Ostrich 2007, 78(1): 13–20
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OSTRICH
EISSN 1727–947X
doi: 10.2989/OSTRICH.2007.78.1.3.47

Breeding biology and nest site characteristics of the Rosy-faced Lovebird *Agapornis roseicollis* in Namibia

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The breeding biology of the Rosy-faced Lovebird *Agapornis roseicollis* was investigated in its natural habitat at three Namibian localities: Claratal, Hohewarte and Haris. The lovebird nests in colonies often shared by Sociable Weavers *Philetairus socius*. Birds nested in trees at a mean height of 3.8m, on telephone poles at 6.6m, windmills at 11.2m, and artificial nest boxes at 3.3m. *Acacia erioloba* and *A. karroo* were most often used for nest location. Nest tree habitats had low density vegetation with short (4m) trees, mostly *A. erioloba*, spaced at distances of about 10m. No specific nest entrance orientation was chosen. Birds obtained nest materials from the bark of small branches, branchlets from the tips of branches, twigs, sticks, leaves and thorns of trees, predominantly *A. karroo*, *A. erioloba*, *Ziziphus mucronata* and *Boscia albitrunca.* Nine colonies, comprising 20 nests, were monitored every four days to establish incubation and fledging periods. Rearing and fledging of chicks was found to be successful in eight nests. Measurements of 18 young from four nests were used to monitor growth rate. Nesting success was calculated at 0.1, following the revised Mayfield method. Mean clutch size at laying, hatching, and fledging was 4.42 ± 1.7, 2.26 ± 2.1 and 1.65 ± 2.1 (n = 20), respectively. There was no significant difference in mean mass, nor bill and tarsus length of young that hatched first or subsequently, but a Duncan test revealed a significant difference in mean mass of young that hatched first or fifth.

Introduction

African lovebirds are the only parrots, other than Monk Parakeets *Myiopsitta monachus*, that construct their own nests. Four species (*Agapornis personata*, *A. fisheri*, *A. lilianae* and *A. nigrigenis*) build domed nests, whereas *A. roseicollis* builds a cup-shaped nest within cavities (Eberhard 1998). In *Agapornis* species, nest building is associated with colonial breeding and nest building in parrots (Psittaciformes) either evolved from the habit of lining the cavity with nest material, or through nest site adoption.

The Rosy-faced Lovebird is a non-territorial, sociable and gregarious species (Forshaw 1989) that is highly water-dependent (Harrison *et al.* 1997). They roost and nest in shrub grassland where they may feed, although most feeding occurs in highly wooded riparian vegetation on dry water courses. The Rosy-faced Lovebird is sedentary (Fry *et al.* 1988), occurring largely at the Namibian escarpment (Harrison *et al.* 1997) and is near-endemic to Namibia, with a range exceeding 50 000km^2 (Simmons *et al.* 2001).

Rosy-faced lovebirds are colonial breeders with natural breeding sites in the inaccessible and often vertical cracks found in steep rock faces on exfoliating granite or sandstone koppies (Harrison *et al.* 1997).

However, *Agapornis roseicollis* is highly adaptable and nests in communal nests of the Sociable Weaver *Philetairus socius* and White-browed Sparrow Weaver *Plocepasser mahali* (Fry *et al.* 1988) and on telephone poles (Harrison *et al.* 1997). Nest site selection is a key determinant of reproductive success; sites offer protection from predators and harsh environmental conditions. Peak egg-laying months are February–March (Harrison et al. 1997).

The viability of an avian population depends on the delicate balance between natality and mortality (Johnson 1979), and we infer demographic status by estimating rates of births and deaths. This is not always easy, but the proportion of eggs that hatch can be used to gauge natality as a measure of reproductive performance.

Here we present original breeding data from a wild population, since previous information on the species' breeding biology was based on captive studies. Since most nests were found during the incubation and the nestling periods, it was difficult to estimate when nest building had begun. The objective of this study was to investigate the nesting characteristics and breeding biology of the Rosy-faced Lovebird in its natural habitat and to identify plant species critical for its reproductive success.

Study area and methods

Fieldwork was carried out from January to July 2004 as part of a wider study on the ecology and status of the Rosy-faced Lovebird. The study was based at three Namibian localities: Claratal (22°44'S, 16°45'E), Haris (22°43'S, 16°51'E) and Hohewarte (22°37'S, 17°20'E), in the Namibian escarpment at altitudes between 1 778m and 2 114m above sea level. The localities contained dense shrub savanna and scattered trees; however, grassland with

26–50% scattered shrub cover was the dominant vegetation. The study sites were located on commercial farms managing domestic animals (mainly cattle) and wildlife. Water was provided in many localities on the farms and was readily available to the lovebirds. Nest searching involved walking the plains and driving along gravel roads next to farms. Once discovered, the positions (location, elevation and distances between sites) of the nest colonies were recorded using a Garmin eTrex Venture GPS. Nest contents were monitored.

Heights of nests from ground level and distances between nest trees were measured. Ladders were used to access nests in trees, or an elliptical mirror — attached to an easily foldable aluminum pole — was used to examine the nest contents and the internal shapes of the nests. Information on nesting site characteristics was collected, including the plant species on which the nest was located, height of the tree, height of the nest above ground, elevation (height above sea level), co-ordinates at nest locations, nest orientation, and habitat type.

Observations on breeding biology were made simultaneously with observations on feeding behaviour. Nest monitoring was done early in the morning (06:00–07:00 in summer and 06:45–07:00 in winter). Most of the nests in Hohewarte were in nest boxes with small nest entrances. Hence, nests were monitored with the aid of a mirror and a torch. At hatching, and at four-day intervals, the following measurements were taken: date, nest number, colony, age of chicks (in days), body mass and wing, bill and tarsus lengths.

Nesting success was estimated using the method of Mayfield (1975), namely: success = (1 – [losses/exposure]) ^np where exposure is the total number of active nest days, and np is the period in the nesting cycle being considered.

Overall, nesting success was calculated as the product of success during the laying and incubation periods combined, and the nestling period. The variance of Mayfield's estimator was derived from the following expression, developed by Johnson (1979): ([exposure – losses] x losses)/([exposure] ^3).

Breeding behaviours were observed using Bushnell 8x42 binoculars and a Kowa 40x telescope. Activity and behaviour of the flock, time, date and flock size were recorded. Rosy-faced Lovebirds are sexually monomorphic (Forshaw 1989) and pair bonds were only assumed when individuals performed certain reproduction-related behaviours. Eighteen young were marked with either plastic colour bands, permanent ink or nail varnish, to distinguish them individually.

Results

Breeding behaviour

Nest locations

In the study locations, lovebirds nested in communal nests with Sociable Weavers. Nine colonies, comprising 20 nests, were active. Nests were observed in *Acacia* spp. trees, on telephone poles, on windmill structures, and in artificial nest boxes. Nests were located in trees at a mean height of 3.8m above ground, at 6.6m on telephone poles, at 11.2m on the windmill and at 3.3m on nest boxes above ground (Table 1).

Table 1: Mean height above ground (m) of nests and nest structures and mean elevation (m above sea level)

	n	Mean ± SD
Trees		
Tree height	5	5.9 ± 1.0
Nest height	5	3.8 ± 0.8
Elevation	5	1 929.2 ± 6.2
Telephone poles		
Telephone pole height	6	7.8 ± 1.8
Nest height	6	6.6 ± 0.6
Elevation	6	1 962.3 ± 26.4
Nest boxes		
Structure height	8	3.5 ± 0
Nest height	8	3.3 ± 0
Elevation	8	1 793.0 ± 0
Windmill structures		
Windmill height	1	14.0
Nest height	1	11.2
Elevation	1	1 928.0

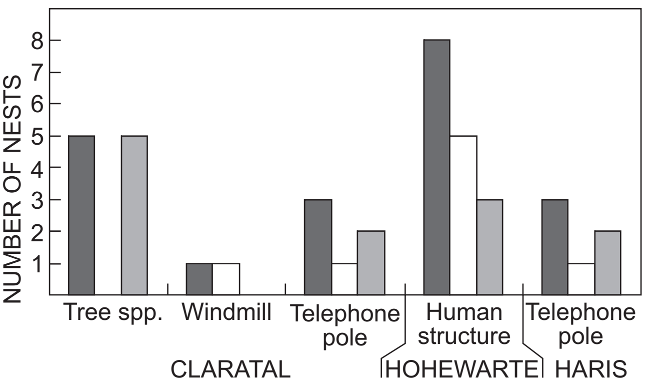

Figure 1: Nest success of Rosyfaced Lovebirds according to nest site and study location; black = total number of nests, white = success, grey = failure

At Claratal, birds preferred to nest in dead and/or partially dead trees, but five nests located in trees failed (Figure 1). Two of six nests located on telephone poles, and five of eight nests in nest boxes, were successful. Most of the nests were found on structures other than trees. Birds added nest materials to the nests during and after incubation.

Choice of nest trees

The lovebirds nested exclusively in Camel Thorn *Acacia erioloba* or Sweet Thorn *Acacia karroo*. *A. erioloba* was the most preferred tree species for nest location (71%), perhaps because these trees also served as a source of food and nest-building material. *A. erioloba* occurred mainly in the drier parts of the lovebird's habitat, while *A. karroo* occurred in the open grassland and along dry river courses.

Nearest neighbour for nest site trees

Distances from the nest tree to the nearest adjacent tree were small, ranging from 1.6–20m (Table 2). This, however, was a poor indicator of the density of the vegetation around nest trees because most plants found near nest trees were

Table 2: Distances (m) from nest trees or nest structures to nearest neighbouring trees or shrubs, and heights (m) of nest trees/structures

Description	n	Mean ± SD	Min.	Max.
Distance	20	10.2 ± 8.4	1.6	20
Height of nest tree/structure (at three sites)	20	8.4 ± 5.7	1.5	15
Height of nest tree/structure (at two sites)	12	4.0 ± 2.0	1.5	7

very short, ranging from 1.5–7m in height, and did not offer effective cover to the nest trees. Nest trees were conspicuous among smaller trees and shrubs.

Mean tree height for the three locations was not a good indicator of the environment around the nest trees because eight nests, mostly in nest boxes, in Hohewarte, formed one colony, with its neighbouring tree 15m high. This was not characteristic of the other two study sites where mean height of the 12 nests there was much lower (4m).

A. erioloba was the commonest species adjacent to the nest trees and structures, with a higher frequency than *A. karroo* and *A. mellifera* (Figure 2). These trees provided food and cover for the lovebirds.

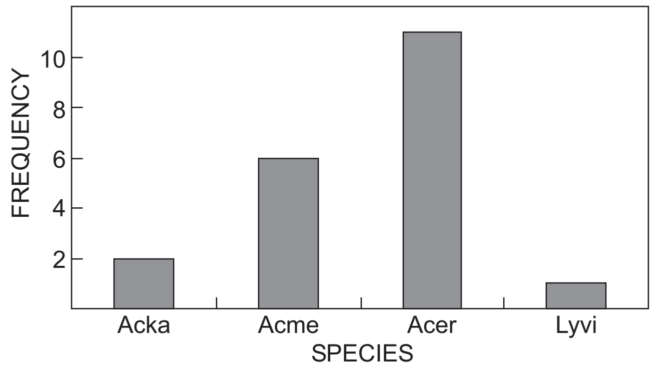

Figure 2: Frequency with which species were nearest neighbour to nest trees or structures. Acka = *Acacia karoo*, Acme = *A. mellifera*, Acer = *A. erioloba*, Lyvi = *Lycium villosum*

Nest entrance orientation

Nest entrance orientation was predominantly westerly (Figure 3). Eleven nests (55%) had their entrances facing north-west, four to the south-west and two to the west. The predominant wind direction (north and north-west) probably affected the direction of nest entrances. Most nest entrances faced into the wind.

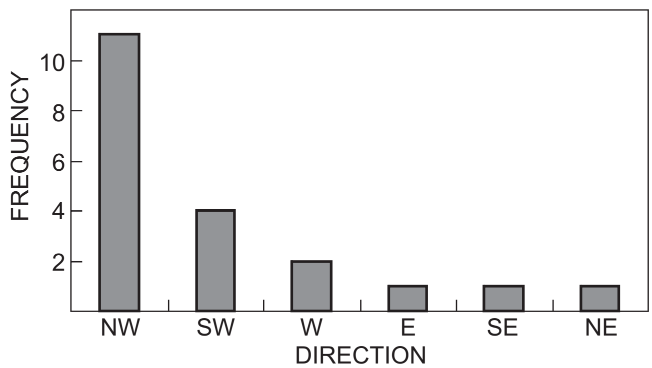

Figure 3: Frequency of nest entrance orientations

Nest building and building materials

Nest building materials were obtained from the bark of branches, branchlets obtained from the tips of branches, twigs, sticks, leaves, and thorns. The branchlets, leaves and thorns were mainly accessed from *A. karroo* and *A. erioloba*. Buffalo-thorn *Ziziphus mucronata*, Shepherd's Tree *Boscia albitrunca*, *Acacia erioloba,* and *A. karroo* were the sources of strips of bark, which were the most commonly-used nest-building material. These materials were used to line the inside of the nests, especially where the eggs were laid and where nestlings rested. Nest materials were used to block nest entrances so that eggs and young would not fall from the nest.

Nest materials were cut using the strong, sharp bill and transported under the feathers of the rump and the flanks. Grasses were not collected, nor used to line the nest. Birds made two cuts on the bark of a small branch, one above and one below the patch to be stripped. They then used the bill to peel off the bark in narrow strips, tucking them under their feathers. Birds flew to the nests and inserted the materials at the sides of the nest, leaving a medium-sized, elliptical cup-shaped nest at the centre. The Sociable Weaver nest colony was made of grass woven together to form a huge neatly-woven structure. The communal nests of Rosy-faced Lovebirds and Sociable Weavers were located within this structure.

Each communal nest colony contained many breeding chambers, sometimes connected to one another, especially those occupied by lovebirds. There were two openings to each nest, one for entry and the other for escape. It is not known whether previously-used nests were reused, but it is likely that they were.

Breeding biology

Seasonality

Eighteen colonies, comprising 32 nests in three locations, were identified between January and May 2004. Of these, nine colonies with 20 nests were active. Nest colonies of *A. roseicollis* occurred communally with those of Sociable Weavers *Philetairus socius.* They were permanent structures, and were likely to be used for several breeding seasons.

The timing of laying and incubation by different pairs was closely synchronised with each other and with rainfall (Table 3), photoperiod and food availability. Laying and incubation at the three study locations ran from February through to the end of March, during the peak of the rainy season, when grass seeds were abundant.

Rains gradually declined during April and ceased in May. When hatching began in June, nestlings appeared and fledging occurred. Food, however, was still available. *Anthephora schinzii*, a preferred grass species, had by then 'dropped' all seed from its inflorescences and birds shifted attention to other food items, but continued to feed on seeds of this grass species from the ground (Ndithia and Perrin 2006a).

Clutch size and breeding success

Clutch size varied from 3–8, with a mean of 4.4 ± 1.7 (n = 19) (Table 4). There was no significant difference in clutch size between the different locations (one way ANOVA, $p = 0.19 > 0.05$), but there was a marked difference in clutch size between laying, hatching and fledging (Tukey HSD for unequal N, $p = 0.00055 < 0.05$; Table 5).

Eggs were laid at intervals of one day; that is, one egg every other day. Incubation began with the first egg laid, so the young hatched asynchronously, causing a considerable difference in size of individuals of the same brood. Incubation and fledging lasted 23 and 43 days, respectively (Table 6).

A total of 711 nest days of observation were used to determine breeding success: 337 during the incubation period and 374 during the nestling period. Seven nests were lost during incubation and 13 during the nestling period. Extrapolation determined the onset of incubation for nests that were well advanced.

Breeding success was computed using the Mayfield method (Table 7). The daily survival rate of chicks during incubation and the nestling period were 0.97 and 0.97, respectively, predicting survival rates of 0.62 and 0.23 for these developmental periods. This generates an overall survival rate of 0.14 from egg laying to fledging, and 1.65 successful fledgings per successful nest.

Growth rate and development

Four nests, comprising 18 young, were monitored. The fifth-hatched chick was smaller than the previously-hatched chicks (Table 8). Mean bill and tarsus length of chicks decreased slightly from early to late chicks (Table 9).

One-way ANOVA did not reveal any significant differences in mean body mass, or bill and tarsus length of successively-raised young. However, a post hoc ANOVA with a Duncan test revealed a significant difference in mean body mass of the young hatched first and hatched fifth ($p = 0.0370 < 0.05$; Table 10). A Duncan test did not reveal any significant difference between the mean bill or tarsus length of young that hatched first or fifth. Correlation analysis showed that the three variables body mass, bill length and tarsus length were significantly correlated (Table 11). Table 12 summarises the relationship between the parameters ($y = -43.5 + 6.3\ b + 0.95\ t$, where y = mass, b = bill and t = tarsus).

All pairs raised a single brood and the pattern of feather development of chicks was uniform. Upon hatching, young

Table 3: Mean monthly rainfall (mm) for 2003 for Windhoek, Namibia, near the study site

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
71.1	73.7	76.2	50.8	12.7	0	0	0	6.4	12.7	38.1	50.8

Table 4: Mean clutch size (± SD (n)) at laying, hatching and fledging at three different locations

Parameter	Location			
	Claratal	Haris	Hohewarte	Total
Laying	4.13 ± 1.7 (8)	4.33 ± 1.1 (3)	4.75 ± 2.0 (8)	4.42 ± 1.7 (19)
Hatching	1.63 ± 2.3 (8)	3.33 ± 0.6 (3)	2.05 ± 2.1 (8)	2.26 ± 2.1 (19)
Fledging	1.11 ± 2.2 (9)	1.00 ± 1.7 (3)	2.50 ± 2.1 (8)	1.65 ± 2.1 (20)

Table 5: Tukey HSD for unequal n test showing marked differences in clutch sizes at laying, hatching and fledging; *indicates significant difference

	Laying (1) M = 4.2000	Hatching (2) M = 4.2000
Laying (1)		
Hatching (2)	0.007454*	
Fledging (3)	0.000819*	0.724760

Table 6: Mean incubation period and fledging time (days) for *Agapornis roseicollis* at three study locations

	Days	n
Incubation		
Claratal	23.3	3
Hohewarte	22.2	5
Haris	23.3	3
	Mean = 22.9	Total = 11
Fledging		
Claratal	42	2
Hohewarte	43.5	4
Haris	44	1
	Mean = 43.2	Total = 7

were covered with a rather dense reddish down. They grew rapidly and after nine days pin feathers began to replace the natal down. The eyes opened about 11 days after hatching, and the parents fed the young by regurgitation.

After 13 days, the bodies of young were entirely covered with down and pin feathers. After 18 days, green juvenile plumage started to appear on the wings and body, and the bill was well developed and horny-black. At 22 days, the young were fully feathered (wings, head and tail) with dull green plumage that covered the grey down beneath.

At Day 27, pale orange feathers had developed on the neck and breast. At Day 34, more pale orange feathers had developed; the rump was blue and the tail had red tips on the outer tail feathers. Adult plumage was almost fully developed, but the neck and breast were still a pale orange colour, in contrast to the adult plumage of bright red to rose pink.. The upper half of the bill was black, the lower half dark yellow, in contrast to the pink of the adult bill. Young attempted to fly at Day 39, but had poor flight capabilities. Young fledged at 42–44 days and flew well. They made short flights from the nests, and flew back to the nest at any slight disturbances, and did not fly again for several hours.

Table 7: Nest success probabilities averaged for all localities

Incubation	Nestling	Hatching	Overall
0.62	0.23	0.51	0.14

Discussion

Nest site selection

There was a relatively high success rate of nests located on telephone poles, although two had dead chicks, not caused by predation but perhaps attributable to disease or other factors. Nests in nest boxes had a high success rate, probably because of their location adjacent to human habitation where predators were absent. Lovebirds preferred structures to trees as nest site locations because they were higher above ground and, most probably, in more secure situations. Snakes easily climbed trees to reach nests but were less likely to climb a structure like a wall or a pole or iron structures. Birds avoided bushes, and nest colonies on trees were usually on, or very near, the main trunk, high in the canopy. Alonso and Muñoz-pulido (1991), in a study of nest site selection and nesting success of the Azure-winged Magpie *Cyanopica cyana*, showed that nesting success was not correlated with nest height above the ground. Santisteban *et al.* (2002) showed that elevated nest height increased nest vulnerability to visually-oriented nest predators in the Fish Crow *Corvus assifragus*.

Nest re-use

Whether a pair uses the same nest and/or colonies in the subsequent breeding seasons remains unknown. The same nest colonies were apparently re-used in subsequent breeding seasons, as lovebirds were observed entering old nests, but some Sociable Weaver colonies had no active

Table 8: Mean body mass of first-, second-, third-, fourth- and fifth-hatched young across all clutches

Hatched	Mean ± SD	n
First	48.4 ± 15.1	19
Second	46.3 ± 14.9	20
Third	45.6 ± 17.2	20
Fourth	40.3 ± 21.4	17
Fifth	34.1 ± 23.0	16

Table 9: Mean bill and tarsus length (± SD (n)) of the first-, second-, third-, fourth- and fifth-hatched young across all clutches

	Bill	Tarsus
First	12.1 ± 1.7 (18)	17.6 ± 1.7 (18)
Second	12.0 ± 1.7 (19)	17.8 ± 2.2 (19)
Third	12.0 ± 2.0 (19)	17.6 ± 2.7 (19)
Fourth	11.0 ± 2.4 (16)	16.3 ± 3.6 (15)
Fifth	10.9 ± 2.3 (13)	16.3 ± 2.6 (12)

Table 10: Duncan test showing significant difference at $p < 0.05$ of the mean of body mass of young that hatched first and fifth. Note that $p = 0.037$ for means of Young 1 and 5

Young		(1) M = 48.4	(2) M = 46.3	(3) M = 45.6	(4) M = 40.3	{5} M =34.1
1	(1)		0.728	0.668	0.232	0.037
2	(2)			0.912	0.360	0.070
3	(3)				0.387	0.077
4	(4)					0.312
5	(5)					

Table 11: Correlations of body mass, and bill and tarsus length. All correlations are significant at $p < 0.05$ ($n = 83$)

Variable	Body mass	Bill	Tarsus
Mass	1.00		
Bill	0.94	1.00	
Tarsus	0.86	0.89	1.00

Table 12: Summary of the regressions for body mass, bill and tarsus length. Adjusted $r^2 = 0.8765$

	Beta	se	Beta	se	t(80)	p-level
Intercept			-43.46	4.08	-10.64	0.00
Bill	0.79	0.085	6.31	0.67	9.37	0.00
Tarsus	0.16	0.085	0.95	0.51	1.85	0.07

lovebird nests. Some lovebird nests in the colonies were found to be inactive throughout the breeding season. They had been previously used, but were not re-used, and the entrances were found to be blocked. During the nestling period, nests were regularly cleaned of the wastes of the young but after the chicks fledged, nests contained heaps of dry hardened excreta, which may prevent the re-use of the nests.

Parrots are known to have a strong fidelity for nesting sites and use a small fraction of potential habitat for breeding (Synder *et al.* 1987, Robinet and Salas 1999). At Lake Naivasha, Kenya, hybrid lovebirds (*A. personatus* X *A. fisheri*) permanently occupy the same tree cavities throughout the year (Thompson 1987). The re-use of nests by Rosy-faced Lovebirds (and Black-cheeked Lovebirds (Warburton 2003)) remains an open question. Nest boxes were re-used at Hohewarte and inactive nests were used for roosting during the day.

Sociable Weavers constructed the huge grass-thatched nest structures that formed the nest colonies. They were often seen transporting grass materials to nest colonies, but the lovebirds only lined the inside of the nests to make the internal environment suitable for eggs and chicks. The huge nests were large colonies established over many years, and had taken much effort, time and energy to construct.

Threat to nesting locations

Nesting sites for breeding lovebirds are not limiting in the natural habitat, but may be limiting with respect to telephone poles and other man-made structures. *A. karroo and A. erioloba* are common as nest trees and are important for the continued survival and viability of the lovebird population in Namibia, particularly if the lovebirds are unable to access nesting sites associated with human habitation, where breeding success is greater.

Nest orientation

Lovebirds placed their nests on structures with regard to wind direction, i.e. westerly; winds are strong in some months of the year in Namibia. This orientation may be influenced by protection from rain and direct temperature effects, which can be scorching. Only one nest faced east.

Nesting success

Few published data are available for the nesting success of wild African parrot populations (Wirminghaus *et al.* 2001, Symes 2004, Warburton and Perrin 2005, Taylor and Perrin 2006). Nestling survival data are, however, available for the Australian Galah *Eolophus roseicollis*, but vary between seasons and study sites (Rowley 1990). The percentage fledged range from 58–65% for broods of three to five. Smallest and largest broods raised a lower percentage of fledglings, which probably reflects chilling of isolated nestlings and high mortality of the last hatched chick, respectively. Reproductive success also varied with rainfall and food availability.

Breeding stimulation and number of broods raised

Lovebirds raised one brood per pair during the fieldwork period. It is not known if they raised a second or more broods after July. Dilger (1960) reported that young *A. roseicollis* become sexually mature at 37 days after fledging but only behaved sexually after the post-juvenile moult was complete, at about four months. His data were, however, based on captive studies, the relevance of which in the wild is questionable. Simmons (1997) indicated that breeding season extension of Namibian birds may occur opportunistically when conditions are favourable, after the summer rains, and that breeding coincides with the timing of maximum food availability immediately following heavy rain. This appeared to be so for the lovebirds in this study, as breeding followed the heavy rains that occurred in January and February, which caused an abundance of grass seeds, the preferred diet of the lovebirds.

In the arid and semi-arid subtropics, where rainfall is erratic and unpredictable, it is rainfall, through its influence on food availability, that is the key proximate determinant of both clutch size and the timing of breeding in many bird species (Marchant 1960, Immelmann 1973, Boag and Grant 1984, Lloyd 1999). In southern Africa, the importance of rainfall in the timing of breeding seasons is well established (Maclean 1970, Immelmann 1973, Lloyd 1999). In this study, the study sites were commercial wildlife and livestock farms supplied with artificial watering points. Water restriction therefore did not limit the lovebirds from drinking and did not prevent breeding or raising a brood (or subsequent broods). This was because the rains, not drinking water, determined the advent of good seed and insect crops, which in turn determined breeding success. *A. fischeri* X *A. personatus* hybrids at Lake Naivasha, Kenya, breed at any time in the year, mainly because of the bird's ability to feed on maize, which is widely grown (under irrigation) in the area throughout the year (Thompson 1987). Where rains occur twice a year in Kenya and when farmers grow the seed crop fed upon by this lovebird, they breed year round (Dodman pers. comm.).

Rosy-faced Lovebirds are entirely vegetarian (HN and MRP unpublished data) and whether a second brood is attempted may depend on rainfall and other climatic factors, through their ongoing influence on food availability. During the present study no rains came at the end of the first brood in May, and most plants that formed part of the lovebird's diet had lost their seeds. Seed pods had hardened after drying and became difficult to crush. Plant leaves remained available but were less preferred. If these factors are significant, it is unlikely that a second brood was raised.

The lovebird's dependency on water, with respect to habitat choice, however, was very pronounced, and their distribution was localised, apparently because of water availability. Lovebird nesting activity was conspicuously absent from locations where water was absent. Telemetric, feeding and drinking studies done alongside the breeding project revealed long flight patterns to water points and feeding grounds (Ndithia and Perrin 2006b).

Developments of young

The last-hatched chick realised a lower final asymptotic body mass, probably because sibling rivalry caused less feeding by the parent or because of contest, not scramble, competition for food. Hatching asynchrony is adaptive: large chicks survive while small ones have greater mortality rates.

Likely causes of nest failure

In addition to water and food availability, nest site location influenced the choice of breeding sites. All nests located in trees failed and predation was observed in at least two of the nests. Protection against predators was an important consideration and nesting success was higher for nests located on telephone poles and in nest boxes than in acacia woodland. One cause of nest failure was predation by a Boomslang *Dispholidus typus* found inside a lovebird nest 4.2m above ground. Boomslangs are good tree climbers and after the snake was removed from the nest, no eggs or young remained. After a few days, a neighbouring Rosy-faced Lovebird nest with seven eggs was lost, which was attributed to snake predation. Boomslangs have been recorded as a nest predator of Red Bishop *Euplectes orix* (Friedl and Klump 2000), Green Wood-Hoopoe *Phoeniculus purpureus* (du Plessus 1989), Water Thick-knee (Water Dikkop) *Burhinus vermiculatus* (Hockey *et al.* in press), and Cape Rockjumper *Chaetops frenatus* (Holmes *et al.* 2002). If all nests in which eggs and nestlings were missing were attributed to predation, then predation reduced the reproductive success by 73%.

Implications for conservation

Rosy-faced Lovebirds are only abundant locally in Namibia, in pockets of habitats forming a metapopulation. There is no apparent immediate threat to the populations nesting in rock faces (Harrison *et al.* 1997). However, with only eight of the 20 nests investigated here succeeding, and only 1.65 chicks being reared per nest, there is concern as to whether this rate of reproduction can support the metapopulation. Can a nest and breeding success rate offset lifetime mortality? With the de-listing of the species from Appendix II of CITES, one wonders what would happen to the population if commercial trade was reintroduced.

The current numerical and demographic status of the Rosy-faced Lovebird is unknown, so any policy suggesting trade should be resisted. Therefore, one questions whether the revision of the CITES status should be implemented. There is certainly a need to maintain population demographic and capture trend data through long-term field studies, to investigate at what age young in the wild start to breed, and to determine what impact this has on the viability of the species. Simmons (pers. comm.), as Namibia's ornithologist, was consulted by CITES; he recommended the down-listing because of the lovebird's widespread distribution (probably larger than its historical range because of all the new water points), and the ease with which it is bred in captivity. Although the lovebirds in this study population had low breeding success, this effect may be offset by the fact that most of the population breed in inaccessible cliffs that neither snakes nor even baboons are likely to reach. Thus, breeding success is probably much higher than indicated by the present study. In addition, the birds are capable of multi-broods while conditions are good. Last, there is no indication from parrot breeders that populations have declined (Simmons pers. comm.).

Recommendation

Since little is known of the biology of this species in the wild, further studies are necessary to contribute to knowledge that will act as a basis for decision-making. It is especially important to investigate whether pests and disease contribute to the nest failure and death of young reported in this study. Further research efforts should investigate avenues for increasing breeding success in wild populations, exploring reasons for breeding failure in trees and what these mean for the viability of the species.

Acknowledgements — We thank the South African National Research Foundation and the University of KwaZulu-Natal for research funding, DAAD (Deutscher Akademischer Austauch Dierst, the German Academic Exchange Programme) for a student bursary (to HN), and Prof Michael Meuhlenberg for academic and research planning. Drs John Mendelsohn and Chris Brown are thanked for acting as supervisors during the field study, and providing guidance and assistance.

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Received April 2005, accepted September 2006
Editor: RE Simmons