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Background. The **Black Harrier** (*Circus maurus*) is a **rare** and **vulnerable** southern African **endemic** raptor, with an estimated world population of less than 1000 breeding birds (Birdlife International, 2012). Yet, little is known about this ground-nesting species and how extrinsic and intrinsic parameters define breeding patterns and could be affecting their population dynamics in space and time. We use a large data set of monitored breeding events in South Western South Africa over 13 years to report on patterns of variation of key breeding parameters.

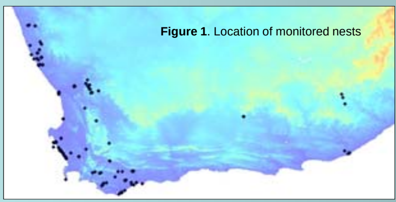


Figure 1. Location of monitored nests

Methods. 458 black harrier nests were monitored in 2000-2013, in the Western, Northern and Eastern Cape provinces of South Africa (Fig. 1).
Data included: **1**) habitat of the nest area, location (coastal or inland), and breeding site dampness (0=dry; 1=damp or wet); **2**) clutch size (CS = number of eggs laid), hatched brood size (HBS=number of young hatched) and fledged brood size (FBS=number of young fledged); **3**) lay date (LD), estimated from chick age. Not all data were available for all monitored nests, so sample size varies depending on parameters.

We analyzed variation in breeding parameters (LD, CS, HBS and FBS, fitted to a normal distribution; hatching success=HBS/CS, fledging success = FBS/HBS, fitted to a binomial distribution), in relation to: Province (Western, Northern, and Eastern Cape), Location (coastal *vs* interior-mountain breeding sites), Year, site Dampness and Laying Date. Data were analyzed using SAS 9.02.

Results. Most monitored nests were in coastal sites (N=332; 124 in interior-mountain areas).

Laying initiation was spread over 8 months (May to December) with a peak between mid August and mid September (Fig. 2). Lay date varied between years, provinces (being earlier in Eastern than Northern Cape) and location (earlier in coastal than interior-mountain sites), and tended to be earlier in wet than in dry sites (Table 1, Fig. 2). Lay date influenced all breeding parameters except fledging success (Table 1, Fig. 3), with breeding more productive if starting early in the year.

Clutch sizes were larger in dry than in wet sites (Table 1). Hatched brood size followed the same trend, but not significantly (Table 1).

Hatching success, and thus hatched brood size, varied between locations, being larger in coastal than in interior-mountain sites (Table 1). Fledged brood size varied strongly between years (Table 1; Fig. 2).

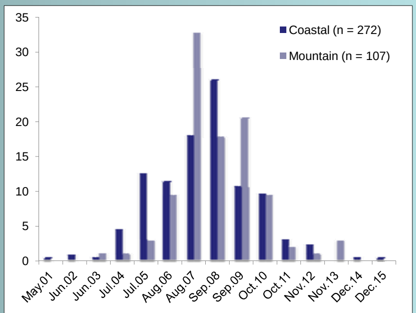


Figure 1. Frequency distribution (% nests) of lay dates (15-day periods) in mountain and coastal sites

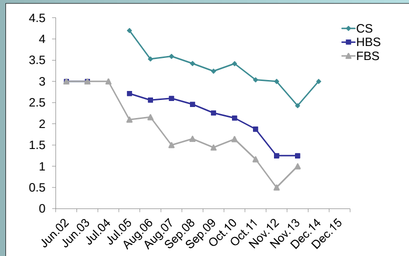
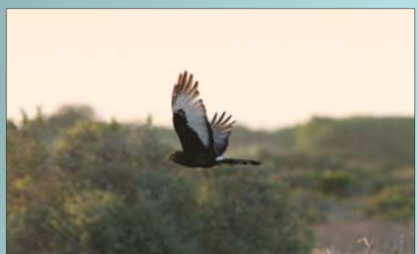


Figure 2. Relationships between average Clutch Size (CS), Hatched Brood Size (HBS) and Fledged Brood Size (FBS) with lay date (15-day periods)

Table 1. Results of analyses testing for variation in breeding parameters. LS Means and slopes of significant explanatory variables are given in blue

Dependent: / Explanatory:	Laying date* 7= 1-15th August 9=1-15th September	Clutch size (CS) (N. of eggs laid)	Hatched brood size (HBS) (N. of chicks)	Fledged brood size (FBS) (N. of fledglings)	Hatching success (HBS/CS)	Fledging success (FBS/HBS)
Province	$F_{2,272}$=7.70; p=0.006 E. Cape: 7.05 N. Cape: 9.37 W.Cape: 8.92	$F_{2,194}$=0.10; p=0.90	$F_{2,190}$=0.06; p=0.93;	$F_{2,169}$=0.56; p=0.57	$F_{2,149}$=0.03; p=0.97	$F_{2,94}$=0.16; p=0.85
Location	$F_{1,272}$=6.86; p=0.009 Coastal: 8.09 Mountain: 8.80	$F_{1,194}$= 0.21 ; p=0.65	$F_{1,190}$=5.48; p=0.02 Coastal:2.48 Mountain:2.00	$F_{1,169}$=0.08; p=0.77	$F_{1,149}$=8.70; p=0.004 Coastal: 0.73 Mountain:0.52	$F_{1,94}$=0.03; p=0.87
Year	$F_{13,272}$=4.98; p<0.0001	$F_{13,194}$=1.35; p=0.19	$F_{13,190}$=1.99; p= 0.02	$F_{13,169}$=2.38; p=0.006	$F_{13,149}$=1.34; p=0.19	$F_{13,94}$=1.77; p=0.06
Breeding site dampness	$F_{1,272}$=3.57; p=0.060 Dry: 8.65 Wet: 8.24	$F_{1,194}$=8.53; p=0.04 Dry: 3.55 Wet: 3.20	$F_{1,190}$=3.49; p=0.06 Dry: 2.38 Wet: 2.10	$F_{1,169=}$3.15; p=0.08	$F_{1,149}$=0.42; p=0.52	$F_{1,94}$=2.56; P=0.11
Lay date	NA	$F_{1,194}$=6.87; p=0.009 Slope: -0.08 ± 0.03	$F_{1,190}$=9.67; p=0.002 Slope: -0.13 ± 0.04	$F_{1,169}$=10.29; p=0.002 Slope: -0.19 ± 0.06	$F_{1,149}$=3.66; p=0.06 Slope: -0.13 ± 0.07	$F_{1,194}$=1,25; p=0.27



Discussion & conclusions. Most breeding parameters decreased with lay date: harriers starting to breed in winter were **more productive** than those starting to breed in spring, which suggests that environmental conditions deteriorate during the season. However, most birds started breeding later, suggesting constraints to breed at the most productive time of the year. Birds breeding on the coast laid earlier than those breeding in interior-mountain areas and had a **better hatching success**. Coastal sites appeared thus to be more favorable: weather conditions might be more favorable for incubating than in interior-mountain areas (i.e. higher rainfall level, milder temperatures); food abundance may also be greater in coastal sites, particularly early in the breeding season. This may be an indication of a **factor limiting distribution**, as coastal sites are more limited spatially than interior sites. Nesting site dampness also appeared to be an important variable for harrier breeding, with harriers breeding earlier in damp sites (suggesting preference for this characteristics, probably because the vegetation cover is more important and taller, or because of a greater abundance of rodents). However, CS and HBS were lower in damp sites, which suggests interactions with predation or food abundance. Finally, all parameters varied among years, which indicates that environmental conditions (either weather or food) are also key for the species.

Future work should identify how individual (quality, body condition, health) and environmental parameters (weather, prey abundance) in both types of location (coastal vs. mountain), affect diet, levels of predation, reproductive success and ultimately demographics of this endemic and rare species

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