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Short Note

Summarising biometrics from the SAFRING database for southern African birds

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Biometrics form a key characteristic of a species. Here, we provide a summary of biometrics held by the South African Bird Ringing Scheme (SAFRING), which was initiated in 1948, including measures of mass and lengths of the tarsus, head, culmen, tail and wing. We include all species in southern Africa for which there was sufficient data. Accordingly, we present biometric data for 674 of the 904 southern African bird species. We also investigated whether there were sex-specific differences for each species, and provide summaries for species where values significantly differed between the sexes. We found 376 species with significant sex-specific differences for at least one measure (e.g. mass). Although SAFRING holds data entries for many ringed individuals, a sizeable proportion of the entries was not useable as biometric data. Therefore, in this article, we aim to: 1) present a complete, standardised reference of summarised biometric data for the birds of southern Africa; 2) provide ringers with benchmark values that could guide data-capturing; 3) identify data-deficient species; and 4) highlight the importance of collecting and capturing biometric data carefully and consistently.

Synthèse de la biométrie à partir de la base de données SAFRING pour les oiseaux d'Afrique austral

La biométrie constitue une caractéristique essentielle d'une espèce. Nous fournissons ici un résumé des données biométriques détenues par le programme de baguage des oiseaux d'Afrique du Sud (SAFRING), lancé en 1948, comprenant des mesures de la masse et de la longueur du tarse, de la tête, du ulmen, de la queue et des ailes. Nous incluons toutes les espèces d'Afrique australe pour lesquelles il y avait suffisamment de données. En conséquence, nous présentons des données biométriques sur 674 des 904 espèces d'oiseaux d'Afrique australe. Nous avons également recherché s'il existait des différences spécifiques au sexe pour chaque espèce et fourni des résumés pour les espèces pour lesquelles les valeurs différaient de manière significative entre les sexes. Nous avons trouvé 376 espèces présentant des différences significatives selon le sexe pour au moins une mesure (par exemple, la masse). Bien que SAFRING contienne des entrées de données pour de nombreux individus bagués, une proportion non négligeable d'entrées n'était pas utilisable comme données biométriques. Par conséquent, dans cet article, nous visons à: 1) présenter une référence complète et normalisée de données biométriques résumées pour les oiseaux d'Afrique australe; 2) fournir aux utilisateurs des valeurs de référence pouvant guider la saisie des données; 3) identifier les espèces pour lesquelles les données sont insuffisantes; et 4) souligner l'importance de la collecte et de la saisie des données biométriques avec précaution et cohérence.

Keywords: avian morphometrics, Afrotropical, bird banding, bird ringing, citizen science, data collection, ecomorphology, functional traits

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Measurements of morphological features (biometrics) form a key characteristic of a species and are important for the correct identification, aging and sexing of many bird species. These characters can also serve to examine changes in populations, measure adaptive potential, and infer or predict life-history traits, using, for example, wing length and migration (e.g. Lo Valvo et al 1988; Marchetti et al. 1995; Milá et al. 2008), or beak morphology and diet (Grant and Grant 1996). Variations in biometrics are driven by multiple factors, such as fluctuating predation pressure (Gosler et al. 1995), urbanisation (Liker et al. 2008), climate change (Gardner et al. 2006; Yom-Tov et al. 2006; Teplitsky et al. 2008) and migration strategy (Tellería and Carbonell 1999).

Bird ringing/banding is a useful and cost-effective method with which to study bird biology. Used globally it has led to better understanding of the movements, population demography and life-history traits of many bird species. The South African Bird Ringing Unit (SAFRING) was started in 1948 (Ashton 1950), and, although smaller than similar schemes in Europe or America, it has managed to draw a consistent number of participants over the years. Currently, approximately 200 participants

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(mostly citizen scientists) contribute ringing data annually. SAFRING bird ringers fund their own activities. To date, more than 2.6 million bird-ringing records have been captured in the SAFRING database. Ringers are encouraged to collect and submit biometric measurements, although registering particular data is not required, and training in the data collection is not standardised.

There is currently no complete, standardised reference of biometric data for the birds of southern Africa. While numerous publications have presented biometric data on some southern African species, most report data on single species and often in only a portion of the species' range. Examples are: Green-winged Pytilia *Pytilia melba* (Symes and Wilson 2008), White-browed Sparrow-Weaver *Plocepasser mahali* (Leitner et al. 2009), Sociable Weaver *Philetairus socius* (Oschadleus 2004), Pale-winged Starling *Onychognathus nabouroup* (Henry et al. 2015), and Crowned Eagle *Stephanoaetus coronatus* (McPherson et al. 2017). Although Hockey et al. (2005) summarises known biometric data for many southern African birds, such data are frequently sourced from small and localised studies, and often the source is unknown, or the data are based on measurements obtained from museum study skins.

A complete summary of updated avian biometrics for a region is important for numerous reasons. Practically, biometrics are useful to ringers in confirming identifications of some species (Oschadleus 2013) and assist with sexing birds that show sexual size dimorphism as well as the aging of individuals in some species (Svensson 1992; Pyle and Howell 1997). Second, data summaries help us to recognise which species are poorly described or data deficient despite being common or endemic. Third, baseline summaries are a vital resource for researchers who frequently need this data to study a wide variety of questions. An analysis of avian functional diversity patterns, for example, frequently relies on biometrics (Coetzee and Chown 2016); these functional traits are often important when making predictions about changes in species assemblages in response to climate change (Pigot et al. 2016), agriculture (Sekercioglu 2012) or urbanisation (Pauw and Louw 2012), and about changes in ecosystem processes and services (Cadotte et al. 2011).

In this summary we review our present knowledge of the biometric measurements most commonly recorded while ringing birds, namely: mass, wing length, head length, culmen length, tail length and tarsus length. Where possible, we also provide sex-specific measurements and tested these for differences between sexes. We attempt to validate the data to ultimately present a summarised version of acceptable mean values, with upper and lower bounds, which could be used as guides.

We extracted biometric data on ringed birds, housed with SAFRING and managed by the University of Cape Town, South Africa. These data have been seldom utilised as they are rarely linked to research projects, and historically there have been few ways to check data. Thus, we applied a range of data-cleaning and data-selection criteria to obtain our final dataset of measurements. We requested permission from bird ringers to use the data; only two ringers wished to have their data excluded. All analyses were done in R Core Team (2013) using packages 'RCurl' (Lang et al. 2018) and 'rjson' (Couture-Beil 2018) for data extraction. Packages 'dplyr' (Wickham et al. 2018) and 'broom' (Robinson 2018) were used for data manipulation.

Prior to data validation, the total number of ringed and retrapped birds for each species were noted. We only included the initial ringing records and retrap records because these records tend to be more reliable than recovery records (records of dead birds), which often lack details. Retrap records make up a small percentage of available data; thus, including the retrap records are unlikely to have significantly influenced the results. For instance, when we examined the effect of including retrapped birds we found no difference in metrics for the Acacia Pied Barbet *Tricholaema leucomelas*, Jackal Buzzard *Buteo rufofuscus* and Cape Sugarbird *Promerops cafer*, but found a higher probability of metrics being recorded on at least one occasion. For the data validation, we first selected only adult birds (SAFRING age code '4'). Next, we removed any data that were entered as the value 0 (e.g. mass = 0). If there were more than 10 records remaining after these selection criteria, we initiated further data-quality checks.

The location of each record (latitude, longitude) was checked against the potential range of the species, according to the Southern African Bird Atlas Project (SABAP) (Harrison et al. 1997; see http://sabap2.adu.org.za). This restricted the data mostly to individuals ringed in South Africa, Lesotho, Swaziland, Namibia, Mozambique, Botswana and Zimbabwe, with additional records from Nigeria (West Africa). If a record was reported for outside the species range, then this record was rejected. This step was useful for removing erroneous records (for example, incorrectly identified species) and for range-restricted species, but was less useful for identifying errors for widespread species. The next step involved removing individuals outside the 99% quantile of each biometric measure calculated by species, which through prior inspection were more likely to represent errors in the database rather than extreme measurements for a species. Inspection of these values (discussed below) indicated that this range is rather liberal: that is, it likely includes more errors than excludes extreme measurements. However, this threshold was used to maximise sample size, which was important for species with little data. Where the 99% quantile was too liberal, as identified for species with SD > mean, then a 95% CI was applied. We also cross-validated the SAFRING summary metrics against those presented in Hockey et al. (2005), and corrected errors or re-ran summary metrics based on the 95% CIs if differences were likely due to database errors. For each species with >10 ringing records we present the mean, standard deviation, 95% CI, and sample size for these measurements.

For each species, separate summary biometrics were reported for males and females. We tested for significant differences between the sexes by determining the number of contributing ringers and then either performed a linear mixed-effects model (with Ringer as the random effect if there were more than two ringers), or else a simple linear regression. Species were only included if there were more than 10 records for each sex of that species. The linear mixed-effects model was implemented using package 'lmerTest' (Kuznetsova et al. 2017).

Following data validation, we were able to present summary biometrics for 674 species of the 904 southern African bird species listed in the SAFRING database; the results are included as Supplementary Table S1. For most of the species, large amounts of data were not usable. Across the 674 species, the percentage of usable data varied from 0.04% to 89%, with an average of 49.5% useable records (Supplementary Table S1).

Our results also identified species for which insufficient biometric data exist. Of the 230 southern African species without summary biometric data presented, we identified 70 species (Supplementary Table S2) for which this lack of data is surprising. Several of these species are either relatively common or endemic, and consequently could be good candidates for targeted efforts in the future.

Sex-specific results were obtained for 376 southern African species; the results are presented in Supplementary Table S3. For 250 species, values of wing length differed significantly between male and female individuals, whereas 175 species had significantly different values for mass.

Overall, we were able to summarise biometric data for almost 75% of southern African bird species. This provides the first reviewed database for biometrics for the region and identifies species that are data deficient. Of those species with data, we found that 56% showed statistically significant sexual dimorphism, although the biological relevance of these differences should be evaluated at a species-specific level as we did not attempt to cross-validate sex codes.

Within the 674 species, there was much variation in the amount of useable data after the data-validation steps. On average, less than half of the available data were usable. For many species the number of individuals for which biometric data had been recorded were very low (in some cases, only a single individual). Furthermore, not all 674 species had all six biometrics represented. Regrettably, there were high proportions of obvious measurement errors in the database. The sources of error varied; many records had to be discarded because they fell outside the bounds in the data confidence intervals (Supplementary Table S1). However, erroneous values often appeared to be a case of mixing data types (e.g. entering wing length as mass), while in other cases this was due to not using standard SAFRING units (e.g. using g for weight rather than kg, or mm for other measures).

It is important that ringers record biometric measurements of ringed birds if this does not compromise the bird's health. A ringed bird with no associated biometrics has limited scientific use given low recapture rates (e.g. Oschadleus 2016; Rose and Oschadleus 2017). Historically, ringing activities were driven by the need to understand bird movements (Bonnevie et al. 2003), but this situation is gradually changing as that information can be more usefully obtained using telemetry and spatial-logging techniques. Certainly, current ringing activities can be useful for determining survival (Collingham et al. 2014), identifying moult and inferring breeding patterns (Symes and Wilson 2008), for long-term individual-level population monitoring (e.g. Covas et al. 2004; Pietersen et al. 2010; Ridley 2016; Sumasgutner et al. 2016; Bolopo et al. 2019), and for estimating relative abundance (Lee et al. 2015).

Useable data are correctly captured data. Currently, although trainee ringers need to register for a licence at SAFRING, the training process is not centralised, and the official SAFRING ringing manual (de Beer et al. 2001) is outdated. Trainee ringers typically learn techniques from one or two mentors. Observer bias during data collection is unavoidable, yet ringers need to be actively aware of the various stages at which systematic errors can be introduced and how to minimise these (see Morgan 2004 for a detailed review). Care should be taken during the actual measurements to ensure that the technique is correct and that rounding-off errors are minimised. Measurements should be attributed to the correct species and special care needs to be taken where a scribe is recording the data for one or more ringers, rather than directly by the ringer(s). However, perhaps most importantly, the transcribing of data should be double-checked (e.g. ensuing entries are recorded in the correct column). Greater use should be made during data entry of the values otherwise provided to ensure that entries more-or-less conform to a species' measurements. As equipment can also introduce errors, these need to be regularly checked (Morgan 2004).

Notably, the types of biometric ringing data entered in the SAFRING database have changed over time. It was only possible to submit measurements of mass to SAFRING before 1998. As a result, records of mass are available for most of the 70 years of bird-ringing effort in southern Africa, though other biometrics were mostly collected during the last two decades (other than a few from before 1998 that were added retrospectively). Between 1998 and 2000, wing length and moult condition were added (Oschadleus 2000), followed a few years later by the remaining biometric parameters. However, to the present date and despite the duration of the scheme, not all ringers take or report biometric measurements.

The results presented here are generally robust but should be carefully interpreted at the species level. For instance, sex differences for Sociable Weavers *Philetairus socius* (see Supplementary Table S3) are not biologically meaningful. This sexually monomorphic species (Spottiswoode 2005) has been intensively studied, with many individuals being sexed by DNA from blood samples (Doutrelant et al. 2004). Mass and wing length are listed as differing significantly between sexes (Supplementary Table S3); even so, biometrics cannot be used to accurately sex this species (an example is through comparison of their mean mass: males = 27.3 g, SD = 1.6, n = 1 083 vs females = 27.5 g, SD = 1.7, n = 1 043). Statistical significance could simply be an artefact of high sample numbers without being biologically significant (see Underhill [1999] for a discussion on statistics in ornithology).

Other complications for some species arise when ringers sex individual birds based on the morphometrics, which may drive some of the highly significant sex differences in the database. For instance, the Cape Sugarbird is often sexed based on tail length (pers. obs.); individuals with long tails are coded male, and those with short tails are coded female. However, individuals with intermediate tail lengths have a higher probability of being coded as unsexed, thereby causing large differences when these measures are removed for the sex-differences test. These differences should therefore be interpreted with care when the sexing methods are suspected of being based on biometrics.

Geographical size variation occurs in some southern African species, for example the Southern Masked Weaver *Ploceus velatus* (Oschadleus 2005) and the Southern Red Bishop *Euplectes orix* (Craig 2005), and therefore could influence the biometric results for these species. However, most ringing effort is concentrated in the southern region of these species' ranges (SAFRING, unpublished data), representing the region where the larger variants occur. Therefore, the biometric data could be biased towards larger individuals, and this needs to be taken into account when interpretations are made. Furthermore, for some species, time of day may influence mass, so values of this measure this should be taken into account as necessary.

We strongly encourage SAFRING ringers to carefully and accurately collect biometric data on the birds caught for ringing/banding. We hope that this initial summary will be useful to bird ringers in their ringing activities, and perhaps prompt greater effort, which will ultimately benefit the integrity and usefulness of the SAFRING database.

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