

PROPAGATION OF CAPTIVE RED-NECKED FALCONS

Falco chicquera

C.D. OLWAGEN and K. OLWAGEN

P. O. Box 1451

Pretoria

0001

Abstract — The Red-necked Falcon *Falco chicquera* is a threatened species in southern Africa. Seven individuals were established at a breeding unit near Pretoria during 1980 to study breeding behaviour and experiment with captive propagation techniques. The falcons were acquired from the wild as adults. Two pairs were established and one pair bred during 1981. During 1982 both pairs produced young. Both pairs bred again during 1983, but a yearling pair (hatched in captivity during 1982) made no attempt at breeding. Unlike other *Falco* species in captivity, the female adopts the dominant role and feeds the male during pair-bond feeding. Detailed observations on copulation, eggs, incubation and nestlings are presented including a new behavioural pattern termed toe-crossing. The male participated in incubation previously unrecorded. The moult of adults and juveniles is discussed. The vocalisations of Red-necked Falcons in captivity include at least three different calls.

Introduction

The Red-necked Falcon *Falco chicquera* is a small (mass 170 – 240g) but rapacious bird-killing falcon. Although recorded as closely associated with the distribution of Borassus palms *Borassus aegyptium* in Africa by authorities from Von Heuglin (1869) to Osborne (1981), this species is found mainly in arid regions of southern Africa. Repeated personal surveys of stands of Borassus palms in the north eastern Transvaal (Du Plessis 1955; J.C. Oosthuysen, *pers. comm.*) were completely negative for this falcon. In the Kalahari and Namib deserts, it is found where there are thorn trees, especially *Acacia erioloba*, along dry watercourses and pans. This falcon usually breeds in the natural depressions at the base of Borassus palm fronds or old stick nests, including those of the Lappet-faced Vulture *Torgus tracheliotus* and the Pied Crow *Corvus albus*.

Like all true falcons, it does not build its own nest. The Red-necked Falcon is listed as a vulnerable Red Data species with negligible information indicated (Siegfried, Frost, Cooper & Kemp 1976). Brown (1970) stated that "little is known" of the ecology of the African sub-species *F.c. ruficollis*. Osborne (1981) studied the Red-necked Falcon in Zambia but had few

detailed observations on breeding behaviour. Personal observations and field studies on the wild Red-necked Falcon were conducted irregularly over a period of four years in suitable habitats in southern Africa. Although recorded breeding in the Transvaal (Roberts 1910; Malherbe 1963), the Red-necked Falcon in the Transvaal appears to be on the edge of their breeding range. Apparently due to intensified farming activities, there seems to be a decline in their numbers.

To gain more knowledge on the breeding of the species, it was decided that a captive breeding project would be more appropriate because of the time and cost involved in field observations. Furthermore, the smaller falcons *Falco* spp. have shown a propensity towards breeding in captivity (Willoughby & Cade 1964). The Red-necked Falcon has been once reported successfully bred in captivity (Koehler 1970). This was apparently the Indian subspecies *F.c. chicquera*. Further attempts with the nominate race were unsuccessful (Bednarek 1973, 1974). Among the larger falcons, the Peregrine Falcon *F. peregrinus* has hatched eggs and reared young successfully in captivity since 1945 (Waller 1968; Peterson 1968).

Methods

Source of Birds

Seven adult Red-necked Falcons of unknown age were trapped at different localities in the Kalahari Gemsbok National Park (KGNP) during visits from December 1978 to May 1980 (Fig. 1). The falcons were captured using standard falconry techniques, and then weighed, sexed and measured (Table 1). Although a total of sixteen adults were observed, no immature falcons were observed during these visits.

Table 1
Measurements of Red-necked Falcons at time of capture

	Sex	Age	Wing length(mm)	Mass (g)
Pair A	F	Adult	238	235
	M	Adult	198	170
Pair B	F	Adult	235	239
	M	Adult	205	175
Pair C	F	Adult	241	225
	M	Adult	204	176
	M	Adult	185	172

Taming of Birds

Using falconry techniques, the falcons were tamed and prepared for captivity. Particular attention was paid to individual personality traits and potential adaptability of each falcon before pairs were selected and released together into the breeding chambers.

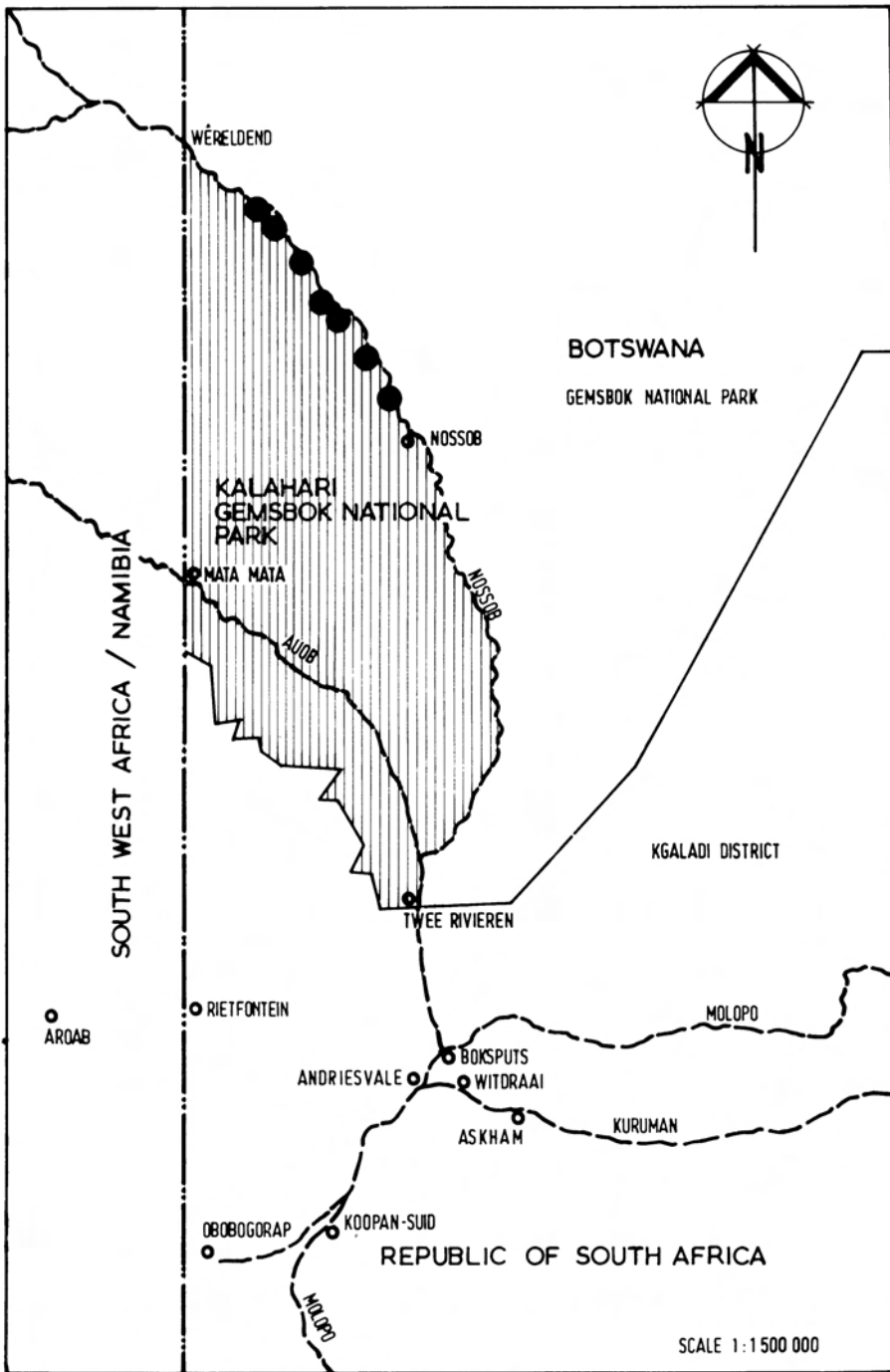


Fig. 1. Map of the Kalahari Gemsbok National Park showing capture sites of seven individual Red-necked Falcons for propagation in captivity.

Housing

The first breeding unit consists of a framed, treated timber construction and has three chambers, each measuring $3,6 \times 3,6 \times 2,4\text{m}$ and an observation room of $3,6 \times 1,8 \times 2,4\text{m}$ (Fig. 2). The height of the breeding unit had to be kept low because of high winds. The walls of the unit were additionally lined with "Malthoid" waterproofing membrane to seal the chinks and ensure privacy. The floors of the chambers consist of a 50mm thick layer of concrete stone to improve drainage and cleaning. The floor of the observation room consists of brick paving. Two-thirds of each chamber was covered with metal IBR-type roof sheeting. The remaining roof over each chamber was covered with $25 \times 50\text{mm}$ "Bonnox" welded mesh and 150mm below that a 50% shade cloth, fixed tautly for the birds' protection.

A variety of nests (old crow and man-made nests) and perches at various heights were erected in each breeding chamber. No artificial lighting was installed. The unit was built on a north-south axis. Observations were made daily through a 300mm square "one-way" glass window fitted to each breeding chamber. The seven falcons were housed in the first breeding unit during 1980-81, where one pair bred in 1981. Before the onset of the 1982 reproductive season, the first breeding unit was abandoned, and the falcons were relocated in a second breeding unit.

The second breeding unit again consists of a framed, treated timber construction but has five chambers, each with a floor area of 17m^2 and an observation room with a floor area of $3,3\text{m}^2$ (Fig.3). As with the first breeding unit, the height of 2,4m had to be maintained because of high winds. The walls are made out of 10mm thick asbestos cement flat sheeting and finished with an exterior quality acrylic paint. The floors of the chambers consist of a 50mm thick layer of concrete stone as before. The observation room floor is brick-paved. Two triangular asbestos cement roofs are provided at the corners of each breeding chamber and the remaining 90% of roof area are covered with 30mm \varnothing wire mesh. Fixed tautly 150mm below the wire mesh is a 50% nylon shade-cloth as before. The observation room roof is covered in asbestos cement sheeting. An old crow nest and a variety of perches are erected in each breeding chamber. Regular observations were made through a $300 \times 600\text{mm}$ 'one-way' glass window fitted to each breeding unit above the feeding platform. This platform consists of a timber frame covered with $10 \times 10\text{mm}$ 'Bonnox' welded mesh for easy cleaning. Water was available at all times in shallow plastic trays, but the birds seldom drank or bathed.

Diet and Feeding

Food, presented twice daily on the feeding platform had an average mass of 30-50g/falcon/day. This consisted of fresh day-old chickens, small passerine birds, doves, pigeons, mice and beef. Weather conditions normally dictated the quantity of food presented with more being consumed on cold days. The type and quantity of food presented was initially arranged to encourage pair-bond formation and courtship feeding. This was achieved by anchoring larger food items to the feeding platform, successfully inducing the pair to feed together. Small birds were presented freshly killed and fully feathered. Larger birds were defeathered and cut into suitable sizes. Mice were presented freshly killed. A vitamin-mineral preparation, 'Beefee' (Centaur Laboratories (Pty) Limited), was added to the food approximately every third day.

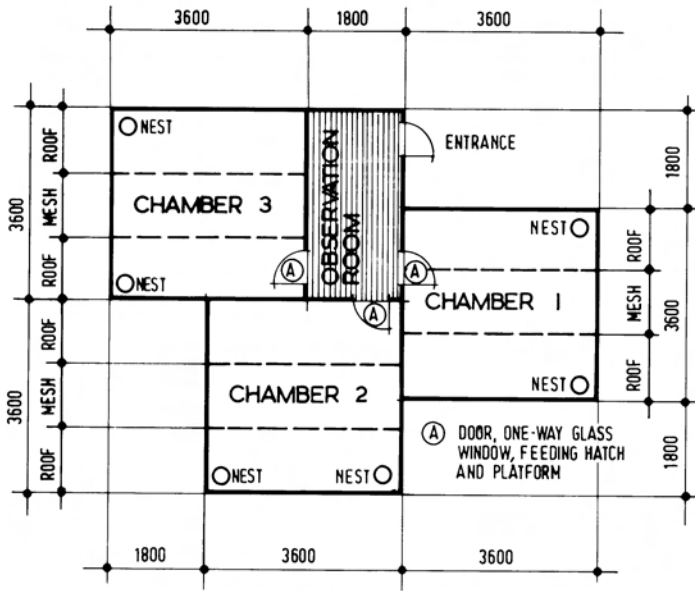


Fig. 2. Plan of First Breeding Unit. Scale 1:100

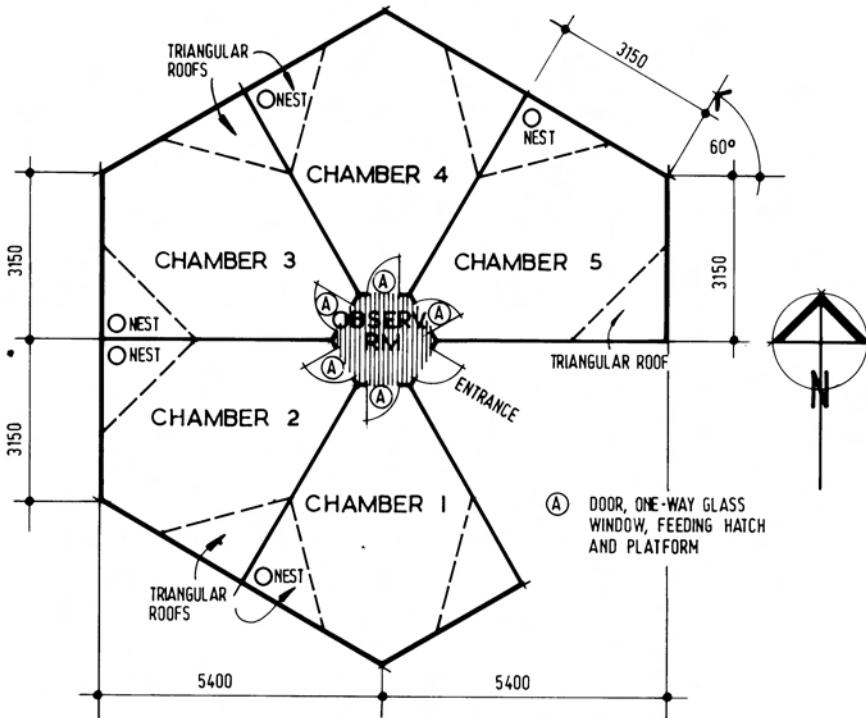


Fig. 3. Plan of Second Breeding Unit. Scale 1:100

Behavioural Responses

Although the falcons were tamed beforehand, they soon became wild once released into the breeding chambers. After several days in the breeding chambers, they usually became as wild as wild-caught adults. The falcons adapted readily to their chambers, and no injuries to any of the falcons occurred. The falcons had visual contact with the outside world only through the wire-shadecloth roof, and became excited or distressed when crows or other birds of prey flew over the breeding unit. Noise resulting from human activities in the vicinity of the breeding unit did not cause any alarm or distress. Observations through the 'one-way' glass windows caused no suspicion among the falcons. However, their own reflections in the 'one-way' glass windows were sometimes viewed suspiciously. Food presented by hand through an access panel at the feeding platform caused minimal distress. In most cases, the falcons came readily to the feeding platform to fetch their food, and sometimes even snatched food items out of hand.

Cleaning and filling of water containers was undertaken when necessary. This necessitated entering each breeding chamber to just beyond the entrance door. On such occasions, the falcons were alarmed and flew to the rear of the chambers. Each breeding chamber was thoroughly cleaned, only once a year, at the end of summer.

Observations

The birds were kept under surveillance throughout the year. They were observed for a minimum of one hour/day during the non-breeding season. Total observation time over a period of four years (April 1980 – April 1984) was 3 525 hours, with 2 337 hours during the breeding season and 1 188 hours during the non-breeding season.

Results

1979 and 1980 reproductive seasons

In 1979 only one pair of falcons (Pair A) was available for study. Their relationship developed to the early stages of courtship. The male died on 15 April 1979 and the female died on 4 July 1980. Post-mortems were performed, with the deaths ascribable to bacterial infection and pneumonia respectively. During 1980 a second and third pair of falcons (Pairs B and C) were obtained, tamed, prepared and released into separate breeding chambers. Both pairs developed a pair-bond soon after release into the chambers, and did not progress beyond courtship feeding. Another male was also obtained during 1980, but was held in reserve.

1981 reproductive season

Pair B began courtship feeding and this continued during copulation, egg-laying and subsequently (see later). Three of the four eggs laid hatched (Table 2, Fig. 4), but the fourth egg was trampled into the nest-material. Two of the chicks died after three days, with one chick reaching maturity. The surviving chick, a male (B1), was removed from parental care after it could fly. Kept under falconry conditions, it was studied until its death on 21 December 1982, from indeterminate causes. It had moulted into adult plumage between the beginning of March and mid-July.

Table 2

Egg mass and embryo survival of captive Red-necked Falcons

	Egg No.	Egg mass (g)	Survival point	Sex	Embryo mass (g)
Pair B/1981	B1	21,5	H	M	18,3
	B2	22,7	H/ED	—	18,3
	B3	25,3	H/ED	—	21,0
	B4	—	B	—	—
Pair B/1982	B5	24,8	H	F	21,1
	B6	23,6	H/ED	—	19,8
	B7	22,5	I	—	—
Pair C/1982	C1	21,5	H	M	18,3
	C2	24,1	H/ED	—	20,2
	C3	22,9	I	—	—
Pair B/1983	B8	21,2	H	M	17,8
	B9	22,6	H	M	19,2
	B10	25,2	H	F	21,0
	B11	23,4	I	—	—
Pair C/1983	C4	24,7	H	F	20,5
	C5	22,8	H	M	18,9
	C6	—	H	F	20,8

B – Broken trampled into nest material
H – Hatched, early death
I – Infertile
M – Male
F – Female

Pair C progressed to the courtship feeding stage. The male died on 17 August 1981 from indeterminate causes. The reserve male was then released into the breeding chamber with the female. No aggression was noted between the two falcons and their pair-bond slowly strengthened, but as with Pair A no reproduction occurred.

Relocation of the falcons in 1982

During 1982, before the onset of the reproductive season, pairs B and C were relocated in the more advanced second breeding unit. The relocation of the falcons caused no disruptions, evident by the success achieved during the 1982 reproductive season.

1982 and 1983 reproductive seasons

The 1982 reproductive season was only moderately successful (Fig. 4). Pair B bred again and three eggs were laid (Table 2). Two eggs hatched, one chick died after two days and one chick reached maturity. The unhatched egg (B7) was removed and sent to the CSIR in Durban for pesticide analysis (Table 3). The surviving chick, a female (B5), was removed from parental care after she could fly. Kept under falconry conditions, she was studied and prepared for captive breeding.

Table 3

Results of pesticide analysis conducted on Red-necked Falcon eggs by the C.S.I.R. at Durban, South Africa. February 1983 (mg/kg wet mass)

Egg	DDT	DDE	TDE	PCB	Dieldrin	Lindane
B7	n.d.	1630	n.d.	n.d.	30,1	n.d.
C3	n.d.	1320	n.d.	9690	24,3	n.d.

n.d. = Not detected.

Pair C's pair-bond was now well developed, copulation occurred and three eggs were laid (Table 2). Two eggs hatched, one chick died soon after hatching and one chick (C1) reached maturity. The unhatched egg (C3) was removed and again sent for analysis (Table 3). Chick C1, a male, was removed from parental care after it could fly. Kept under falconry conditions, it was also prepared for captive breeding.

The 1983 reproductive season was the most successful to date. Pair B laid a clutch of four eggs (Table 2), of which three hatched, and all three chicks reached maturity. The unhatched egg (B11) was removed and sent for pesticide analysis. Pair C laid a clutch of three eggs (Table 2) of which all hatched and the chicks reached maturity.

Pair D, consisting of female B5 and male C1 hatched in captivity during 1982, were released into a breeding chamber on 12 February 1983. Both falcons were still in immature plumage. At the beginning of March, both falcons began to moult and by mid-July were in full adult plumage. No aggression was noted between the two falcons, but the male displayed a reluctance to participate in any activities with the female. At the end of the 1983 reproductive season, no development towards a pair-bond was noted.

Reproductive behaviour

The breeding cycle of Red-necked Falcons in captivity is detailed in Fig. 4. This shows that the falcon is a dry-season breeder and confirmed observations by Osborne (1981). The first signs of sexual behaviour appeared in the first week of August. The level of pre-incubation activities, which included toe-crossing, nest-inspection, vocalization, courtship feeding and copulation, reached a peak in the second week of August.

Toe-crossing

At the onset of the breeding cycle in the second week of July, the falcons displayed previously undescribed behaviour, which was frequently observed before and after feeding. This is termed 'toe-crossing', and involved restless alternate crossing of the toes of one foot over the toes of the other foot. The falcon would also bend down and pull with its bill at individual toes. This odd behaviour continued for up to five minutes after commencement. It was usually terminated by 'rousing', an action during which all feathers are slowly raised, the bird shakes itself, and the feathers then settle slowly back

into place. This 'toe-crossing' was observed in both sexes, but more frequently in females, continuing for 25-30 days into the breeding cycle (Fig. 4). This previously undescribed behaviour is puzzling and should be investigated in other falcon species. This has been invariable in Pairs B and C prior to egg-laying, in three successive reproductive seasons.

Vocalization

The vocalization of the Red-necked Falcon included at least three different calls.

1. "Chip" or "chik"

- (a) Uttered loud and clear, this call was the most common. It was voiced by both sexes when excited, during feeding, prior to mating and when chicks were being fed. Calls were repetitive, abrupt, and of short duration. It was heard frequently throughout the reproductive season. Variation was noted between breeding pairs, and the tone of females was lower and sharper than that of males. Males used this call more frequently than did females.

When males plucked prey before feeding, a series of chips or chiks followed at about one per second. The call was uttered during feeding time, or when females were approached, and when the nest was visited. Females generally uttered this call while on the nest.

- (b) Uttered very softly, repetitive and short. This call was uttered mostly by the female when courtship-feeding the male or feeding the chicks.

2. "Kek-kek"

- (a) Uttered aggressively by both sexes, loud and clearly, this involved repeated but staccato calls (kek-kek-kek), lasting 5-10 seconds in duration. It was sometimes given for longer periods with pauses in between. This "aggressive" kekking was usually used as an alarm when wild birds of prey or crows flew over the breeding unit. Pronounced aggressivity was invariably noted towards hovering Black-breasted Snake-eagles *Circaetus pectoralis* and all Pied Crows *Corvus albus*, slightly less towards Black Crows *Corvus capensis*, but distinctly less towards Black shouldered Kites *Elanus caeruleus*, Black Eagles *Aquila verauxii*, Wahlberg's Eagles *Aquila wahlbergi*, African Hawk-Eagles *Hieraetus spilogaster*, Ovambo Sparrowhawk *Accipiter ovampensis*, Peregrine Falcons *Falco peregrinus minor* and Lanner Falcons *Falco biarmicus*.

- (b) Excited kekking was uttered by both sexes. These were loud and clear calls, but drawn out (keek-keek), about 3-4 seconds long, often involving a change in tempo. This call was usually uttered when there was activity at the nest, such as nest-inspections, or when food was presented through the feeding hatch.

3. "Kek-chirk"

Uttered by both sexes, mainly before copulation. These rhythmical sounds (kek-chirk-kek-chirk) lasted 4-5 seconds. The female usually took up a submissive pose, with bent head and body held horizontally, and calling. Males, however, usually uttered this call in an erect posture.

Courtship feeding and Pair-bond feeding

During courtship feeding, males of all other studied species of falcons apparently feed the female (Cade 1982). However, this did not occur with the captive Red-necked Falcon, with the female adopting the dominant role in courtship feeding and feeding the male. There was a clear increase in intensity at the commencement of breeding or "courting" in the last week of July.

Although the initial function was courtship, such feeding continued in more or less the same manner, but with less obvious excitement and without copulation. Clearly the function became the re-enforcing of the pair-bond, and for this reason it is subsequently termed "pair-bond feeding". In captivity the level and occurrence of courtship feeding and pair-bond feeding depends on the size and number of food items presented. During the non-reproductive season, if one large food item was presented, the dominant female would normally take possession of the food on the feeding platform and start to eat. The male would then join her, chipping and begging for food. The female would then feed the male. If the male happened to seize the food first, the female would approach him in a submissive posture, kekking and chipping. The male would then allow the female to take the food and she would feed him. If more than one small food item was presented, each would take an item and feed separately. Even when more than one small food item was presented, pair-bond feeding often still occurred. It would be inaccurate to term such pair-bond feeding "courtship" feeding, and it is suggested that they be differentiated. In contrast to regular feeding of the males by the females, males presented food to females only during the incubation period and after the chicks had hatched. The large size of a food item obviously stimulated pair-bond feeding in this species. However, in similar situations, quarrelling was often observed in captive Lanner Falcons *Falco biarmicus*. It is suggested that this behaviour therefore possibly does not occur in Lanners, where quarrelling was sometimes serious.

Nest activities

Observations indicate that the nest itself served as a stimulant to reproductive activity. During the last two weeks of July and the first week of August, captive pairs engaged in nest-site examination (Fig. 4).

This consisted of either bird going repeatedly on and off the nest, sometimes standing in the cup so that only their heads were visible. All nest-sites were thoroughly investigated, and of possible choices, the old crow nests were invariably chosen. After final selection, there was great excitement, with both sexes calling frequently. Females spend much time in the nests, where they fidgeted with the nesting material. No form of nesting material was ever added or removed by the falcons, nor any attempts made to change the shape of the nest.

Copulation

Copulation in captive Red-necked Falcons occurred during the first and second week of August. The female encourages or incites the male to mate. She stands bent over with her head held low, so that her body forms an angle of approximately 15-30° to the horizontal. The tail held in line with the body

and the tail feathers are held together. The male takes up his position on her back, on his elbows, with toes in balled fists while he flaps and balances with his wings. His tail is brought down vertically to one side so that the cloacas are in contact. During copulation, both falcons call (kek-chirk) for four to five seconds. Copulation occurs more than once over extended periods, and lasts for two to ten seconds. Similar to other birds of prey, copulation takes place up to three times a day over a period of 14 days until the last egg has been laid, and the female begins incubation.

Eggs and incubation

Eggs are creamy-white, densely spotted with reddish-brown over the entire surface. The pigmentation tends to fade as incubation progresses, and the eggs become stained with excreta. Clutches range from three to four (n=5), and a total of seventeen eggs were laid during the study. Captive females lay their first eggs between 3-20 August at intervals of one to three days. Although egg examinations were kept to a minimum, the captive laid eggs corresponded in all respects of those described by Colebrook-Robjent & Osborne (1974) in Zambia.

The measurements of the eggs were: 44,3 – 46,4 × 31,8 – 34,6 (n=16). The mean weight of 16 eggs less than 24 hours old was 23,3g (range 21,2 – 25,3g) (Table 1). The egg weight loss after incubation averaged 15,9%.

Incubation began when the last egg of the clutch was laid. Osborne (1981) stated that only females incubate, but was unable to obtain detailed observations (*pers. comm.*). With detailed observations possible in captivity, it was determined that the captive males did participate in incubation. This was for 15 to 20% of the observed periods of incubation. Males were usually observed incubating after sunrise, at mid-day, before sunset, and during the course of the day when females were feeding. The mean incubation period in captivity was between 34-35 days and corresponded with that of Red-necked Falcons in the wild (Osborne *op. cit.*). The period of incubation is calculated from the day on which the last egg of clutch was laid to the day on which the first chick hatched. The incubation period of the Red-necked Falcon is longer than that of any other falcon or kestrel of similar size (Brown & Amadon 1968).

Young

Of the 16 eggs laid, 13 young hatched, four died soon after hatching and nine reached maturity. The day-old chicks were very small, covered in creamy-white down, with a mean weight of 19,7g (range 18,3 – 21,1g) (Table 2). They were very weak after hatching, and did not eat for the first 24 hours. After this they were fed by the female, and were a little more active. Soft “peep” sounds could be heard from time to time. The statement by Koehler (1970) that she could distinguish between male and female calls, even in the egg, is disputed. The reasons for the death of the four young soon after hatching is unknown. The three unhatched eggs exhibited no embryonic development and were assumed to be infertile. The young were brooded constantly by the females for the first ten days, except when the females were eating. The males would then brood the young. Within 15 days, the

quills of the wing and tail feathers began to appear. At 18 days, the quills of the rest of the feathers appeared. At 23 days, most of the down has been replaced, and the young were able to move around the nests. After 34 to 35 days the young were fully feathered (hard-penned), except for some down on the head and shoulders.

The nestling period ranged between 34 to 35 days, and corresponded with the known nestling period of wild Red-necked Falcons (Osborne 1981). The nestling period of the Red-necked Falcon is longer than that of any other falcon or kestrel of similar size (Brown & Amadon 1968). Captive females lost interest in the young at about 30 days after hatching, but the males continued to feed the young in the nest.

Nest hygiene

Observations show that the captive Red-necked Falcon does not observe any form of nest hygiene. Food remains are not removed from the nest, but are eventually trampled into the nest-material. This happened even when there are eggs or young in the nest. The adult females and the young defaecate directly into the nest, and seldom leave it or move to the rim of the nest to perform this function.

Moulting

Information on moulting is applicable only to adult and juvenile falcons in captivity. Adults begin moulting during the breeding season (from the third week of September) until it is completed after about four and a half months (early in February, Fig. 4). Three captive-bred juveniles commenced moulting at the beginning of March, approximately five and a half months after hatching. At mid-July, about four and a half months later, they were in adult plumage. The sequence of moulting in Red-necked Falcons is similar to other falcons and kestrels (Brown & Amadon 1968). The onset of moult is first indicated by the loss of one of the large primary feathers. The falcons usually lose the seventh primary feather and the moult then proceeds in both directions. The moult is completed with the replacement of the outermost primary. In the interval between, most of the rest of the plumage is shed and re-grown.

Feeding behaviour

The falcons generally plucked most of the feathers of their prey, while head- and neck-feathers were usually eaten with the rest of the bird, and discarded much later in small oval-shaped pellets. The legs and claws of small birds were eaten and digested, while the meat on the bones of large birds was eaten off and the bones rejected. Approximately 5 to 10% of the pelts of mice were removed by the falcons, and the remainder of the mice were eaten whole except for the entrail, which were rejected. The young were fed on small pieces of meat, torn by the females from the food brought to them by the males. Only flesh *per se* or together with soft bones were fed to the young. Heads, legs, wings, large bones and skin with feathers or fur were not fed to the young, but were eaten or rejected by the females. Food left-over, if any, were regularly removed from the feeding platform and the latter were washed once a week.

During the breeding season, food caching was observed among adult pairs. Food remains were normally cached in shady places, on the horizontal framework of the breeding chamber above floor level. Food caching-places seemed to be carefully selected, and no ants or flies were ever observed at the cached food. Food caching started approximately when the first egg was laid, and was discontinued once the young were flying. Four to five food remnants were cached per week. The caching of food was more frequently observed among males than females. Food remnants, which were left in the nest, seem not to be cached. These were normally trampled into the nest.

Play behaviour

Play behaviour was observed among adults in the non-breeding season. Objects like stones and pieces of bark were utilised as toys. Both sexes would engage in vigorous play for up to 30 minutes at a time once or twice daily. Individual toys were selected, and most play was observed on the floor of the breeding chamber. Play consisted of repeated mock attacks with the birds grabbing at the "toy" with one or both feet, jumping away and fluttering around the "toy". Two to three toys were normally stored in the nest or on the feeding platform. Play behaviour among juveniles was also observed, and corresponded with that of adults except for the storing of toy objects, which the juveniles never did.

Play behaviour is thought to develop "footing" ability, condition and possibly strengthens the bond between sexes when toy-objects are stored in nests or on the feeding platform. The play behaviour of the Red-necked Falcon is not fully understood and merits further study.

Discussion

The Red-necked Falcon is a little-known, threatened bird of prey, personal surveys covering several years indicate it has apparently declined in the Transvaal. This includes total disappearance from areas where they are formerly recorded as having bred (Gunning & Roberts 1911; Roberts 1922; Malherbe 1963). This species is difficult to maintain in captivity on account of its small size. In spite of this, reasonable breeding success was obtained. The study was conducted to simulate natural conditions as far as possible, with the minimum of human interference. The reasons are:

- (a) Only limited stocks of falcons were available for the study;
- (b) The use of artificial techniques such as artificial incubation was not attempted as the risks were considered too great;
- (c) The small size of the newly hatched chicks made hand-rearing undesirable and would have induced possible imprinting;
- (d) Breeding observations on "natural" captive-bred Red-necked Falcons would be more easily comparable with wild Red-necked Falcons, to result in more knowledge and understanding of this apparently endangered species, described as "vulnerable" by Siegfried *et al.* (1976).

Eggs which did not hatch were considered infertile, but pesticide residue analysis of these eggs showed that, in some instances, fairly high levels of pesticides were apparent (Table 3). This poses additional problems. The food-source of these birds such as day-old chickens, domestic mice, wild-

caught House Sparrows *Passer domesticus*, feral pigeons *Columbia livia* and Red-billed Quelea *Quelea quelea* could have been contaminated. Therefore a purer food-source may have to be investigated. Analysis of the various food sources is still pending.

The total cost in maintaining and running this private propagation project is based on the cost per falcon/day. This approximates R2,93/falcon/day. The total cost over a period of three years (April 1980 – April 1983) was R19 250,00. All expenses were self-financed.

Conclusion

Although the reproductive success of the falcons for the first two years left much to be desired, the knowledge and information acquired from this project, the first of its kind on the African subspecies of the Red-necked Falcon, has shown that these falcons can be successfully propagated in captivity. Data on certain behaviour, which is difficult to obtain under wild conditions, was collected which contributes to the biology of this falcon. Further refinements in management methods, involving additional knowledge of factors such as disease, nutrition, and artificial propagation techniques, would permit more efficient and economical production. Such captive-bred falcons would later be released in suitable habitat in the wild, where this species has apparently been eliminated (Gunning & Roberts 1911; Roberts 1922; Malherbe 1963).

The following factors are considered to have been important in the reported captive propagation success:

- (i) Wild adult falcons were captured which had not been imprinted on man.
- (ii) Organised and thorough planning and preparation for the trapping, handling and transport of the falcons from the wild was undertaken.
- (iii) The preparation and selection of falcon pairs, prior to release in the breeding chambers, by means of accepted falconry methods and techniques.
- (iv) The successful design of the breeding units, which gave the falcons the necessary privacy and security, particularly with regard to human activities.
- (v) The provision of different types of nests which permitted a choice of the most desired type.
- (vi) Adequate fresh and balanced food, presented twice daily.
- (vii) The method of food presentation to encourage pair-bond feeding.
- (viii) Long-term freedom in the breeding chambers with a minimum of human interference.

Captive propagation is still very much in its infancy, especially in South Africa, and even if birds of prey are provided with every facility, there is no guarantee that they will breed. Providing suitable breeding chambers, purchasing incubators, brooders and other equipment which may be required, is most expensive. Most of all, it is decidedly time-consuming. The future of captive propagation holds exciting possibilities. This means that it should be possible to ensure that no species of bird of prey becomes extinct. Some species may eventually be unable to sustain themselves as populations in the

wild, if their optimum habitats are destroyed. However, if man chooses to conserve them, they can apparently be kept as captive populations.

Acknowledgements

The interest and enthusiastic co-operation of the National Parks Board of Trustees and the Division of Nature Conservation of the Republic of Bophuthatswana is gratefully acknowledged. The Transvaal Nature Conservation Division kindly provided the necessary permits. We thank P. le S. Milstein, N.H.G. Jacobsen, C.J. Nel and T.O. Osborne for commenting on the draft manuscript. Special thanks to T.J. Cade and J.D. Weaver for valuable advice and assistance on captive propagation techniques.

REFERENCES

- BEDNAREK, W. 1973. An attempt to breed Red-headed Falcons *Falco ch. chicquera*. *Captive Breeding of Diurnal Birds of Prey* 1(4): 7-8.
- BEDNAREK, W. 1974. Observations on breeding experiments in captivity with Peregrines *Falco peregrinus brookei*, Red-headed Falcons *Falco chicquera chicquera*, and Sparrowhawks *Accipiter nisus*. *Captive Breeding of Diurnal Birds of Prey* 1(5): 3-4.
- BROWN, L. 1970. *African birds of prey*. London: Collins.
- BROWN, L. and D. AMADON. 1968. *Eagles, hawks and falcons of the world*. London Country Life.
- CADE, T. J. 1982. *Falcons of the world*. London: Collins.
- COLEBROOK-ROBJENT, J.F.R. and T.O. OSBORNE. 1974. High density of the Red-necked Falcon *Falco chicquera* in Zambia *Bull. Brit. Orn. Club* 94: 172-176.
- DU PLESSIS, S.S. 1955. The Borassus palm in the Transvaal. *Fauna and Flora* 6: 85-93.
- GUNNING, J.W.B. and A. ROBERTS. 1911. New records and descriptions of new species of birds in the Transvaal Museum collection. *Ann. Transv. Mus.* 3: 109-118.
- KOEHLER, AMÉLIE. 1970. Red-headed Merlins breed in captivity. *Captive Breeding of Diurnal Birds of Prey* 1(1): 16-20.
- MALHERBE, A.P. 1963. Notes on the birds of prey and others at Boshhoek, north of Rustenburg during a rodent plague. *Ostrich* 34: 95-96.
- OSBORNE, T.O. 1981. Ecology of the Red-necked Falcon *Falco chicquera* in Zambia. *Ibis* 123: 289-297.
- PETERSON, R.S. 1968. The domestic raising of Peal's Peregrine Falcon. *J.N. Am. Falconer's Assoc.* 7: 64-67.
- ROBERTS, A. 1922. A review of the nomenclature of South African birds. *Ann. Transv. Mus.* 8: 187-272.
- SIEGFRIED, W.R., P.G.H. FROST, J. COOPER and A.C. KEMP. 1976. South African Red Data Book – Aves. *S.A. Nat. Sc. Prog.* 7: 30.
- VON HEUGLIN, T. 1869. *Ornithologie Nordost-Afrika's*. Berlin: Fischer Cassel.
- WALLER, R. 1968. A report of the first successful breeding of Peregrine Falcons in captivity. *J. N. Am. Falconer's Assoc.* 7: 45-57.
- WILLOUGHBY, E.J. and T.J. CADE. 1964. Breeding behaviour of the American Kestrel (Sparrow Hawk). *Living Bird* 3: 75-96.