MigrantWatch: A citizen science programme for the study of bird migration

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Abstract: What are the consequences of rapid global change for the behaviour and ecology of wild species? Answering this very broad question is a challenging but important task. One relatively manageable question under this broad umbrella is how the timing of biological events (i.e., phenology) is changing as the earth's climate changes. In this article, we describe a new programme aimed at assessing the timing of migration of birds that winter in the Indian Subcontinent and monitoring changes in this timing over the long term. MigrantWatch is a volunteer-based programme in which participants record the arrival, presence and departure of migrant species across India. We also outline the goals, structure, and open-access philosophy of the programme, and illustrate its potential by briefly describing information collected on the arrival patterns of winter migrants in the second half of 2007.

Introduction

The world is changing, with important and often severe effects on our natural systems. Important changes include destruction of natural habitats, spread of invasive species, and the changing climate. These changes are modifying how ecosystems work, are changing the distribution and abundance of species, and are altering the timing of biological events. Altered phenology (the timing of events) in response to climate change is particularly dramatic. Examples include changes in the timing of flowering, fruiting and leafing of trees, the timing of breeding in birds, amphibians, and insects, and in the migration of birds and butterflies (Parmesan & Yohe 2003; Menzel et al. 2006). However, almost all studies of these phenomena have been carried out in temperate regions, and much less is known about the effect of changing climate on phenology in the tropics and sub-tropics (see Fig 1.8 in Rosenzweig et al. 2007). This is because long-term studies monitoring phenology are scarce or absent in these areas.

The timing of bird migration: patterns and conservation concerns

Many studies in temperate regions have assessed changes in the timing of bird migration. These studies tell us that pre-breeding (i.e., spring) migration in birds has been advancing by an average of 3.4–4 days per decade in the second half of the 20th century (based on first arrival dates; Lehikoinen et al. 2004). This is comparable to an average advance of all spring events (of plants and animals) by 1.7–3.2 days per decade (Parmesan & Yohe 2003). Changes in the timing of post-breeding (autumn) migration of birds are less studied (Sparks & Mason 2004; Gordo 2007), and patterns may be more complicated than those found for spring migration. For example, Jenni & Kéry (2003) found that autumn migration in western European birds has advanced for those species wintering south of the Sahara, but has been delayed for species wintering north of the Sahara. Patterns of rainfall may be particularly important for the physical condition and migration schedules of birds that spend the non-breeding season in the tropics (Katti & Price 1996; Studds & Marra 2007).

Apart from being interesting in their own right, changes in timing can also lead to conservation concerns if they give rise to a mismatch between the ideal and actual behaviour of a species (Visser & Both 2005). If birds use air temperature as a cue to migrate, spring migration to temperate regions is expected to advance as the climate becomes warmer; but a mismatch may occur if the availability of insect or other

food on the breeding grounds shows no corresponding shift, or if the shift is too large or too small. For example, in some areas of The Netherlands, the time of peak abundance of caterpillars in the spring has advanced considerably, but migration (and thus breeding) timing of Pied Flycatchers *Ficedula hypoleuca* has not; flycatcher populations are declining where these events are mismatched (Both et al. 2006). Such mismatch problems and other concerns have stimulated great interest in the causes and consequences of changes in bird migration, resulting in for example special issues of the journals *Advances in Ecological Research* (2004, Vol. 35) and *Climate Research* (2007, Vol. 35).

Despite a relatively long history of ornithology in the Indian Subcontinent, we still lack basic information on the timing of bird migration and so we can assess neither whether migration times are changing, nor the degree to which any such changes may pose conservation problems. India is an important wintering ground for a large number of migrant species. For some species, such as the Rosy Starling *Sturnus roseus*, the Indian Subcontinent holds almost the entire global population in winter (Feare & Craig 1998). How can we begin to gather baseline information on the timing of migration across the country, and then monitor changes? The only possible way to do this is with the participation of volunteers.

Citizens' role in understanding the natural world

Large-scale studies designed to collect basic information on wild species and monitor changes are practicable only with the help of volunteers. In fact, ornithology is distinguished by the great extent to which amateurs have contributed to the discipline (Greenwood 2007; Shyamal 2007). Volunteer-based monitoring of birds is well established in several countries. Examples include the Audubon Society's Christmas Bird Count in the USA (http://www.audubon.org/bird/cbc/), the Breeding Bird Survey in the UK (http://www.bto.org/bbs/), and the Southern African Bird Atlas (Harrison et al. 1997). These programmes have generated a wealth of information on bird populations, distribution and habitat, and continue to do so, so that long-term changes can be documented. It has been estimated that, in Britain, collaborative ornithology of this nature involves about 1.5 million person-hours per year (Greenwood 2007).

The achievements of these "citizen science" programmes are impressive. The first large-scale collaborative study began in 1749 in Finland, collecting arrival dates of spring migrants, and still continues (Greenwood 2007). This, and similar studies in Europe and North America enabled the drawing of "isochronal lines" (lines of equal arrival date) as early as the 19th century, forming valuable baseline information. Similarly, volunteers have been instrumental in collecting data on bird distribution and abundance, so that for some parts of the world detailed information is available on habitat requirements, change in the geographic range of species and numerical increases or decreases in population sizes (Greenwood 2007).

Large-scale, coordinated programmes for gathering information of this kind are rare in India, a notable exception being the Asian Waterfowl Census, coordinated by Wetlands International and run since 1987 (Wetlands International 2007). With the burgeoning interest in nature and conservation in India, the potential for naturalists and enthusiasts to play an important role in understanding the status and changes in our biodiversity is increasing rapidly. MigrantWatch draws together volunteers from all walks of life to cooperate in collecting information on the timing of bird migration in India.

The MigrantWatch programme

MigrantWatch was conceived in mid-July 2007 as a collaborative effort, organised jointly by *Indian Birds* journal (published by the New Ornis Foundation) and the National Centre for Biological Sciences, Bangalore. The goal of the programme is to collect information on the arrival, presence and departure of migrant birds that spend the winter in India. Over the years, it will also be possible to assess any changes that occur in the timing of migration. For the first year of the programme it was decided to focus on a handful of migrant species, chosen for their commonness, widespread occurrence, presence around human habitation, and importantly, ease of identification. The nine target species for 2007–2008 are Northern Shoveller *Anas clypeata*, Marsh Harrier *Circus aeruginosus*, Wood Sandpiper *Tringa glareola*, Common (or Barn) Swallow *Hirundo rustica*, Grey Wagtail *Motacilla cinerea*, Brown Shrike *Lanius cristatus*, Black Redstart *Phoenicurus ochruros*, Greenish Warbler *Phylloscopus trochiloides*, and Rosy Starling *Sturnus roseus*. Participants in MigrantWatch can choose to collect and send in information at one or both of two levels.

In Level 1, participants record the date on which they first see a species in the second half of the year at a named location. To assess how closely these first sighting dates might truly reflect the date of arrival of a species, participants are asked to send the following accompanying information: the date at which they started looking for migrants at that location, and the frequency with which they look for birds at that location (categorised as: Daily, Twice a week, Weekly, Fortnightly, Monthly, Irregular, First visit). First sighting dates are more likely to reflect actual arrival dates at those locations where birds are looked for frequently from the beginning of the season. Although records from one-off visits to locations (marked "First visit") are also gathered, this information is less valuable in assessing migration times.

To gather information on patterns of overwintering as well as on departure dates, participants also have the option to contribute information at a more detailed level (Level 2). This involves making regular observations at named locations, noting the presence or absence of each species every time. The frequency of these observations is left to participants. Again, more frequent observations yield finer-scale information. Departure dates are much more difficult to assess than arrivals, because departures can only be detected in retrospect (i.e., following an extended period of absence). The nine target species are likely to

depart from various parts of the country between February and April. Because the Level 2 information for 2007–2008 is still incomplete, results presented here are focussed on arrival information.

Box 1. Contacting MigrantWatch

Website:	http://www.ncbs.res.in/citsci/migrantwatch/
Email:	MigrantWatch@ncbs.res.in
Post:	Citizen Science Programme National Centre for Biological Sciences GKVK Campus, Bellary Road Bangalore 560 056 India

Participation

MigrantWatch was launched on 7 August 2007 by sending email messages to individuals and mailing groups asking interested birdwatchers, naturalists and enthusiasts to join. A full-colour pamphlet was designed and 2,000 copies printed on 19 November. The pamphlets were sent to addresses provided by *Indian Birds* and the Indian Bird Conservation Network, Mumbai. Coverage of MigrantWatch in the print and online media has included articles in the Bengali, English, Malayalam and Marathi press. The MigrantWatch website (Box 1) gives a full list of media coverage, including many press clippings. Fig. 1 shows the growth in individual participation since MigrantWatch began, up to 31 December 2007. It shows that spurts in participant registration often occurred soon after a newspaper article was published or after an email update on the programme was circulated.

Participation is, as might be expected, concentrated in and around urban areas of the country (Fig. 2). A special effort has been made to find postal and email addresses of potential participants in under-represented areas and to invite them to join. This has been partly successful, but large areas of poor coverage remain, as can be seen from Fig. 2.

In addition to individual participation, MigrantWatch encourages group participation by any interested organisation, including NGOs, research institutes, nature clubs, and birding groups. At the time of writing, there are 355 individual and 31 group participants.

Data policy, collection and storage

MigrantWatch adheres to a policy of free and open access to information (Box 2).

At first, after MigrantWatch was launched, most data were collected over email, following a standard format,

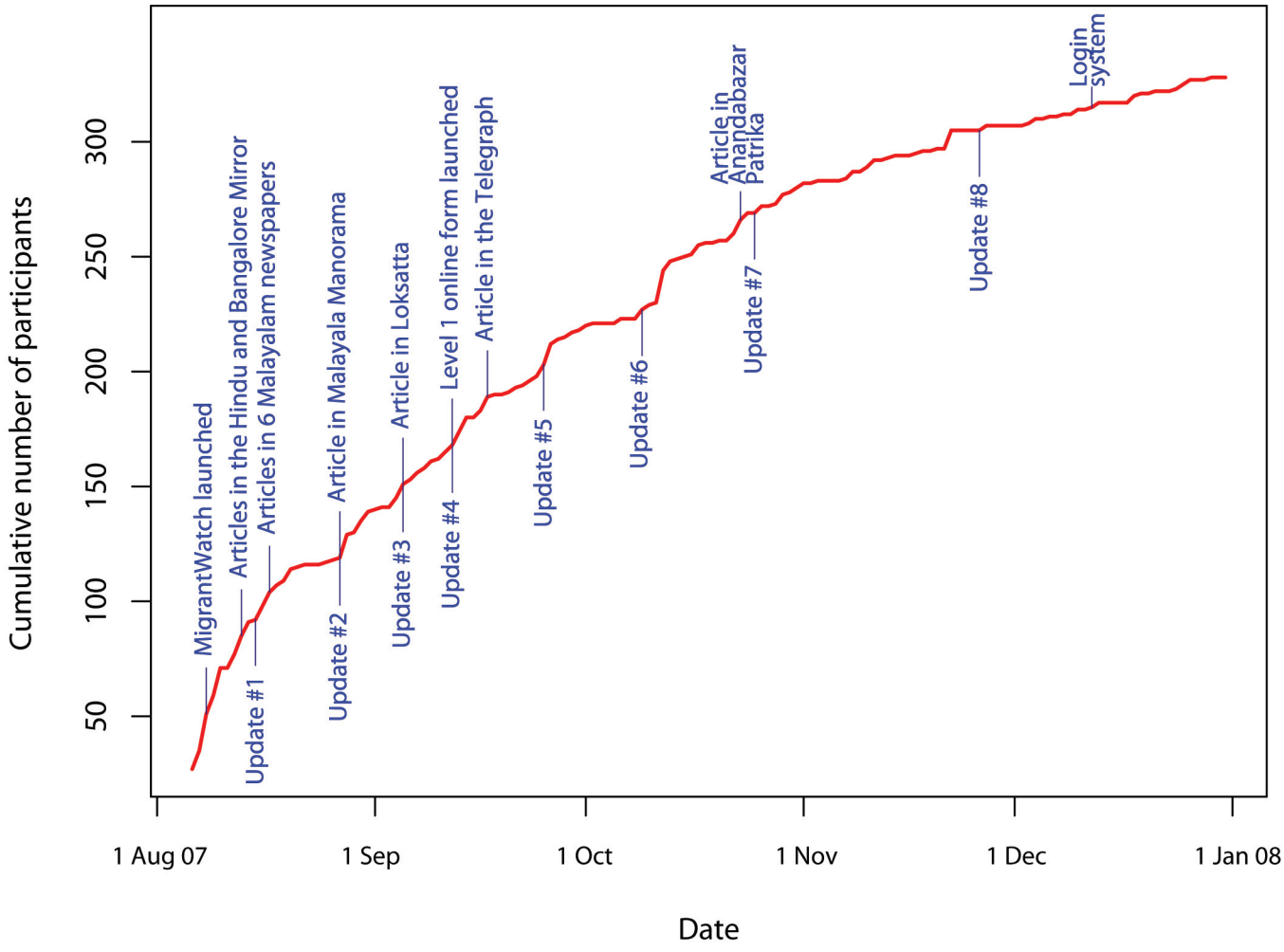

Fig. 1. Growth in the number of participants from the launch of MigrantWatch until 31 December 2007.

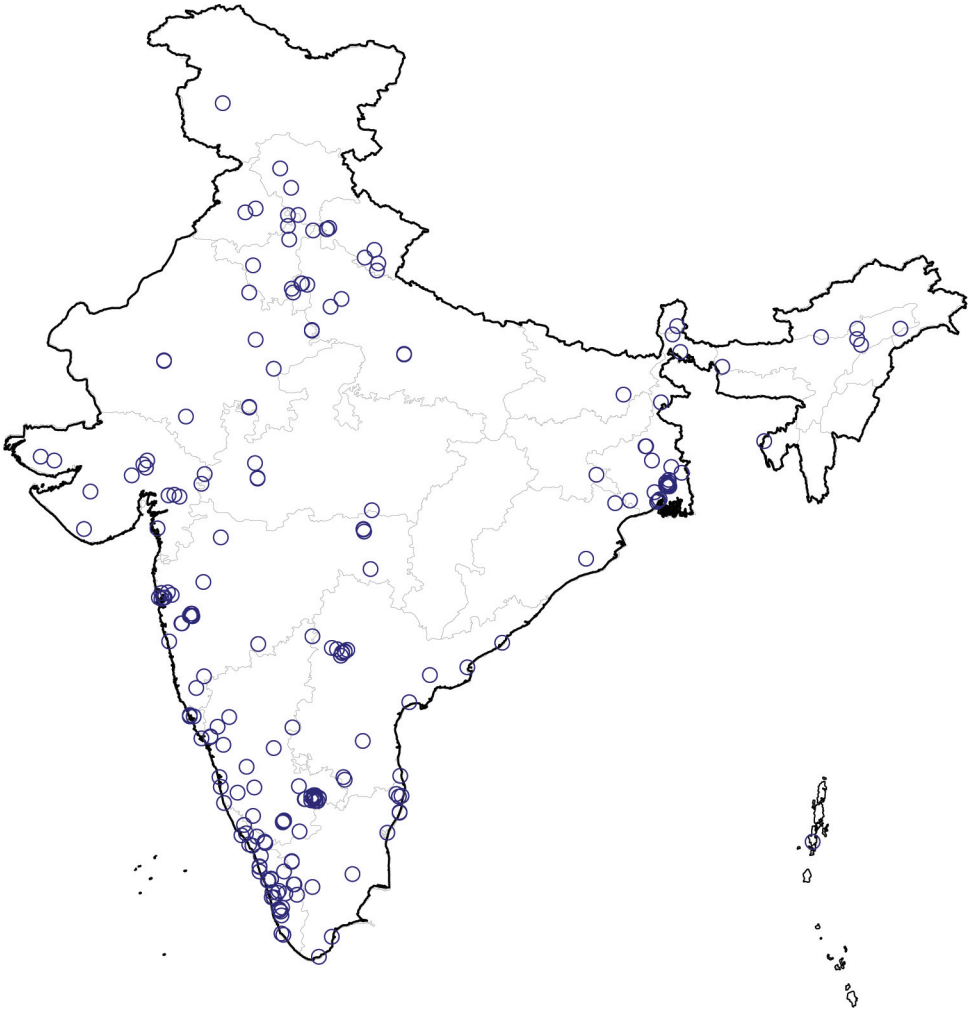

Fig. 2. Map of the main locations of MigrantWatch participants.

Box 2. MigrantWatch policy on submitting and using data.

1. Submitting data
   a. Records are provided to MigrantWatch by participants on the understanding that the information will be compiled and made publicly available.
   b. Every data record will be associated with the name of the record provider; all other personal information (eg, email or postal addresses) will be deleted from the publicly available version of the compiled data.

2. Data availability
   a. Complete datasets will be made available for free download from the MigrantWatch website after compilation.
   b. Before compilation, MigrantWatch will seek to rectify errors and fill in gaps in information. All post-submission modifications will be documented so that, as far as is possible, users will be able to re-create the original, unmodified records as submitted to MigrantWatch.

3. Using the data
   a. The quality and completeness of data cannot be guaranteed. Users employ these data at their own risk.
   b. The compiled dataset is licensed under a Creative Commons Attribution 3.0 License <http://creativecommons.org/licenses/by/3.0/>. Users are free to copy, analyse and publish the data as long as they give credit to MigrantWatch.

and the information was then manually transferred to a spreadsheet. On 12 September, an online form was introduced to facilitate data collation for Level 1 records. Participants could enter their information into the form, and this was stored directly in an online database. At this stage, participants could not view and, if necessary, correct or edit their records after submitting them to MigrantWatch. To enable participants to check their records, the web interface was completely redesigned, and on 12 December a login system was launched. Participants can now log on to a personal account, submit new Level 1 information and check and edit their records. At present online Level 2 reporting is not possible, and participants send these records by email in a spreadsheet or text document (templates of which are available for download from the website).

The first sighting data are stored in a database consisting of four linked tables (Fig. 3).

Assessing data quality and correcting errors

Data sent to MigrantWatch are subjected to certain quality checks. For example, the date of first sighting cannot be earlier than the date observations started at location, and neither of these can post-date the submission of a record. After the implementation of the login system, internal checks

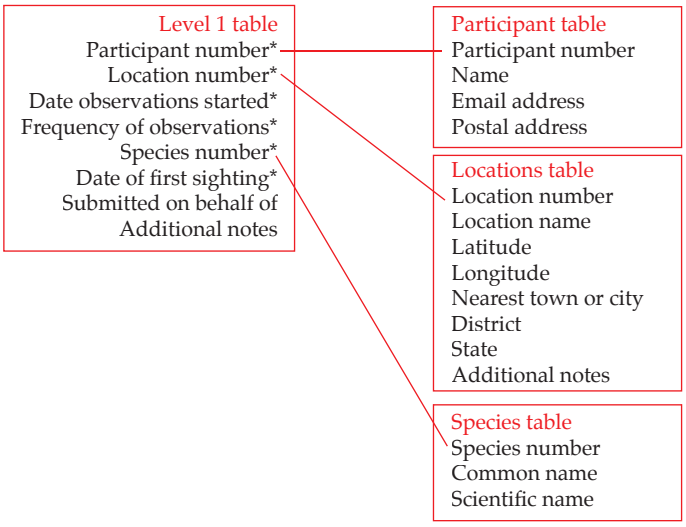

Fig. 3. Structure of the database in which first sighting (Level 1) information is stored. Each table consists of a specific set of information, and each table is linked to at least one other table by a common field (shown as connecting lines). Asterisks mark mandatory fields.

are performed and an error message is displayed if a user tries to submit information that violates the criteria above. However, some data submitted earlier show inconsistent dates. Similarly, if a user does not fill in all required fields, an error message is displayed; but prior to implementing the login system some records had missing fields. In all such cases (inconsistent dates and missing fields), participants were sent an email asking them to edit their records. For those uncorrected records where the specified start date remains later than the date of first sighting, the start date has been changed to the date of first sighting.

Users sometimes provided geographical coordinates (latitude, longitude) of the location of sightings; when this information was missing, coordinates were found using online and published resources. All geographical information is checked, but we should caution that errors might remain in the compiled database.

Preliminary results

First sighting (Level 1) information for 2007 has been compiled and checked, and is now available through the website. To access the data, individuals are required to register if they have not done so already. Users can view and/or download either the entire Level 1 database or a specific subset. A mapping facility based on Google Maps is also available through the website for those who wish to explore the first dates visually without having to download the dataset. Outstanding issues, notes, and cautions about the information in the database are explained on the website.

To illustrate some of the first sighting results, we present two visual representations of the data for each of the nine target species: a map, and a plot of first sightings in relation to latitude of observation. To produce these, we took the following steps. We removed all records with first sighting dates before 1 July 2007 or after 30 November 2007 because these records are unlikely to represent true first arrivals. (But note that this is a simplifying assumption and may not necessarily be correct.) For records with an unspecified date for start of observations, we took the sighting date to represent the date observations started at that location.

For mapping first dates (Fig. 4), we further excluded records with start date later than 60 days after the first observation of the species in the country. For example, the first sighting of Rosy Starling was on 14 July, so we only considered records where the start date was on or before 12 September. First sighting dates were then mapped in different colours after being grouped into roughly 15-day intervals (except for the first interval, which covers the period 1–31 July; see the key to Fig. 4).

The relationship between latitude and all first dates between 1 July and 30 November (regardless of start date and frequency of observation) is shown in Fig. 5. A first sighting at a particular location may be later than the true first arrival of the species, but (barring misidentification) is unlikely to be earlier than the true arrival. This means that the trend in arrival date in relation to latitude is likely to be best reflected by the left edge of the scatter of points in Fig. 5. That is, the left edge of the points represents our best estimate of the pattern of arrival of a species. The line drawn in each of the plots shows the estimated 10% left-most boundary of points (produced by quantile regression); that is, the estimated 10% earliest date recorded at each latitude.

Figs. 4 and 5 show that Wood Sandpiper, Common Swallow and Rosy Starling are among the earliest to arrive, with the first two species spreading quickly southward, and Rosy Starling taking considerable time to reach the southern tip of India. Later arrivals include Northern Shoveller, Black Redstart and Greenish Warbler. For most species there is considerable variation in the first sighting dates at a particular latitude, making it difficult to track the north–south progression of any given species. An exception is Rosy Starling, for which the north–south trend is very clear. Variation in start date and number of participants may partly explain the lack of a clear north–south progression in the data for most species, but it is possible that for some species, the first individuals fly directly south, with later individuals "filling in" progressively northwards.

While interpreting these figures, note that the most accurate first dates will come from locations that are visited frequently (e.g., daily or weekly), and where the nine target species have been looked for since early in the season (e.g., from before the middle of August). For the purposes of this article, we have chosen not to limit Figs. 4 and 5 to these records alone. Instead we invite those interested to download the full dataset and examine the data after imposing more stringent filters than we have done here.

These limitations to the data, particularly those stemming from late starts in observation, are due partly to the late launch of MigrantWatch relative to when winter migrants start arriving and partly to the time taken to publicise the programme amongst potential participants. We anticipate that these issues will pose less of a problem in subsequent years.

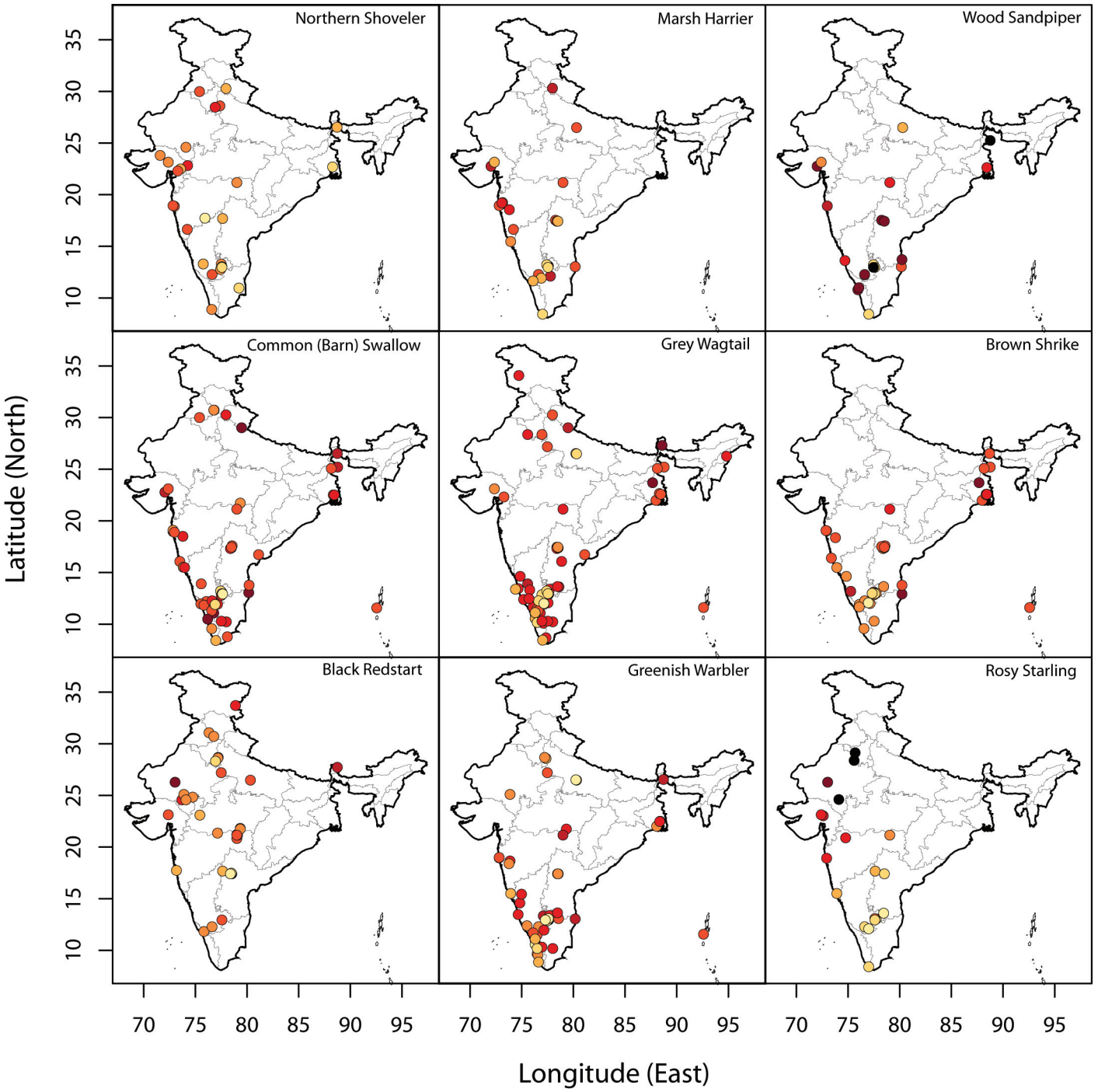

Fig. 4. Locations of first sightings of the nine target species in the second half of 2007, colour-coded by sighting date. The location of each point has been moved by a small random distance for better viewing.

Future directions

We expect MigrantWatch to continue in much the same general fashion in the future. However, certain issues require further consultation and discussion. These include:

Species coverage: The nine species currently covered are a small fraction of all winter migrants to India and perhaps do not represent the best possible coverage across regions of India. How many species should an expanded list contain? All winter migrants? Or perhaps a carefully chosen core group of 20 or 30 species, with participants having the option to record information for all the remaining migrants? One obvious species to include is the Red-breasted Flycatcher *Ficedula parva*, for which changes in spring arrival at breeding grounds has been documented (Mitrus et al.

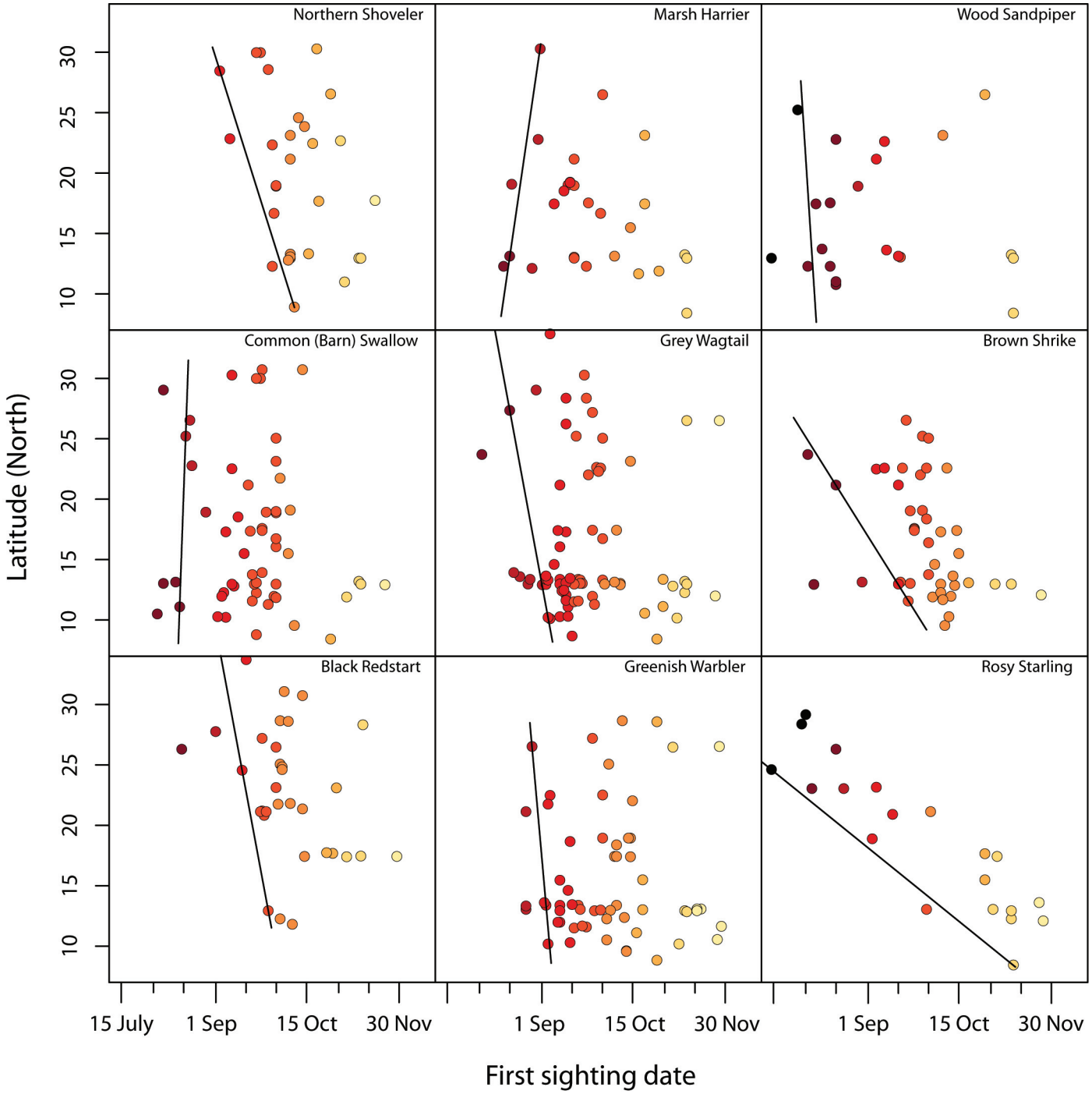

Fig. 5. Relationship between latitude and first sighting dates for the nine target species. Colour codes are the same as in the key to Fig. 4.

2005), but no information on arrival or departure from non-breeding areas in the Indian Subcontinent is available.

Additional information: At the moment, no information on habitat or numbers of individuals is asked for. Habitat may be important because early arriving individuals may preferentially settle in the best habitats (e.g., Green Leaf Warbler *Phylloscopus* (*trochiloides*) *nitidus*: Katti & Price 1996). Counts are needed if one is to track the overall progression of migration, and not just the first-arriving individuals. Should habitat and count information be collected, and if so, should this be mandatory or only optional?

Please send your opinions on these and any other issues to MigrantWatch@ncbs.res.in.

In addition to collecting information on arrival and departure dates in subsequent years, MigrantWatch is also facilitating the collection of such data from previous years. Historical information is extremely valuable in examining long-term patterns in the timing of migration. We strongly encourage readers with information from previous years on arrival and/or departure dates of any migrant species

to contact MigrantWatch. These dates may come from notes that have been kept specifically for arrival and/or departure; or they could be assessed in retrospect from species lists made at a location that is visited regularly. Although the historical information is likely to be sparse, it will supplement the ongoing MigrantWatch programme and will be made available, as always, for free download from the website.

Conclusions

MigrantWatch is the first completely open-access citizen-based effort to collect ecological information over the entire land area of India. Although it is designed to assess the timing of bird migration and its change over the years, the timing of many other biological phenomena could be studied in a similar fashion. These include the timing of flowering and fruiting of plants, of migration in butterflies, of emergence of insects and herbs, and of reproduction in almost any group of organisms. Such studies, when conducted at the country or subcontinental scale will rely on the participation of a large number of naturalists and enthusiasts. We hope and trust that collaborative and cooperative efforts such as these will multiply and also diversify into regular assessments of distribution and abundance of species (Urfi et al. 2001). If this happens, a comprehensive biodiversity monitoring scheme for the entire South Asian region may finally become a reality.

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