Evidence of large-scale range shift in the distribution of a Palaearctic migrant in Africa

Caroline Howes | Craig T. Symes | Patrik Byholm

School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Wits, South Africa
Novia University of Applied Sciences, Ekenäs, Finland

Correspondence
Caroline Howes, School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Wits, South Africa.
Email: caroline.grace.howes@gmail.com

Funding information
National Research Foundation

Editor: Tomas Vaclavik

Abstract

Aim: Long-distance Palaearctic migrant birds are declining at a faster rate than short-distance migrant or resident species. This is often attributed to changes on their non-breeding grounds and along their migratory routes. The European honey buzzard (Pernis apivorus) is a scarce migrant in southern Africa that is declining globally. This study assessed the distribution and abundance of honey buzzards in southern Africa over the past four decades and compared it to trends in the East African population to examine possible drivers of population expansion in southern Africa.

Location: Southern and East Africa.

Methods: European honey buzzard reporting data were collected from a variety of sources including citizen science databases (1983–2017). In addition, records of all other southern African vagrants (including ten other regularly occurring species) were gathered to account for changes in birdwatching effort in the subregion. To assess the effect of forest loss on honey buzzard abundance, rolling correlations were performed using forest cover in East Africa and number of honey buzzard records in both subregions.

Results: European honey buzzard records in southern Africa have increased over five times more than other regularly occurring vagrant species and almost 40 times more than honey buzzard in Tanzania, where the population has remained stable. Loss of forested area in East Africa was correlated with an increase in European honey buzzard records in southern Africa.

Main conclusions: We suggest that the European honey buzzard shift in wintering range may be driven by a decline in suitable habitat further north in Africa amongst other possible reasons. This effect may have been amplified by an increase in appropriate habitat across southern Africa brought about by anthropogenic changes to vegetation such as increased tree cover in urban areas. This study further highlights the importance of using African distributional data banks to understand the effects of global change on Palaearctic migrant bird species.

Keywords
birdwatching, citizen science, European honey buzzard, forest loss, Pernis apivorus, population shift, range change, range expansion, southern Africa
1 | INTRODUCTION

It is important that migratory birds select non-breeding sites beneficial to both their breeding success and survival (Gunnarsson, Gill, Newton, Potts, & Sutherland, 2005; Norris, Marra, Kyser, Sherry, & Ratcliffe, 2003; Saino et al., 2004). Given this, the low migratory connectivity (birds breeding in close proximity in Europe migrating to vastly different locations in Africa) of many Palearctic migrant bird species indicates that multiple factors affect where birds migrate post-fledging (Finch, Butler, Franco, & Cresswell, 2017; Liechti, 2006; Thorup, Alerstam, Hake, & Kjellén, 2003).

Previous research has shown that wind patterns en route and habitat quality affect where migrating birds establish non-breeding territories (Gunnarsson et al., 2005; Norris et al., 2003; Richardson, 1990; Saino et al., 2003; Thorup et al., 2003; Vansteelandt, Kekkonen, & Byholm, 2017). Adult birds are more able to account and correct for the effects of wind but inexperienced juveniles, who are likely not navigating to a specific location, are not as able to rectify their direction (Thorup et al., 2003). The direction and strength of the wind are likely to have a large effect on where young birds initially arrive in Sub-Saharan Africa (Vansteelandt et al., 2017). However, it is not clear how this may affect where they eventually settle.

Habitat quality in the non-breeding season has also been shown to have strong effect on both survival and breeding success in Neotropical and Palearctic migrants (Gunnarsson et al., 2005; Norris et al., 2003; Saino et al., 2004). For example, more productive non-breeding territories have been shown to correlate with earlier arrival and better breeding territories in American Redstart (Setophaga ruticilla; Norris et al., 2003). The same is true for Icelandic Black-tailed Godwit (Limosa limosa); individuals that spent the non-breeding season in more productive coastal habitats had higher quality breeding sites and improved breeding success than those that selected less productive inland non-breeding locations (Gunnarsson et al., 2005). Once a productive site is located, many adult migratory birds, particularly long-lived species such as raptors and waterbirds, return to the same non-breeding site year after year (Cresswell, 2014). It is believed that returning to known suitable sites benefits long-term survival by reducing mortality risk during the non-breeding season (Cresswell, 2014).

These sites are likely to be located during juvenile exploratory movements earlier in life, which allow the bird to find more suitable locations (Cresswell, 2014).

Long-distance Palearctic migrant bird species are declining at a faster rate than both short-distance migrant and resident species (Sanderson, Donald, Pain, Burfield, & van Bommel, 2006; Thaxter, Joys, Gregory, Baillie, & Noble, 2010; Vickery et al., 2014). This is believed to be due to change in climate and habitat degradation on both the breeding and wintering grounds as well as mortality during migration. A study of British migrant birds reflected this trend, with Afro-tropical migrants declining more rapidly than species spending their winters in the United Kingdom or other parts of Europe (e.g., residents and short-distance migrants; Thaxter et al., 2010). From 1986 to 2006, species that spent the non-breeding season in the humid West African forest and savanna declined at a greater rate than those in the more arid northern zone of Africa (Thaxter et al., 2010). This may be due to large-scale habitat loss and fragmentation from forest clearing and intensification of agriculture in this region (Thaxter et al., 2010).

The European honey buzzard (Pernis apivorus Linnaeus 1758) is a Palearctic raptor that migrates annually from its breeding grounds in Europe to its non-breeding grounds in Africa (Cramp & Simmons, 1979). This dietary specialist breeds in dense forest where it feeds mostly on wasps and bees (Hymenoptera) with frogs (Anura) as an important alternate prey (Gamauf, 1999; Itämies & Mikkola, 1972). Following breeding (or fledging in the case of juvenile birds), honey buzzards migrate south en masse (Cramp & Simmons, 1979). It is thought that the vast majority of birds spend the Northern Hemisphere winter in the tropical rainforests of west and central Africa with a small proportion migrating to East and southern Africa (Agostini et al., 2007; Bruderer, Blitzbau, & Peter, 1994; Hake, Kjellén, & Alerstam, 2003).

While the European honey buzzard is listed as a species of Least Concern by the IUCN, it has declined across Western Europe and Scandinavia over the past 30 years (Bensusan, Garcia, & Cortes, 2007; IUCN, 2019; Kostrzewa, 1987; Löhmus, 2005). This may be due to habitat transformation and loss on both the breeding grounds in Europe as well as the non-breeding grounds in Africa (Bensusan et al., 2007; Kostrzewa, 1987; Löhmus, 2005). Persecution during migration also plays a role in the decline (Brochet et al., 2016). Migration counts at Gibraltar in Spain and Batumi in Georgia show stable or declining numbers of honey buzzards passing annually (Batumi Raptor Count, 2017; Bensusan et al., 2007).

The European honey buzzard is generally considered a scarce migrant to southern Africa (Cramp & Simmons, 1979; Hockey & Ryan, 2005). Over the past three decades, the number of reported records of this species has appeared to increase. This study aimed to examine the drivers of the apparent increase in the European honey buzzard population in southern Africa using citizen science data. We assessed two hypotheses: (a) the growth in records was due to an intensification of birdwatching and citizen science in the southern African subregion and (b) the changes further north in the honey buzzards range (e.g., habitat loss) have driven the range shift in the European honey buzzard and have consequently caused an expansion in the southern African population.

2 | METHODS

2.1 | Southern African rarity record collection

European honey buzzard records in southern and East Africa were collected from a variety of sources. East African records were selected for comparison based on tracking data which indicate that most southern African honey buzzards migrate from the eastern portion of their breeding range and travel through East Africa on their way to and from southern Africa (C. Howes, P. Byholm, & C. T. Symes, unpublished data).
To begin, eight museums were surveyed to determine if they had European honey buzzard specimens from southern and East Africa. These museums were as follows: (a) American Museum of Natural History (New York, NY, USA), (b) Ditsong Museums of South Africa (Pretoria, South Africa), (c) Field Museum (Chicago, IL, USA), (d) Iziko Museums (Cape Town, South Africa), (e) Museum für Naturkunde (Berlin, Germany), (f) Royal Museum for Central Africa (Tervuren, Belgium), (g) Smithsonian National Museum of Natural History (Washington D.C., USA) and (h) Natural History Museum at Tring (Tring, UK). Only records with spatial and temporal information were included.

Southern African honey buzzard records were collected from the three following sources. The Southern African Rare Bird Newsletter (SARBN), which covered from July 2008 to July 2017, contributed the greatest number of southern African records. This is a bi-weekly email list serve which informs birdwatchers about rare bird species in the southern African subregion. A total of 2,320 emails were examined in the SARBN Google Group. The second source was the National Rarity Committee (NRC), which assesses and records rarities in southern Africa. It provided records from January 1982 to December 2002. Records were also sourced from the Zest for Birds website which covered January 2002 to December 2010. This site documents photos and information on rare species in southern Africa and spans the time gap between NRC and SARBN coverage.

In addition to European honey buzzard records, southern African rarity records for all subregion rarities were also collected from SARBN, the NRC and the Zest for Birds website. Pelagic rarities were excluded. The total number of rarity records provided a measure of observer effort over the study period. The ten most regularly occurring migrant rarities were assessed to examine whether records of all vagrant species were increasing due to increased observer skill and effort in the subregion. Each of the ten occurred at a rate of above one record per season. They included one migrant raptor species, Western Marsh-harrier (Circus aeruginosus) and nine migrant shorebird species, that is American Golden Plover (Pluvialis dominica), Pacific Golden Plover (Pluvialis fulva), Black-tailed Godwit (Limosa limosa), Red-necked Phalarope (Phalaropus lobatus), Red Phalarope (Phalaropus fulicarius), Common Redshank (Tringa totanus), Green Sandpiper (T. ochropus), Eurasian Oystercatcher (Haematopus ostralegus) and Pectoral Sandpiper (Calidris melanotos).

2.2 | Southern African Bird Atlas data collection

The Southern African Bird Atlas Project (SABAP) is a collection of bird distribution data collected by citizen scientists (SABAP 2, 2018). It is divided into two parts, SABAP 1 and SABAP 2, which use different protocols and spatial scales. SABAP 1 occurred from 1987–1991 while SABAP 2 is ongoing since 2007. SABAP 1 was collected by quarter degree grid cell (QDGC), and SABAP 2 is collected by pentad (Bonnevie, 2011). A pentad is one ninth of a QDGC and is a 15 min grid (~9 km by 9 km). SABAP 1 had sampling periods of two to seven days in a QDGC during which all bird species heard or seen were recorded (Bonnevie, 2011). All SABAP 1 data were used.

SABAP 2 has three classes of data of which we used only full protocol data. A full protocol atlas card for SABAP 2 is a minimum of two hours and a maximum of five days in a given pentad. Every bird species seen or heard during this period is recorded. Cards are then submitted, and the reporting rate of each species is calculated using the total number of species records divided by the total number of full protocol cards for each pentad. The data for European honey buzzard were downloaded by species as SABAP 1 versus SABAP 2 reporting rates at a QDGC level in August 2017.

In addition, SABAP 1 versus SABAP 2 data for Forest Buzzard (Buteo trizonatus) were also downloaded for the same period. This species appears to have similar habitat requirements to European honey buzzard as well as presenting a challenging identification to many birdwatchers. Therefore, it is the ideal species to compare with European honey buzzard in terms of range expansion in order to provide a quality check of the atlas data.

2.3 | Tanzanian Bird Atlas data collection

For East Africa, European honey buzzard records from the Tanzania Bird Atlas were obtained on 15 October 2017 (TBA, 2017). Tanzania Bird Atlas data were selected due to their long time series and generally good spatial cover. Only records from 1983 to 2017 were included in analyses, corresponding to the time-scale of the southern African dataset.

2.4 | European honey buzzard record analysis

For all records of European honey buzzard from southern Africa and East Africa, the date and location were recorded and catalogued. Repeat records, based on date and location, were removed from analysis. The records were then plotted spatially in ArcGIS 10.3. A QDGC grid was plotted over the records, and the records were extracted to the grid to understand the distribution of honey buzzards spatially and temporally. The data were grouped seasonally from July to June to include the full non-breeding season of the European honey buzzard. Total records per season were compared for each subregion over time.

To examine the effect of observer effort on the number of southern African records, the total number of European honey buzzard records per season was divided by the total number of rarity records per season. This was then plotted to assess whether observer effort accounted changes in the number of records over time.

2.5 | Southern African rarity record analysis

Records of the other ten southern African vagrant species examined were similarly plotted over seasons (July–June), a period covering an entire Austral summer period. In addition, the annual number of records for each species as well as European honey buzzard was compared before and after SARBN using a Wilcoxon rank sum test to determine the effect of increased birdwatching effort and communication on reporting rate.
In order to assess whether trends in European honey buzzard numbers differed significantly from other vagrant species, a generalized linear mixed model for number of annual vagrant records was created. Species was the random variable. The fixed variables were year, perapi, a binomial variable indicating whether or not the species was European honey buzzard, and an interaction term between year and perapi. The model was created using the “glmer” function (with a Poisson distribution) from the package “lme4” in R. The function “confint” was used to determine 95% confidence intervals for all fixed variables. Confidence intervals that did not overlap with zero were taken to be significant.

2.6 Southern African Bird Atlas data analysis

For both European honey buzzard and Forest Buzzard in South Africa, the number of QDGCs in each reporting rate change category (SABAP 1 only, decrease in SABAP 2, increase in SABAP 2, and SABAP 2 only) was compared using a χ² test to determine whether the two species showed similar changes in range and reporting rate between the two periods. Only South Africa was assessed as Forest Buzzard does not occur in the other southern African countries.

2.7 Global forest change data collection and analysis

Global Forest Change 2000–2016 data layers were downloaded for East Africa (Burundi, Kenya, Rwanda, Tanzania and Uganda), where there is a large amount of suitable habitat for the European honey buzzard (Hansen et al., 2013). The two datasets included in our analyses were the forest cover for the year 2000 and the year of gross forest loss. Pixels (30 m by 30 m) were defined as forest if there was over 30% cover, as was defined in the forest loss layer (Hansen et al., 2013). The total area of forest for the subregion was calculated, and the amount of forest loss annually was subtracted from previous year’s total forest area.

Rolling correlations were created for the relationship between the annual number of honey buzzard records in southern Africa in relation to the annual number of honey buzzard records in Tanzania to assess the relationship between the two populations over time. Rolling correlations were also calculated for: (a) the relationship between the annual number of Tanzanian honey buzzard records with the total forested area in East Africa and (b) the annual number of southern African honey buzzard records with the total forested area.

FIGURE 1 The number of European honey buzzard (Pernis apivorus) records from birdwatching sources (South African Rare Bird Newsletter, Zest for Birds, National Rarity Committee and Tanzania Bird Atlas) in (a) southern Africa and (b) Tanzania between December 1983 and May 2017. Note the different y-axis scales
in East Africa. Lastly, rolling correlations for the association of the total forested area in East Africa with the proportion of southern African rarity records that were European honey buzzards were computed in order to assess how observer effort affected the relationship. A rolling correlation is a time series analysis which uses a moving window (in this case time) to assess the correlation of two variables during that window. This was used to determine how the relationships between the two populations as well as the two populations and habitat availability may have changed over time. The rolling correlations were calculated, using the R package "roll," for seven different intervals ranging from three years (the minimum number of points for a correlation) to nine years. Different intervals were used because a species response to altered habitat, particularly that of a habitat specialists, is not usually immediate (Uezu & Metzger, 2016). For all time intervals, a minimum of three points was required to include a correlation value. The $R^2$ values for each window were plotted for the last year of that window.

3 | RESULTS

Nine southern African European honey buzzard specimens were found in three of the eight museums (see Supporting Information Table S1). These specimens were collected as early as 1894. Six specimens were from South Africa and three were from Zimbabwe. Eight specimens from three museums were from East Africa. The first specimen was collected between 1895 and 1897. Six specimens were from Kenya and three were from Tanzania.

A total of 1,136 records of European honey buzzard in southern Africa were obtained from three different sources from December 1983 to May 2017. The majority of records (91% or 1,030 records) were collected from SARBN, followed by 7% (78 records) from the Zest for Birds website and 2% (28 records) from NRC documents. Over the same period, the Tanzania Bird Atlas collected 306 records for Tanzania.

There has been a notable increase in the number of European honey buzzard records in southern Africa with sharp increases in the 2005–2006 (67% increase from the previous season), 2010–2011 (78% increase), 2013–2014 (165% increase) and 2016–2017 (56% increase) seasons (Figure 1a). The greatest number of honey buzzard records in Tanzania was in the 2001–2002 season (Figure 1b). There were not sharp increases in the Tanzanian records over the study period.

The number of QDGCs with a European honey buzzard record has also increased in southern Africa over the past 30 years (Figure 2; Supporting Information Figure S1). The number of QDGCs with honey buzzard records increased in Tanzania until the 2000s before it declined in the 2010s. In the 1980s and 1990s, honey buzzards occurred in 0.1% ($n = 6$) and 0.3% ($n = 16$) of southern African QDGCs, respectively. In these same periods, European honey buzzard was reported in 1.0% ($n = 14$) and 3.0% ($n = 41$) of Tanzanian QDGCs. In the 2000s in southern Africa, this increased to 0.9% ($n = 45$) of QDGCs followed by an increase to 5.8% ($n = 291$) QDGCs in the 2010s. In Tanzania, the number of QDGCs with honey buzzards peaked with 5.3% ($n = 72$) in the 2000s and then dropped to 2.8% ($n = 38$) in the 2010s.

A total of 2,517 subregion rarity records of 87 species were assessed (Supporting Information Table S2). The three most common species were European honey buzzard ($n = 1,094$), Green Sandpiper ($n = 179$) and Pectoral Sandpiper ($n = 96$). The annual number of records has consistently increased over time with the greatest number of records documented in the 2016–2017 season ($n = 433$; Figure 3a). The proportion of European honey buzzard records has also increased over time with a similar pattern to the total number of honey buzzard records (Figure 3b).

3.1 | Comparison of European honey buzzard and other rare bird species in southern Africa

Of the rare species examined, all 11 showed a significant increase in southern Africa between the annual number of records before and after the introduction of SARBN (Table 1). There was no significant difference in the Tanzanian honey buzzard records. European honey buzzard in southern Africa showed the greatest increase of the species examined followed by Green Sandpiper and Red Phalarope. Western Marsh-harrier (the species that is most phylogenetically similar to European honey buzzard, and with the most similar life history and distribution) showed only a modest increase in comparison to honey buzzard.

Two of the three fixed variables in the rarity record generalized linear mixed effects model had confidence intervals that did not overlap with zero, that is year and the interaction term between year and the binary variable (perapi) that indicates if the species is European honey buzzard (Table 2). Both Western Marsh-harrier and Green Sandpiper showed a longer and less drastic increase over time than European honey buzzard over the same period as is indicated by the interaction term (Figure 4).

3.2 | Comparison of European honey buzzard and Forest Buzzard SABAP data

The European honey buzzard had a significantly greater proportion of pentads with an increase between SABAP 1 and SABAP 2 than the Forest Buzzard ($\chi^2(3) = 155.16, p < 0.01$). The majority (80%) of QDGCs with European honey buzzard were new in SABAP 2 while Forest Buzzard had smaller percentage (25%) of new QDGCs (Supporting Information Figure S2).

3.3 | Correlations of European honey buzzard records in southern Africa and Tanzania

The five-year interval rolling correlation between southern African and Tanzanian records showed the strongest negative correlation during the 1980s and the strongest positive correlation during the 2010s (Figure 5). The 1990s and 2000s showed very weak correlations. The trends were similar for rolling correlation
Over the 16 years assessed, there was an 11.6% (46,367.0 km²) loss of forest area in East Africa (Table 3). The majority of the forest loss (66.2%) was in Tanzania.

Southern African honey buzzard records showed a strong negative correlation with forest coverage in East Africa, starting in 2005 (Figure 6). Tanzanian honey buzzard records generally showed a strong positive correlation with East African forest cover except from 2009 to 2012. The trends for both regions were similar for intervals ranging from five to nine years (Supporting Information Figures S4, S5). The proportion of southern African rarity records that were European honey buzzards had a strong negative correlation with East African forest coverage, beginning in 2008 (Figure 7). The trend was similar for intervals ranging from five to nine years (Supporting Information Figure S6).

FIGURE 2 The number of European honey buzzard (Pernis apivorus) records from birdwatching sources (South African Rare Bird Newsletter, Zest for Birds and National Rarity Committee) in quarter degree grid cells (QDGCs) in South Africa during (a) 1983–1989 (5 QDGCs, 0.3%), (c) 1990–1999 (15 QDGCs, 0.8%), (e) 2000–2009 (40 QDGCs, 2.0%), and (g) 2010–2017 (229 QDGCs, 11.6%), and in Tanzania in (b) 1983–1989 (14 QDGCs, 1.0%), (d) 1990–1999 (41 QDGCs, 3.0%), (f) 2000–2009 (72 QDGCs, 5.4%) and (h) 2010–2017 (38 QDGCs, 2.8%).

4 | DISCUSSION

From the records collected for European honey buzzard from multiple sources, it is unquestionable that there has been an increase in both the abundance and distribution of the species in southern Africa over the 34 years for which data were analysed. This massive increase more likely reflects an actual increase in the number of birds migrating to the subregion, rather than an artefact of increased birdwatcher effort in the area. Over the period of largest expansion in southern African honey buzzards, there was a small decline in Tanzania.

4.1 | Increase in European honey buzzard

All species examined, including the European honey buzzard, have shown a sharp increase in southern Africa since the advent of SARBN. This includes two species that are listed as Near Threatened by the
IUCN due to population declines, the Eurasian Oystercatcher and Black-tailed Godwit. While all the species did increase, none of the species increased to the same extent as European honey buzzard. European honey buzzard showed a five times greater increase than the species with the next greatest increase, the Green Sandpiper. Interestingly, the Green Sandpiper is also one of only two species on the list that is regarded as increasing along with the Western Marsh-harrier which may similarly explain the sandpiper’s large increase (IUCN, 2019). In the case of the European honey buzzard, the enormous increase in a species that is declining in many parts of its range indicates that there are other factors contributing to the increase in records (Bijlsma, Vermeulen, Hemerik, & Klok, 2012; IUCN, 2019; Ottvall et al., 2009).

In addition to the greater increase in European honey buzzard records, the timing of the increase also differed from similar species. While most species (including Green Sandpiper and Western Marsh-harrier) showed increases immediately following the introduction of SARBN, European honey buzzard showed the greatest increase much later in the 2012–2013 season rather than in the 2008–2009 season (when SARBN began). This suggests that there may be different drivers for this increase in records, for example climatological or habitat changes, rather than increased observer effort. This is further supported by similar trends in the number of European honey buzzard records, regardless of standardization for observer effort.

There is also the argument that birdwatchers have simply become more adept at identifying European honey buzzards, and therefore the species reporting rate has increased. This seems unlikely considering that other difficult to identify vagrant species did not show a significant increase over the same period despite being equally challenging to identify. For example, Western Marsh-harrier is superficially very similar to African Marsh-harrier (Circus ranivorus), and Green Sandpiper is comparable to the regularly occurring Wood Sandpiper (Tringa glareola; Hockey & Ryan, 2005). These two species have shown a much smaller increase over the period examined as have other easier to identify species such as Eurasian Oystercatcher and Common Redshank.

Like elsewhere, for example the United States of America and United Kingdom, southern Africa has clearly shown an increase in the numbers of birdwatchers, although it is difficult to define the extent of this increase in the subregion (Connell, 2009; Rogerson, Simango, & Rogerson, 2013). The number of rarity records
submitted annually to SARBN as well as SABAP 2 effort has both increased annually since the 2008–2009 season (SABAP 2, 2018). In addition, SABAP 2 now covers a greater number of pentads than ever before due to an increase in participants (SABAP 2, 2018). The best records for the number of southern African birdwatchers come from the South African Ornithological Society (SAOS) which became BirdLife South Africa (BLSA) in 1996. In 1986, there were a total of 5,416 members to SAOS which is greater than the 4,129 members BLSA currently holds. The number of members of BLSA has remained fairly steady over the past decade (pers. comm. Mark Anderson, CEO, BirdLife South Africa). This may indicate that the number of birdwatchers has not increased significantly which may signify that more efficient communication and documentation of rare birds may have a greater effect on the increase in European honey buzzard than the overall change in the number of birdwatchers.

4.2 Explanations for the population increase

Based on the evidence detailed above, the European honey buzzard has truly increased in abundance and distribution in southern Africa and this is not merely a reflection of increased reporting rate. While other species have also increased, none have increased to the same extent and the number of honey buzzard records appears to have increased disproportionately to the overall birdwatching effort. This brings to the forefront the question of what has caused this seemingly sudden increase in a species that is declining, particularly in Western Europe (Bijlsma et al., 2012; IUCN, 2019; Ottvall et al., 2009).

One possible explanation for the increase in European honey buzzards is the large-scale change in habitat further north in Africa which could, in turn, result in driving birds further south where they seek suitable overwintering habitat. The correlations between forest cover and honey buzzard records support this hypothesis. As forest area has declined in East Africa, there has been a concurrent increase in the number of honey buzzards reported in southern Africa. This trend began in the mid-2000s and has remained the same since then which may indicate that a forest loss threshold for the honey buzzards was reached at this time. At the same time, there is a positive relationship between Tanzanian honey buzzard records and forest cover, with the exception of 2009 to 2012, an extreme drought period across much of East Africa (Awange, Khandu, Schumacher, Forootan, & Heck, 2016; Hassan, Mdemu, Shemdoe, & Stordal, 2014). This may indicate that European honey buzzards have been driven further south due to the loss of habitat in East Africa (Hansen et al., 2013). The extreme drought may have exacerbated the effect of forest loss and caused a reduction in honey buzzard prey availability (Awange et al., 2016; Hansen et al., 2014). This hypothesis is further supported by the slight decline in Tanzanian honey buzzard records over the same period as well as the small contraction of its range.

4.3 The influence of covariates

| Variable | Estimate | SE | 95% CI |
|----------|----------|----|--------|
| Intercept | 0.32 | 0.14 | 0.03 to 0.62 |
| as.factor(perapi) | 0.42 | 0.45 | -0.53 to 1.39 |
| scale(year) | 0.90 | 0.04 | 0.82 to 0.99 |
| as.factor(perapi):scale(year) | 2.01 | 0.10 | 1.82 to 2.21 |

Note. The model includes species as the random effect and all fixed variables are scaled. 95% CI: 95% confidence interval. Estimate: variable slope, and SE: standard error. See methods for definitions of model covariates.

### TABLE 1

| Species | Total records (1982–2017) | Avg. annual records (pre-SARBN) | Avg. annual records (post-SARBN) | Increase factor |
|---------|---------------------------|-------------------------------|-------------------------------|----------------|
| European honey buzzard (Southern Africa) | 1,133 | 2.31 ± 0.49 | 119.22 ± 31.29 | 51.66*** |
| Green Sandpiper (Tringa ochropus) | 202 | 1.73 ± 0.37 | 17.44 ± 1.97 | 10.08*** |
| Red Phalarope (Phalaropus fulicarius) | 78 | 0.77 ± 0.28 | 6.44 ± 0.88 | 8.38*** |
| Eurasian Oystercatcher (Haematopus ostralegus) | 66 | 0.84 ± 0.18 | 4.89 ± 0.67 | 5.78*** |
| Pectoral Sandpiper (Calidris melanotos) | 101 | 1.35 ± 0.27 | 7.33 ± 2.04 | 5.45*** |
| Western Marsh-harrier (Circus aeruginosus) | 77 | 1.23 ± 0.29 | 5.00 ± 0.53 | 4.06*** |
| American Golden Plover (Pluvialis dominica) | 50 | 0.85 ± 0.19 | 3.11 ± 0.61 | 3.68*** |
| Red-necked Phalarope (Phalaropus lobatus) | 43 | 0.77 ± 0.27 | 2.56 ± 0.38 | 3.32*** |
| Pacific Golden Plover (Pluvialis fulva) | 45 | 0.85 ± 0.28 | 2.56 ± 0.69 | 3.02** |
| Black-tailed Godwit (Limosa limosa) | 52 | 1.04 ± 0.26 | 2.78 ± 0.66 | 2.67* |
| Common Redshank (Tringa totanus) | 72 | 1.50 ± 0.26 | 3.67 ± 0.47 | 2.44*** |
| European honey buzzard (Tanzania) | 302 | 8.51 ± 1.19 | 11.22 ± 1.52 | 1.32 |

Note. Kruskal–Wallis test p-values of pre-SARBN average annual records versus post-SARBN annual records: * p < 0.05; ** p < 0.01; *** p < 0.001.
It is important to note that there are limitations to the large-scale correlative methods used in this study. This study highlights a broad pattern in the shifts of the European honey buzzard but further research examining the finer-scale relationships between the migratory bird populations of the two regions is needed, as well as more evidence on how honey buzzards select and establish their non-breeding home ranges. By understanding more about these factors, we can better model how both region's populations may be affected by habitat loss.

In addition to the above limitations, we have also not assessed the large-scale alteration of habitat and change in climate in southern Africa during this period (Buitenwerf, Bond, Stevens, & Trollope, 2011). Many of the areas that honey buzzards frequent in the subregion are urban areas that have experienced increased afforestation, for example the Cape Peninsula, Gauteng province and Windhoek, Namibia (Hockey & Midgley, 2009; Hockey, Sirami, Ridley, Midgley, & Babiker, 2011; Symes, Roller, Howes, Lockwood, & van Rensburg,
These forested habitats may be attracting or supporting a larger population of European honey buzzard than was possible in previous decades. Lastly, while non-breeding habitat may be driving the change in honey buzzard numbers in southern Africa, we have not evaluated how changes in the breeding population or breeding success of the species could also be contributing to the increased abundance of the species in the subregion. Four European honey buzzards tracked from South Africa to their breeding grounds have migrated to Finland (one individual) and Russia (three individuals; C. Howes, P. Byholm, & C. T. Symes, unpubl. data). Based on these data, it is likely that many of the southern African honey buzzards are migrating from the east of their breeding range, particularly Russia. The Russian population of European honey buzzards has not been well studied and so the population trend in this region is unclear. However, migration counts in Batumi, Georgia, a bottleneck for European honey buzzards migrating from the east of the species range, have not shown any measurable change (Batum Raptor Count, 2018). A better understanding of the trends in the Russian honey buzzard population could improve our understanding of the population increase on the southern African non-breeding grounds.

Migrating significantly further south may put European honey buzzards at greater risk regarding breeding success. A longer migration from southern Africa may lead to a later arrival on the breeding grounds. It has been demonstrated in many migratory species that late-arriving individuals are likely to have less productive breeding habitats and lower breeding success (Aebischer, Perrin, Krieg, Studer, & Meyer, 1996; Fulin, Jerzak, Sparks, & Tryjanowski, 2009; Smith & Moore, 2005). This could have long-term consequences for the species if the southern African population continues to grow.

Many migrant bird species have been shown to be changing their migration timing and patterns in response to global change (Both, 2010; Gill et al., 2014; Jones & Cresswell, 2009; Moussus, Clavel, Jiguet, & Julliard, 2010; Stanley, MacPherson, Fraser,
FIGURE 6  A 5-year rolling correlation between square kilometres of forest in East Africa from Global Forest Change and the number of European honey buzzard (*Pernis apivorus*) records in both southern African and Tanzania from birdwatching sources (South African Rare Bird Newsletter, Zest for Birds, National Rarity Committee and Tanzania Bird Atlas).

FIGURE 7  A five-year rolling correlation between square kilometres of forest in East Africa and the proportion of all rarity records from birdwatching sources (Southern African Rare Bird Newsletter, Zest for Birds and National Rarity Committee) in southern Africa that are European honey buzzard (*Pernis apivorus*) records.
McKinnon, & Stutchbury, 2012). It has been suggested that this is as a result of plasticity within individuals but plasticity within individual migrants has rarely been observed (Gill et al., 2014). It has been shown that new recruits to the population are more likely to arrive earlier, perhaps due to earlier hatching subsequently facilitating earlier migrations to and from the breeding grounds (Gill et al., 2014). These recruits are likely to be driving changes in population-level migration patterns (Gill et al., 2014). In the case of the European honey buzzard, it seems likely that the juvenile birds would be the drivers of the southwards overwintering range shift based on tracking studies of the species. Adults have high site fidelity and are unlikely to change their non-breeding grounds while juvenile birds wander widely in Africa for at least three years, presumably to find the most suitable non-breeding territory (Strandberg, Hake, Klaassen, & Alerstam, 2012). This pattern strongly supports the serial residency hypothesis which predicts that a proportion of juvenile birds will find suitable non-breeding habitat that can be used as an adult, allowing for overall population resilience to large-scale change in the species’ environment (Cresswell, 2014).

This study documents the response of one migrant species, the European honey buzzard, to changes in its non-breeding grounds. We show that the apparent increase in southern Africa is a real expansion of the population in the subregion and hypothesize that it is new recruits that are driving this southwards shift. This shows remarkable flexibility for a specialist species but may have negative, long-term consequences for the species due to decreased breeding success of late-arriving individuals. A southwards shift is in contrast to many previous studies of Palaearctic migrants which have predicted or documented a northwards shift (closer to the breeding grounds) in response to climate change (Ambrosini et al., 2011; Barbet-Massin, Walther, Thuiller, Rahbek, & Jiguet, 2009; Visser, Perdeck, Van Balen, & Both, 2009). This may be because the focus of past studies has also been on climatological factors rather than habitat variables. With a likely increase in the collection of bird distribution data across Africa due to new and repeat atlas projects in Kenya and Nigeria as well as throughout southern Africa, we will be able to better answer questions regarding how both climate and habitat changes are affecting migrant birds on the non-breeding grounds at a finer scale. With much of the current understanding of Palaearctic migrant birds’ response to global change based on European data, we emphasize the importance of better using these African distribution data resources to increase our understanding of shifts in non-breeding ranges, phenology and more for migrant bird species.

ACKNOWLEDGEMENTS

We would like to thank BirdLife South Africa for access to the archives of the National Rarity Committee and other important literature, as well as access to their membership numbers, Trevor Hardaker for the Southern African Rare Bird News and the Zest for Birds archives, the Southern African Bird Atlas Project and all of its citizen scientists for their contributions, and Neil Baker and the atlassers of the Tanzania Bird Atlas for their records. We also acknowledge Andreas Lindén for his assistance with statistics. Lastly, we recognize the National Research Foundation for funding.

DATA ACCESSIBILITY

All species records have been uploaded onto Dryad under DOI number https://doi.org/10.5061/dryad.8m36rq2.

ORCID

Caroline Howes https://orcid.org/0000-0002-3681-3324
Craig T. Symes https://orcid.org/0000-0002-8027-7055
Patrik Byholm https://orcid.org/0000-0003-0216-137X

REFERENCES

Aebischer, A., Perrin, N., Krieg, M., Studer, J., & Meyer, D. R. (1996). The role of territory choice, mate choice, and arrival date on breeding success in the Savi’s Warbler Locustella luscinioides. Journal of Avian Biology, 27(2), 143–152. https://doi.org/10.2307/3677143
Agostini, N., Panuccio, M., Mellone, U., Lucia, G., Wilson, S., & Ashton-Booth, J. (2007). Do migration counts reflect population trends? A case study of the Honey Buzzard Pernis apivorus. Ardeola, 54(2), 339–344.
Ambrosini, R., Rubolini, D., Møller, A. P., Bani, L., Clark, J., Karca, Z., ... Salino, N. (2011). Climate change and the non-breeding range shifts of the European Honey Buzzard Pernis apivorus in the African wintering range of the barn swallow Hirundo rustica. Climate Research, 49, 131–141. https://doi.org/10.3354/cr01025
Awange, J. L., Khandu, M., Schumacher, M., Forootan, E., & Heck, B. (2016). Exploring hydro-meteorological drought patterns over the Greater Horn of Africa (1979–2014) using remote sensing and re-analysis products. Advances in Water Resources, 94, 45–59. https://doi.org/10.1016/j.advwatres.2016.04.005
Barbet-Massin, M., Walther, B. A., Thuiller, W., Rahbek, C., & Jiguet, F. (2009). Potential impacts of climate change on the winter distribution of Afro-Palaearctic migrant passerines. Biology Letters, 5, 248–251. https://doi.org/10.1098/rsbl.2008.0715
Batumi Raptor Count (2017). Migration Count Data. Retrieved from http://www.batumiraptorcount.org/raptor-migration/migration-count-data
Benusen, K. J., Garcia, E. F. J., & Cortes, J. E. (2007). Trends in abundance of migrating raptors at Gibraltar in spring. Ardea, 95(1), 83–90. https://doi.org/10.5253/078.095.0109
Bijlsma, R., Vermeulen, M., Hemerik, L., & Klok, C. (2012). Demography of European Honey Buzzards Pernis apivorus. Ardea, 100(2), 163–177.
Bonniev, B. T. (2011). Some considerations when comparing SABAP 1 with SABAP 2 data. Ostrich, 82(2), 161–162. https://doi.org/10.2989/00306525.2011.603486
Both, C. (2010). Flexibility of timing in avian migration to climate change is masked by environmental constraints en route. Current Biology, 20(3), 243–248.
Brochet, A. L., van den oosche, W., Jbour, S., Ndang’ang’a, P. K., Jones, V. R., Abdou, W. A. L. I., ... Butchart, S. H. M. (2016). Preliminary assessment of the score and scale of illegal killing and taking of birds in the Mediterranean. Bird Conservation International, 26(1), 1–28.
Visser, M. E., Perdeck, A. C., Van Balen, J. H., & Both, C. (2009). Climate change leads to decreasing bird migration distances. Global Change Biology, 15, 1859–1865. https://doi.org/10.1111/j.1365-2486.2009.01865.x

**BIOSKETCH**

**Caroline Howes** is a Ph.D. candidate in the School of Animal, Plant and Environmental Sciences at the University of the Witwatersrand. Her research focuses the ecology of African raptors.

**Craig Symes** is a research scientist whose primary research interests include bird community ecology, urban ornithology and bird movement and migration.

**Patrik Byholm** is a senior researcher and lecturer at Novia University of Applied Sciences. His research interests focus on the ecology of birds in the forest and coastal environments.

**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**How to cite this article:** Howes C, Symes CT, Byholm P. Evidence of large-scale range shift in the distribution of a Palaearctic migrant in Africa. *Divers Distrib*. 2019;25:1142–1155. [https://doi.org/10.1111/ddi.12922](https://doi.org/10.1111/ddi.12922)