# Nest height of the red bishop (*Euplectes orix*)

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Heights of nests and reeds in a colony of red bishops (*Euplectes orix*) in *Phragmites mauritianus* reeds on the Makabusi River, Zimbabwe were measured in two breeding seasons. Nests were placed high in the reeds with fewer above the mean and more below the mean than in a normal distribution. During the course of a breeding season, nest height increased in response to increasing reed height and the nest height/reed height percentage was relatively constant at 70%. Nest height had a higher correlation and regression coefficient with reed height in lower reeds than in reeds over 280 cm tall. Most nests were placed in reeds with diameters of 10 – 12 mm. Higher positions, where the diameters of the reeds were smaller than this, the reeds were weaker probably because of a lack of lignification. In one breeding season, nests used by females were significantly lower than nest frames left unused but breeding success appeared unaffected by variation in nest height. Nesting high in the reeds might be a response to ground predators and climatic factors, particularly the requirement for nest ventilation to remove excess water vapour.

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Die hoogte van neste en riete in 'n kolonie rooivinke (*Euplectes orix*) in *Phragmites mauritianus*-riete langs die Makabusirivier, Zimbabwe, is gedurende twee broeiseisoene gemeet. Neste is hoog in die riete gebou met 'n negatief-afwykende verspreiding. Gedurende die broeiseisoen het neshoogte toegeneem, maar dit is gekoppel aan toenemende hoogte van die riete, en die persentasie neshoogte/riethoogte het relatief konstant gebly op 70%. Neshoogte het 'n hoër korrelasie- en regressie-koëffisiënt met riethoogte getoon waar riete laer was as by riete hoër as 280 cm. Die meeste neste is gemaak waar die riete se deursnee 10 – 12 mm was. Hoër liggings, waar die riete dunner is, het 'n laer breekpunt heelwaarskynlik omdat sekondêre verdikkings in die riete ontbreek. Gedurende een broeiseisoen was die neste wat deur wyfies gebruik is, betekenisvol laer geplaas as die ongebruikte nesrame maar broeisukses is skynbaar nie deur neshoogte beïnvloed nie. Die plasing van neste hoog in riete mag 'n beskermingsmaatreël teen grondroofdiere wees en voorsien ook noodsaaklike nesventilasie om van oortollige vog ontslae te raak.

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Nest site selection has been studied in a variety of birds since Preston's (1946) early work on nesting heights. Location of the nest is often a compromise between conflicting selection pressures, particularly those of predation and climatic factors (Horváth 1964; Calder 1973; Burger, Siegfried & Frost 1976; Burger & Shisler 1978; Loman 1979; Lawton & Lawton 1980; Walsberg 1981). A common difficulty with many studies has been the large number of potentially important variables involved in nest-site selection, necessitating the use of multivariate analysis to determine the significant factors (Burger *et al.* 1976; McCrimmon 1978; MacKenzie & Sealy 1981; MacKenzie, Sealy & Sutherland 1982).

The red bishop *Euplectes orix* provides a convenient species for a study of nest-site selection since it breeds in large colonies and, in the study area, almost invariably built its nests in the reed *Phragmites mauritianus*. This means that there is only one major variable, nest height, to be considered in their selection of nest sites.

## Study area and Methods

Nest heights were obtained from a red bishop colony in a large (750 $m^2$) isolated reed bed of *Phragmites mauritianus*, on the banks of the Makabusi River near Harare, Zimbabwe (17°51'S/31°04'E). A general description of the colony has been given by Woodall (1971). In 1972/1973 and 1973/1974 the colony was visited weekly during the breeding season. At each visit new nests were located and numbered and old nests were inspected and their contents recorded.

The initial outer structure built by the male was termed the 'nest frame'. If this was lined and eggs were laid in it by the female, the nest was termed 'used'. A 'successful' nest was one which produced at least some flying young from the clutch of eggs, while an 'unsuccessful' nest produced no flying young from the clutch.

The height of the nest from ground level (even if under water) to the entrance hole, was measured to the nearest centimetre using a steel tape-measure. Usually only a small percentage of nests were over water which was generally less than 40 cm deep. The height of the tallest reed supporting the nest was measured similarly. This is termed 'reed height'. The second and occasionally third reeds supporting the nest were generally less than 10 cm below the tallest reed. The diameter of 25 reeds was measured at 10-cm intervals from base to tip using vernier callipers.

Since the nest height was often measured several weeks after the nest had been built and first recorded, it was necessary to correct the reed height to the height it would have been during the period of nest building. The mean growth rate of reeds between December 1972 and February 1973 was 0,81 cm day$^{-1}$ but since growth rates are not constant it is preferable to use a Relative Daily Growth Rate (Radford 1967):

$$\log_e (Ht_2) - \log_e (Ht_1) / t_2 - t_1$$

This value (0,003; SE = 0,0003; $n$ = 49) was used to correct all reed heights.

The mechanical strength of the reeds was investigated in Brisbane using the closely related *Ph. australis*. Reeds were clamped horizontally at 10-cm intervals along their length and 10 cm from the clamp; a gradually increasing vertical force was applied using a Salter spring balance. The minimum force required to deform and break the reed was termed the 'breaking force'.

## Results

Nest height did not change significantly while the reeds were growing. Nests which were measured on two occasions, 40 days apart, were found to have slipped down the reed by 1,4 cm on average, but this was not statistically significant (paired $t$-test: $t$ = 1,61; $n$ = 49; $0,2 > P > 0,1$). During the same period, reed height had increased by 32 cm.

### Distribution of nest height

The overall frequency distribution of nest heights and reed heights is shown in Figure 1, following the orientation of axes used by Preston (1946). Both nest height and reed height are normally distributed with means of 201 cm and 283 cm respectively. Red bishop nests are clearly built high, near to maximum reed heights, with no nests being placed lower than 1 m.

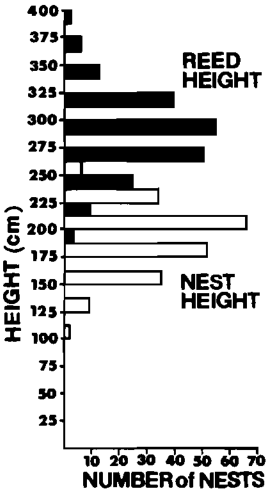

**Figure 1** Frequency distribution of reed heights (solid bars) and red bishop nest heights (open bars). Combined data from 1972/73 and 1973/74 ($n$ = 203).

However, this distribution of nest height is somewhat misleading since it represents an accumulated total of nest and reed heights changing with time (see below). The distribution of nest heights from a more limited period (4 – 11 February 1973, $n$ = 61) shows significant negative skewness. This indicates that the mean is shifted towards the maximum with fewer nest heights greater than the mean and more nest heights lower than the mean than would be expected in a normal distribution. Over the same period reed heights were normally distributed.

### Seasonal changes in nest height

During the course of the breeding season (Table 1) there was a general increase in mean reed height and, with more variability, in nest height. By contrast, nest height expressed as a percentage of reed height (nest height/reed height (%)) remained fairly constant during the course of the two breeding seasons at about 70% (Table 1).

**Table 1** Seasonal changes in nest and reed height at a red bishop colony in Zimbabwe

| Date | Sample size | Nest height ($\bar{x}$; S.E.) | Reed height ($\bar{x}$; S.E.) | Nest height/ reed height % ($\bar{x}$; S.E.) |
|---|---|---|---|---|
| 26 December 1972 | 38 | 178,3; 3,5 | 259,6; 4,3 | 68,8; 1,2 |
| 1 January 1973 | 21 | 178,9; 3,6 | 255,4; 4,8 | 70,8; 1,4 |
| 4 February 1973 | 17 | 212,1; 7,4 | 282,0; 5,9 | 75,1; 1,9 |
| 11 February 1973 | 61 | 207,7; 3,1 | 286,9; 4,0 | 72,7; 0,8 |
| 6 January 1974 | 36 | 199,8; 3,4 | 284,4; 3,9 | 70,3; 0,9 |
| 27 January 1974 | 14 | 209,6; 11,2 | 299,2; 12,3 | 69,6; 2,1 |
| 3 February 1974 | 9 | 236,2; 6,0 | 334,2; 11,2 | 70,9; 2,2 |
| 10 February 1974 | 7 | 234,3; 4,4 | 337,8; 10,4 | 69,4; 1,6 |

### Nest height and reed height

The relation between nest height and reed height is not a simple linear function (Figure 2). Nest height in lower reeds (< 280 cm) increased more rapidly with respect to reed height than in higher reeds (> 280 cm). This was confirmed by linear regressions on the raw data:

(a) For reed heights up to 280 cm:
Nest height = 0,793 (reed height) − 19,5
($n$ = 98, correlation coefficient $r$ = 0,637)

(b) For reed heights over 280 cm:
Nest height = 0,433 (reed height) + 84,4
($n$ = 105, correlation coefficient $r$ = 0,482)

The regression coefficient for reeds under 280 cm (0,793; S.D. = 0,098) is significantly greater than that for reeds over 280 cm (0,433; S.D. = 0,078) ($t$ = 2,90; $P < 0,01$).

Nest height expressed as a percentage of reed height also varied with reed height (Figure 2). In reeds under 3 m, nests were built proportionately higher up the reed (70 – 76%) than in reeds over 3 m (65 – 70%) but a linear regression of this relationship was not significant at the 5% level ($0,1 > P > 0,05$).

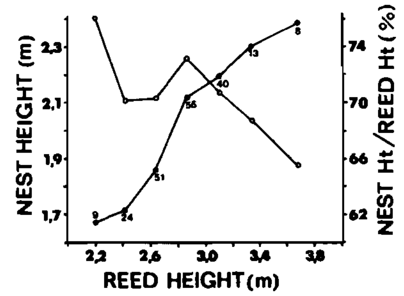

**Figure 2** The relation between nest height (•) and reed height, and (nest height/reed height) (%) (○) and reed height. Figures indicate sample size for each reed-height category.

### Stem diameter

Less than 7% of all nests were placed at more than 80% of reed height. It seemed possible that this upper limit might be structural in nature, that is, the upper 20% of a reed does not afford sufficient support for a nest. The relationship between stem diameter and reed height is shown in Figure 3 with linear regression lines acting as isoclines to indicate the stem diameter for reeds of various heights and for various positions on the reed (60%, 70%, etc. of total reed height). Mean nest heights, as percentages of reed height, for various reed heights, have also been plotted on Figure 3. The majority of nests were placed at stem diameters of 10 – 12 mm. Nests placed in the shortest reeds (2,0 – 2,25 m) were at stem diameters slightly less than 10 mm, while nests placed in the tallest reeds (over 3,5 m), also had the largest stem diameters, nearly 13 mm.

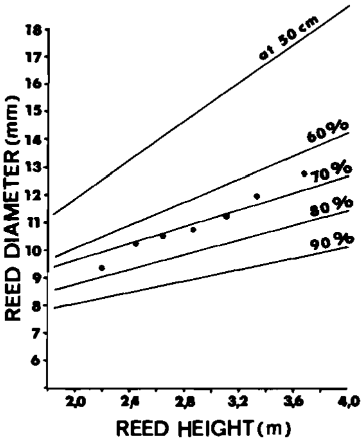

**Figure 3** The relation between reed diameter and reed height. Linear regression lines represent isoclines indicating reed diameters at various positions (percentages of total reed height). Mean nest positions, as percentages of reed height, are also indicated (●).

## Reed strength

Figure 4 shows that the breaking force of reeds under 9,5 mm diameter was a linear function of stem diameter and almost all values were under 2 kg. The breaking force of stem diameters greater than 9,5 mm was much more variable and often much greater than the linear regression for small diameters would have indicated:

(a) For reed diameters under 9,5 mm:

Breaking point (g) = 319 (reed diameter) − 1454
($n$ = 96, correlation coefficient $r$ = 0,688)

(b) For reed diameters over 9,5 mm:

Breaking point (g) = 1202 (reed diameter) − 9811
($n$ = 110, correlation coefficient $r$ = 0,621)

The variability in these latter values can often be explained by the position of the reed in the clamp: when it was clamped near a node the breaking force was much greater than when it was clamped in the middle of an internode. The greater breaking force needed for these larger stem diameters is probably the result of lignification of the stem.

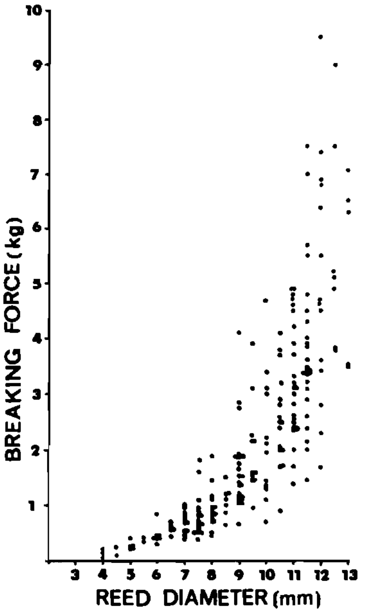

**Figure 4** The relation between breaking force and reed diameter for *Phragmites australis* reeds. See text for details.

## Nest-frame selection and breeding success

Not all nest frames built by male red bishops are used by females for egg laying and some remain as frames throughout the breeding season. The relationship between nest height and the use of nests by females was investigated (Table 2). When considered on a seasonal basis, the height of used nests was significantly greater than that of nest frames in 1972/73 and the opposite was true in 1973/74. However, this averaging of seasonal totals can be misleading because of differences in breeding activity. Egg laying was relatively late in 1972/73 so that many of the used nests were built in older, taller reeds while a large proportion of the frames had been built earlier in the breeding season in shorter reeds, thus accounting for the difference in nest heights between seasons. A more valid comparison of nest heights can be made by using data for new nests built in a restricted period, at a time of maximum breeding activity. The results for two such dates (11 February 1973 and 6 January 1974) are also given in Table 2. There were no significant differences in nest height or nest height/reed height (%) between nest frames and used nests on 11 February 1973 but on 6 January 1974, used nests were significantly lower than nest frames and the difference in nest height/reed height (%) approached significance ($0,1 > P > 0,05$).

Nest height within the observed range appeared to make little difference to the probability of successfully raising flying young. In both seasons, there were no significant differences in nest height or nest height/reed height (%) between successful and unsuccessful nests (Table 2).

## Discussion

Breeding colonies of red bishops offer many advantages for an investigation of nest height. Large sample sizes can be readily obtained and the conspicuous nature of the nests, in a relatively uniform habitat, means that one can be quite confident that no nests have been overlooked.

The nests are built high in the reeds, on average 71% up the tallest reed. Preston & Norris (1947) suggested that most birds tend to nest near to the ground in undisturbed areas but they found in suburban areas, where disturbance by humans and domestic animals was great, that birds did nest off the ground.

Ground predators such as slender mongoose *Herpestes sanguineus* and banded cobra *Naja haje* have frequently been seen near the red bishop colony and the high density of nests may make them very vulnerable to predation. Therefore nesting high in the reeds may be an important anti-predator device in red bishops. Other species of *Euplectes* nest closer to the ground but not in such dense colonies (Craig 1980; Emlen 1957)

**Table 2** Nest heights of the red bishop in relation to nest use and breeding success

| | | Nest category | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Nest frame | | | Used nest | | | |
| Period | Measurement | mean | S.E. | *n* | mean | S.E. | *n* | Significance[a] |
| 1972/73 | Nest height (cm) | 194 | 2,58 | 109 | 208 | 4,71 | 27 | * |
| | Nest ht./Reed ht. (%) | 71,6 | 0,68 | 109 | 71,7 | 1,17 | 27 | NS |
| 1973/74 | Nest height (cm) | 226 | 3,57 | 28 | 202 | 4,49 | 36 | *** |
| | Nest ht./Reed ht. (%) | 70,3 | 1,15 | 28 | 69,6 | 0,97 | 36 | NS |
| 11 Feb. 1973 | Nest height (cm) | 208 | 3,65 | 41 | 212 | 3,9 | 20 | NS |
| | Nest ht./Reed ht. (%) | 72,9 | 1,08 | 41 | 72,3 | 1,01 | 20 | NS |
| 6 Jan. 1974 | Nest height (cm) | 213 | 5,61 | 12 | 193 | 3,83 | 24 | ** |
| | Nest ht./Reed ht. (%) | 72,8 | 1,96 | 12 | 68,6 | 1,13 | 24 | NS |
| | | Unsuccessful nest | | | Successful nest | | | |
| 1972/73 | Nest height (cm) | 211 | 6,37 | 14 | 212 | 5,06 | 12 | NS |
| | Nest ht./Reed ht. (%) | 70,6 | 1,91 | 14 | 73,4 | 1,26 | 12 | NS |
| 1973/74 | Nest height (cm) | 197 | 3,82 | 19 | 189 | 9,50 | 8 | NS |
| | Nest ht./Reed ht. (%) | 68,8 | 1,04 | 19 | 69,9 | 2,20 | 8 | NS |

[a]Significance: NS = not significant, $P > 0,05$; * = $P < 0,05$; ** = $P < 0,01$; *** = $P < 0,001$. (Student's *t*-test.)

and so may avoid high predation by dispersion.

Climatic reasons may also be important for nesting high. At night, cold-air drainage into the low-lying reed beds reduced temperatures considerably (pers. obs.). Burger *et al.* (1976) also found an air temperature inversion at night with the coldest air closest to the ground. In dense vegetation, where the ground was shaded, this inversion persisted all day. Burger *et al.* (1976) showed that a mean temperature difference of 0,6 °C occurred between heights of 100 cm and 200 cm above the ground in dense vegetation at night. Thus nests placed relatively high above the ground may experience warmer ambient temperatures, particularly at night. They also found that nests of the cape sugarbird *Promerops cafer* placed high in dense vegetation had a greater radiation heat loss at night than those placed closer to the ground. However, this loss would be less from the enclosed nest of a red bishop compared with the open cup-shaped nest of a sugarbird.

Woodall & Parry (1982) have shown that nest ventilation is essential to prevent an excessive accumulation of water vapour around the eggs. During the day, very high humidity levels can be expected low down in the sheltered reed beds close to the water, thus making attempts at nest ventilation by the incubating female ineffective. High nests will achieve better nest ventilation and facilitate reduction of water vapour pressure in the enclosed nest. Nesting high in the reeds exposes the nests to the effects of wind and rain but Woodall (1971) found that the entrances of red bishop nests predominantly faced west or south-west and suggested that this provided protection from the rain which generally came with easterly or north-easterly winds.

If it is beneficial for red bishops to nest high in the reeds, why do they build the nest at 71% of the reed's height and not higher? The answer to this seems to lie in the mechanical strength of the reeds. At about 70% of reed height most reeds are 10–12 mm in diameter and this is the lower limit of a marked increase in the breaking strength of the reeds, probably caused by lignification of the stem. Although the breaking strength experiments were conducted on a different species of *Phragmites* to that used in the red bishop colony, both species are very similar in general appearance, morphology and structure and cannot be readily separated by any single character (Clayton 1967; Fernandes, Launert & Wild 1971). Both show considerable intraspecific variation caused by factors such as chance genetic combination, ecotypic selection and plastic adaptation, and at the boundary between species, introgression may occur (Clayton 1967). The samples of *Ph. australis* used in the breaking strength experiments were chosen to resemble the height and growth form of *Ph. mauritianus* used by the red bishops. The stem strength of both appeared similar and differences are likely to be merely a matter of degree.

The colony is occasionally subjected to wind and rain storms which can blow nests over (pers. obs.), hence the mechanical strength of the reeds can be of considerable importance. On one occasion in February 1974, virtually all nests in the colony were blown over. Two that remained upright were placed at 51% and 73% up the reeds. With such limited data it is impossible to draw any conclusions but as a general principle, the higher up the reed a nest is, the greater the moment of force applied near the base of the reed and the greater the chance of the reed breaking.

It is popularly believed that weaverbirds (Ploceinae), can predict seasons of high rainfall and build their nests correspondingly higher to avoid potential flooding. This study has shown that in a season of early and above-average rainfall (1973/74: November–February = 1158 mm) the nests were indeed placed higher in the reeds than in a year of late and low rainfall (1972/73: November–February = 380 mm), but the reason for this seems to be associated with vigorous reed growth following higher rainfall (Table 1) rather than any forecasting ability by the birds.

These results also provided an indication that in one season, (1973/74) females selected and used lower nest frames than the frames left unused. The possible reasons for this are obscure although this was a year of heavy rainfall in which a freak flood later washed out most of the colony. Much further work will be required to identify all the factors involved in nest-site selection by the males and subsequent selection of some frames by the females.

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