Conservation Letter: Monitoring Raptor Populations – A Call for Increased Global Collaboration and Survey Standardization

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CONSERVATION LETTER: MONITORING RAPTOR POPULATIONS – A CALL FOR INCREASED GLOBAL COLLABORATION AND SURVEY STANDARDIZATION

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INTRODUCTION

A minimum of 159 bird species, including eight raptor species, have gone extinct since the year 1500 (BirdLife International 2021). Monitoring programs can help prevent extinction if they alert conservationists to population losses in time to take action (Martin et al. 2012, Lindenmayer et al. 2013, Woinarski et al. 2017). Indeed, monitoring, which is defined as "collecting and analyzing repeated observations or measurements to identify changes and evaluate progress of management towards stated aims" (Robinson et al. 2018) is essential for conservation (Wiens 1984, Nichols and Williams 2006, Lovett et al. 2007) and provides for the prioritization of taxa and places for conservation effort.

Raptors tend to be long-lived and to reproduce slowly, making their populations susceptible to changes in adult survival (Newton 1979). Decreases in survival of adult raptors can therefore cause precipitous population declines (Pain et al. 2008, Ogada et al. 2016) that must be detected quickly to avert catastrophe. Importantly, these species tend to be wide-ranging and occur at relatively low densities (Newton 1979). Thus, a single scientist or program might not be able to cover sufficient area or attain the sample sizes necessary for inference of population dynamics, whereas a consortium of researchers could monitor raptors more effectively. Collaboration is therefore needed for global populations of most raptors to be properly monitored. This Conservation Letter provides the results of a survey of raptor researchers across the globe to identify current spatial, taxonomic, and topical gaps in raptor monitoring. The intent of the Raptor Research Foundation (RRF) is to provide readers with evidence-based recommendations for more impactful global raptor monitoring and greater collaboration among raptor researchers, and to provide readers with a better understanding of where and for which species gaps in raptor monitoring persist.

SURVEY OF RAPTOR RESEARCHERS

We developed a questionnaire, distributed as a Google form in English (https://forms.gle/wNsU6hWAemiST9hr9) and Spanish (https://forms.gle/8dupapvZEkGTgtA68) to survey researchers regarding the countries where they conduct raptor monitoring, the species that they monitor, and the types of data they collect. We designed the survey to gain information about data collected by professional

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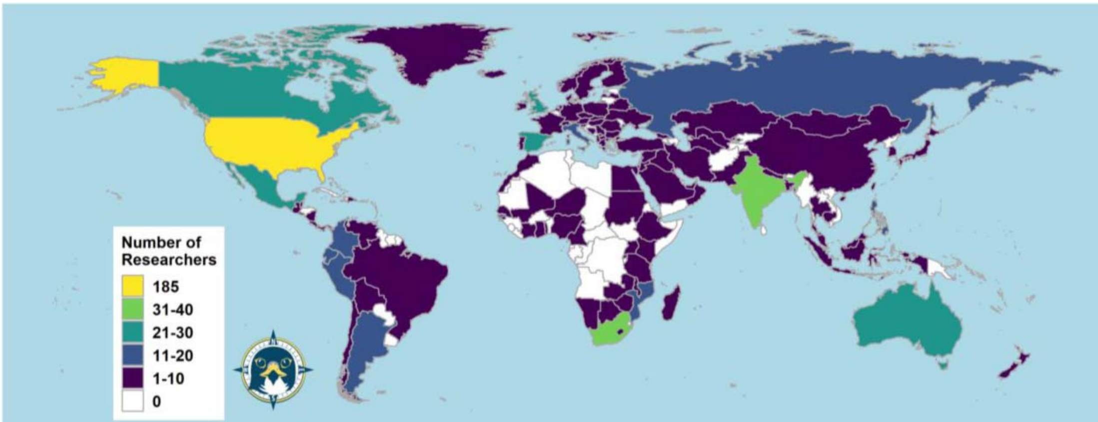

Figure 1. World map indicating countries where respondents of a survey of raptor researchers are collecting data.

researchers within the past 5 yr and specified this in our invitation (i.e., we asked about data collected professionally, and not as citizen or community scientist). We distributed the survey via email to the membership of the Raptor Research Foundation, the Asian Raptor Research and Conservation Network, the Neotropical Raptor Network, and the AFRICORN list serve. We also distributed the survey to our personal contacts and on social media. We (i.e., the authors) collectively study raptors on every continent except Antarctica, and we therefore believe that our personal networks should not have biased survey results. The survey ran for 44 d, after being made public on 3 March 2022, and we analyzed the responses up until 16 April 2022. We mapped the countries where respondents reported conducting monitoring and ranked the species for which the most researchers collected data. We also ranked the types of data collected by the number of researchers reporting collection of each data type.

Differences in taxonomy often complicate raptor research (McClure et al. 2020), so we conformed to BirdLife International's taxonomy (Handbook of the Birds of the World and BirdLife International 2019) as much as possible. However, not all respondents followed this taxonomy and thus sometimes we had to convert reported species to the BirdLife taxonomy, infer the taxon to which they were referring, or remove the taxon from consideration if it could not be deduced. We thus only included in species tallies those instances where we could confidently place the taxon into BirdLife International's taxonomy.

The survey was taken by 527 researchers collecting data in 114 countries on 322 species (58% of raptor species). Respondents were distributed unevenly across the globe. Most respondents collected data within North America, with the USA being the site of by far the most raptor research conducted by respondents (Fig. 1, Supplemental Material). The top three countries where respondents conducted research were the USA (185 researchers), South Africa (37 researchers), and India (32 researchers). Although the USA only contains 10% (56 species) of raptor species (McClure et al. 2022a), we expected a plurality of respondents to collect data within the USA for three reasons: (1) The Raptor Research Foundation distributed our survey to its membership, who mostly reside in the USA, (2) although English is the predominant language of science, language barriers still exist (Ramírez-Castañeda 2020). We therefore included a Spanish translation of our survey to specifically target researchers in South America, but speakers of other languages may have been unable to take our survey. And (3), in our experience, a plurality of raptor research occurs in the USA. We interpret our results to suggest not that raptors within the USA are over-studied, but instead that other regions deserve increased attention specifically because most of these understudied regions also host a greater biodiversity of raptor species (Amar et al. 2018, Buechley et al. 2019).

Many countries desperately either need more researchers, or need their scientists to be better connected with the global network of raptor researchers. For example, China has the largest human population of any country and contains 92 raptor species (16%; McClure et al. 2018), but only one survey respondent conducted raptor research in China. Similarly relevant for human population growth is Nigeria, where demographic projections show an increase from 201 million people in 2019 to over 400 million by 2050 (United Nations 2019). Nigeria is rich in biodiversity and hosts 70 raptor species (13%), but only five researchers reported studying Nigeria's raptor fauna. South Sudan currently shows the highest human population growth rate (5.05%; United Nations 2019) and harbors more raptor species (76 species; 14%) than, for example, South Africa (75 species; 14%; McClure et al. 2018), yet no respondents reported studying raptors in South Sudan. Indeed, given that tropical areas should be a priority for raptor research

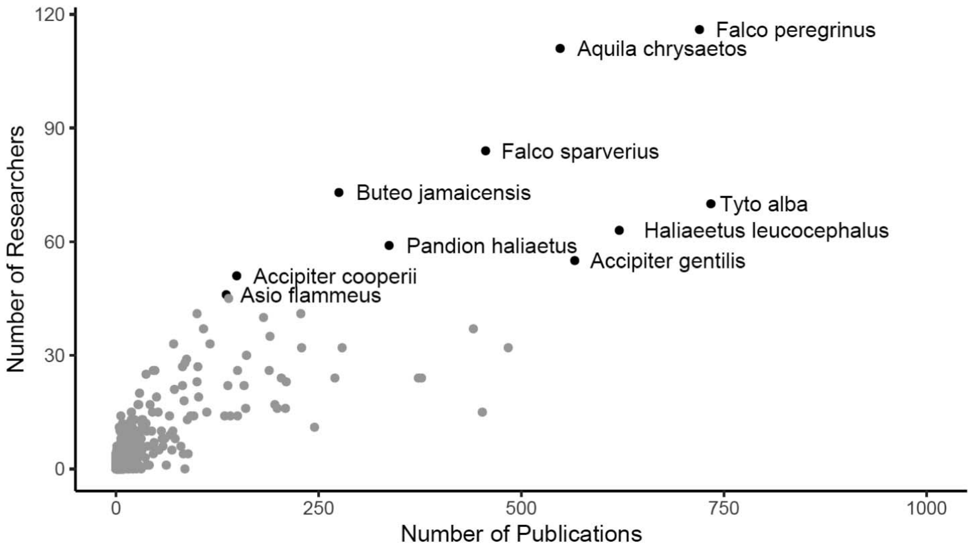

Figure 2. Number of survey respondents collecting data regarding a given species and the number of publications reported by Buechley et al. (2019) for that species. The black and labeled points in scatterplot depict the 10 most-reported raptor species by researchers and the grey unlabeled points depict all other raptor species.

and conservation (McClure et al. 2018, Buechley et al. 2019, Cruz et al. 2021) and have fewer researchers compared to the Global North (Fig. 1), outreach, education, and funding efforts aimed at recruiting local researchers in the Global South should be a priority (Santangeli et al. 2019, Reynolds et al. 2021).

Study effort of respondents was also unevenly spread across species. The 10 most-studied species accounted for 24% of reported raptor monitoring (Fig. 2), whereas 42% of species were unmonitored by our survey respondents. These 10 most-studied species all occur in North American or European countries. The top three most-studied species were the Peregrine Falcon (116 researchers; *Falco peregrinus*), Golden Eagle (111 researchers; *Aquila chrysaetos*), and American Kestrel (84 researchers; *Falco sparverius*). Therefore, more than one in five respondents collected data on Peregrine Falcons or Golden Eagles. These results resemble those of Buechley et al. (2019) who demonstrated that 10 species were the subject of one-third of studies published about raptors. Linear regression reveals that the number of researchers and publications per species (as reported by Buechley et al. 2019) are correlated ($\beta = 0.12$, SE < 0.01, $P < 0.01$, $R^2 = 0.73$; Fig. 2). Therefore, not only do patterns in publication reveal that past research primarily focused on a few species, but our results suggest that the same is true for monitoring conducted over the last 5 yr. The issue of researchers focusing on a few species thus appears to be a continuing problem. As indicated above, however, our results should not be interpreted as some species being over-studied. Species with large ranges require the effort of many researchers to properly monitor their populations. We thus call for continued monitoring of well-covered species and increased resources for those that are currently poorly monitored.

The three types of data that respondents most reported collecting were nest occupancy surveys (341 researchers; 65%), behavioral observations (330 researchers; 63%), and productivity (259 researchers; 49%; Fig. 3; Supplemental Material). These results thus reveal a pattern of focus in the breeding season with only 127 researchers (24%) reporting conducting wintering surveys and 118 (22%) conducting migration counts. Past authors have suggested raptor researchers should also focus more outside of the breeding season (McClure et al. 2017, 2022b) and we echo such recommendations.

We distributed our survey in two languages and across multiple media to as many researchers as possible. It is likely, however, that many raptor researchers either did not receive, or did not respond to, our survey, which we confirmed by personal correspondence. It is also possible that the countries where we reside are overrepresented because we sent the survey to our personal contacts. However, we believe that although our list of survey respondents is incomplete, it is extensive and generally covers a representative portion of the raptor research community. Our results thus provide a useful index of global raptor research activity over the past 5 yr. Therefore, we believe the spatial (Fig. 1), species (Fig. 2), and topical (Fig. 3) trends that we report can be used to discern patterns in raptor research.

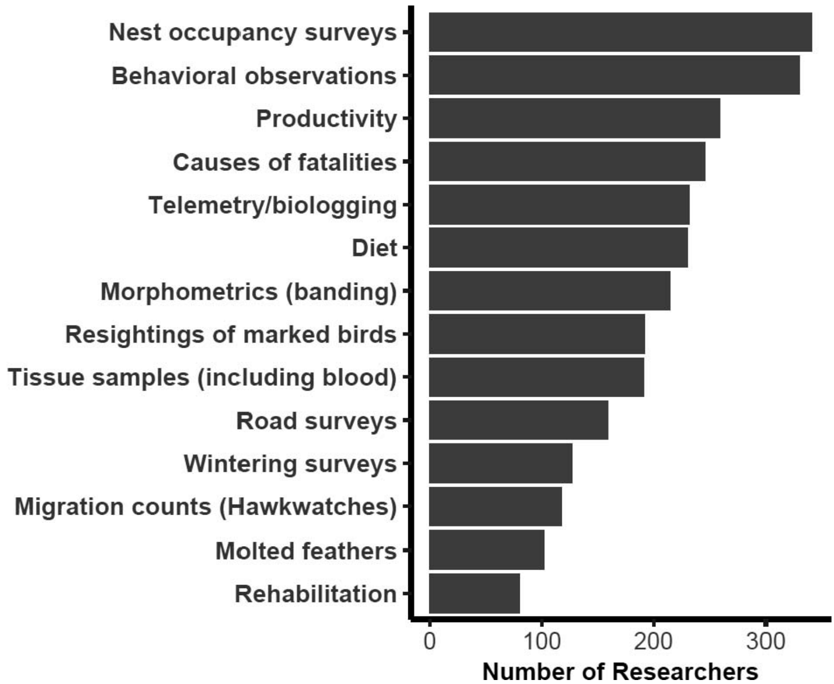

Figure 3. The number of survey respondents reporting collecting certain types of raptor data.

TOWARD MORE IMPACTFUL RAPTOR MONITORING

The wildlife ecology and conservation literature contain much discussion of "proper" monitoring methodology. We briefly summarize this discussion while presenting our own specific recommendations for raptor researchers. Past authors have recommended "adaptive monitoring" (Lindenmayer and Likens 2009, Reynolds et al. 2016), which has explicit goals and regularly uses data to confront *a priori* hypotheses. This is in contrast to "surveillance monitoring," which is not guided by *a priori* hypotheses and has been lamented as prone to failure and wasting resources (Nichols and Williams 2006). Too many monitoring programs fail to define goals or hypotheses, while also ignoring issues of study design, data quality, and statistical power (Legg and Nagy 2006). These criticisms likely apply to many initiatives monitoring raptor populations. We recommend that raptor monitoring programs not only estimate trends, but also explicitly test hypotheses regarding the drivers of such trends. In this way, raptor researchers can help ensure their data will be used to both detect and remedy declines.

Scarcity of funding and deficient in-country capacity are major limitations to long-term monitoring. One way to guarantee that monitoring is performed where it is most needed is for institutions from the Global North to provide grants, hands-on training, and support to students from the Global South. Several entities in the Global North already provide funding and training to students from the Global South (e.g., The Peregrine Fund, Hawkwatch International, the Royal Society for the Protection of Birds, and the Hawk Mountain Sanctuary Association). Despite these efforts, far more resources are needed to monitor raptors where they are most diverse.

Long-term and large-scale monitoring is needed to assess trends in and drivers of raptor populations because raptors tend to be long-lived and wide-ranging (Newton 1979). Standardization can help ensure that short-term or local monitoring efforts can be combined into long-term and regional or global efforts. There have been several efforts toward standardization of protocols. For example, authors have presented standardized protocols for migration counts (Dunn et al. 2008, Panuccio et al. 2018) and surveys of vultures (Perrig et al. 2019) and owls (Takats et al. 2001). The European Raptor Biomonitoring Facility coordinates best sampling practices and data exchange for contaminant monitoring (Espín et al. 2021). Some books have also been published attempting to standardize raptor research (Giron Pendleton et al. 1987, Hardey et al. 2006, Bird and Bildstein 2007, Malan 2009, Anderson et al. 2017). Other aspects of raptor monitoring are in need of standardization including road count methodology (McClure et al. 2021b) and techniques used to inventory forest raptors (but see Thorstrom 1996). We recommend authors use standardized protocols, data collection and storage tools, and analyses whenever possible.

While recognizing the need to standardize survey protocols where possible, we also acknowledge the importance of historical baseline datasets, which allow comparison to future repeated surveys. For example, in Africa and India repeating prior ad hoc surveys revealed drastic declines in raptor populations (Prakash et al. 2003, Thiollay 2006, Garbett et al. 2018). Thus, in many regions without systematic national level monitoring programs, the ability to detect trends will depend on identifying and safeguarding historical baseline surveys to provide the potential for comparison to future surveys.

Technological infrastructure can help standardize efforts across monitoring programs. Further, online data repositories serve as back-up systems for data storage and can facilitate data sharing. The Hawk Migration Association of North America (HMANA) coordinates the effort of >300 count sites across the continent via its website, www.hawkcount.org. A consortium of various organizations has developed Trektellen (www.trektellen.org), which has advanced the sharing, collation, and dissemination of counts of migrating birds, particularly in Europe (Troost and Boele 2019). The Max Planck Institute of Animal Behavior's MoveBank (Kays et al. 2021) standardizes and stores animal telemetry data from across the globe. The Peregrine Fund's Global Raptor Impact Network (GRIN; www.globalraptors.org) collects, stores, analyzes, and distributes information about raptors from around the world (McClure et al. 2021a). GRIN provides a free mobile application for data collection that aids in standardizing raptor monitoring efforts, particularly road counts. Researchers should consider using these online platforms for data curation and sharing—both to aid in standardization and to more easily collaborate with fellow researchers.

TOWARD CLOSER COLLABORATION

The standardization facilitated by online data platforms aids collaboration by ensuring that data can be seamlessly collated and analyzed. Such infrastructure allows researchers to take advantage of scientific opportunities as they arise. For example, a recent collaboration, the Global Anthropause Raptor Research Network (GARRN; Sumasgutner et al. 2021), leverages the capacity provided by GRIN to bring raptor researchers together to study the effects of the COVID-19 anthropause (Rutz et al. 2020). Examination of the possible long-term consequences of the COVID-19 anthropause can best be ensured when standardized research methods are applied and a robust data management tool is used to organize such global analyses. For instance, the raptor subproject of the International Biologging Initiative uses MoveBank to facilitate data storage, standardization, and sharing. These initiatives are excellent examples of modern technology being leveraged to facilitate collaboration and test specific hypotheses from monitoring data.

Although standardization lowers barriers to collaboration, it need not be a prerequisite. Many existing monitoring programs use various methods and should continue to use existing methodology for internal consistency. GRIN is developing analyses to combine such disparate datasets stored within its database to estimate the global ranges and population trends of raptor species. In this way, researchers collecting data using seemingly incompatible protocols will be able to collaborate to monitor the world's raptors.

Data sharing and collaboration improve the efficiency and scaling-up of monitoring programs. Given the many anthropogenic threats that raptors face (McClure et al. 2018), and the scarcity of funding for monitoring, raptor researchers must work together to ensure raptors thrive into the future. The two reasons for not sharing data that are most frequently expressed to us are (1) a concern that raptors may experience an increase in poaching or persecution and (2) a concern from the scientists of having their work "scooped"—i.e., someone else publishing results from their data (C. J. W. McClure, unpubl. data). Although such concerns are legitimate, most modern collaborative programs including GRIN, GARRN, and the International Biologging Initiative have implemented measures to prevent sensitive data from being used by nefarious actors and also to guarantee authorship for data contributors. Hypothesis-driven research also ensures that the intentions of such research programs are transparent and outlined before data contributions are made. This way, data owners can minimize any overlap between intended research questions and those addressed by larger initiatives. Before sharing data, researchers should ensure that any data curation entity has explicit and legally vetted policies regarding protection of sensitive data and authorship. If such protections are in place, the benefits of data sharing far outweigh the risks, and will ultimately benefit raptor conservation efforts (e.g., Phipps et al. 2019, Buechley et al. 2021, Gauld et al. 2022).

Importantly, GRIN is committed to facilitating collaboration between raptor researchers. Results from this survey of monitoring by raptor researchers will be made available on the GRIN website to aid researchers in finding potential collaborators. The survey will also remain available on the GRIN website so that new raptor researchers can join the database.

CONCLUSIONS

As a leading professional society for raptor researchers and raptor conservationists, the RRF is dedicated to the accumulation and dissemination of scientific information about raptors, and to resolving raptor conservation concerns. We recommend that monitoring be prioritized for understudied raptor species, especially in the Global South. All species, however, should be monitored via programs that test *a priori* hypotheses regarding potential drivers of population trends, follow standardized protocols, and share data with entities that ensure the protection of sensitive information. We realize that calling for all raptor species to be effectively monitored might seem unrealistic given that scarce resources often result in conservation triage (Bottrill et al. 2008, 2009). However, even with finite resources, raptors can be better monitored with efficiencies gained through technology and collaboration. This enhanced and efficient monitoring is needed to ensure that extant species of raptors survive for the foreseeable future.

SUPPLEMENTAL MATERIAL (available online). Survey results excel file.

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