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