A Comparison of Temperatures Recorded in Nest Chambers Excavated in Termite Mounds by the Golden-shouldered Parrot

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Two types of termitaria, meridian mounds constructed by *Amitermes laurensis* and conical mounds constructed by *A. scopulus*, are used by Golden-shouldered Parrots *Psephotus chrysopterygius* for nesting. The nest comprises a horizontal tunnel dug into the side of the termitaria with a rounded, unlined chamber hollowed out at the end. A significant preference is shown for nesting in conical mounds (Weaver 1982). This preference suggested that some feature of the internal environment of conical mounds is more acceptable to the birds, although other factors must also influence the selection of nest sites as some birds choose to nest in meridian mounds that occur in areas where conical mounds are also present but not used for nesting. Nest-chamber temperature suggested itself as a likely relevant feature, and so the way it varied in response to changes in ambient temperatures was examined in both mound types to see if differences occurred.

Between 1979 and 1984, a 'Grant Mini Recorder' was used to measure temperatures inside the nest-chamber simultaneously with ambient temperatures from nine meridian and nine conical mounds at each hour over a minimum recording period of 24 hours.

The height of tunnel entrances above ground level and the total lengths of each tunnel were measured, and a compass bearing of the tunnel direction was taken for all active nests located during the survey period.

Results and Discussion

Ambient temperatures ranged from an average minimum of 16.6°C (min. 11.5°C) to an average maximum of 30.4°C (max. 37.5°C) for the nine meridian mounds and 15.8°C (min. 12.4°C) to 30.6°C (max. 37.0°C) for the nine conical mounds. There were no significant differences in ambient temperatures between days or sites over the period of study. Mean hourly ambient temperatures are therefore included in Figure 1.

Nest-chamber temperatures ranged from 13.0°C to 41.2°C in meridian mounds and from 14.8°C to 36.0°C in conical mounds. Significant differences between nest-chamber temperatures for each mound type are indicated in Figure 1. A parametric *t*-test and a non-parametric Mann-Whitney test were both used as sample sizes were small and the nest temperatures in meridian mounds showed a greater variation than those in conical mounds, particularly during the heating phase of the day.

The results indicate that as the ambient temperatures rise, meridian nest-chamber temperatures rise faster than in conical nest-chambers; these temperatures also remain higher during the warmest time of the day. As the ambient temperatures drop, nest-chambers in conical mounds maintain warmth for a longer period than nest-chambers in meridian mounds.

Conical mounds thus provide nest sites with temperature regimes that are different from those of meridian mounds and this may be a significant factor in the observed preference for this mound type for nesting by the Golden-shouldered Parrot.

Table 1 shows that a significant difference between

TABLE 1 A comparison of the height of nest tunnel entrances and the length of tunnel entrances in the two types of termitaria used by the Golden-shouldered Parrot for nesting.

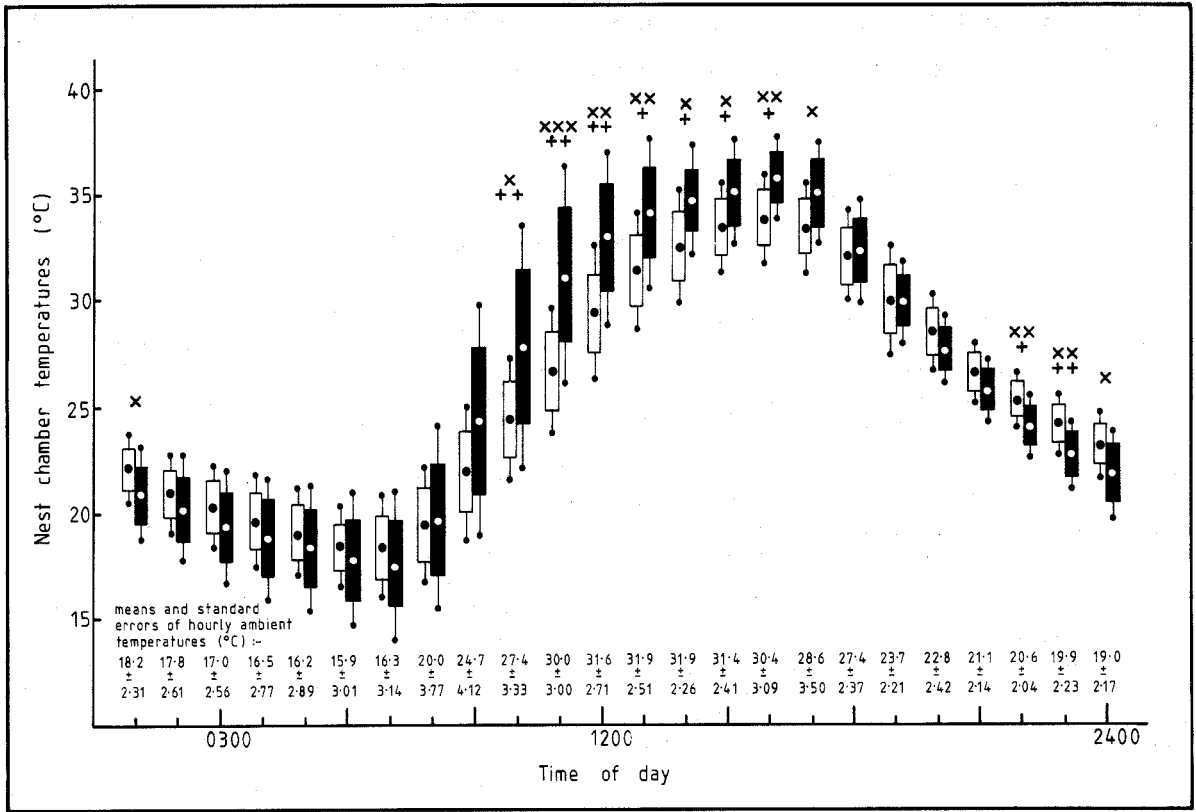| Type of measurement	Type of mound	$\bar{X}$	$S\bar{x}$	range	n	One way analysis of variance		
						F	$d.f.$	significance
Height of tunnel from ground (cm)	Meridian	80.0	23.0	49.0-125.0	13	12.8	1, 30	$0.002 < P < 0.005$
	Conical	60.0	20.8	46.0- 91.5	19			
Length of tunnel (cm)	Meridian	40.0	12.1	20.0- 61.5	13	11.1	1, 30	$0.002 < P < 0.005$
	Conical	28.3	7.8	20.5- 37.5	19			

FIGURE 1. The comparison of Golden-shouldered Parrot nest temperatures in nine conical and nine meridian mounds. Means of hourly temperatures are designated by ● for conical and ○ for meridian termitaria. Vertical lines denote the predicted range of temperatures at 95% confidence intervals. The standard errors of means are designated by the blank vertical bars for conical mounds and by the black vertical bars for the meridian mounds. The significance of difference according to the parametric *t*-test and non-parametric Mann-Whitney (M-W) test are designated as follows:

t-test (1-sided)	M-W (1-sided)	Probability
xxx	+++	1.0% < P < 2.5%
xx	++	2.5% < P < 5.0%
x	+	5.0% < P < 10.0.5%

meridian and conical mounds occurred for the measured tunnel lengths and for the height of tunnel entrances above ground level. Table 2 shows that the orientation of tunnel entrances in meridian mounds was predominantly on the northern aspect; in contrast, there was no significant preferred direction for tunnel entrances in conical mounds. A circular, one sample, test for randomness ('Rayleigh' test for directedness [Batschelet 1981]), was used for the analysis of angular tunnel entrance data. Further distinction between nest sites exists therefore, based on the orientation of tunnel entrances, tunnel lengths as well as the height of tunnel entrances above ground level. However, samples are not large enough for definite conclusions to be drawn and it remains to be shown whether these

TABLE 2 A comparison of the orientation of tunnel entrances in the two types of termitaria used by the Golden-shouldered Parrot for nesting.

Type of measurement	Type of mound	Mean angle	Mean angular deviation	n	Significance ('Rayleigh' test for directedness)
Direction of tunnel entrance (°)	Meridian	355.6°	47.79°	13	0.003 > P > 0.002
	Conical	245.4°	54.23°	19	0.084 > P > 0.063

criteria influence nest-chamber temperature, and in what way this happens.

The nest temperatures in meridian mounds are higher and exceed preferred incubation temperatures of other avian species (35.7°C, Drent 1975) for longer periods of time than conical mounds. Therefore, birds incubating eggs in meridian mounds may have to spend considerably more time, water and energy actively cooling eggs so that lethal egg temperatures are avoided. The more acceptable temperature regime in conical mounds may also result in higher productivity and more rapid development of nestlings.

Acknowledgements

References

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Sexual Size Dimorphism in Raptors: Intrasexual Competition in the Larger Sex for a Scarce Breeding Resource, the Smaller Sex

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Sexual dimorphism in size is a characteristic of many species of birds. Raptors are unusual in the extent of divergence in size between the sexes in many species and the fact that the female is more often the larger sex (reversed sexual dimorphism or RSD). This has elicited much speculation as to the explanation for and adaptive significance of size dimorphism in this group (e.g. Mueller & Meyer 1985).

The most widely accepted explanations for the evolution of avian sexual dimorphism are the avoidance of intersexual competition and sexual selection (Selander 1966, 1972; Trivers 1972; Searcy 1979). The competition avoidance theory, which links the degree of divergence in size between the sexes to differential niche use, has been well explored in its application to raptors (e.g. Newton 1979; Temeles 1985); while it may account for the degree of dimorphism, in general, it offers no explanation for the larger size of the female (Newton 1979; Mueller & Meyer 1985). The theory of sexual selection, on the other hand, attributes the larger size of one sex to the advantage it confers in epigamic display and intrasexual competition (Darwin 1871; Selander 1972; Trivers 1972.).

We believe that, as a consequence of their 'breeding system', intrasexual competition is the primary cause of dimorphism in raptors. We propose that the larger sex (the female in most raptors) competes for a scarce breeding resource (the male in most raptors). To our knowledge, this idea has never been advanced as an explanation for dimorphism in raptors, with the exception of preliminary notes by ourselves (Olsen & Olsen 1983, 1984, 1986).

Aspects of the breeding system of raptors

Raptors differ from many other birds in what we have termed their 'breeding system'. In particular, the female generally cannot successfully hatch and raise a brood in the absence of a male; the male therefore has a higher investment in the breeding attempt than is the case in many other avian species. The male is often the sole provider for the female, from courtship until several weeks into the nestling period (Newton 1979). Consequently, the male must be a willing provider and a skilled hunter with a good knowledge of his hunting area, particularly in those species that catch agile, fast or otherwise difficult prey. It would be advantageous, though not essential, for the male to hold