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Birding trip reports as a data source for monitoring rare species

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Abstract

Monitoring long-term trends in population size is important for species' conservation assessments. However, it may be unfeasible for rare species, for which past records are typically sparse. Here, I investigate the potential of birding trip reports as an underappreciated source of biological information to monitor rare species. For this purpose, I used an uncommon species – the Peruvian thick-knee *Burhinus superciliaris* – as an example to assess population trends over 2000–2010, using flock size dynamics as a proxy. I collected all observations of thick-knees that could be accessed from birding trip reports across the entire geographic range of the species. In total, I compiled 218 records of 2403 individuals, of which 73.9% were fully useable for this study. Mean flock size declined slightly over the study period in Central Peru, whereas in North Chile it increased at the beginning of the decade and then decreased nearly 90% until the end of the study period. This suggests that, at least at the southernmost part of the distribution range of the thick-knee, the magnitude and speed of the change in population size could be sufficient to qualify for a threatened category. The use of birding birding trip reports as a data source for monitoring trends of rare species seems promising compared to other sources, since sightings of sought-after species are increasingly posted online as a form of tourist attraction and so made publicly accessible for researchers and managers. This study highlights the great utility that birding birding trip reports freely available online may have to provide retrospective data on rare species that would otherwise be impossible to collect. Nonetheless, they might not be universally valid due to species-specific differences and possible lack of non-detection records. Potential biases due to varying sampling effort or detectability should also be carefully considered.

Introduction

Monitoring long-term trends in population size is a straightforward and informative way of tracking species' responses to human-induced environmental change and thus is commonly used as an important criterion to assess the conservation status of the species (Balmford, Green & Jenkins, 2003). To estimate population trends, past and contemporary data on the local abundance of species are required. Nevertheless, these data often suffer from taxonomic and spatiotemporal biases, and they may not be always available depending on the species, and the study area and period (Balmford *et al.*, 2003; Boakes *et al.*, 2010). Data scarcity is particularly acute for uncommon and rare species, which are usually a conservation priority (Hartley & Kunin, 2003). For these species, reliable historical records are typically sparse and limited to those countries using standardized monitoring methods (Roberts, Donald & Fisher, 2005). However, conventional sampling designs, such as simple or stratified random sampling, may be inefficient because of, for example, their scarcity, cryptic behavior, and locally restricted distributions (Rushton, Ormerod & Kerby, 2004; Snäll *et al.*, 2011). Efficient ways to sample additional primary data (i.e. those derived from field observations) on rare species are therefore urgently required (Guisan *et al.*, 2006).

Due to the increasing popularity of electronic tools for biological recording, a large amount of biological information is currently available in open-access platforms. Conservation assessments increasingly include consideration of opportunistic sightings reported voluntarily by the public to specifically designed platforms or websites (Roberts *et al.*, 2005; Sullivan *et al.*, 2009; Barlow *et al.*, 2015). Nevertheless, additional potential sources of biological records, such as social networks and birding birding trip reports have received comparatively little attention (Dixon *et al.*, 2009; Boakes *et al.*, 2010; Roberge, 2014).

Nature-based tourism, and more specifically, wildlife-based tourism, is an increasingly popular activity. Possibly, no group lend themselves more readily to the concept of public participation in data gathering than birds (Sullivan *et al.*, 2009; but see Roberge, 2014). Each year, many amateur naturalists and environmental professionals travel the world to watch birds recreationally, and they mainly focus on finding rare species (Snäll *et al.*, 2011). During these tours, a great amount of observational data on poorly known groups may be obtained, and much of these records are publicly accessible in the form of online reports (Roberts *et al.*, 2005). For example, in the last 2 years (March 2013–2015), a total of 14 259 reports of birding trips worldwide have been uploaded to one of the largest birding trip report repositories (http://www.cloudbirders.com). From the 1990s to the current decade, birding trip report records have increased steeply (Boakes *et al.*, 2010) and, for many areas, they may be the only existing source of past information on some of their bird populations (Roberts *et al.*, 2005). Typically, the data contained in birding trip reports consist of daily descriptions of all the observations made by experienced birding trip leaders and recreational observers, including additional basic information (e.g. species name, number of individuals, time of day, habitat type, or individual marks) and therefore, they are simple enough to be considered as being reliable. However, despite the increasing popularity of nature-based tourism, birding trip reports remain as an underappreciated source of biological information.

Here, I investigate the potential of birding trip reports as a data source for retrospective long-term monitoring of rare species. For this purpose, I collected observational records of an uncommon bird species, the Peruvian thick-knee *Burhinus superciliaris* (hereafter, 'thick-knee') from online birding trip reports for the period 2000–2010. Because of their cryptic behavior, thick-knees are difficult to detect and monitor, and many questions remain about their life history (Camacho, 2012; Iannacone *et al.*, 2012). However, the species has a wide geographic range, occurring from southern Ecuador to northern Chile, and hence, is not thought to approach the thresholds for 'vulnerable' under the range size criteria of the IUCN (International Union for Conservation of Nature; Extent of Occurrence <20 000 km^2). Neither is believed to be decreasing sufficiently rapidly to meet these thresholds under the population size (<10 000 mature individuals) or population trend (>30% decline over 10 years or three generations) criteria. For all these reasons, the species is currently listed as 'Least Concern' (BirdLife International, 2012), although there are no recent estimates of population size or trends (BirdLife International, 2012). Here, I use past data collected exclusively from online birding trip reports to assess retrospectively the temporal trends of thick-knee populations – using interannual changes in mean flock size as a proxy – at the edge and the core of its geographic range to highlight the overlooked applications of online birding trip reports in conservation science.

Materials and methods

Data compilation

To gather as many records of thick-knees from the past decade as could be accessed from birding birding trip reports, in March 2015, I conducted an exhaustive search for birding trip reports from 2000 to 2010 throughout the entire range of the species by using standard Internet search engines (http://www.google.es) and one of the largest publicly accessible repositories (http://www.cloudbirders.com). For all birding trip reports, I searched for the term '*Burhinus superciliaris*', and the species' common name in English, French and Spanish. Care was taken to use reports that featured on different websites once only. Basic information [i.e. number of individuals seen together, exact date(s) and location(s)] along with some additional data (e.g. behavior, habitat type) including the annual number of visits per site were extracted from each report. Further, in cases where basic information was missing (<10% reports), I emailed the birding trip leaders to request unpublished data, most often geographic coordinates and/or descriptions of the sampling sites, which yielded a response rate of 78.2% (n = 23). Descriptions of the sampling sites were converted to geographic coordinates using Google Earth (http://www.google.com/earth) and further validated by checking that each data point was within reasonable distance from the site described.

Definition of the study area and population size

Based on the total number of sightings (see Results), I selected two focal study regions to perform the trend analyses, namely Central Peru and North Chile. Both study regions were defined as the area within a 25 km radius around the pair of sampling sites hosting the majority of records (i.e. Pantanos de Ventanilla, Peru: 11°51′S, 77°8′W; Río Lluta, Chile: 18°24′S, 70°19′W). This is because it seems very likely that birds in close proximity, which is reasonably assumed to be 25 km, belong to the same population. I used the number of thick-knees in a flock (i.e. flock size, ranging from 1 to 53 birds) as a measure of local population size. Note that records of a single individual account for <10% of the data set. I am confident that flock size is a reliable proxy for population size because a functional relationship between flock size and local population density exists in other bird species (Beauchamp, 2011; but see Hart & Freed, 2003) and apparently also in the thick-knee (Camacho, 2010). Furthermore, flock size has been proven useful to assess population trends (Lawson *et al.*, 2012).

Statistical analyses

To analyze temporal variation in flock size, I used generalized linear models (GLMs) including flock size (number of birds) as the response variable. Separate GLMs were fitted for Central Peru and North Chile, since (1) initial exploratory models showed that the temporal trends in mean flock size varied significantly between the two regions, that is there were significant year × region and year^2 × region interactions (see Supporting Information Appendix S1); and (2) the flocking behavior of thick-knees – and possibly also the functional relationship between mean flock size and local abundance – change throughout the year in Central Peru, but not in North Chile (Camacho, 2012). I treated year as a continuous predictor variable to formally test for temporal trends in flock size, and included in the models linear year and quadratic year as fixed effects. Fortnight (scaled variable: 1 = 1st half of January; 24 = 2nd half of December) was also included in the models to account for circannual variation in group size (Camacho, 2012). For this purpose, the fortnight number was first converted to a circular variable (i.e. sine and cosine of $2\pi \times$ fortnight number/24) and then its sine and cosine were included into the models. Flock count data exhibited a left-skewed distribution in which zero values cannot occur (i.e. there are no flocks of size zero) and, moreover, they were overdispersed (i.e. the variance was greater than the mean). Thus, to model these data I used a zero-truncated negative binomial distribution and a log link function (Zuur *et al.*, 2009). The models may be written as: $N \sim \mathrm{NB}\ (r,\ p)$, where $N > 0$, the shape parameter $r = 0, 1, 2 \ldots$, the probability parameter $p \in (0, 1)$, and $\log(\mu) = \beta_0 + \beta_1(\text{year}) + \beta_2(\text{year}^2) + \beta_3[\sin(2\pi \times \text{fortnight}/24)] + \beta_4[\cos\text{in}(2\pi \times \text{fortnight}/24)]$. In this model, μ is mean flock size, β_0 is the intercept, and $\beta_1 \ldots \beta_4$ are the coefficients for the explanatory variables.

Because a standardized field protocol is rarely used by recreational observers to collect data, some correction for spatial and temporal changes in sampling effort (e.g. number of visits per site) is generally required to reach unbiased estimates of long-term trends (Zbinden *et al.*, 2014). In this study, uneven effort is unlikely to influence the estimates because the counts are not a function of the effort applied to the visits, that is, thick-knees are counted only once a flock is detected. Initial exploratory analyses showed no significant influence of the number of visits per site on the trend estimates, and hence this term was not further considered in the models. I am aware that flock size could be underestimated by non-experienced observers, particularly under bad observation conditions. However, the birding trips considered in this study were always guided by professional birdwatchers and, as stated in the reports, it is they who collect all sightings and prepare the final reports.

Consecutive observations (<24 h) from the same locality (1.8%) were omitted from analyses to reduce the likelihood of counting already recorded flocks twice, that is, each of the records included in the models are assumed to represent a different flock. GLMs were fitted in R 2.14.0 (http://www.R-project.org) using the function *vglm* in the 'VGAM' package with the argument family set to posnegbinomial to ensure that a zero-truncated negative binomial model was applied (Zuur *et al.*, 2009). To test for the significance of seasonality, which is represented by two different terms, I fitted a reduced model excluding sine and cosine terms and then compared it to the final model (i.e. containing only statistically significant terms) using a likelihood ratio test (LRT).

Results

In total, the Internet search yielded 218 records of 2403 thick-knees seen during guided birding tours between 2000 and 2010, at an average rate of 19.8 (SD = 7.31) records per year. Most of these were from the Tarapacá region in northern Chile and several localities in Peru (39.2% and 57.6%, respectively), whereas Ecuador contributed only to 3.2% of the database. Records lacking the exact date (3.2% of all sightings) and those from outside the focal study areas (20.2%) were removed from the data set, resulting in the loss of $n = 58$ records (26.6%). This left a total of 79 usable records of flocks from North Chile and 81 from Central Peru. Results of the GLMs run on these latter data showed that the temporal trends in mean flock size varied markedly depending on the sampling site (Table 1). Mean flock size decreased non-significantly over the study period in Central Peru, after controlling for the significant influence of seasonality (LRT with d.f. = 2; $P < 0.001$). However, in North Chile, mean flock size increased during the first years of the decade up to 16 birds (95% prediction interval: 13.9–18.7) and then decreased steeply until the end of the study period up to <2 birds, which represents a nearly 90% decline (range: 60.4–100% based on prediction intervals; Fig. 1).

Discussion

By using records of thick-knees accessed from birding trip reports as an example, this study illustrates the potential of these data as a source for the long-term monitoring of rare species. Mean flock size declined slightly throughout the last decade (2000–2010) in Central Peru, whereas in North Chile, it fluctuated markedly and eventually decreased to very low

Table 1 Results of the generalized linear models showing the linear and non-linear effects of year on flock size of Peruvian Thick-knees in North Chile (a) and Central Peru (b)

	Estimate	SE	*Z*	95% CI	*P*-value
(a) North Chile					
Intercept	1.695	0.470	3.607	0.774, 2.615	<0.001
Year	0.526	0.207	2.538	0.120, 0.932	0.012
Year^2	−0.063	0.021	−3.042	−0.104, −0.022	0.003
Fortnight sine	−0.351	0.233	−1.508	−0.808, 0.105	0.134
Fortnight cosine	−0.162	0.268	−0.605	−0.687, 0.363	0.546
(b) Central Peru					
Intercept	2.559	0.296	8.659	1.980, 3.139	<0.001
Year	−0.080	0.046	−1.729	−0.171, 0.011	0.086
Year^2	0.014	0.017	0.866	−0.017, 0.045	0.388
Fortnight sine	0.283	0.230	1.230	−0.168, 0.735	0.221
Fortnight cosine	−1.162	0.190	−6.114	−1.534, −0.789	<0.001

Fortnight numbers were converted to a circular variable and its sine and cosine were included into the model to control for the effect of seasonality on flock size. Number of observations = 79 in North Chile and 81 in Central Peru; number of years = 11. Statistics and *P*-values of non-significant terms are those obtained by adding them individually to the final models, in which only significant predictors were retained.

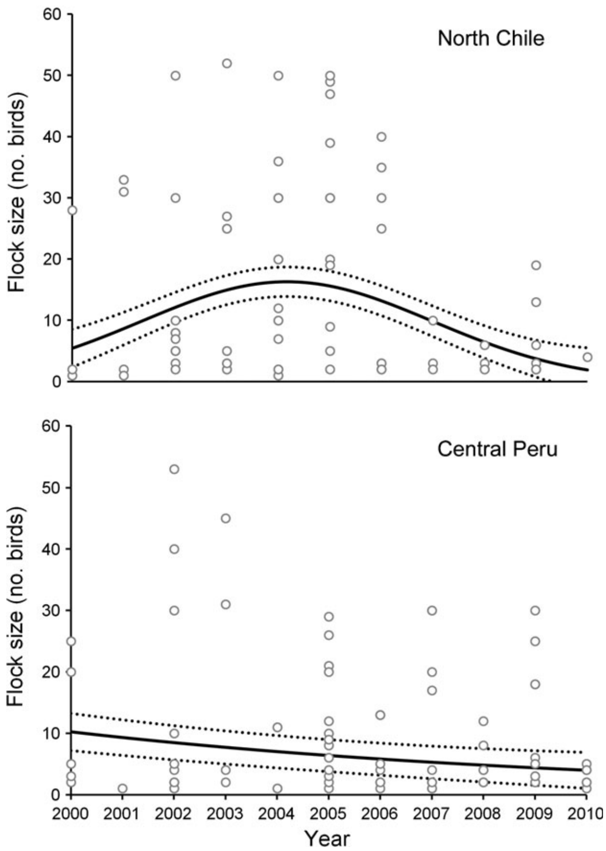

Figure 1 Flock size of Peruvian Thick-knees seen in North Chile and Central Peru over the study period. Solid lines show the fitted response of the generalized linear models, in which fortnight numbers were converted to a circular variable and its sine and cosine were included into the model to control for the effect of seasonality on flock size. Dotted lines show prediction intervals at 95% confidence level, and open circles show raw data.

values by the end of the study period. It is unknown whether the negative trend observed in Central Peru actually started before the study period, yet the magnitude and speed of the change in population size at the southernmost part of the species range (around 90% in <10 years) may be sufficient to cross the threshold to qualify for a threatened category (>30% decline over 10 years; BirdLife International 2012).

Flock size has been proven effective in assessing population trends of some bird species (Lawson *et al.*, 2012), and appears to be a reliable proxy for local abundance also in the thick-knee. As in many other gregarious species (Beauchamp, 2011), a functional relationship between flock size and local population abundance apparently exists in the thick-knee, though the strength of this relationship may vary seasonally in some regions of the geographic range of the species (Camacho, 2012). However, in many other species, particularly non-gregarious species (see Hart & Freed, 2003), the number of individuals seen together might not reflect the actual abundance, and this might strongly affect the reliability of the estimates. Further research (e.g. species-specific sampling) or validation (e.g. using the data from systematic surveys) would then be required prior to analyses to determine whether population dynamics estimated from birding trip data on animal aggregations (e.g. flocks, herds or breeding colonies) parallels the actual population dynamics of the species of interest.

Lack of primary data from monitoring programs constitutes a serious barrier to obtain abundance estimates of uncommon and rare species, for which prevalence in biological databases is, by definition, reduced (Pearson *et al.*, 2007). Conversely, this is a major strength of the data collected during the birding trips, as recreational observers mainly focus on finding these species (Snäll *et al.*, 2011). By using birding trip reports, a relatively large and spatially balanced data set was obtained so, at least in the thick-knee, the amount of data was not an issue for estimating population trends. Neither was the spatiotemporal scale, as there were records available for the last decade throughout the entire geographic range of the species. Online birding trip reports are relatively recent (although less than globally accessible checklists; e.g. Sullivan *et al.*, 2009), and their contribution to long-term data sets might be relatively small compared to conventional data sources (e.g. museum collections, atlases, literature information; Boakes *et al.*, 2010). Nevertheless, as shown here and by Snäll *et al.* (2011), this does not seem to be true for uncommon or rare species, for which past records may be readily available from publicly accessible birding trip report repositories and tour operator websites. Possibly, it is scarcity that makes rare and/or endangered species the most sought-after targets for recreational observers, so that tour operators regularly post such 'sensational' sightings as a form of tourist attraction and, at the same time, make them accessible to researchers and managers.

During the birding trips, a standardized sampling protocol is seldom used and thus records for a particular region or time period are often missing. However, important information may be retrieved directly from the tour guides, whose name and contact details are generally provided in the reports. For example, birding trip reports typically lack precise details of location (Boakes *et al.*, 2010), and reflect proximity to a reference site (e.g. human settlements, geographical features and protected areas) with a maximum accuracy of *c.* 1 km. Fortunately, local tour operators offer fixed departure tours covering the same routes, and the leader for each particular route is usually the same. Then, if higher spatial accuracy of bird-watching localities is needed, GPS coordinates can be requested by e-mail from the birding trip leader and, as shown here, successfully obtained in most cases. Birding tours are usually conducted several times a year according to customer's requests, so, a thorough search for different tour operators makes it possible to compile relatively complete large data series covering most, if not all, phases of a species' annual cycle. Studies using birding trip reports for estimating trends would have the advantage of long-term data (possibly older than those from e.g. real-time checklist programs) and relatively fine spatial and temporal resolutions (e.g. per km^2 and year) that can be used to investigate (Camacho, 2012) or control for (this study) within- and between-year variation in species abundance.

Because of the non-systematic nature of birding trip report records, a great care and good knowledge of their limitations is required to estimate unbiased trends. Biases may be induced by uneven species detectability and sampling effort per visit, and also temporal and spatial changes in sampling effort (Isaac & Pocock, 2015). Biased records may be removed from the data set if detected or, alternatively, potential biases could be explicitly modeled (Isaac & Pocock, 2015), though some difficulties may be hard to solve anyway. For example, birding trips may not be mutually independent, as birding trip organizers also read the reports by other tour operators and may then travel to the areas where the species of interest were last seen. Note that this may produce large numbers of records for a particular site or in a short time period, and multiple records of the same individual. Biased sampling could potentially mask true population declines, since most records may come from the sites where the focal species is most abundant (Snäll *et al.*, 2011).

Detection of species may differ between birding trips due to, for example, the number and skills of the observers, or changes in vegetation structure or weather conditions. During the birding trips, animals are counted once a flock is detected by the experienced guides, so that the estimated number of individuals in a group – but not the number of groups sampled – need not necessarily be a function of the detection possibilities under good observation conditions. For non-gregarious species, however, the accuracy of abundance estimates could be strongly affected by detectability, as solitary individuals may be more difficult to see even by skilled observers. Data on environmental variables are generally freely accessible via the Internet, and thus their potential effects can be controlled for in the models. Nonetheless, species detectability is only partly known concerning the recreational observers, since birding trip reports generally provide the number of birding trip participants, but their previous experience is unknown. It should be noted that this is unlikely to influence long-term trend estimates because, on one hand, it is professional guides who normally collect the sightings and, on the other hand, there is no reason to believe that the average experience of the birding trip participants changes among years.

For recreational observers, some destinations could be particularly attractive and thus the number of birding trips may differ between sites. Furthermore, the birding trips to different sites may differ in duration or search effort for particular species, but, as noted above, the number or duration of the visits should not affect the recorded flock size. On the other hand, a major disadvantage of the data collected during the birding trips is that they will be always truncated, since a zero count cannot occur, and zero-truncated distributions should therefore be applied. Even so, the lack of information on observed absences means that population abundance might not be directly estimated, thus limiting the utility of birding trip data for those species for which flock size is not a good proxy of abundance. Several improvements can be made in future birding trip data analyses. First, any trend analysis would benefit from information on absences. So, it would be great if these could be somehow inferred from field data (e.g. from the reported presence of more common species) or requested from field guides. A second improvement would be to apply modern statistical methods – for example, Bayesian hierarchical models (Snäll *et al.*, 2011) or resampling methods (Zbinden *et al.*, 2014), which enable to separate inferences on observation and state, here abundance (e.g. Link, Sauer & Niven, 2006). Such methods are especially useful if more detailed information on the observation process would become available, such as duration of field birding trips and the quality of observers. Thus, extraefforts to obtain important missing information are cost-effective.

To summarize, this study illustrates the great utility that birding trip reports housed in online collections may have as a data source to monitor rare species, for which the accuracy of conservation assessments is constrained by the scarcity of data. Using the thick-knee as an example, I show for the first time to my knowledge (1) that unlike standardized survey programs, records of rare species are particularly numerous in birding trip reports; (2) that these may provide great amounts of past data that would otherwise be very difficult to collect; (3) that in contrast to species-specific surveys, data of uncommon or cryptic species can be collected with minimal cost, time and personnel requirements; and (4) that these data may be used to estimate interannual population changes and long-term trends over timescales of, at least, a decade. Nevertheless, these data might not be universally valid, and given the potential difficulties of using count data collected during the birding trips to estimate population trends, conservation assessments should be carefully considered. Looking to the near future, I suggest that extensive examination of nature birding trip reports and subsequent request for sampling details if lacking should be incorporated into standardized conservation assessments of poorly known species.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix S1. R code for the analysis of trip report data.