

Aspects of the Breeding
Ecology of the
Red-necked Falcon
Falco chicquera horsbrughii
and its Hunting Association with the Gabar
Goshawk
Micronisus gabar in the
South-Eastern Kalahari

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SUMMARY

The breeding ecology of the Red-necked Falcon *Falco chicquera* is investigated in the Kalahari Gemsbok National Park. Breeding takes place early, mostly during September, and hatching occurs just before the first summer rains. It is suggested that this timing could be to take advantage of newly-fledged prey species. Nest spacing is in relation to waterholes. High predation rates on eggs and nestlings were observed, as well as a high turnover for males in individual territories. The hunting association with the Gabar Goshawk *Micronisus gabar* is documented.

INTRODUCTION

The Rednecked Falcon *Falco chicquera* occurs in southern Africa mostly in the Kalahari and Namib deserts, along dry watercourses with large trees (Maclean 1958; Brown 1988; Braine 1987). In Zambia (Osborne 1981) and Botswana and Mozambique (Steyn 1982) it is largely confined to areas with *Borassus* palms. In South Africa the Kalahari Gemsbok National Park supports the only major breeding population. However, it has also been reported sporadically from the western Orange Free State, western Transvaal and northern Kruger National Park (Steyn 1982).

STUDY AREA AND METHODS

The Kalahari Gemsbok National Park is situated in the south-western region of the Kalahari semi-desert, between the dry Auob and Nossob Rivers and the surrounding dune area. These dry river systems have eroded the red sand dunes to expose the underlying limestone plains. The Nossob River, which runs the full length of the Park along its eastern boundary with Botswana, is dominated by stands of *Acacia erioloba* but in the southern part the *Acacia haematoxylon* is more prevalent. Detailed descriptions of the vegetation are provided by Leistner (1967) and Leistner & Werger (1973). Rainfall occurs in summer to early autumn (November to April) with more than 50 % falling between January and April (Nel 1990).

Red-necked Falcons were studied in the northern half of the dry Nossob River and in the surrounding dunes from Kaspersdraai in the south (25°36'S; 20°42'E) to Union's End (24°50'S; 20°03'E) in the north, a distance of 167 km. Each nest site located was plotted on a map and examined at least five times during each breeding season. Observations were made between August 1988 and November 1991, covering four breeding seasons. Red-headed Finches *Amadina erythrocephala* were mistnetted during the falcon breeding season of 1988. Observations on the hunting association between the Red-necked Falcons and Gabar Goshawks were also made.

RESULTS

Timing of breeding

Most clutches were laid during August (n=13; 68%) and September (n=6; 32%) and hatched during September (n=9; 69%) and October (n=4; 30,7%) during all four breeding seasons (Fig. 1). Hatching occurred just before the first summer rains, when the Kalahari is at its driest and cover sparsest. It is also a time when seed-eating birds such as the Red-headed Finch, Scaly-feathered Finch *Sporopipes squamifrons* and Grey-headed Sparrow *Passer griseus* occur in large non-breeding flocks at waterholes to drink (pers.obs.). 1988 immature Red-headed Finch numbers (Fig. 2) peaked at waterholes during August and September (pers. obs. and trapping results 1988) and probably reflects the annual pattern for this winter-breeding species (Maclean 1985).

Although many seed eating species may breed in winter after rains the Red-headed Finch is the only small passerine that regularly breeds mainly in winter. It is suggested that the breeding season of Red-necked Falcon is unusually early in the spring so that advantage can be taken of the new inexperienced Red-headed Finch fledglings which become available when the falcon chicks have just hatched.

Nest placement

All eggs were laid in old Black Crow *Corvus capensis* nests. One nest with three half-grown Red-necked Falcon nestlings was found in an *A. erioloba* tree which also contained the nest of a Greater Kestrel *Falco rupicoloides* with three fully-feathered nestlings. The two nests were approximately four metres apart.

All nests were in *A. erioloba* trees. Mean nest height was 6.8 m (n=14; range 3.8 - 8.9 m; SD = 1.8 m) above ground level. Mean tree height was 9.0 m (n = 13; range 6 - 12.3 m; SD = 1.9 m). The canopy diameter of nesting trees average 10.0 m (n=13; range 3.7 - 19.4 m; SD = 4.6 m). Nests were placed in forks (n = 8; range 4 - 10; SD = 1.8). Of 16 nests, five (31.3%) were on the southern side of the tree, two (12.5 %) faced south-west, three (18.8 %) west, three (18.8%) east, one (6.3%) north-east and two north (12.5%). Thus 62.5% of all nests were situated on the south, south-west or western side of trees.

The mean distance of nests from the nearest waterpoint was 3.1 km (n=16; range 0.2-9.9 km; SD=2.8 km) and the mean distance between waterholes in the study area was 10.7 km (n=16; range 3.9 - 22.5 km; SD=5.3 km). Pairs observed in the dune habitat (n=7) were always associated with waterholes, which shows clearly an association with waterpoints, and it is likely that the provision of a local abundance of prey species attracted to the water is the reason. Except in one instance, a new nest was used every year for each nesting attempt by the falcons.

Figure 1. Rainfall and Red-necked Falcon clutches hatching per month.

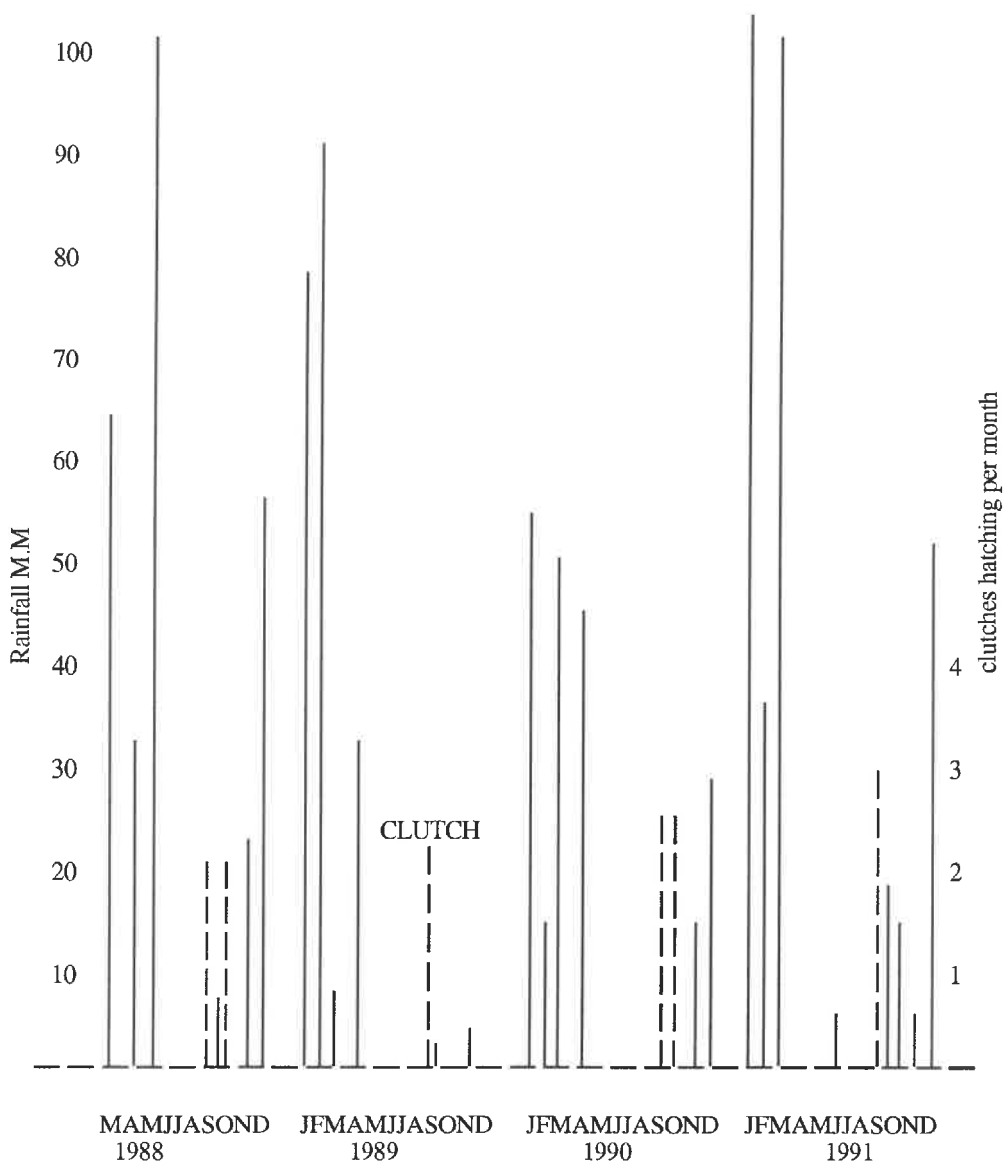
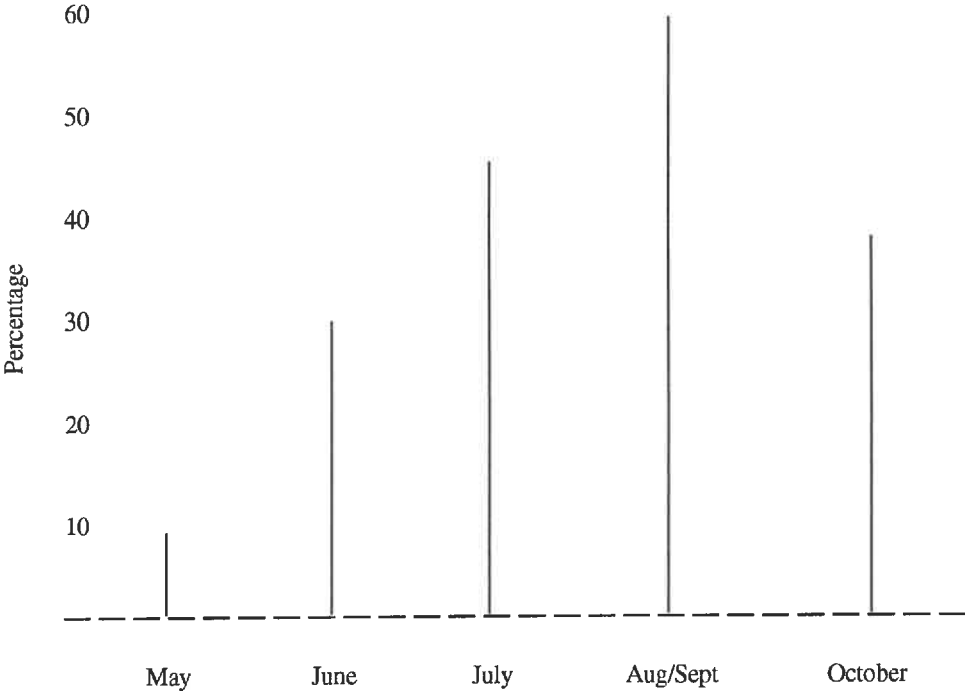


Figure 2. Percentage of immature Red-headed Finches in trap samples for 1988



Clutch size

Of 19 clutches examined, six (31.5%) contained four eggs and 13 (68.5%) three eggs, with a mean clutch size of 3.3 eggs.

Breeding success

From 1988 to 1991 a total of 19 breeding attempts were monitored. Of these, 10 were successive attempts by four known pairs. The other (n=7) were for random pairs found along the Nossob River and in the dunes away from the river (n=2). A total of 63 eggs were laid of which 36 hatched (57%) and 21 young (58% of eggs that hatched) fledged successfully. This gives a recruitment of 1.1 young per pair per year (ypp) (Tables 1 & 2).

Of the four known pairs, however, breeding success varied between 0 (n=2 years) and 1.7 ypp (n=3 years), with a mean of 0.9 (Table 1). For the other nine nests found a success rate of 1.3 ypp was observed (Table 1). Although the territories of these pairs were examined each year, the birds or their nests were seldom found.

Table 1. Breeding statistics of individual pairs of Red-necked Falcons in the Kalahari Gemsbok National Park

Pair	1988			1989			1990			1991			YPP
	Egg	Hatch	Rear	Egg	Hatch	Rear	Egg	Hatch	Rear	Egg	Hatch	Rear	
NOS	3	0	0	3	2	2	N/F			4	3	3	1.7
KAN	3	1	0	N/F			3	3	0	N/F			0
RO	N/F			3	1	1	3	0	0	4	4	0	0.3
KO	N/F			N/F			3	3	3	3	0	0	1.5
TOT	6	1	0	6	3	3	9	6	3	11	7	3	0.9
Random Nests													
MA	4	0	0										
BA	4	3	3										
OK	3	3	3										
BED	3	3	3										
KA							4	4	0				
KAG							3	0	0				
UE							3	3	3				
KW										4	3	0	
LA										3	0	0	
TOT	14	9	9				10	7	3	7	3	0	1.3
Overall													
TOT	20	10	9	6	3	3	19	13	6	18	10	3	1.1

N/F = nest not found

Table 2. Breeding statistics of Red-necked falcons in the Kalahari Gemsbok National Park

	1988	1989	1990	1991	Total
Total nesting attempts known	6	2	6	5	19
Clutch laid/failed to hatch	2	0	2	2	6
Clutch laid/hatched/fledged	3	2	2	1	8
Clutch hatched/killed by predator	1	0	2	2	5
Young fledged/breeding pair	1.5	1.5	1.0	0.6	1.1

Table 3. Prey pursued by Red-necked Falcons

Species		No
Birds		
Yellow Canary	<i>Serinus flaviventris</i>	1
Cape Turtle Dove	<i>Streptopelia capicola</i>	2
Namaqua Dove	<i>Oena capensis</i>	1
Red-headed Finch	<i>Amadina erythrocephala</i>	1
Scaly-feathered Finch	<i>Sporopipes squamifrons</i>	2
Grey-headed Sparrow	<i>Passer griseus</i>	1
Lilac-breasted Roller	<i>Coracias caudata</i>	1
Mammals		
Striped Mouse	<i>Rhabdomys pumilio</i>	2
Termites		
<i>Hodotermes sp.</i>		

Predation on eggs and nestlings

Of 19 clutches laid, the eggs of 31.6% were preyed upon by unknown predators (Table 2). As far as could be ascertained, no clutches were abandoned, although this was possible, as indicated by broken egg-shells in the nests. Of clutches which hatched (Table 2), the young of five broods were killed by predators. On two occasions remains of nestlings were seen hanging from branches around the nests or had fallen to the ground. No predator was ever identified but species such as Honey Badger *Mellivora capensis*, African Wild Cat *Felis lybica* and Pale Chanting Goshawk *Melierax canorus* abound in the area.

Post-fledging dependence

A young male ringed less than a week after fledging was retrapped together with both parents 4 km away from the nest site 64 days later. A young female was retrapped at least 71 days after fledging and two kilometres from the nest site, still with the parents.

Nest site fidelity

Rooikop territory

In the Rooikop territory, a high degree of adult replacement was observed between 1988 and 1990. For example, an adult male (6-59074), captured on 12 November 1988 in this territory, was replaced by another male (6-59093) ringed here six months later on 12 May 1989. It in turn was replaced by male 6-59072, first captured seven months later on 17 December 1989 and recaptured on 14 June 1990. The adult female from this territory (6-63434) was colour-ringed on 24 June 1990 and still occupied the territory 16 months later at the termination of the study.

Nossob territory

Adult male 6-59033 was ringed near Nossob Camp on 14 August 1988 and recaptured there 20 months later on 24 March 1990. The female of this pair (6-59038) was ringed on 8 September 1988 and recaptured 37 months later on 20 October 1991, still in the same territory. The very wary male could not be retrapped, but was most probably the same male.

Kwang territory

The adult female (6-59100) was ringed on 17 September 1989 and subsequently retrapped in the same area four months later on 27 January 1990. This bird was not trapped again.

Marie's Windmill

Adult male 6-59035 was ringed on 16 August 1988 and the adult female 6-59096 on 10 May 1989. Both birds were replaced by a different pair trapped on 18 June 1990 (adult female 6-63427 and 28 June 1990 (adult male 5-84947) respectively. It is not known if the former disappeared from the territory before the new pair arrived, or were ousted from it.

Hunting success

Of 12 observed foraging attempts on various prey species 42 % (n=5) were successful with the majority of items pursued being small birds and mice (Table 3). Termites were also taken occasionally after rains. Two bat (unidentified species) kills were observed during daylight hours, when they were accidentally disturbed from a tree and captured by a female Red-necked Falcon while flying.

Population density

A population survey conducted in the study area along the Nossob River valley yielded a total of 21 pairs with a mean inter-pair distance of 7.2 km (n=19; range 1.9 - 15.5 km ; SD = 3.3 km). A similar survey was conducted in the dunes in the northern third of the park where 7 adjacent pairs were located with a mean inter-pair distance of 15 km (n=4; range 13-18 km; SD=2.2 km). Further south from Kaspersdraai to Twee Rivieren (26°28'S; 20°37'E) 6 pairs were seen with an inter-pair distance of 16.5 km (n=4; range 7.5-28.0 km; SD = 8.8 km), thus giving a minimum of 27 pairs for the whole of the Nossob's 300 km dry course inside the park. However, the area to the south was not as intensively surveyed as the northern part and may have contained more pairs. No similar data are available for the Auob River.

Hunting association with the Gabar Goshawk

Finch-Davies & Kemp (1980) suggested that the sharp-winged Red-necked Falcon and round-winged Gabar Goshawk *Micronisus gabar* are often closely associated with one another in what may be a mutually beneficial arrangement, in which the goshawks may flush from cover birds which are then preyed upon by the falcon. In turn the latter may force birds into cover where they are more readily captured by the goshawks. This association was also observed in the present study and Red-necked Falcons and Gabar Goshawks often came down to the Balchatri together while I was trapping either species. In addition, 71.4 % of Red-necked Falcon territories (n=21) supported a pair of Gabar Goshawks. These observations prompted an investigation into the interactions of these two bird-eating species.

The following observations of co-operative hunting were documented. During September 1990 a Red-necked Falcon (sex unknown) stooped and knocked a Red-headed Finch to the ground, but before the falcon could return to the kill it was taken by a Gabar Goshawk.

On a second occasion (15 August 1991 at Bitterpan) I observed a Red-necked Falcon and a pair of Gabar Goshawks co-operatively hunting a Yellow Canary *Serinus flaviventris*. The canary, chased by the falcon, dived into an *Acacia mellifera* bush. One Gabar Goshawk immediately followed it into the bush while the other hovered just above. The falcon, however, remained some 15 metres above the bush and as soon as the canary broke cover, unsuccessfully stooped at it. This sequence was repeated once more before the birds disappeared from sight. The eventual outcome

is not known.

On a third occasion (2. October 1991), a female Gabar Goshawk and a male Red-necked Falcon were observed chasing a Grey-headed Sparrow. The falcon chased the bird until it dived into the canopy of a tree at which time the goshawk went in after it while the Red-necked Falcon remained some 10 metres above the canopy. As soon as the sparrow broke cover the falcon made an unsuccessful stoop. The sparrow then took cover in the canopy of a nearby tree but was again flushed by the goshawk and soon afterwards captured in an exhausted state by the falcon.

A fourth instance involved a male Red-necked Falcon and a female Gabar Goshawk perched together less than one metre apart on the top of a dry tree. As soon as the goshawk flew off, it was followed by the falcon until it perched some 50 metres off. The goshawk later took off again and was immediately followed by the falcon. This happened three times and strongly suggests that the falcon was actually following the goshawk. This behaviour was again observed at Kameelsleep, where a falcon and a goshawk were seen perched together. As soon as the goshawk flew off (undisturbed) the falcon followed it until they disappeared from sight.

DISCUSSION

As was the case in Osborne's study (1981) the Red-necked Falcons in the study area occupied a relatively undisturbed and pristine environment, except for the presence of artificial boreholes. No pesticides were ever used in this area.

Eggs were laid mostly during the driest months of the year and hatched during September and October. At this time the food requirements of falcons feeding young birds were greatest. Large flocks of non-breeding seed-eaters are then present in the study area and gather to drink at the waterholes, providing an abundant source of food for the breeding falcons. Red-headed Finches breed during the winter (Maclean 1985) and large numbers of recently fledged young (Fig. 2) also gather at waterholes to drink, and due to their inexperience may constitute a more easily available food source. Groundcover is less dense during September and October, which may make prey more vulnerable (Osborne 1981).

After the first good summer rains, large numbers of larks, finch-larks and quail move into the area and breed. Since this occurs only 2-3 months after young Red-necked Falcons fledge, these birds may provide a source of inexperienced young prey for the young falcons. Flying termites (*Hodotermes* sp.) are also abundant at this time and are frequently eaten by young falcons on the wing. In this study area, Osborne (1981) speculates that the longer grass during the rainy seasons may make it more difficult for falcons to hunt young seed-eaters. This is probably not a major factor in the Kalahari. The grass, especially on the trampled areas around the boreholes, is never very dense and prey visibility is generally good.

All breeding attempts were in old Black Crow nests (Maclean 1958; 1985) and except in one instance, a new nest was used each year by the individual pairs of Red-necked Falcons. Osborne (1981) found that a higher frequency of falcon pairs used the same nests in subsequent years, probably because palm trees provide a more stable breeding platform than old crow nests.

Most nests were situated on the outer lower perimeter of the trees and a significant number of all nests observed (62.5 %) faced south, south-west or west; this is the coolest side of the tree and also shelters nests from the predominant north-easterly winds. Nests were placed closer to the ground in this study as compared with those in the Zambian study (Colebrook-Robjent & Osborne 1975).

Brown (1988) suggested some spatial segregation between the Red-necked Falcon and Greater Kestrel pairs in the Namib. No evidence of this was found in the KGNP where the two species were often seen in close proximity, as is illustrated by the two breeding together in one tree.

Clutch size in this study consisted mostly of three (68.5%) and four (31.5%) eggs and was thus similar to clutch sizes reported by Osborne (1981), Steyn (1982) and Olwagan (1983).

Breeding success averaged 1.1 ypp while in Zambia this figure was 1.3 ypp (Osborne 1981), and 1.5 ypp in a captive study by Olwagan (1983). Of all eggs laid 57 % hatched and thus similar to observations for Zambia, where the hatching rate was 56 % (Osborne 1981). The high percentage of 42.8 % of eggs failing to hatch was due mainly to predation. However, a small percentage may have been infertile. This is similar to the 44 % observed for the Zambian population (Osborne

1981). Of all young that hatched, 41.6 % did not fledge due to predation.

Osborne (1981) cited winds and predation by monkeys and avian predators for mortality of young birds. In the present study there were no monkeys and no evidence of wind destruction, and losses were probably largely due to predation.

The post-fledging periods, of at least 64 and 71 days respectively, are considerably longer than the 24 days mentioned by Osborne (1981). This parental dependence may be variable and governed by environmental factors during the breeding season.

In 10 male pair-years a 40%, and in females a 12.5% (n=8 pair years) turnover was noted. This high turnover in males may be due to mortality and/or movements of the individuals. There is some evidence for a degree of nomadism since in some territories birds breed each year, while in others, pairs were totally absent in following years. It is possible that the population as a whole is subject to annual fluctuations (Pickford *et al.* 1989), as is the case with Pale Chanting Goshawks and Greater Kestrels in this study area (pers.obs.). Some territories may be marginally suitable for breeding purposes and thus may be occupied only in good years. Osborne (1981) found a high mortality in females in Zambia. Only one killed female was found under a deserted nest during this study.

Also, when breeding these falcons are regularly seen in the breeding territory and in fact hunt mostly in it, but outside the breeding season they move into the dunes and then hunt over a much wider area. This may also be part of the reason why one seldom sees these falcons outside the breeding season.

A hunting success of 42% was observed in the present study, compared with 30.7% in Zambia (Osborne 1981). This could be the result of the more open foraging habitat. Prey consisted mostly of small birds, rodents and termites taken in flight or on the ground. Birds either hunted individually or in pairs. In the latter case one bird flushed the prey and the other attacked it (pers.obs.; G. Malan 1991; Osborne 1981; R. Liversidge pers. comm.). It is also possible that bats are caught more often since on a number of occasions falcons were observed to hunt at dusk (e.g. Bitterpan). However, no actual kills were ever observed as it was too dark. Once some bats were accidentally flushed from a dead tree and two were taken by the Red-necked Falcons soon afterwards, suggesting that they recognized them as prey (Fry 1964).

The inter-pair distance of 7.8 km is similar to the 8.3 km recorded by Brown (1988) in the Namib, but much greater than the 2.05 km reported by Colebrook-Robjent & Osborne (1975) and 2.15 km by Osborne (1984) in Zambia. In the KGNP inter-nest distances are governed by the spacing of waterholes, which influence the choice of a nesting location. Without man-made waterpoints the density and numbers of Red-necked Falcons may change drastically and it may be suggested that few pairs would exist in the Park if waterholes were absent due to the effect on prey availability. The small seedeaters and doves would mostly disappear during the dry season when the falcons breed if there was no surface water. In the dunes pairs were always located close to waterholes and the inter-pair density of 15 km (n=7) largely reflects the spacing of waterholes.

During a survey of the area to the east into Botswana, where there is no surface water for hundreds of kilometres, only a few pairs of Gabar Goshawks were located. Further north-east towards the Mabuasehube Game Reserve some Little Banded Goshawks *Accipiter badius* were observed. No Red-necked Falcons were seen here, suggesting that insectivorous birds and the unstable and seasonal numbers of larks and Scaly-feathered Finch could not support resident falcon pairs in this densely bushed area. The falcons need open areas to hunt (Osborne 1981) such as trampled areas around waterholes. Without waterholes only the seasonal incursions of birds such as larks and quail would occur in the study area after the rains and would probably not support such a large breeding population of falcons as presently occurs in the Park.

How hunting success is influenced by co-operation between the Gabar Goshawk and Red-necked Falcon is still a question to be answered, but it probably benefits both species in the long run, although only one of the two benefits from any particular hunt.

Of the three co-operative attempts observed, two kills resulted. The Red-necked Falcon is an aerial hunter, and while the Gabar Goshawk may also take prey in the air, it is also well adapted for inter-canopy pursuit. Thus, although both species prey largely on the same food types, different hunting techniques probably enable them to obtain adequate food to co-exist in harmony. Further research on this hunting behaviour is needed. This study in general agrees with the findings in Zambia (Osborne 1981) on *Falco chicquera ruficollis*.

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