Population biology, behavioural ecology and management of the Redwing Francolin *Francolinus levaillantii* and Swainson's Spurfowl *Pternistis swainsonii*

by

Raymond Jansen

Submitted in fulfillment of the degree of Doctor of Philosophy in the
Faculty of Science, Department of Zoology, Percy FitzPatrick Institute,
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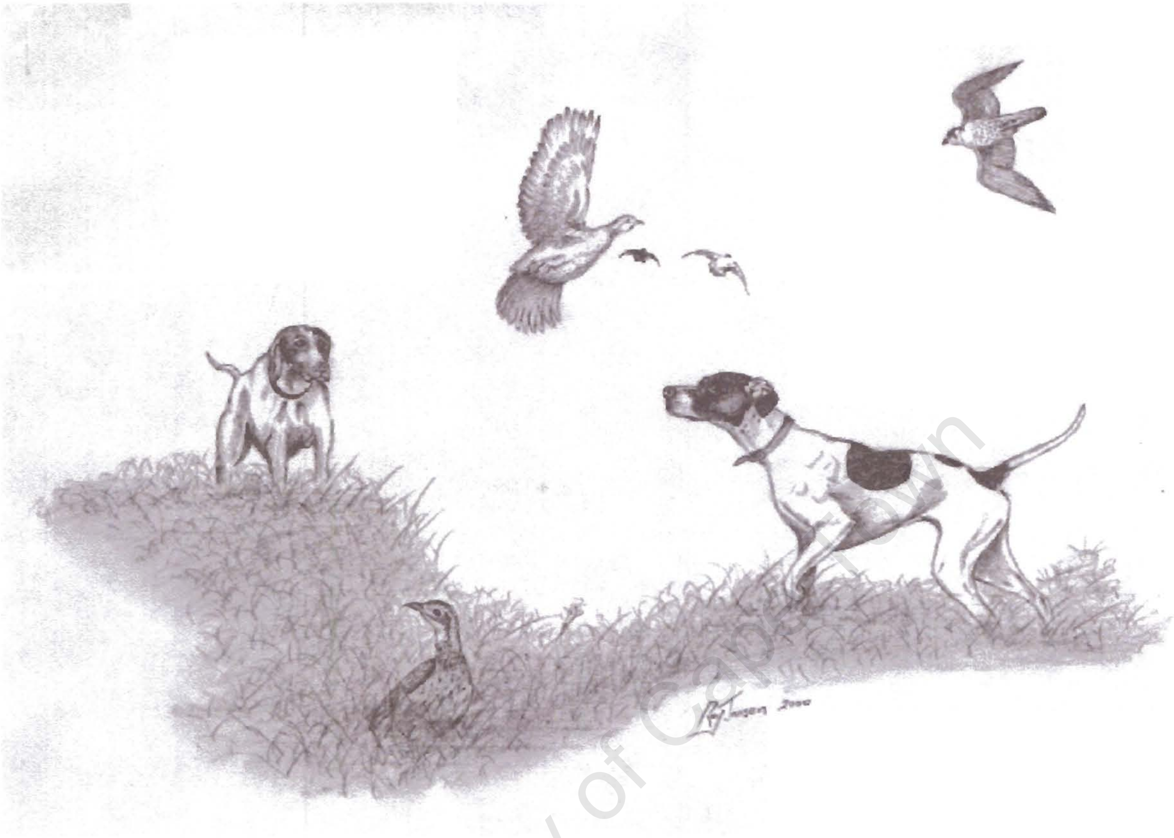
DECLARATION

This thesis reports the results of original research I conducted under the auspices of the Percy FitzPatrick Institute of African Ornithology, Department of Zoology at the University of Cape Town between 1995 and 2000. All assistance that I received has been fully acknowledged. This work has not been submitted for a degree at any other University.

Raymond Jansen

To my family, Louise, Robyn & Sean
and to my parents, Hendrik & Mona



Shannon, Penny & Inca
"working the Redwing"

"I value more than the discovery of many specimens and facts new to science, the education that it was for me. And this combined with a treasury of memories, is ample pay for all the hardships, worries, and troubles that so often lead us to the verge of desperation in the scientific work that takes us in the field".

Ernst Mayr, A re-account of a field trip into New Guinea, 1932.

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ABSTRACT

This study was undertaken to assess the status of Redwing Francolin on farmland, particularly within the montane grasslands of Mpumalanga Province, and Swainson's Spurfowl within the Springbok Flats, Northern Province. To date, there had been no scientific studies of the impacts of habitat transformation via agriculture on their population biology.

Extensive counts using trained pointer dogs, were employed to gather data on numbers, dispersal, pairing behaviour, presence of chicks, location of nests and habitat preferences. These data were then pooled according to habitat availability as influenced by agriculture and radio transmitters were fitted to birds to note daily activity patterns and habitat utilisation. Trends in population abundance were related to habitat variables such as the availability and preferences of food and cover so as to provide possible explanations to the noticeable decline in the population of Redwing Francolin and increases in the numbers of Swainson's Spurfowl over recent years.

Making use of standard statistical parametric tests (e.g. one-way ANOVA, MANOVA, *t*-Tests, regression analyses, correlation analyses and chi-square) and non-parametric analyses (e.g. multivariate analyses such as non-metric multidimensional scaling and cluster analyses, log-ratio analyses, Mann-Whitney *U*-test and Tukey test), statistical significance implied that environmental variables such as rainfall, availability of cover and nesting habitat and the extent of burning and grazing pressures play a large role in regulating the numbers of Redwing Francolin. Pristine grasslands with no stock (and not subject to annual burning) held high numbers of Redwing Francolin. In such areas, coveys were larger, further spaced from one another, birds were less prone to parasitic infections and had a greater availability of food. Swainson's Spurfowl, on the other hand, exploited croplands readily, particularly cereal crops such as maize and sunflower in the winter months. Within these habitats, patches of natural vegetation provide a vital ecotone area for cover, roosting and nesting. The success of the species as a whole can be attributed to its wide resource usage, mobility and adaptive capabilities along with a high nesting production and extended breeding season.

GENERAL INTRODUCTION

Redwing Francolin
Francolinus levaillantii
Valenciennes, 1826

Swainson's Spurfowl
Pternistis swainsonii
Smith, 1836

© Paintings: Penny Meakin

Introduction

There are few countries in the world that have not experienced extensive and major modifications to their landscapes as a result of agriculture (McIntyre & Barrett 1992). Moreover, land-use has caused large-scale transformations of the structure and functioning of African ecosystems (Happold 1995). The most significant practices in South Africa are crop and livestock farming and commercial forestry (Allan *et al.* 1997; Downing 1978; Happold 1995). As these anthropogenic forces change the availability of habitats, the proportion of individuals of a given species in any particular habitat type may be altered (Pulliam & Danielson 1991). Some bird species, even threatened ones, may benefit from certain types of agriculture, such as the Blue Crane *Anthropoides paradisea* within maize lands, whereas others, such as the Wattled Crane *Grus carunculata*, are experiencing serious range reductions as a result of habitat degradation through various forms of land use.

The 'short-term, high-gain' approach of current farming practices places increasing pressure on habitats as the intensity of farming increases. Gaining additional income for farmers and land-owners through more 'ecologically friendly' means or 'eco-tourism' tends to relieve the financial burden experienced by many farmers. This approach has gained increasing support from conservation circles and the public at large in recent years. The sustainable use of harvestable species has further gained additional income for landowners and state owned national parks. Gamebirds, and their utilisation through commercial wingshooting operations, has been shown to be both financially profitable and sustainable within certain regions of South Africa (Crowe & Little 1993).

As the commercial importance of these gamebirds increases, so does the need for information on aspects relating to their management, demography and ecology. The ongoing changes in landscape structure, through pasture and crop agriculture, may influence the distribution and abundance of certain of these gamebird species and further influence their availability as potentially commercially important birds within much of the privately owned land in South Africa.

Two such species, the Redwing Francolin *Francolinus levaillantii* and the Swainson's Spurfowl *Pternistis swainsonii*, are highly prized by wingshooters and their distribution falls over commercially important agricultural land within South Africa. The population densities of Redwing Francolin have been the focus of intensive studies within the protected grasslands of the KwaZulu Natal Drakensberg (Mentis & Bigalke 1973, 1979, 1980, 1981a, 1981b, 1985). However, the population distribution and status of this francolin has not been studied scientifically on privately owned farmland. Moreover, studies on Swainson's Spurfowl are virtually non-existent and compromise primarily descriptive accounts in semi-popular publications and bird books.

The objectives of this thesis are to investigate the status, population dynamics and behavioural ecology of the Redwing Francolin in a commercially grazed grassland environment and the Swainson's Spurfowl within an intensive agricultural environment and to present guidelines for the management of these two upland gamebirds in South Africa.

The thesis is divided into 11 chapters within three sections. The first two sections describe the population dynamics of the Redwing Francolin and Swainson's Spurfowl respectively. The section on the Redwing Francolin (section 1, chapter 1 and chapter 5) also contains estimates of distribution and density as well as levels of infections with blood protozoa of the Greywing Francolin *Francolinus africanus* (Stephens 1819), within the study area. Section 3 discusses conservation implications of each study habitat with relevance to other bird species within "Redwing habitat" and "Swainson's habitat". Furthermore, section 3 discusses management implications relating to habitat management, wingshooting seasons and off-take levels.

Redwing Francolin (*Francolinus levaillantii*)

Perdix levaillantii Valenciennes, 1826. *Dict. Sci. Nat.*, p. 441; Cape of Good Hope

This cryptic grassland gamebird is a resident of montane or alpine grasslands and is the largest of the 'red-winged group' of grassland francolins: the Greywing *F. africanus*, Orange River *F. levaillantoides* and Shelley's *F. shelleyi* Francolins

Two subspecies of Redwing Francolin are recognized. *F.l. kikuyuensis* (Ogilvie-Grant 1897) occurs in Angola, Zambia, northeastern and eastern Zaire, east to western and central Kenya, while *F.l. levaillantii* (Valenciennes 1826) is found in northern Malawi, northeastern Zambia and South Africa (Johnsgard 1988; McGowan 1994; Little & Crowe 2000). Within South Africa, its range extends from the Western Cape town of Swellendam, into the Eastern Cape, through the grassland habitat of KwaZulu Natal, westwards into the Free State and northwards into Mpumalanga (Fig. 0.1).

Recent reports relating to the range contraction of this species have implicated habitat degradation of grasslands as the primary cause. Apparently, intensive grazing and overstocking along with extensive and frequent burning reduces the availability of habitat for this grassland specialist, effectively reducing its range (Mentis & Bigalke 1973; Crowe, Keith & Brown 1986; Johnsgard 1988; Mentis & Little 1992; McGowan 1994; Little & Crowe 2000). Its absence from Lesotho and the Transkei provides further evidence of this species sensitivity to habitat degradation, particularly from overgrazing (Little & Allan 1997).

Swainson's Spurfowl (*Pternistis swainsonii*)

Perdix swainsonii A. Smith, 1836. *Rep. Exped. Cent. Afr.*, p. 54; W. Kurrichane, western Transvaal

This highly opportunistic gamebird is associated with habitats ranging from dry grasslands to savanna thornbush and is one of the most common upland gamebirds within South Africa, where it adapts well to transformed agricultural habitats.

This species has recently been reclassified from the genus *Francolinus* into *Pternistis* (Crowe, Harley, Jakutowicz, Komen & Crowe 1992; Little & Crowe 2000) and forms part of the 'bare-throated' group of spurfowls such as the Greybreasted Spurfowl

P. rufopictus of the Rift Valley system and Yellownecked Spurfowl *P. leucoscepus* of East Africa (Little & Crowe 2000). Two subspecies of Swainson's Spurfowl are recognized. *P.s. lundazi* (C.M.N. White 1947) occurs in northern and western Zimbabwe and southern Mozambique while *P.s. swainsonii* (A. Smith 1836) occurs from southeastern Angola, northern Namibia down to southeastern South Africa (McGowan 1994). Swainson's Spurfowl has been known to hybridize with other closely related spurfowl species, as was reported from Zimbabwe between the Swainson's and Red-necked *P. afer* and the Natal Spurfowls *P. natalensis* (Crowe *et al.* 1986).

In southern Africa, Swainson's Spurfowl has extended its range considerably within recent years, owing much of this expansion to the planting of crops, particularly cereal crops (Fig. 0.2). The first records of this bird's movement south into KwaZulu Natal, the southeastern Transvaal and Swaziland date back to 1960 (Clancey 1967).

Prior to the 1950s, the Swainson's Spurfowl was not found south of the Magaliesberg (Gautenge Province). However, there is reliable evidence that much of this range expansion was assisted by translocation (Little 1997) and continues in the Eastern Cape (A. Harvey pers. comm.). However, habitat degradation, primarily from overstocking, in conjunction with over-shooting, has reduced numbers considerably within parts of Botswana (Little 1997; Herremans 1998).

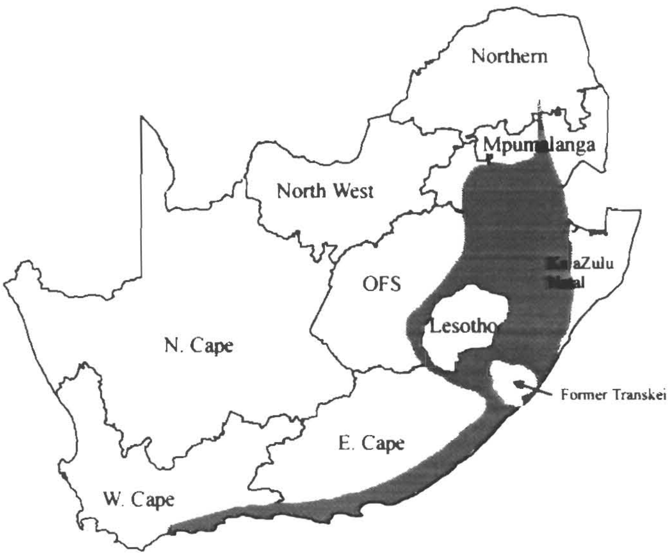


Figure 0.1. Distribution of Redwing Francolin *Francolinus levaillantii* within South Africa (Little 1997; Maclean 1985)

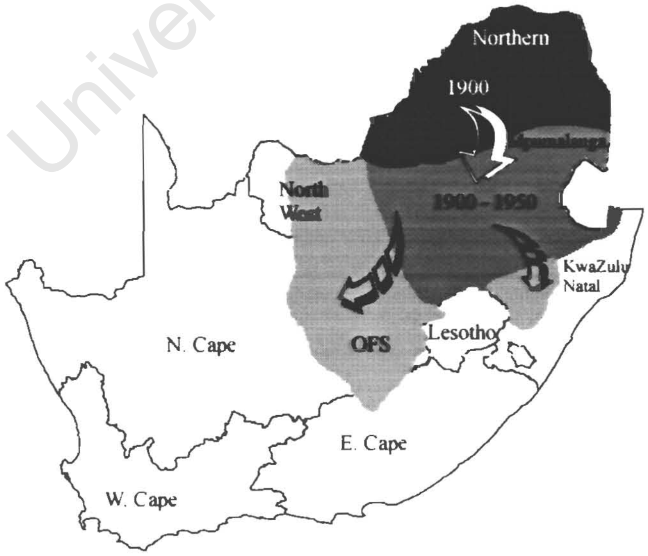


Figure 0.2. Distribution of Swainson's Spurfowl *Pternistis swainsonii* within South Africa indicating historical movement southwards (Clancey 1967; Little 1997; Maclean 1985; Stark 1906; Van Niekerk 2000).

THE PRINCIPAL STUDY AREAS

The Steenkampsberg

Location

The Steenkampsberg, composed of rolling highland grasslands, is situated between the villages of Belfast, Dullstroom and Machadadorp in the northeastern escarpment of Mpumalanga Province (Fig. 0.3). In its widest connotation the name Steenkampsberg applies to an elevated plateau-like region, roughly 20 km wide and extending some 40 km north of Dullstroom, but physiographically even southwards towards Belfast. The name of this berg region stems from its original occupants, the Steenkamps, four closely related families that were awarded adjoining farms in 1847.

Climate

The region is characterized by a sub-alpine climate where winters are cold and summers are moderate. Temperatures can plummet well below 0° C in winter, but hardly exceed 25°C during the misty summers. Within the context of southern Africa, rainfall is relatively high with a mean of 820 mm per annum (see Chapter 3, Fig. 3.2).

Fauna and flora

The flora of the region is classified as North-Eastern Mountain Sourveld by Acocks (1988) and encompasses a total area of 419 054 km^2 (Bredekamp *et al.* 1996). Over 200 species of flowering plants have been recorded within the region, including 54 species of orchids. Many of these plants are endemic to the Steenkampsberg, e.g. the Golden Arum Lily *Zantedeschia pentlandii* which grows naturally on the edges of wetlands (Cameron 1984).

The diversity of bird species is as unique as the flora of the Steenkampsberg. To date, 150 species of birds have been identified, and the region is home to all three crane species, the Blue *Anthropoides paradisea*, Crowned *Balearica regulorum* and Wattled *Grus carunculata* Cranes, the only region in South Africa where all three species co-occur. Other rare and endangered bird species include the Bald Ibis *Geronticus calvus*, Rudd's Lark *Mirafra ruddi*, and the Yellowbreasted Pipit *Anthus chloris*, a South African endemic at the northern most limit of its range on the Steenkampsberg.

Although not high in the diversity of mammals (only 34 species recorded) and reptiles, many species are uniquely adapted to the cold montane grasslands of the Steenkampsberg. Two species of golden mole have been recorded, one of these, the Rough-haired Golden Mole *Chrysospalax villosus* has a very limited and localized distribution with much of its range falling in the Steenkampsberg. The same applies to the rare Smith's Rock Rabbit *Pronolagus rupestris* which has only been recorded in three other localities in the old Transvaal. Other rare mammals include the Striped Weasel *Poecilogale albinucha* and Oribi antilope *Ourebia ourebi* (Batchelor 1984).

Topography and land use

The region is situated at around 2000 m above sea level, culminating in *Die Berg*, the highest point in the former Transvaal at 2331 m. The physiography of the Steenkampsberg is largely determined by its geological composition and structure. It is composed of hard, resistant quartzite layers alternating with bands of shale with intrusions by thick diabase sheets. The soils reflect the aforementioned geological structure where dark colored loams form from weathering diabase sheets whereas the light colored sandy soils arise out of the degradation of quartzites.

Land-use is dominated by pasture stock farming, primarily with sheep and, to a lesser extent, cattle. Much of the grassland is burnt annually; shortly prior to the first spring rains in September to provide 'sweet-veld' grazing for stock. Trout syndicates have purchased a large proportion of the Steenkampsberg since the abundant cold and clean water systems are highly sought after for the stocking and catching of trout. Although this has led to the flooding of many of the wetlands within the region, for the construction of trout dams, a large proportion of the grassland habitat has been conserved indirectly through the acquisition of trout waters.

Study habitats

Ten farms were chosen within the study area (Fig. 0.3) that best represent an array of habitat conditions ranging from heavily grazed and annually burnt habitats, through grasslands that are moderately grazed and burnt every two years, to farms that are not grazed by domestic stock and only burnt every three years.

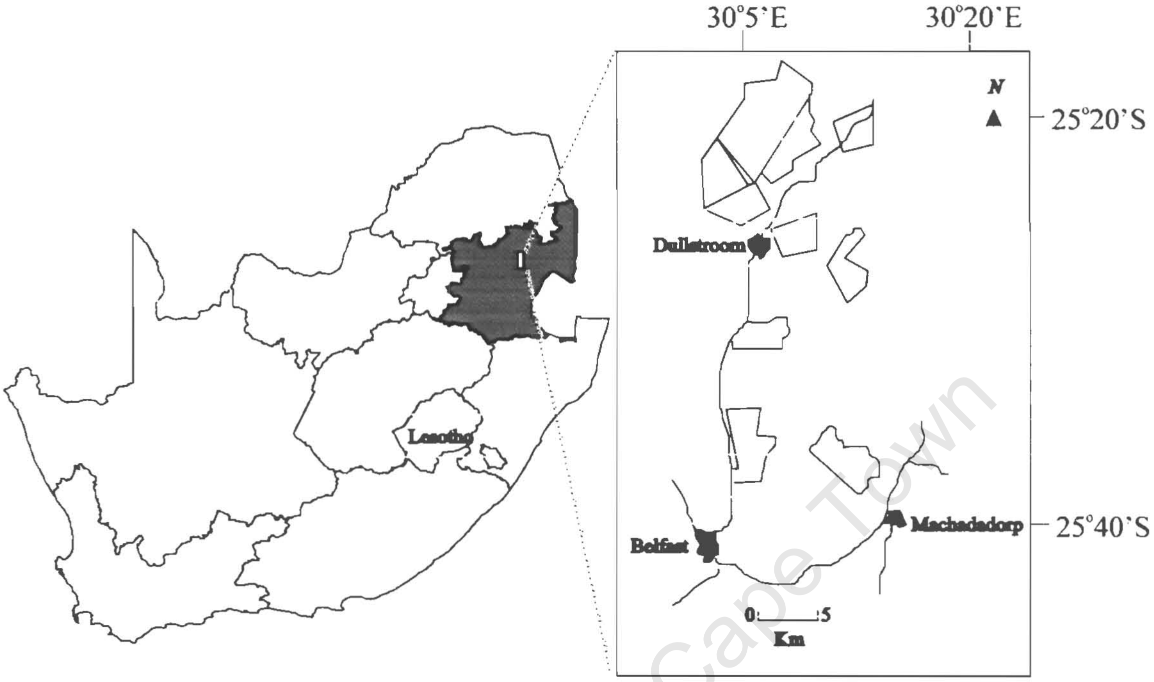


Figure 0.3. Study localities (ten farms) over which Redwing Francolin research was conducted within the Steenkampsberg region of Mpumalanga Province.

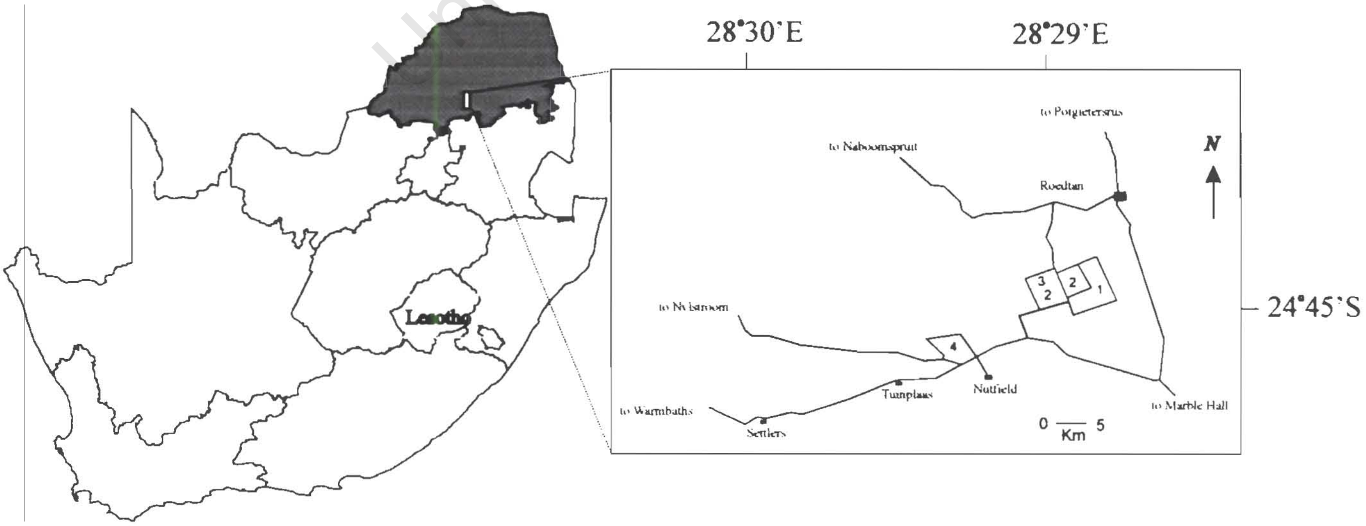


Figure 0.4. Study localities (four farms) over which Swainson's Spurfowl research was conducted within the Springbok Flats region of the Northern Province.

The Springbok Flats

Location

The Springbok Flats is located north of Pretoria between the towns of Warmbaths, Nylstroom and Naboomspruit in the west and extends up to Potgietersrus in the north and Marble Hall in the east (Fig. 0.4). It comprises a particularly flat area of 163 020 km^2 at an elevation ranging between 1050 to 1100 m above sea level. The name *Springbok Flats* is derived from the vast herds of Springbok *Antidorcas marsupialis* which once roamed this habitat, but subsequently went extinct locally in the 1920 s.

Climate

The annual rainfall is moderate and ranges between 450 and 550 mm per annum of which about 90% falls during October – March, with July and August being the driest months. Temperatures in winter rarely drop below 0° C, but can reach 35 – 40°C during peak summer.

Fauna and flora

The flora of the region is classified as Springbok Flats Turf Thornveld by Acocks (1988) or Clay Thorn Bushveld by Van Rooyen & Bredekamp (1996). The Springbok Flats is essentially a savanna ecosystem. The term ‘savanna’ applies to something between a grassland and a woodland system and comprises a grass layer and wood plant layer whose canopy is between 1 – 50%. If canopy cover exceeds 50% the habitat is woodland, if less than this, a grassland (Tarboton 1987). Rebelo (1997) ranked Springbok Flats Turfveld the veld type in greatest need of conservation in South Africa. Up until 1987, none of this veld type was conserved and only 0.28% is currently under protection. Further, it is estimated that 92% of it has been transformed (Macdonald 1989; Rebelo 1997). Due to this extensive transformation, pioneer woody species have invaded much of the Springbok Flats. One such species is the Sickle Bush *Dichrostachys cinerea*, a fast growing small tree or bush the control of which involves exorbitant costs and follow-up operations to remove once it has become established. Remnants of the original savanna still remain in the form of isolated pockets or ‘islands’ or in larger landscapes where landowners have established game farms. The most common trees in these islands are broad-leafed species such as *Burkea africana*, *Terminalia sericea* and *Ochna pulchra* or acacias such as *Acacia tortilis*, *A. nilotica* and *A. fleckii*.

Currently, over 300 species of birds, 62 species of mammals, 57 reptiles and 28 amphibia have been identified within the Springbok Flats. Many of these species spill over from the more productive neighbouring Waterberg into the Flats. Where game farms have been established, many of the larger antelope species have been reintroduced.

Topography & land-use

The soils are characteristically black or red vertical clays, derived from the underlying Stormberg basalts of the Karoo sequence. The soils derived from the basalts are heavy, nutrient-rich clays, commonly called 'black turfs' and are highly prized for the growing of agricultural crops. These soils are easily waterlogged during rains and retain their moisture for long periods. The soils become progressively 'sandy' moving eastwards towards Marble Hall.

The eradication of malaria in the early 1940s opened up the Springbok Flats to large-scale settlement and intensive farming. The region is widely used for the cultivation of crops (72% of the area) such as wheat, maize, cotton and sunflower as well as livestock. Crops are usually planted between September and November and harvested between March and August. The farming is intensive and tractors plough six abreast and the drone of crop sprayers in the summer are common sights within the Springbok Flats.

Study habitats

Four farms were chosen that best represent the array of habitat conditions within the study area (Fig. 0.4). The majority of population studies on the Swainson's Spurfowl were conducted over these four farms. Anatomical measurements, blood smears and the analyses of crop contents were collected from birds over a wider range within the Springbok Flats, usually accompanying commercial wingshooting operations within the region.

SECTION 1

THE REDWING FRANCOLIN

"We had a little work near Heidelberg in the Transvaal, and in one kloof, say a mile long, we saw more than one hundred birds"

Layard (1867)

Chapter 1

Population status and distribution

Summary

The densities of the Redwing *Francolinus levaillantii* and Greywing Francolins *F. africanus* were investigated along a land-use gradient in the highlands of Mpumalanga Province, South Africa. Redwing Francolins cannot tolerate intensive grazing and frequent burning and are confined largely to unburnt, ungrazed grasslands. Redwing populations drop to densities that can not be utilised by wingshooters on a sustainable basis in grasslands that are grazed at even moderate levels or burned annually. The Greywing Francolin is more evenly distributed (although always at sub-utilisation densities) along the grassland land-use gradient, and its density is positively correlated with grazing intensity. Populations of Redwing Francolin in the study area are becoming increasingly dependent on isolated patches of pristine grassland and are threatened by management involving annual burning and high stocking rates on a landscape scale.

Introduction

Threatened highland grasslands

Land-use by humans has caused large-scale transformations of the structure and functioning of African ecosystems (Happold 1995). The most significant practices are crop agriculture, livestock farming and commercial forestry (Downing 1978; Happold 1995; Allan *et al.* 1997). Grasslands, particularly highland grasslands, are amongst the most threatened vegetation types in southern Africa and have been assigned a high priority for conservation action (Macdonald *et al.* 1993). Although the highland grasslands of Mpumalanga Province, South Africa, are rich in endemic plants and animals, they are particularly poorly conserved, since current local conservation efforts have focused on the protection of patches of floristically relatively species-poor afromontane forest (Matthews *et al.* 1993). North-eastern Mountain Sourveld grassland (Acocks 1988), for example, is under considerable pressure from commercial forestry, invasion by alien plants (Matthews *et al.* 1993; Allan *et al.* 1997) and overgrazing by livestock (Tainton 1981a; Hockey *et al.* 1988). Only 55% of the original extent of this vegetation type persists, and largely only in a semi-natural state. Worse still, just 8% of what remains falls within proclaimed protected areas (Bredekamp *et al.* 1996).

Athropogenic transformation

The highland grasslands of Mpumalanga have been transformed chiefly by intense grazing and frequent deliberate burning. Indeed, periodic burning is an essential land management tool employed by farmers to remove unpalatable vegetation in highland sourveld grasslands used for stock farming (Mentis & Bigalke 1973, Mentis & Rowe-Rowe 1979). The optimal burning frequency varies according to the rate of litter accumulation (Stuart-Hill & Mentis 1982). Nevertheless, it is common practice for farmers to burn highland grasslands annually, irrespective of the accumulation of unpalatable vegetation (Tainton 1981b), and the ecological effects of such a burning regime are poorly understood (Tainton & Mentis 1984).

There is increasing evidence that the flora of the eastern escarpment of Mpumalanga Province must have been a long-standing component of the afromontane vegetation mosaic (Matthews *et al.* 1993) and not a secondary, fire-maintained vegetation type (White 1983). Nevertheless, land-use by humans has probably largely determined present-day ecosystem structure and functioning (McNeely *et al.* 1995), since frequent burning can have profound effects on grass species composition and sward structure (Bond 1997). There is also evidence that South African grasslands have been overstocked consistently since the 1930s (Downing 1978). Intense burning and grazing of these grasslands also leads to habitat fragmentation and changes in vegetation height, density and, over longer periods, species composition (Edwards 1981).

This Chapter investigates population densities of two grassland gamebirds, the Redwing Francolin *Francolinus levaillantii* (an indicator species of natural "sour" grassland habitat; Harrison *et al.* 1994) and the Greywing Francolin *F. Africanus*, along a gradient of grazing intensity and frequency of burning in the highland grasslands of the Steenkampsberg, Mpumalanga Province in order to determine the effects of this land-use practice.

Methods

Nine study sites that represent a grazing/burning gradient were surveyed to determine densities of Redwing and Greywing Francolins (Table 1.1). Sites farmed with sheep and cattle and which were grazed and burned annually in spring were classified as being 'farmed'. Sites that were burned every two to three years and grazed only by indigenous antelope were classified as being 'conserved'.

Table 1.1. Grassland management for nine study farms in Mpumalanga Province.

	conservation			farming					
Farm number	1	2	3	4	5	6	7	8	9
Grazing intensity*	100	50	15	5	4.5	3	3	2.5	2
grassland age**	3	2	2	2	1	1	1	1	1

* hectares available per large animal unit (ha/LAU)

** time (yrs) since last burn

Distribution and density of francolins

The method of counting francolins in grassland, as described by Mentis & Bigalke (1985), are applied to this study since the *Themeda triandra* dominated fire climax grassland habitat of the Steenkampsberg is very similar in altitude, structure and height (< 50 cm) to the grasslands of the KwaZulu Natal Drakensberg (Acocks 1988). The Steenkampsberg is further an extension of the Drakensberg grassland biome.

Redwing and Greywing Francolins were located and counted using English pointers. The influence of herbivory and frequent burning would decrease the sward height in some of the study habitats, however, this would have minimal influence on the speed at which dogs worked due to the natural low height of the vegetation (< 30 cm). Density per ha *(D)* was estimated by applying an index of abundance *(I* = birds found per minute of searching) according to the following equation:

$$D = 0.023 + 0.376\,I \text{ (Mentis \& Bigalke 1985)}$$

Counts were made once a month, making use of the same dogs at each of the study sites, by walking transects for 3-4 hours over each study site. The procedure in counting was to cover the site systematically for the duration of the count, taking care not to double-count birds (Mentis & Bigalke 1985). Because counts can vary with sampling area and season (Schluter & Ricklefs 1993), we limited counts to the non-breeding, winter months (April - August 1995 and 1996) and sampled areas of approximately equal size.

Grazing intensity and frequency of burning

Relative grazing intensity was recorded as the number of hectares of grazing land available per large animal unit (ha/LAU). One large animal unit is defined as being equivalent to one cow or five sheep or one LAU, and represents the metabolic equivalent of a 454 Kg cow (Owen-Smith & Danckwerts 1997). Grazing pressure by antelope was negligible, since these taxa were stocked at less than 1 LAU per 50 ha. The frequency of burning was recorded as the time elapsed (in years) since the last burn.

Data analysis

Programs from the Statgraphics (Anon. 1986) statistical package were used to perform regression analysis to determine relationships between grazing intensity and francolin density. *t*-Tests were used to investigate differences in francolin density and covey size in grazed/annually burned and ungrazed sites burned only every two or three years.

Results

Effects of grazing and, burning

The density of Redwing Francolins declined steadily within sites with increasing grazing intensity (Fig. 1.1; $r^2 = 0.95$, $P < 0.001$; $y = 0.04 + 0.04x$). In fact, at even very low grazing intensity, the density of Redwing fell below levels which can withstand even moderate, sustainable wingshooting (Fig. 1.1; 0.1 birds/ha, Little 1992).

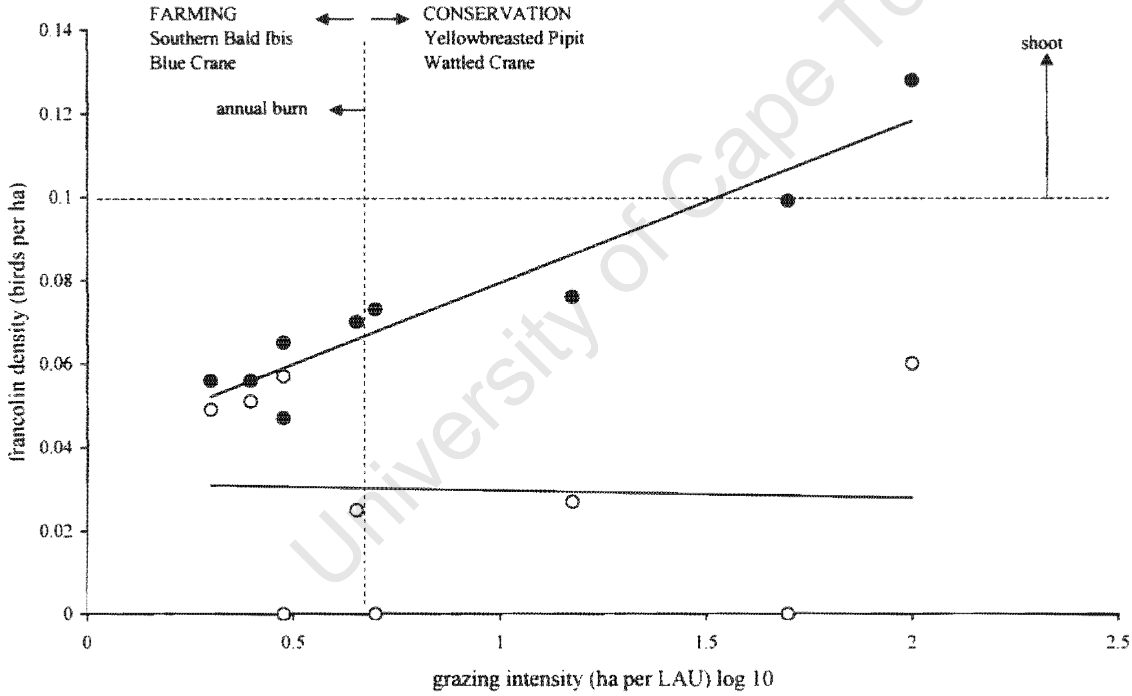


Figure 1.1. Redwing Francolin (solid points) and Greywing Francolin (hollow points) with regression lines showing density in relation to relative grazing intensity over the nine study farms.

There was no significant relationship between the density of Greywing Francolins and grazing intensity ($r^2 = 0.06$, $P > 0.05$) (Fig. 1.1; Table 1.2). However, if the analysis were restricted to sites under private ownership (i.e. if information for Verloren Valei, the sole proclaimed protected area, were excluded), there was a significant positive relationship between grazing intensity and Greywing density ($r^2 = 0.29$, $P <$

0.05), and the correlation between grassland bird species richness and grazing intensity became non-significant.

Both population density and covey size were significantly lower in grazed/annually burned farmland sites for Redwing, but, for Greywing, only covey size was significantly lower in grazed/annually burned farmlands (Table 1.2).

Table 1.2. Comparison of francolin population densities in grazed and conserved grasslands

	Redwing Francolin				Greywing Francolin			
	No. birds	No. coveys	x covey size	density/ ha	No. birds	No. coveys	x covey size	density/ ha
conserved	418	111	3.77	0.119	97	12	8.1	0.040
grazed	399	135	2.96	0.063	153	34	4.5	0.030
t - test			$t = 2.90$ $P < 0.05$	$t = 6.35$ $P < 0.001$			$t = 13.30$ $P < 0.001$	$t = 0.44$ $P > 0.05$

Discussion

Grazing, burning and francolins

Previous research on grassland francolins (Mentis & Bigalke 1979, 1981a, 1981b; Mentis & Little 1992; Little *et al.* 1993) has hypothesised that both Redwing and Greywing Francolins prefer habitat burnt every two to three years, and that Redwing are more sensitive to more frequent burns than Greywing. Results here support this hypothesis and highlight the importance of protected grasslands for these economically important gamebirds (Little & Crowe 1993a), especially the Redwing Francolin, even in situations where moderately grazed grasslands outside of protected areas are burnt relatively infrequently. The lower population densities of Greywing on the Steenkampsberg compared with those on the Stormberg (mean density = 0.094 birds/ha, n = 698 birds; Little *et al.* 1993) are probably due to a lack of moderately grazed grasslands under infrequent burning regimes and the closeness of the study area to the species' northern range limit.

Redwing Francolins are clearly highly threatened by frequent burning and heavy grazing. Similar results have been obtained for gamebirds on the Great Plains of North America where increased grazing pressure led to population declines of Sharp-tailed

Grouse *Pedioecetes phasianellus* and Sage Grouse *Centrocercus urophasianus* (Kantrud & Kologiski 1982). In Britain, for example, the habitats of Black Grouse *Tetrao tetrix* and Capercaillie *Tetrao urogallus* have shrunk dramatically. Black Grouse populations have reached dangerously low levels due to overgrazing and other habitat modifications (Baines 1991, 1996) and Capercaillie went extinct and had to be re-introduced from elsewhere (Perrins 1992). Closer to home, Berry and Crowe (1985) also suggested that overgrazing may have led to dramatic declines in populations of Orange River Francolin *F. levaillantoides* on a normally very well-managed private nature reserve in the Northern Cape, South Africa. The Redwing Francolin is thus a useful bird whose presence is indicative of healthy grassland (Harrison *et al.* 1994) and which can potentially provide rural economies with add-on income through moderate hunting (Little & Crowe 1993a). However, it is declining to such an extent in grasslands heavily utilised for stock farming that it is effectively becoming a locally vulnerable species.

Conservation implications and management recommendations

Clearly, the highland grasslands of Mpumalanga are under threat, and populations of birds associated with these grasslands are becoming increasingly dependent on protected areas and fragments of non-agricultural grassland areas (see Chapter 10). Effective conservation of this assemblage of birds would require management of the mosaic itself rather than selected habitats within the mosaic (Wiens 1994). However, private enterprise and unregulated grassland management policies prevent this more conservation-orientated management policy. Biotic diversity in grassland ecosystems is maintained by fluctuating conditions which favour first one species, or a group of species, and then another (Mentis & Bailey 1990). This is at odds with the uniform grassland management policies involving high stocking rates accompanied by annual burning, which is a "short-term, high gain" approach currently practiced by most of the local, commercial livestock farmers. Habitat diversity or the formation of "patches" of burnt and unburned grass with various levels of grazing pressure, forming the fine-scale grassland mosaic proposed by Mentis & Bigalke (1981b), would provide suitable habitat for the Redwing Francolin and a range of other grassland species. The rationale is that the fire regime under which the biota evolved, i.e. natural fires ignited by lightning strikes, is the most likely to ensure survival (Bond 1997). Only in situations where grasslands are under a "protection" blanket, i.e. free from commercial livestock farming, can populations of Redwing Francolin reach levels that can be exposed to commercial wingshooting. At this level, the sustainable use of a harvestable resource, such as the Redwing Francolin, through commercial hunting operations, can provide financial incentives to landowners to conserve grassland ecosystems and their associated biotic diversity. However, a review of certain land-use practices (e.g. domestic livestock grazing and associated burning practices) and commercial forestry (not considered here) should be undertaken and management recommendations made available to landowners if this grassland and its ecological processes are to be maintained.

Chapter 2

Home range and habitat use of the Redwing Francolin

Summary

The effects of intensive commercial livestock farming on the distribution and habitat-use of Redwing Francolin *Francolinus levaillantii* were investigated to identify habitat constraints that may contribute towards the observed decline of this species on livestock farms. Data on the size, placement of the home ranges and compositional habitat use from 10 radio-tracked individuals, five in commercially grazed (and frequently burned) and five in protected (and infrequently burned) highland grasslands, were collated to determine habitat preferences. Mean home range size within protected and grazed grassland study sites were similar and ranged between 7.6 - 15.4 hectares. However, habitat-use by groups in grazed grasslands was restricted to areas of greater cover and food availability. Group sizes were significantly larger in protected (mean 3.77, *N* = 111 coveys) than in grazed and frequently burned grassland (mean = 2.96, *N* = 135 coveys). Smaller coveys in grazed habitats had smaller home ranges and were further spaced from one another. It is therefore suggested that habitat degradation, through excessive defoliation of the grassland from heavy grazing and frequent burning, both fragments francolin sub-populations and reduces the ecological availability of suitable habitat, thus, undermining the meta-population structure of Redwing Francolin in these commercially grazed grasslands.

Introduction

The Redwing Francolin *Francolinus levaillantii* is an indicator species of healthy "sour" highland grassland habitat in South Africa (Harrison, Allan & van Hensbergen 1994), being most successful in unburned and ungrazed grasslands (see Chapter 1). Massive transformation of the grasslands due to overgrazing may cause population declines and local extinctions in previously suitable habitat (Little & Allan 1997), since the density of Redwing Francolin is negatively correlated with grazing pressure (see Chapter 1) and positively correlated with grass cover and height (Mentis & Bigalke 1979). Furthermore, the abundance, species composition and availability of its preferred food, underground storage organs of geophytes (Mentis & Bigalke 1973, 1979, 1981a), relate to the structure of the grassland (Mentis & Bigalke 1973; Mentis & Little 1992). Since many bird species appear to define their niches largely in terms of habitat structure (Wiens 1973), this francolin should proliferate in areas that satisfy both their food and cover requirements and to decline in defoliated grasslands where the quality and quantity of food are reduced through grazing (Mentis 1973; Mentis & Bigalke 1973, 1979). But this has not been demonstrated quantitatively.

The Redwing Francolin is monogamous and pairs are apparently territorial and distributed uniformly throughout suitable grasslands (Little & Crowe 2000). This spacing breaks down once the chicks hatch and birds become more gregarious within home ranges (Mentis & Bigalke 1973, 1980, 1981a). Territoriality can thus provide a behavioural mechanism through which variation in the abundance of food or other habitat features control a species' density (Göransson *et al.* 1991; Newton 1992). Should this be the case with the Redwing, it should utilise certain areas more intensively (e.g. those with high quality and quantity of food and cover) within their home range (Bingham & Noon 1997). This Chapter investigates the home ranges of Redwing Francolins quantitatively and, more specifically, determines how habitat characteristics influence the use of space within protected and grazed/burned grasslands.

Material and Methods

Counts for the estimation of density, covey size and spacing between coveys were conducted over 10 farms within the study region (see Chapter 1). Home range studies were carried out on two of these farms, representing extremes in grassland management. Farm 1 is a 5900 hectare protected area where the grassland is burned on a triennial basis and is not grazed. Farm 2 is a 500 hectare commercial pasture farm where the intensity of grazing is high and the grassland is burned annually. Furthermore, a mosaic of equally sized farms that follow similar management regimes surrounds farm two. Both study farms are similar in elevation, aspect and geomorphology.

Home range and radio tracking

Five Redwing Francolin were trapped in April (autumn) 1997 on each farm (total of ten birds) by dragging a net in front of pointer dogs on point. Birds were fitted with a 2.9g (0.6% body mass, mean body mass of 32 birds sampled over study region = 498.6g) necklace radio-collar (Biotrack Co. Ltd; Kenward 1987a) which gave an effective ground to ground range in the 148 MHz band of 500 - 1200m using a Yaesu radio receiver and a four-element hand-held Yagi antenna.

Birds were tracked for fourteen days on each study site. Directional radio fixes were obtained by three-point triangulation. On moving to the triangulation intersection plot, a small 15cm vertical antenna (Yaesu) was fitted onto the receiver which gave a more accurate (to within 10m) close-up directional and distance estimation plot. Each fix was plotted on a 1:5000 aerial photograph of the study area and note made of the habitat-type the fix was taken in. For each radio-tagged bird, fixes were taken approximately ever two hours over a ten-day period for each study site. The home range study was conducted in autumn (April - May) shortly after the breeding season once birds had grouped into coveys.

The Range IV program (Kenward 1990) was used to calculate the following home ranges: the minimum convex polygon (MCP), or so-called minimum area polygon (Mohr 1947) enclosing 95% of radio locations, the harmonic-mean area using isopleths limited by the isoline which enclose 95% of radio locations (Dixon & Chapman 1980), and the Kernel analysis home range with the same 95% isoline (Worton 1989).

Habitat use

Analysis of habitat use was based on the methods described by Aebischer, Robertson & Kenward (1993). Briefly, habitat use is compared to habitat availability within the overall study area. Assuming that use differs from random, habitats can be ranked according to relative use, and significant between-rank differences located. Total habitat area was defined arbitrarily as that area that includes the outer most location radio fix plot for all coveys in the study area. Habitat availability/area was calculated by superimposing a scaled 25 x 25m grid on a 1:5000 topographical aerial photograph, and counting the grid cells that fall on each of the habitat types.

The proportions of radio-locations were transformed for each animal in each habitat type (y) and available habitat (y_o = total study area) to log-ratios using the proportion of grass as the denominator, then calculated the difference ($d = y - y_o$). In this case, the log-ratio transformation of percentage radio locations would be:

$$y_i = In\ (x_i/x_j)$$

where, x_i/x_j = percentage radio location of bird x in habitat i / percentage of grass (denominator) available.

Hypothesis testing relies on a generalised likelihood ratio statistic Λ that tests simultaneously over all habitat types for random habitat use as follows. The residual matrix R_2 is the matrix of raw sums of squares and cross products calculated from d; R_1 is the matrix of mean-corrected sums of squares and cross-products calculated from d then $\Lambda = R_1 / R_2$. If the quantity $-N \ln \Lambda$ yields $P < 0.05$, habitat use is significantly non-random when compared to χ^2. To rank the habitat types in order of use, a matrix of the kind described in Aebischer *et al.* (1993, table 1) was set up for each bird. Then, at each position in the matrix, the mean and standard error of the elements were calculated over all five birds in both study sites. For each element, the ratio mean/standard error gives a t-value measuring departure from random use, thereby pinpointing where non-random use occurs. Each mean element in the matrix is replaced by a sign, a triple sign represents significant deviation from random at $P < .05$. By counting the positive values in each row achieves a habitat rank. This compositional method of habitat use (Aebischer *et al.* 1993) was compared to a simpler procedure described by Jacobs (1974):

$$P = (R_1/R_2 - A_1/A_2) / (R_1/R_2 + A_1/A_2)$$

where P = Jacobs' preference index, R = number of radio fixes, A = area of habitat, 1 = for a particular habitat, 2 = for all habitats or all fixes.

Spacing indices between coveys

Distance between coveys was recorded by searching for birds with two English pointers and noting the time interval between successive coveys (spacing index) whilst walking for three to four hours over a particular study farm. Ten farms were chosen that represent an array of habitat conditions. Counts were carried out over the non-breeding season (April - August 1995 and 1996) and form part of another study (see Chapter 1).

Vegetation analyses

Three dominant habitat-types occur within these grasslands, namely, wetlands (partly submerged damp areas), rocky outcrops (protrusions of quartzite and diabase on the land surface) and grasslands (open expanses of *Themeda* dominated grass species). The number of individuals and diversity (number of species) of food plants belonging to the families Iridaceae, Amaryllidaceae and Cyperaceae, sward height and percentage cover were measured in 1m x 1m quadrats over three habitats (wetland, rocky outcrops and grassland areas) in both radio-telemetry study sites. Quadrat samples were taken every five metres along a randomly chosen line transect incorporating 20 samples per habitat and 60 samples per study farm.

Data analyses

All statistical procedures were carried out using Statgraphics statistical graphics package (Anon, 1986). Mann-Whitney *U*-test was used to compare mean home range sizes of birds between protected and grazed/burned habitats, between smaller and larger covey ranges, and between mean spacing indices for protected and grazed/burned habitats. Simple one-way ANOVA was used to test for significance in vegetation height, percentage cover and number of individual food plants between wetland, rocky and grass habitats in protected and grazed/burned study sites. If the overall ANOVA was significant, a Tukey test was used to establish which habitats differed significantly from the others. Mean values for sward height, percentage cover and number of individual food plants were compared between study sites (protected vs. grazed/burned) for wetland, rocky and grassland habitats using a *t*-Test.

Results

Home range

The home range was defined as the smallest area containing 95% of the utilisation distribution (Seaman & Powel 1996). Mean home ranges for Redwing Francolin over a ten-day period ranged between 7.60 and 15.41 hectares. The mean home range of birds in protected habitat was not significantly different from that of birds in grazed/burned habitat (Table 2.1). MCP home ranges were only slightly larger than Harmonic mean ranges, but almost twice as large as Kernel analyses home ranges. Covey size was significantly correlated with home range size ($r = 0.463$, $P < 0.05$), with smaller coveys having smaller home ranges. Using the Harmonic mean home range sizes, smaller (<3 birds) coveys had significantly smaller home ranges than did larger (>3 birds) coveys (Mann-Whitney *U*-test: $Z = -2.30$, $P < 0.05$; small: mean = 8.71 ha, SE = 1.39, $N = 5$; large: mean = 18.46 ha, SE = 2.49, $N = 5$).

Habitat use

Percentage radio locations and percentage habitat availability (Table 2.2) were used to calculate log-ratios and difference in log-ratios. The difference in log-ratios (*d*) was significant in protected habitat($\Lambda = 0.1848$, $\chi^2 = 8.443$, $P < 0.05$) and even more so in grazed/burned habitat ($\Lambda = 0.0871$, $\chi^2 = 12.201$, $P < 0.01$), suggesting that habitat use by Redwing Francolin was non-random for both study sites.

A simplified ranking matrix (Table 2.3a) ranked habitat preference for Redwing Francolin in protected grassland in the order: wetland > rocky > grass. In grazed/burned grassland, habitat preference for Redwing ranked rocky > wetland > grass. Jacobs' preference index showed similar results (Table 2.3b) and ranked protected and grazed/burned grassland in the same order as the method described by Aebischer *et al.* (1993).

Table 2.1. Home range (hectares) analyses utilising 95% radio locations (excluding 5% outliers) for ten Redwing Francolin in protected and grazed/burned grassland habitat.

	bird number	MCP* range	harmonic mean	Kernel analyses	range** width (m)
protected	1	6.35	6.17	0.57	373
habitat	2	26.01	17.12	22.50	1147
	3	3.58	4.83	1.70	553
	4	13.26	25.39	7.60	846
	5	27.85	12.31	14.10	825
	mean	15.41	13.16	9.29	748.8
grazed/burned	6	13.76	14.49	5.81	796
habitat	7	20.44	23.01	10.89	813
	8	16.85	12.30	6.48	628
	9	6.19	10.01	2.90	555
	10	6.09	10.23	3.28	555
	mean	12.67	14.01	7.60	669.4
	MEAN	14.04	13.59	7.58	709.1

*MCP = Minimum Convex Polygon

**calculated from MCP home range

Table 2.2. Percentage radio locations in three grassland habitats for Redwing Francolin in protected and grazed/burned study sites.

	bird	number	% radio locations		
	number	fixes	wetland	rocky	grass
protected	1	33	15.2	30.3	54.5
habitat	2	32	25	43.7	31.3
	3	39	15.4	10.2	74.4
	4	32	3.1	56.3	40.6
	5	31	29	6.5	64.5
% habitat			5.7	10.2	84.1
grazed/burned	6	34	44.1	47.1	8.8
habitat	7	34	17.7	73.5	8.8
	8	34	70.6	8.8	20.6
	9	34	20.6	64.7	14.7
	10	35	2.9	82.8	14.3
% habitat			14.4	13.4	72.2

Table 2.3. Simplified ranking matrices for Redwing Francolin based on (a) compositional habitat use method (Aebischer *et al.* 1993) comparing total percentage habitat availability with percentage radio locations per habitat type (data from table 2.2), a triple sign represents significant deviation from random at $P < .05$ (t-value at 4 df = 2.776). (b Jacobs' preference index (P) (Jacobs 1974) for five Redwing Francolin in protected and five in grazed/burned grassland study sites.

(a)

	protected				grazed/burned			
	wetland	rocky	grass	rank	wetland	rocky	grass	rank
wetland		+	+ + +	2		-	+ + +	1
rocky	-		+ + +	1	+		+ + +	2
grass	- - -	-		0	- - -	- - -		0

(b)

	protected		grazed/burned	
habitat	P	rank	P	rank
wetland	0.506	2	0.366	1
rocky	0.476	1	0.611	2
grass	- 0.219	0	- 0.686	0

Spacing indices

Spacing indices between coveys measured in the ten regional study farms were significantly smaller on protected grasslands (Mann-Whitney U-test: $Z = 5.24$, $P < 0.0001$; protected: mean = 13.22 min, SE = 0.76, $N = 111$ coveys; grazed/burned: mean = 21.82 min, SE = 1.43, $N = 135$ coveys), indicating a closer spacing pattern between coveys in an environment more saturated with birds. Furthermore, both density and covey size were significantly lower in grazed/burned habitats (see Chapter 1).

Vegetation analyses and food plant availability

Mean vegetation height and cover followed the order: wetland > grass > rocky in both protected and grazed/burned study sites. Number of individual food plants followed the order: wetland > rocky > grass in both study sites (Table 2.4a) with the highest number of individual food plants recorded in the grazed/burned wetlands. In the protected study site, height and cover is significantly different ($P < 0.05$, Tukey) between all three habitat types, but not between rocky and grass habitat in grazed/burned grassland (Table 2.4b). There was no significant difference between availability of food plants in wetland vs rocky and rocky vs grass habitats in protected grassland and between rocky vs grass in grazed/burned grassland. Diversity of food plants was greatest in the rocky outcrops of both study sites, but generally lower in the grazed/burned habitat (Table 2.4a).

Table 2.4. Vegetation analyses of (a) mean ± SE of grass height, vegetation percentage cover, number of individual food plants, number of food plant species (diversity), (b) between-habitat comparison in protected and grazed/burned grassland study sites and (c) between-farm comparison of three habitats.

(a)

PROTECTED	wetland	rocky	grass	ANOVA
height	35.0 ± 1.02	14.6 ± 1.24	24.7 ± 1.51	F = 40.9**
% cover	95.0 ± 1.32	41.4 ± 4.07	78.8 ± 1.88	F = 100.7**
individuals	22.2 ± 5.99	9.35 ± 5.63	3.90 ± 0.74	F = 3.9*
diversity	11	18	8	
GRAZED/BURNED				
height	32.8 ± 1.52	14.8 ± 1.28	18.0 ± 1.51	F = 44.3**
% cover	81.5 ± 2.81	41.1 ± 4.94	50.0 ± 2.64	F = 34.4**
individuals	83.9 ± 13.64	4.5 ± 2.81	1.7 ± 0.58	F = 33.6**
diversity	10	11	6	

*$P < 0.05$, **$P < 0.001$

(b)

	protected			grazed/burned		
	height	% cover	individuals	height	% cover	individuals
wetland vs rocky	*	*		*	*	*
wetland vs grass	*	*	*	*	*	*
rocky vs grass	*	*				

*significantly different means; $P < 0.05$, Tukey test

(c)

	protected vs. grazed/burned farms		
variable	wetland	rocky	grass
height	$t = 1.21$	$t = -0.11$	$t = 3.14$*
% cover	$t = 4.27$**	$t = 0.05$	$t = 8.87$**
individuals	$t = -4.14$**	$t = 0.78$	$t = 2.35$*

*significantly different means; *$P < 0.05$, **$P < 0.001$, t –Test

The most profound difference between the two study sites was in the grassland habitat where sward height ($P < 0.05$), percentage cover ($P < 0.001$) and number of individual food plants ($P < 0.05$) were all significantly lower (*t*-Test) in grazed/burned grassland (Table 2.4c).

Discussion

Although home range sizes for Redwing Francolin were similar in protected and grazed/burned grasslands, habitat-use was more selective on the grazed/burned farm where birds conspicuously avoided open grasslands. Spacing between coveys was similar, since both study sites held ten coveys (Fig. 2.1). However, counts of francolins on all ten farms indicated that coveys were more closely spaced in protected habitats throughout the entire study region. Furthermore, smaller covey sizes were associated with lower population densities for Redwing Francolin in grazed/burned grassland habitats. A situation in which there are small, well-spaced coveys holding small home ranges suggests that birds are restricted to areas where resources are sufficient (e.g. wetlands and rocky outcrops) and avoid open grassland areas where the availability of food and cover is determined by the extent of grazing pressure (Table 2.4). In localised, high-quality habitats, covey ranges may experience some degree of overlap where competition for resources may take place, e.g. coveys 6 and 7 in the grazed/burned habitat (Fig. 2.1b locality marked with an X) behaved aggressively towards one another when they met. In protected environments, social factors relating to spacing and competition for habitats with a high abundance and diversity of favoured food, e.g. the corms of the family Iridaceae (Mentis & Little 1992), may play a greater role in regulating Redwing Francolin home range size and dispersion. In these high-quality grasslands, the greater availability of food plants and cover enable coveys to be larger and home ranges more tightly spaced. Here, territoriality may limit population density as potential settlers are prevented from occupying new territories by the presence of residents. In a removal experiment conducted on Red Grouse *Lagopus lagopus scoticus* (Watson 1967; Watson & Jenkins 1968), many of the non-territorial birds took up territories after removal of established territory owners. Furthermore, Watson *et al.* (1984) showed that food enrichment could influence territory size and spacing behaviour in red grouse populations.

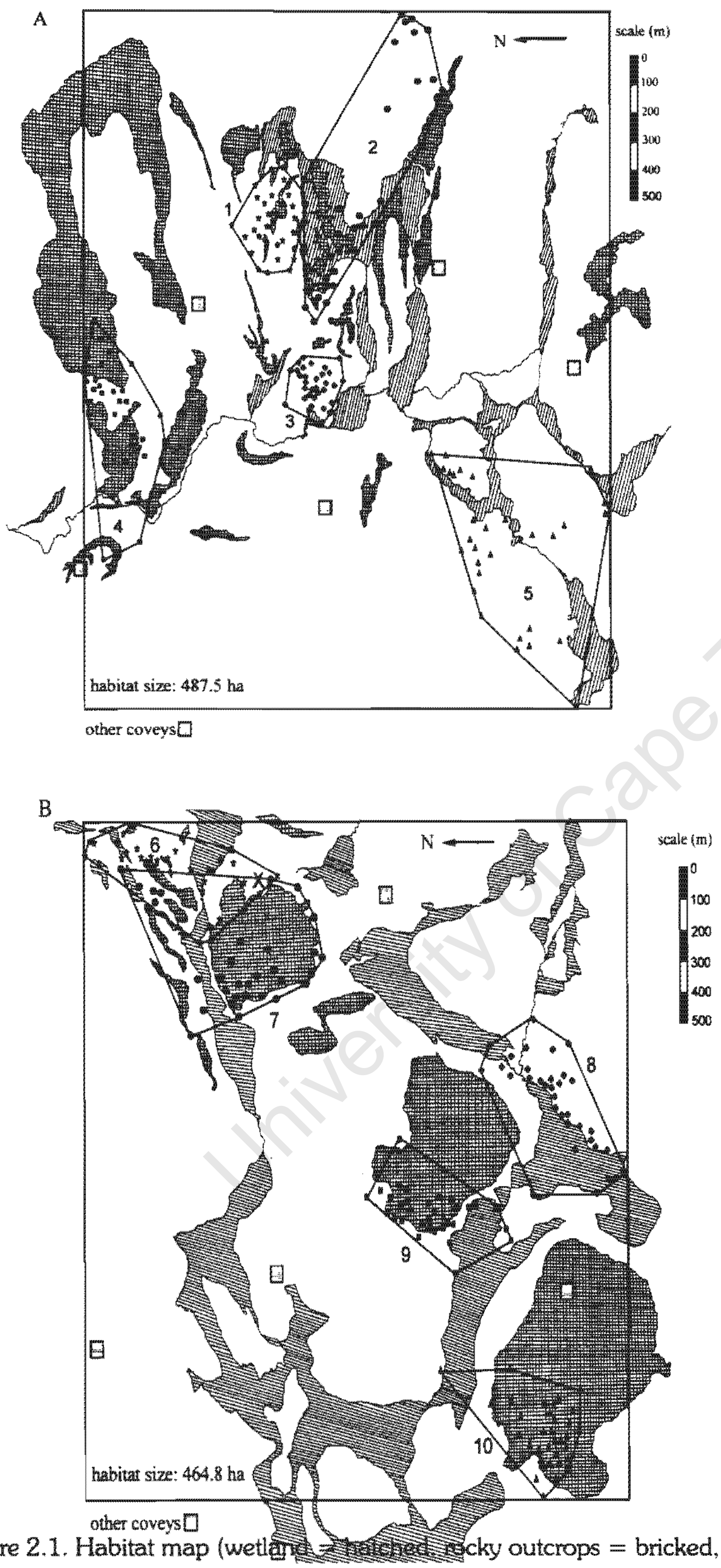


Figure 2.1. Habitat map (wetland = hatched, rocky outcrops = bricked, grass = clear) and location of fixes for ten radio-tracked Redwing Francolin in protected grassland habitat (A) and grazed/burned habitat (B). Point marked with an X in 2B refers to home-range overlap where coveys behaved aggressively towards one another

Habitat-use ranking was similar to food-availability ranking, where birds appeared to prefer areas of high food plant availability. The nutrient-enriched run-off from the rangelands into the streams and wetland systems would encourage the eutrophication of food plants in grazed/burned grasslands. However, the extent of these productive microhabitats in grassland–dominant environments is very small and unlikely to support large numbers of Redwing. Furthermore, these wetlands and sponge systems are under threat from damming operations and extension of pasture and crop fields.

This study provides quantitative support for the hypothesis of Mentis & Bigalke (1979) and Mentis & Little (1992) in that the occurrence of francolins is related to the optimal cover and height of the grass. Redwing are effectively excluded from open grassland areas and restricted to the relatively fragmented rocky outcrop and wetland habitats. Furthermore, large expanses of grassland are burned annually in spring, which coincides with the onset of the summer rainfall cycle and nesting period for Redwing, effectively fragmenting francolin sub-populations and possibly undermining their meta-population structure (Hanski & Gilpin 1991) and diminishing the amount of habitat available for adult birds to establish territories and nesting sites. Such a demographic breakdown could increase the possibility of local extinction's (Hanski & Gilpin 1991). Indeed, in a study conducted by Mentis & Bigalke (1979) in protected areas in the KwaZulu Natal midlands, Redwing Francolin were most abundant in grassland that had been burned one to two years previously and were scarce or absent on recently burned or closely grazed grassland. It is only with biennial or less frequent burning and low grazing pressures under 'conservation' that sufficient cover is provided (Mentis & Little 1992).

Conclusions

On grazed/burned properties, smaller, more fragmented coveys are effectively excluded from the predominant grassland areas where close grazing of the sward reduces optimal cover and ecological availability of that habitat to Redwing Francolin. The layout of their home range is restricted to the remaining inferior grasslands or less prolific microhabitats, e.g. wetlands and rocky outcrops, where food and cover abound, but are insufficient in quantity within the greater region to sustain larger populations. Therefore, observed population declines of Redwing Francolin in the commercial pasture farms of

Mpumalanga Province (see Chapter 1) can be attributed, at least partly, to local extinction due to habitat degradation through excessive defoliation of the grassland from heavy grazing and frequent burning, effectively reducing the accessibility of large-scale habitat areas required to maintain high numbers.

Biotic diversity in grassland ecosystems is maintained by fluctuating conditions which favour first one species, or a group of species, and then another (Mentis & Bailey 1990). This is at odds with the uniform grassland management policies involving high stocking rates accompanied by annual burning, which is a "short-term, high gain" approach currently practised by most of the local, commercial livestock farmers. Habitat diversity or the formation of "patches" of burned and unburned grass with various levels of grazing pressure, forming the fine-scale grassland mosaic proposed by Mentis & Bigalke (1981b), would provide suitable habitat for the Redwing Francolin and a range of other grassland species.

Chapter 3

Breeding biology of the Redwing Francolin

Summary

The breeding biology of the Redwing Francolin *Francolinus levaillantii* was studied in the highland grasslands of Mpumalanga Province during 1995-1996. The breeding season is from August to March. Clutches were incubated by hens only and all nests were located in rank grass close to surface water. Mean clutch size was 4.3 eggs (SD = 0.78; n = 10) and mean egg dimensions were 40.1 x 32.3 mm (SD = 1.07 and 0.81; n = 44). Hatching success was 83.7% and clutch survival rate to 22 days of incubation was 82.8%. Mean production of chicks per clutch was 3.0, observed mean production (counts of hens with chicks) was 2.6 chicks per brood (n = 24 clutches; 62 chicks). The wingshooting season for Redwing in Mpumalanga should be from 15 April to 15 July.

Introduction

The Redwing Francolin *Francolinus levaillantii* is a ground-nesting, highland grassland, monogamous phasianid, which form coveys in the non-breeding season (Mentis & Bigalke 1980). It has a staggered breeding season throughout South Africa with the timing of breeding closely related to rainfall (Clancey 1967; Liversidge 1987; Little & Crowe 2000). In winter rainfall regions (e.g. southern Eastern and Western Cape Provinces), Redwing Francolin populations have been reported to breed from March - July (Clancey 1967; Winterbottom 1971; Maclean 1985) and from August - March in summer rainfall regions (e.g. KwaZulu Natal; Mentis & Bigalke 1980). Timing of wingshooting and off-take levels have been set in relation to breeding seasons and annual recruitment of young birds into the adult population for populations in KwaZulu Natal (Mentis & Bigalke 1980).

The aims of this Chapter were to investigate the timing of breeding, nest success, annual production and recruitment of Redwing Francolins in the highland grasslands of Mpumalanga Province, South Africa and to discuss management implications and the timing of hunting and off-take levels.

Methods

The study was conducted during 1995-1996 on farms in the Belfast, Dullstroom and Lydenburg districts of the eastern escarpment of Mpumalanga Province, South Africa (Fig. 0.3).

Covey sizes, presence of chicks within coveys and the locations of active nests were recorded with the aid of English pointers. Pairing behaviour was taken as the percentage of coveys comprising two birds. Age of chicks was estimated by observing their flight behaviour and plumage development (Little & Crowe 1992): 1-14 day old birds did not fly and had downy heads, 14-28 day old birds were capable of flutter-flight (2-3m) and the downy back chevron was still bold, and older birds (>28 days) flew strongly and had little or no down. Nesting activity (%) was determined by noting (a) the date of sitting hens, (b) the date of eggs within the oviduct of sampled hen birds and (c) by backdating the age of chicks (< 21 days old) to the time of hatching and laying (incubation period of 22 days; Little & Crowe 1993b). Chick mortality rate was determined by counting the number in the brood and estimating their ages by methods described above. Specific broods were not monitored and brood counts were made at random.

Nesting success was determined using methods described by Mayfield (1975):

Clutch survival = probability eggs will survive the duration of incubation
= $[1\text{-}(\text{clutches lost/nest days of incubation})]^{\text{incubation period}}$
Hatching success = the probability that eggs present at hatching will actually produce living young
= number of young/number of eggs before hatching
Nest production = probability that egg at onset of incubation will produce a chick
= (clutch survival x hatching success) x 100

Eggs were measured and nests examined on site. Clutch size was considered to be the largest number of eggs in the nest during incubation. Egg length was measured with Vernier callipers along the longitudinal axis, and egg width across the widest part of the egg. Incubation period was determined by labelling the eggs shortly after laying and counting the number of days from the laying of the last egg in a clutch to the hatching of that egg (Campbell & Lack 1985).

Data for environmental variables (rainfall and temperature) were extracted from Agro Climate Reports (Anon. 1970-1996) from Belfast Station (25°39'S and 30°02'E). Seasonal gonad development was monitored by collecting specimens throughout the duration of the study and measuring the anterior-posterior length of the larger testis (usually the left one) for males (n = 27) and for females (n = 35), the diameter of the largest follicle (Little & Crowe 1993b).

Correlation analyses were done between covey size, pairing and nesting behaviour against measurements of monthly rainfall and ambient temperature. *t*-Tests (comparing two means) were carried out on chick survival age classes. All statistical analyses were performed using Statgraphics statistical graphics package (Anon. 1986).

Results

Timing of breeding

Redwing began to breed in the study area in early August, when birds paired at the onset of early summer rains, and extended through to March. Nesting activity was significantly positively correlated with mean rainfall over the duration of the study ($r = 0.82$; $P < 0.05$) and with rainfall figures collected from 1970 ($r = 0.76$; $P < 0.05$). Mean covey size was significantly negatively correlated with rainfall ($r = 0.67$; $P > 0.05$) and temperature ($r = 0.69$; $P > 0.05$) (Table 3.1). Coveys were smallest during November - January (Fig. 3.1), pairing activity peaked in March and the most active nesting period was during November. Gonad development peaked in November for males and in December for females, corresponding to periods of high rainfall (Fig. 3.2).

Table 3.1. Correlation coefficients (*r*) for monthly breeding activity of Redwing Francolin against rainfall and mean maximum temperature

Correlation variables	*r*	*p*
covey size *vs*		
rainfall	- 0.79	$P < 0.05$
temperature	- 0.61	$P < 0.05$
pairing *vs*		
rainfall	0.67	ns
temperature	0.69	ns
nesting *vs*		
rainfall	0.76	$P < 0.05$
temperature	0.56	ns

Nesting, clutch size and incubation

All 10 nests discovered were in rank grass close (< 100m) to surface water. Nests were all situated on the ground, under the canopy of a grass tuft, and no nests were found in grassland that had been burnt within six months.

Mean clutch size was 4.3 eggs (SD = 0.78; range = 3 - 5; n = 10). Mean egg size was 40.1mm x 32.3mm (SD = 0.81 and 1.07; range = 38.3-43.5 x 31.1-33.3; n = 44). Egg colouration is consistent with the description by Clancey (1967), i.e. brownish yellow, occasionally finely freckled with brown. Incubation period was recorded for a single nest (22 days).

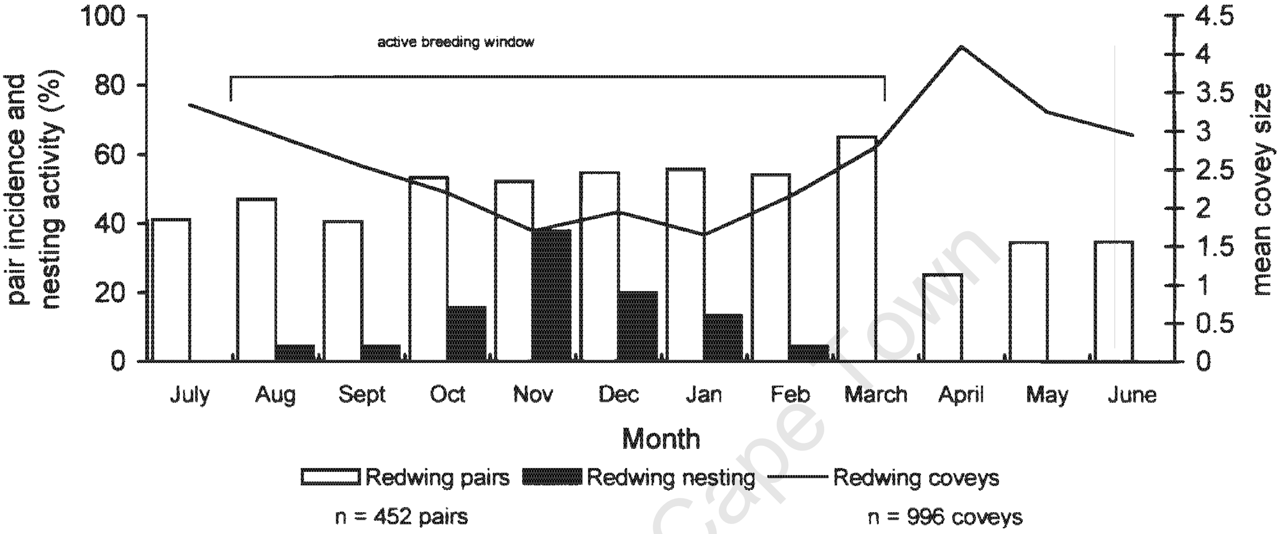


Figure 3.1. Covey size, pairing behaviour and nesting activity for Redwing in Mpumalanga Province

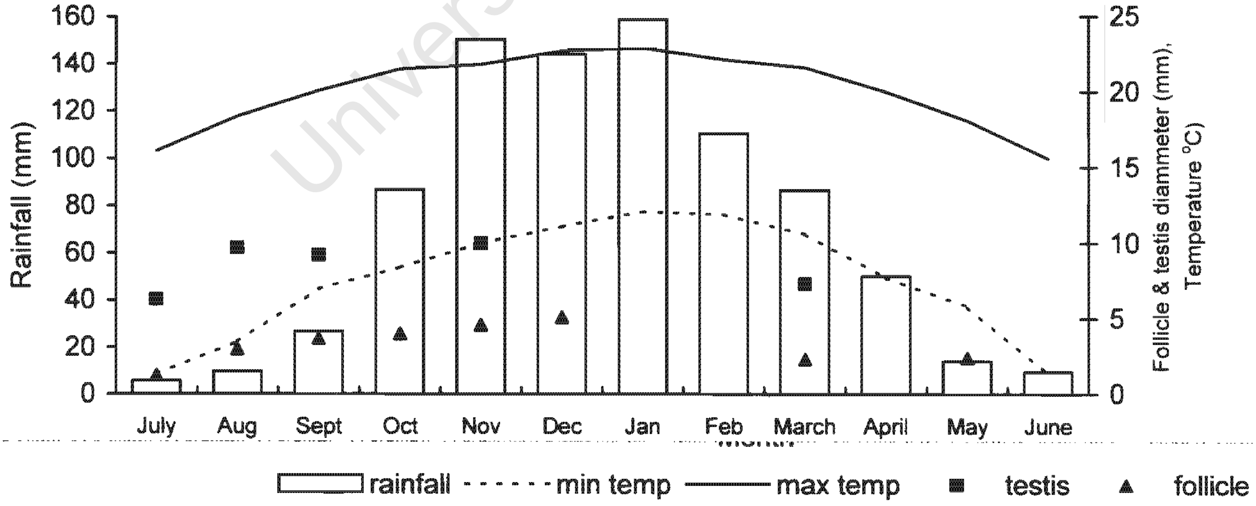


Figure 3.2. Mean follicle (n = 33) and testis (n = 27) diameter for Redwing Francolin against mean annua rainfall and mean maximum temperature

Nest success

Clutch survival rates, hatching rate and nesting production are given in Table 3.2. Only one nest was lost (three eggs) due to abandonment and an unknown predator took a single egg from a second nest. The clutch survival rate (i.e. probability that eggs will survive the duration of incubation) was 82.8%. The hatching rate (i.e. the probability that eggs present at hatching time actually produce living young) was 83.7%. The overall probability that an egg at the onset of incubation will produce a chick was 69.3%. Thus, with a mean clutch size of 4.3 eggs per hen, 3.0 chicks per hen are hatched per season.

Table 3.2. Nest success data used for calculating clutch survival rate, hatching rate and nesting production for Redwing Francolin in highland grasslands, Mpumalanga Province, South Africa.

	nest number	nest days incubation	No. young produced	No. eggs before hatch
	1	6	0	3
	2	22	5	5
	3	13	3	4
	4	9	4	5
	5	7	4	4
	6	17	4	5
	7	9	5	5
	8	12	4	4
	9	18	4	5
	10	4	3	3
total	10	117	36	43

The mean number of chicks observed with hens up to the age of two weeks (N = 62 chicks) was 2.6 chicks/hen. However, the number of chicks dropped significantly (t = 2.32, $P < 0.05$) to 1.9 chicks/hen by four weeks of age, suffering a 27% mortality rate over the first four weeks. If we consider that three chicks per hen are hatched per season, then the mortality rate increases to 36% within the first four weeks (Fig. 3.3). This method may be an underestimation of mortality as it does not take into account whole brood loss or, on the other hand, reproductive capability does not account for adults that never produce a brood for that season.

Discussion

Timing of breeding

In the summer rainfall region of the Mpumalanga escarpment, the breeding season extends from August to March. In the winter rainfall regions, i.e. southern Eastern Cape and Western Cape, Redwing breed from May to September (Liversidge 1987). The relationship between climatic variables (rainfall, temperature and day length) and breeding season have been linked to food availability and, in particular, arthropod abundance (Berry & Crowe 1985; Little & Crowe 1993b). The food resource is critical to both the laying-parent and the newly hatched young as successful breeding can take place only if the female has a large enough protein reserve to form eggs (Earlé 1981) and the chicks have suitable quantities of arthropods available to them to feed on within the first few weeks after hatching (Savory 1977; Green 1984; Rands 1985, 1986b).

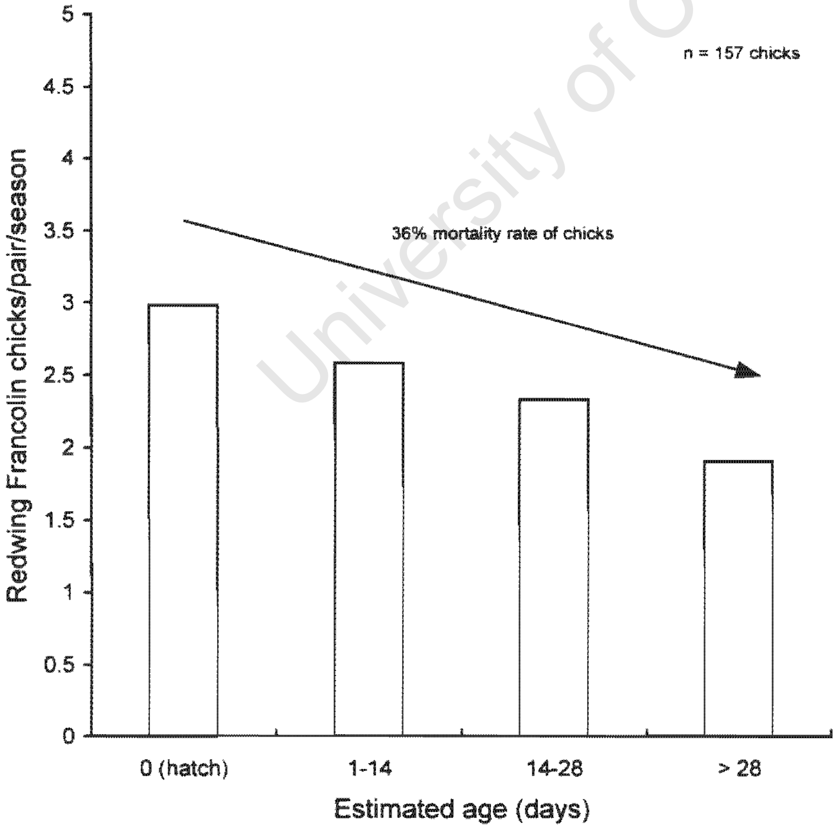


Figure 3.3. Mortality rate of Redwing Francolin chicks in first four weeks after hatch

Nesting, clutch and egg size

Mean egg size for Redwing in this study was consistent with those in other studies for this species (Clancey 1967; Winterbottom 1971; Maclean 1985). However, the upper range of clutch size in this study (five eggs) was lower than the eight eggs reported by Winterbottom (1971) and up to 10 eggs reported by Maclean (1985) and Clancey (1967). Dhondt *et al.* (1992) suggested that smaller clutches may result from increased population densities with proportionally more poor - quality sites available (with smaller clutches). However, low population densities of Redwing observed within the study region (see Chapter 1) does not support the density-dependent clutch size hypothesis but rather the lack of good quality sites for nesting. Moreover, Redwing concentrate activities in habitat where food plant abundance, diversity and grass cover is maximised (see Chapter 4; see Chapter 2) and, as such, their numbers are higher within these sparse habitats.

A Redwing hen fitted with a radio transmitter revealed the possibility that this species may breed twice in one season, as suggested by Mentis & Bigalke (1980). At the time of trapping (28 February 1997) this bird was accompanied by two sub-adult chicks, two weeks later she was located sitting on a clutch of five eggs late in the breeding season. Incubation was by the hen only, usually with the paired male close to the nest. The hen only left the nest for brief periods to feed and did not venture more than a few hundred meters in a radius around the nest.

Nest success and recruitment

Generally, nest success was higher for Redwing in Mpumalanga (82.8%) than for Greywing in the Eastern Cape (31.4%; Little & Crowe 1993b). However, hatching success was only slightly lower for Redwing in Mpumalanga (83.7%) than for Greywing in the Eastern Cape (90%; Little & Crowe 1993b). Making use of Mayfield's (1975) method for estimation of overall nesting production, 3.0 chicks produced per pair per season was higher than the 2.0 chicks hatched per pair per season reported for Greywing in the Eastern Cape (Little & Crowe 1993b). However, the 36% mortality rate observed within the first four weeks of hatching supports the hypothesis that some resource (e.g. food or cover) is limiting (see Chapter 4), and, as such, would adversely influence survival and recruitment of young birds into the adult population. Much of the grassland in the study area is burnt annually and grazed heavily at the onset of the summer rains (July - September) and coincides with the start of the breeding season. This not only affects the quantity, but also the quality of nesting habitat which are important factors in determining efficient recruitment in gamebirds (Rands 1987).

Management implications

From past studies (Mentis & Bigalke 1973, 1979; Mentis & Little 1992; see Chapter 1), it is clear that fire is an important tool in regulating the condition of the grassland sward and thus influencing population densities of Redwing and Greywing Francolin. Our recommendations follow those of Mentis & Bigalke (1973; 1981b) in that breeding site quality will be enhanced by burning grasslands on a biennial basis, developing a fine-scale fire mosaic of burnt and unburned grass, prior to the breeding season. Burning should be done no later than August so as to have least impact on nesting success (Little & Crowe 1993b). Hunting should be designed to take the harvestable surplus shortly after the breeding season. Since Redwing coveys are generally small, one bird out of three or two out of five would be sustainable. Based on the breeding season, we recommend the hunting season for the Redwing Francolin in Belfast and Lydenburg districts of Mpumalanga Province to be from the 15 April to 15 July – a period where no noticeable breeding took place and no young chicks were observed.

Chapter 4

Habitat constraints and diet of the Redwing Francolin

Summary

A variety of habitat characteristics were investigated along a land-use gradient in an attempt to determine which factors may have influenced the population decline of Redwing Francolin *Francolinus levaillantii* in commercial pasture farms in the highland grasslands of Mpumalanga Province. Within three micro-habitats (wetlands, rocky outcrops and grassland), number and diversity of food plants, height of the sward and percentage cover were significantly lower in habitat exposed to commercial grazing with sheep. Increased cover and height of the sward were positively correlated with higher diversity and availability of francolin food plants. Crop analyses revealed a lower intake in the number of food plant species, but higher incidence of invertebrates, ingested by birds collected in heavily grazed and frequently burned grasslands. Intestinal caecae were significantly ($P < 0.0001$) longer in birds collected from grazed/burned grasslands – possibly associated with a low quality, more fibrous diet. Both the quantity and quality of habitat in terms of food abundance, diversity and cover are important factors influencing the distribution of Redwing Francolin in these grasslands.

Introduction

Food and habitat quantity and quality have been identified as primary limiting factors that influence bird populations (Lack 1954). Enrichment of the abundance, availability and quality of food has been known to alter spacing behaviour, territory size and numbers in Red Grouse *Lagopus lagopus scoticus* populations (Miller *et al.* 1970; Watson *et al.* 1984) and other bird species (e.g. Newton 1980). Studies on gamebirds in Europe have shown that species such as the Grey Partridge *Perdix perdix* (Rands 1986a), Red Grouse (Jenkins *et al.* 1963), Black Grouse *Tetrao tetrix* (Baines 1996) and Capercaillie *Tetrao urogallus* (Jones 1984) have highly specific nest site habitat requirements which may be factors important to their survival (Rands 1988).

The optimum environment of a species usually coincides with the most productive types in the range of habitats occupied by a species (Folse 1982). Competition theory (Wiens 1977) predicts that populations will track variation in resources by adjusting population sizes or resource utilisation, since animals are rarely distributed at random over the landscape, but rather according to the occurrence of essential resources (Göransson *et al.* 1991). This has formed the basis of many behavioural studies on competition, exclusion, territory size and foraging in birds (e.g. Hixon 1980; Patterson 1980; Myers *et al.* 1981; Schoener 1983; Lima 1984; Eberhard & Ewald 1994; Moody *et al.* 1997; Stillman *et al.* 1997). However, as natural and anthropogenic forces change the availability of habitats, the proportion of individuals of a given species in any particular habitat may be altered (Pulliam & Danielson 1991). Few studies of terrestrial gamebirds have compared the demographic rates of the same species in different habitats directly where essential resources such as food and cover may be limiting.

The Redwing Francolin *Francolinus levaillantii* has been described as an indicator species of healthy "sour" highland grassland habitat (Harrison *et al.* 1994), being markedly much more successful in protected, unburned, ungrazed grasslands (Little & Allan 1997; see Chapter 1). Population declines have been attributed to severe degradation of grassland, especially from overgrazing and annual burning (see Chapter 1). Furthermore, the distribution and configuration of home ranges of this species may be limited by excessive defoliation of grasslands, and probably the quality and quantity of food available (Mentis 1973; Mentis & Bigalke 1973, 1979; see Chapter 2). However, the effects of fire and grazing regimes on food plant preferences, availability and diversity and sward structure have not been studied for the Redwing Francolin in grassland environments. The aims of this Chapter are to investigate the availability of food, food preferences and habitat characteristics along a land-use gradient for the Redwing Francolin in the highland grasslands of Mpumalanga Province.

Methods

Vegetation analyses

Three farms were chosen that represent a range in grassland management practices from annual burning and high stocking rates (farm 1), biennial burning and moderate stocking rates (farm 2) and triennial burning with no grazing (farm 3). A plant species constitutes a food plant where birds were located, with the aid of pointer dogs, and found to be digging at the base of the stem to access the bulb or root. Counts of the number of individual food plants, sward height and percentage cover was measured in 1 m x 1 m quadrats over three micro-habitats (wetland, rocky outcrops and grass areas) in all three study sites over the months March and April 1997. Individual food plants were identified to the level of species and the proportion of food plant availability (number of individuals) and diversity (number of species) calculated for each microhabitat and study area. Quadrat samples were taken every 5 m along a line transect incorporating 20 samples per microhabitat and 60 samples per study site.

Diet samples and intestinal morphology

The examination of crop contents is a highly suitable method of determining feeding habits and food preferences of grassland francolins, given that they appear to select the best food available (Little *et al.* 1993). Furthermore, the exploitation of a particular food type requires changes in intestinal anatomy to accompany digestion (Newton 1980).

Crops from 56 Redwing Francolin were collected during April 1995 - April 1997 over a number of habitats, not necessarily the farms over which the vegetation analyses was performed, that varying in the degree of grazing intensity and burning frequency. Crop contents were separated into five food types (corms, rhizomes, arthropods, seeds and leaves). Food items from each crop were counted and measured volumetrically by water - displacement method (to the nearest 0.01 ml) per food class. Numbers of species for corms and arthropods were determined for each crop and related to habitat to determine food diversity and food preference.

Since the composition and amount of food eaten affect gut size in gamebirds (Moss 1972a), the length of large intestine, small intestine and combined length of both caecae were measured to the nearest millimetre.

Data analyses

Programs from the Statgraphics (Anon 1986) statistical package were used to perform simple one-way ANOVA between vegetation height, percentage cover and food plant availability between wetland, rocky and grass habitats within and between the three study sites. If the overall ANOVA was significant, a Tukey test was used to establish which habitats differed significantly from the others. Regression analysis was used to determine relationships between the number of food plant species (diversity) and availability of food plants (number of individuals) against percentage cover and height of the sward over all habitats. *t*-Tests were used to test for significant differences in crop contents and intestinal length between birds from habitats varying in grazing intensity. Multivariate analyses of food plant species encountered at the study sites were performed using the cluster analysis (CLUSTER) and non-metric multi-dimensional scaling (MDS) programs in the PRIMER software package (Plymouth Marine Laboratory, U.K.). Briefly, species presence data were summarised in a triangular matrix of similarities between all sites, using the Bray-Curtis similarity coefficient (Bray & Curtis, 1957). Results of this procedure were displayed as a dendrogram that reflects the hierarchical relationships of sites, using group-average linkage, and as a two-dimensional MDS ordination plot which represents these similarities in a non-hierarchical manner.

Results

Vegetation analyses

Vegetation height, percentage cover and availability of food plants all differed significantly ($P < 0.05$) between micro-habitats (wetlands, rocky outcrops and open grass areas) (Table 4.1a). Generally, food plant availability, height of the sward and percentage cover were significantly lower in heavily grazed and frequently burned than in protected grasslands (Table 4.1b, Fig. 4.1). Wetlands had the greatest percentage cover

Table 4.1. Between-habitat comparisons if the Anovas of vegetation height, percentage cover and availability of food plants are significantly different ($F_{0.05(1),2,57}$) within the three study sites (a) and between-farm comparison of three habitats (b) in Mpumalanga Province

(a)

	height	% cover	availability
NO GRAZING			
ANOVA	F = 40.9[b]	F = 100.7[b]	F = 3.9[a]
wetland vs rocky	*	*	
wetland vs grass	*	*	*
rocky vs grass	*	*	
LIGHT GRAZING			
ANOVA	F = 259.5[b]	F = 92.6[b]	F = 8.1[a]
wetland vs rocky	*	*	*
wetland vs grass	*	*	*
rocky vs grass			
HEAVY GRAZING			
ANOVA	F = 44.3[b]	F = 34.4[b]	F = 33.6[b]
wetland vs rocky	*	*	*
wetland vs grass	*	*	*
rocky vs grass		*	

*donates significance at 95% using Tukey multiple range test. [a]ANOVA F-statistic significant at $P < 0.05$. [b]ANOVA F-statistic significant at $P < 0.001$

(b)

	farms**				
	1 vs 2	1 vs 3	2 vs 3	ANOVA	significance
GRASS HEIGHT					
wetland	*		*	F = 5.6	$P < 0.05$
rocky				F = 1.7	ns
grass	*	*		F = 16.1	$P < 0.001$
% COVER					
wetland	*	*		F = 12.0	$P < 0.001$
rocky				F = 1.2	ns
grass	*	*	*	F = 44.8	$P < 0.001$
AVAILABILITY					
wetland		*	*	F = 15.5	$P < 0.001$
rocky				F = 0.9	ns
grass		*		F = 4.2	$P < 0.05$

*donates significance at 95% using Tukey multiple range test

**farms: 1 = no grazing, 2 = light grazing, 3 = heavy grazing

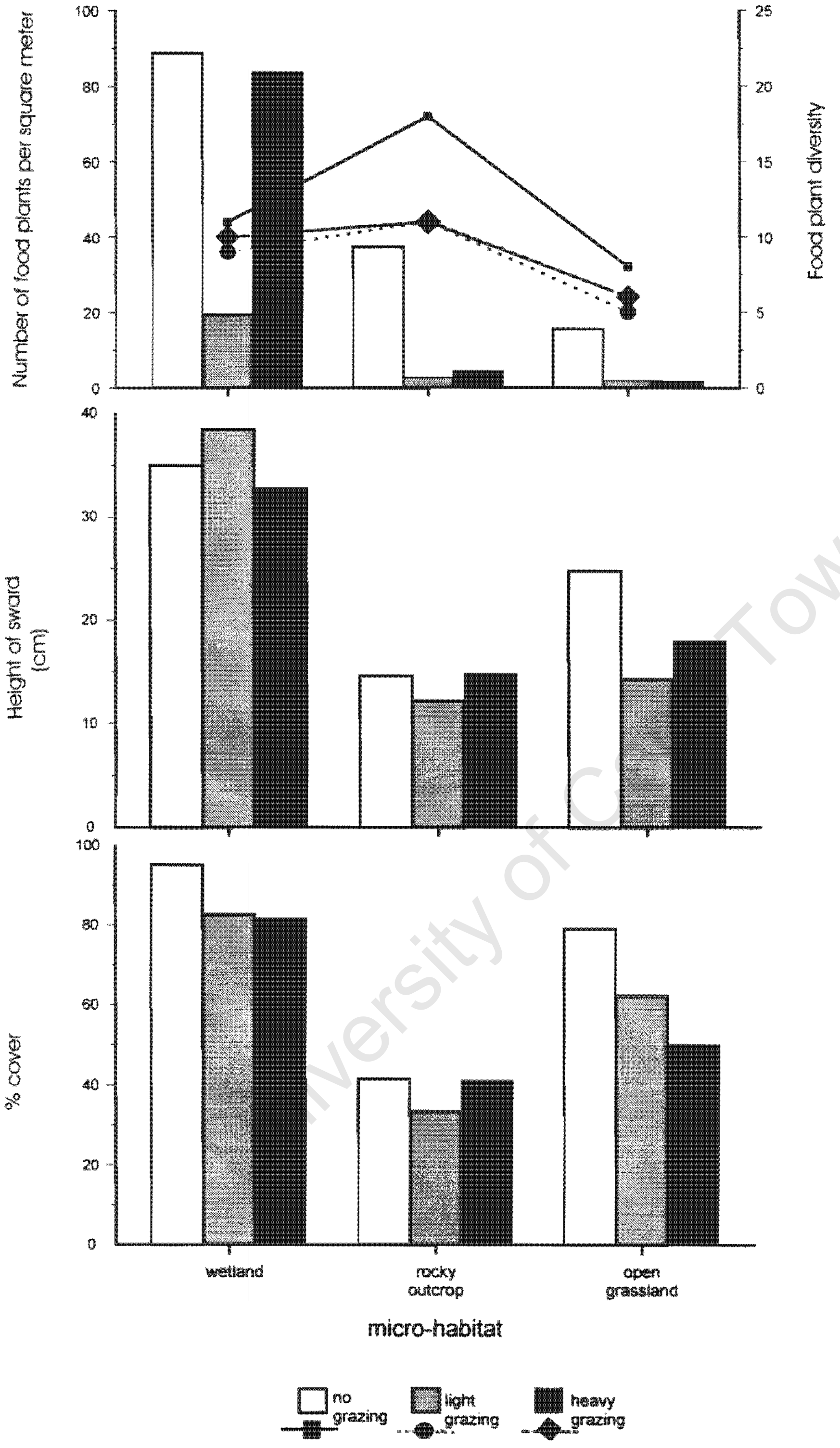


Figure 4.1. Mean values for percentage cover, height of sward, number of food plants (availability) and number of food plant species (diversity) over three microhabitats (wetland, rocky outcrop and grassland) in three study farms varying in the degree of grazing intensity in the highland grasslands of Mpumalanga Province.

and sward height, followed by open grassland and rocky outcrops in all three study areas (Fig. 4.1). Availability of food plants was higher in wetland habitat (Fig. 4.1), especially under heavy grazing, but not significantly different between rocky outcrop and open grassland habitat (Table 4.1a).

Diversity of food plant species was greatest in the rocky outcrops followed by wetlands and then open grass habitat over all study sites (Fig. 4.1), but generally lower within heavily grazed/burned habitats. Ungrazed habitat had 29 food plant species followed by moderately grazed habitat (20 species) and heavily grazed/burned grasslands (18 species). A total of 43 species of food plants was recognised within the study area (Table 4.2) belonging to 14 families. Only three individuals plants could not be recognised to the level of species.

Regression analyses revealed a positive relationship between sward height verses diversity of food plants ($F_{1.178} = 9.45$, $r^2 = 0.050$, $P < 0.02$) and availability ($F_{1.178} = 17.38$, $r^2 = 0.089$, $P < 0.001$) as well as a positive relationship between percentage cover verses diversity ($F_{1.178} = 9.97$, $r^2 < 0.02$, $P < 0.02$) and availability ($F_{1.178} = 15.67$, $r^2 = 0.081$, $P < 0.001$) of food plants when the data was pooled over all habitats.

Multivariate analyses of the food plant species revealed three habitat assemblages. Both species presence and abundance were closely associated with the level of grazing pressure (Fig. 4.2). Heavily grazed habitats are grouped together and are represented by similar food plant species composition. They also represent a low diversity of food plants available to birds. The next grouping, based on food plant species diversity, includes protected and moderately grazed rocky outcrops and grasslands. Protected and moderately grazed wetlands are further distinguished by their constituent food plant species, indicating a diversity not only based on the particular micro-habitat but also on the level of grazing pressure.

Diet, crop analysis and intestinal morphology

Pooling the data obtained from all the crops collected, corms made up the majority of food items ingested both in number (61,7%) and volume (67%). However, although the small number of rhizomes (2.9%) ingested contributed to a large volume (20.7%) to the crop, the opposite was true for arthropods. The large percentage of arthropods ingested (31.7%) accounted for only 9.7% of the crop volume. On separating the crops collected

Table 4.2. Plant species recorded as being used as food by Redwing Francolin over the three study habitats. Plants were identified by one of the authors (ERR) in the C E Moss Herbarium, Department of Botany, University of the Witwatersrand. Names of grasses follow Gibbs Russel *et al.* (1990), *Dierama* is from Hilliard & Burtt (1991), names in *Gladiolus* follow Goldblatt & Manning (1998) and other names are as in Arnold & De Wet (1993).

Monocotyledenous Plants

FAMILY ALLIACEAE
Agapanthus inapertus
Cyrtanthus breviflorus

FAMILY ASPHODELIACEAE
Chlorophytum cooperi
Chlorophytum galpinii
Chlorophytum transvaalensis
Trachyandra asperata

FAMILY COLCHICACEAE
Androcymbium melanthioides
Wurmbea kraussii

FAMILY CYPERACEAE
Cyperus sp
Cyperus halpan
Cyperus marginatus
Mariscus macer
Pycreus betschuanus
Scleria woodii

FAMILY HYACINTHACEAE
Albuca melleri
Drimiopsis atropurpurea
Ornithogalum paludosum
Scilla nervosa

FAMILY HYPOXIDACEAE
Hypoxis angustifolia
Hypoxis rigidula

FAMILY IRIDACEAE
Crocosmia pottsii
Dierama formosum
Gladiolus crassifolius
Gladiolus hollandii
Gladiolus varius var. micranthus
Gladiolus varius var. varius
Gladiolus woodii
Moraea galpinii
Moraea elliottii
Moraea pubiflora
Watsonia bella
Watsonia wilmsii

FAMILY POACEAE
*Alloteropsis semialata subsp. ecklonia*na
Loudetia simplex
Trachypogon spicatus
Tristachya leucothrix

Dicotyledenous Plants

FAMILY ASTERACEAE
Gerbera sp.

FAMILY GERANIACEAE
Pelargonium sidoides

FAMILY OXALIDACEAE
Oxalis obliquifolia

FAMILY POLYGONACEAE
Rumex woodii

FAMILY RUBIACEAE
Conostomium natalense var. glabrum

FAMILY SELAGINACEAE
Hebenstretia dentata
Selago sp.

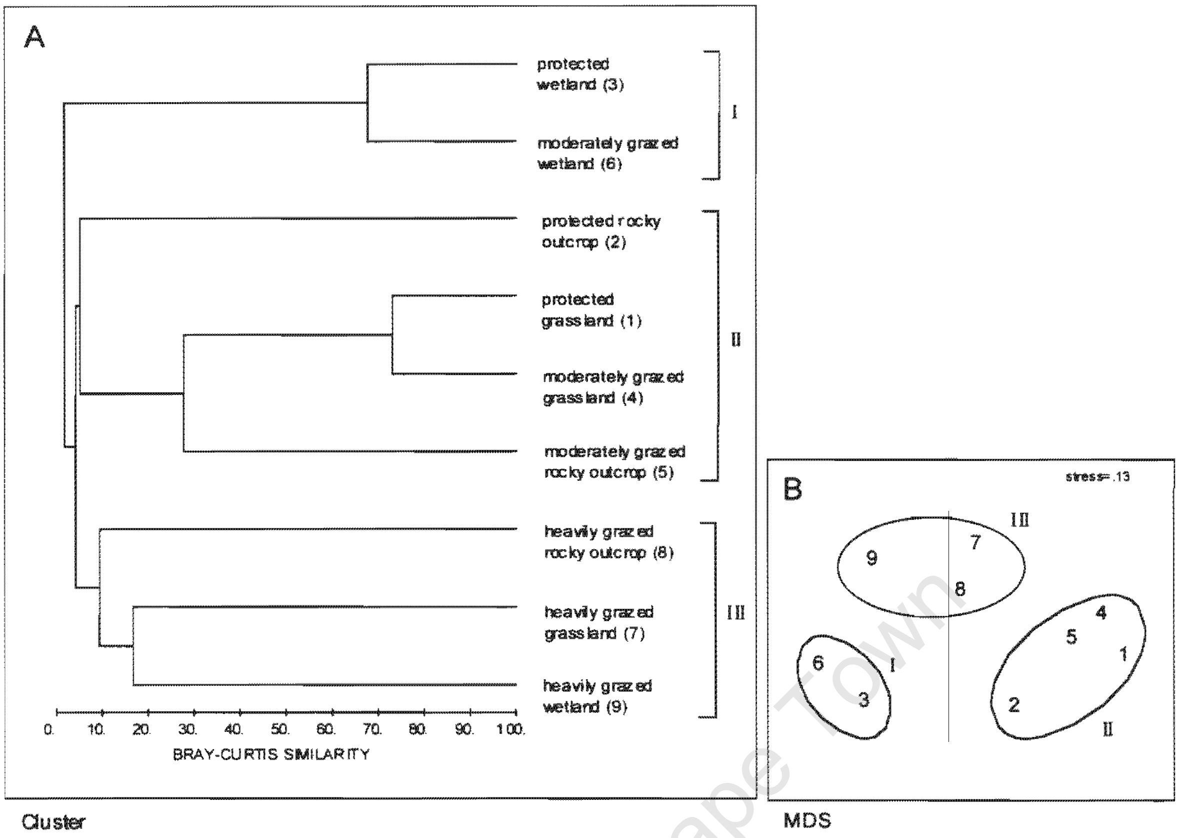


Figure 4.2. Dendrogram of Bray-Curtis percentage similarities in food plant assemblage structure within the three study sites (A) and multidimensional scaling ordination between sites (MDS) (B).

from protected grasslands and grazed/burned grasslands (Fig. 4.3), birds from protected grasslands ingested more corms and rhizomes (protected: 68.3% and 3% *vs.* grazed: 42.3% and 2.6%), but fewer arthropods (25.7%) and seeds (2.4%) than birds from grazed/burned grasslands (49.4% and 5.2%). The mean number of corm species was significantly higher in birds from protected grasslands than for birds from grazed/burned habitats (protected: n = 30 birds, mean corm spp. = 2.2, *SD* = 1.32; grazed/burned: n = 15 birds, mean corm spp. = 1.3, *SD* = 0.62; *t* -Test: *t* = 2.40, $P < 0.05$). Although the corms ingested by birds in grazed/burned grasslands were proportionally larger and accounted for a greater volume in the crop (77.8%), the arthropods were smaller and accounted for a small percentage of the crop volume (6.5%). In terms of numbers; ants, termites and beetles were the favoured invertebrate species ingested (Fig. 4.4). However, worms and millipedes were more abundant in birds from protected habitats and, due to their large size, would account for this large volume.

There was no significant ($P > 0.05$) between the lengths of the small and large intestine between birds from protected and grazed/burned grasslands. However, combined length of caecae was significantly greater in birds from grazed/burned grasslands (protected: n = 27, mean = 226.6, SD = 28.1; grazed/burned: n = 23, mean = 270.3, SD = 40.8; *t*-test: $t = -4.47$, d.f. = 48, $P < 0.001$).

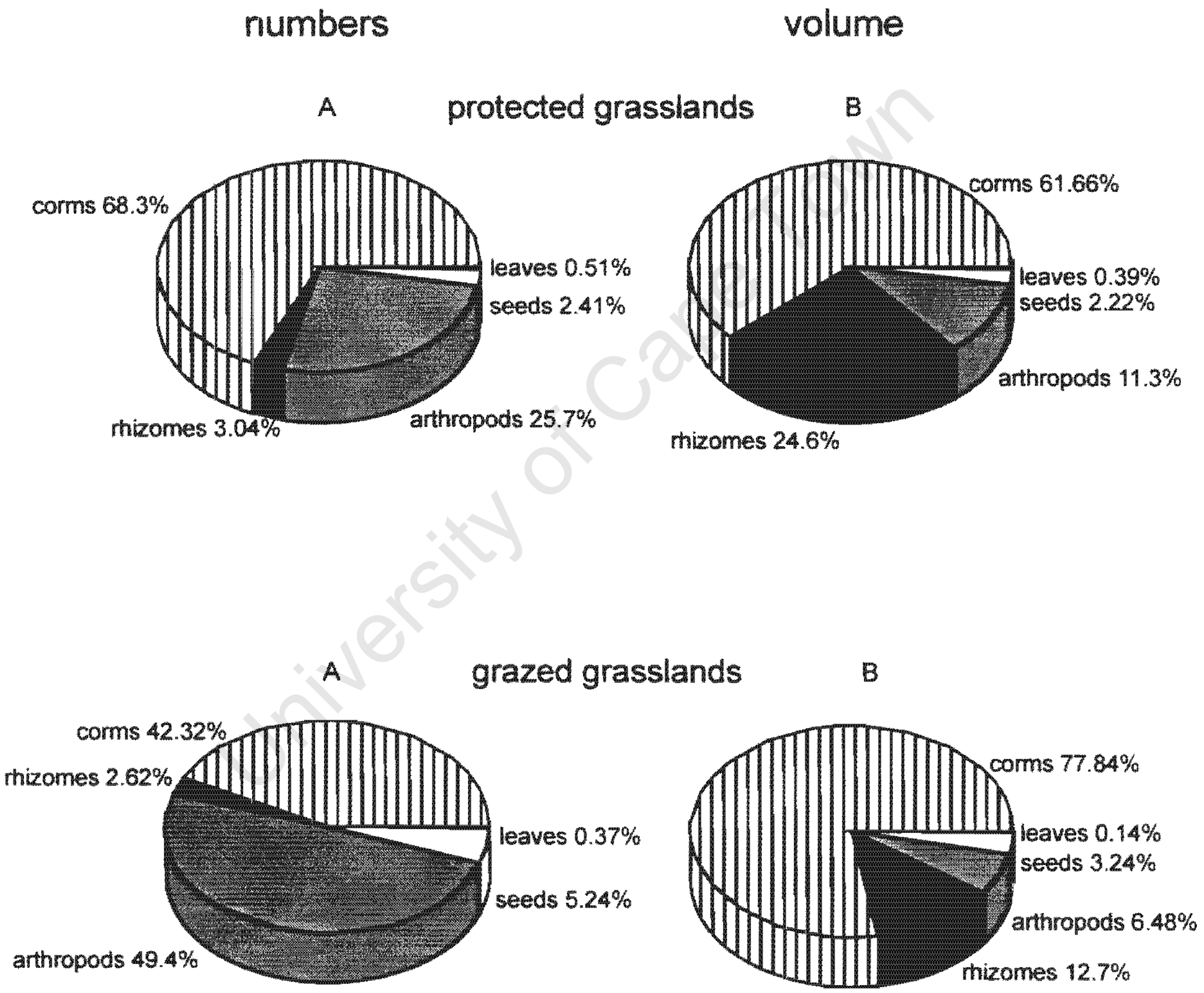


Figure 4.3. Analyses of Redwing Francolin crop contents for number of food items (A) and volume of food items (B) in protected (n = 36) and grazed/burned (n = 20) grassland habitats.

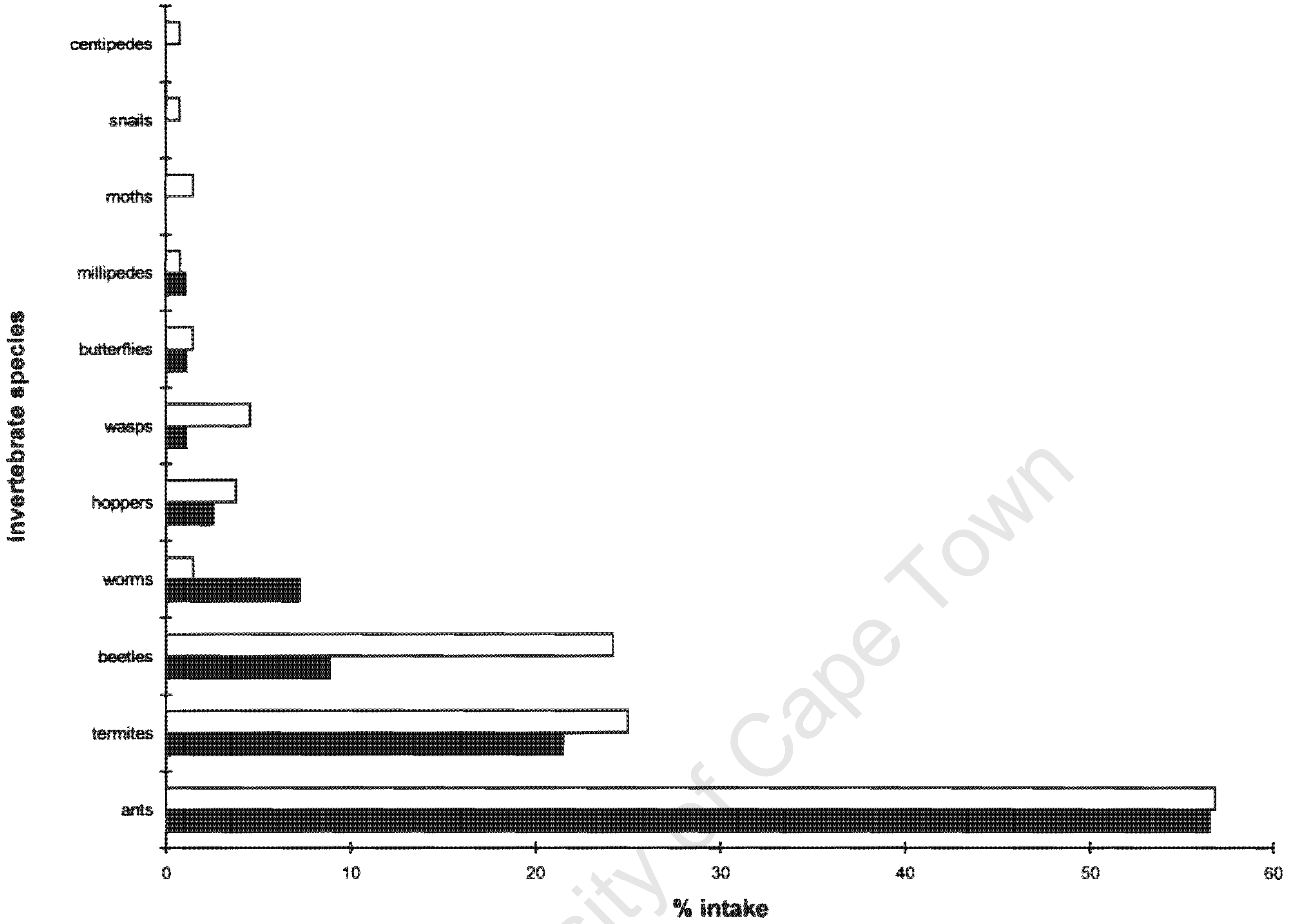


Figure 4.4. Relative intake of invertebrates (number of items reflected as a percentage) collected from crops of Redwing Francolin in protected (solid) and grazed/burned (clear) grassland habitat, Mpumalanga Province

Discussion

The close correlation between Redwing Francolin density and grazing pressure, as discussed in Chapter 1, suggests that there are some environmental constraints on Redwing Francolin population density and covey size. This study supports the hypothesis of Mentis & Bigalke (1973, 1979) and Mentis & Little (1992) that the distribution of these francolins is related to optimal cover and height of the grass. Redwing are effectively excluded from heavily grazed/burned grasslands and are thus restricted to the less dominant, fragmented habitats such as rocky outcrops and wetlands.

The non-random spacing of animals throughout their habitats is often attributed to the heterogeneous distribution of resources (Moody *et al.* 1997), where individuals or groups of animals actively seek out habitats of high or maximum resource availability. The usage of habitat by the Redwing Francolin, as described in the radio-tracking and habitat-use section (see Chapter 2), follows the abundance and diversity of food plants closely, suggesting that, where food is limiting, bird numbers will be low. Thus, as suggested by Little *et al.* (1993), for the Greywing Francolin *F. africanus,* and this study (Chapter 2), for the Redwing Francolin, home-range distribution of grassland francolins is restricted by food plant availability. In other words, Redwing Francolins concentrate their activities in habitats where food plant abundance, diversity and grass cover are maximised. The nutrient-enriched run-off from pasturelands may encourage eutrophication of francolin food plants in wetland systems within grazed/burned grasslands. This habitat is highly sought-after by Redwing Francolins for food and cover, but is uncommon in the study area and is characterised by coveys with small home ranges (7.6 - 15.4 hectares, see Chapter 2). Rocky outcrops, on the other hand, provide suitable habitat for a diversity of food plants where weathering of the parent rock may enhance the chemical composition of the soil and encourage the nutritional value available to birds as diversity of food plants increases (Mentis & Bigalke 1981a). Open grassland constitutes the most abundant habitat, but has the lowest diversity and availability of food plants. Furthermore, food plant diversity and availability are influenced strongly by the presence of the wetlands, rocky outcrops and open grassland micro-habitats as well as the degree of grazing pressure on these habitats (Fig. 4.1).

Diet and percentage intake of food for Redwing Francolin in Mpumalanga grasslands was similar to Redwing in the KwaZulu Natal Drakensberg (Mentis & Bigalke 1973, 1981a). The low number of food plant species in the crops of Redwing from grazed/burned habitats and the lower overall diversity and availability of food plant species on grazed/burned habitats supports the hypothesis that the availability of food plants restricts populations of Redwing Francolins and that birds may be selecting sites based on a particular quality of diet. Competition for food may be related to the distribution or type of food rather than its total amount (Newton 1980), as was observed for the Red Grouse (Savory 1978). However, birds in grazed/burned grasslands ingest corms of greater size, but probably lower nutritional value (Mentis & Bigalke 1981a). A high intake of invertebrates and food of low metabolizable energy may compensate for the scarcity of nutritional food plants in grazed/burned habitats (McDonald *et al.* 1973; Mentis & Bigalke 1981a). It is also possible that fewer arthropods are available to birds as a result of increased grazing and burning pressures (Baines 1996; Fischer *et al.* 1996), and birds in these habitats may actively seek out arthropods to supplement their diet. Redwing Francolins inhabiting farmland also ingested maize kernels where birds where collected in close proximity to croplands.

Changes of the structure of grasslands induced by the changes of management have shifted the proportions of food plants and the amount of cover available, even on a local scale where nutrient runoff from rangelands and leaching from parent rocks influence variation in food plant availability. Most theories of optimal foraging (e.g. Myers *et al.* 1981) predict that individuals should specialise on most productive habitat patches or restrict their diet to the optimal prey types when resources become abundant. Redwing Francolin capitalise on areas of high food plant availability and cover and the layout of their home-ranges are in close proximity to the fringes of wetlands and rocky outcrops, where resources are maximised (see Chapter 2), and restricted from heavily grazed/burned open grassland areas.

The lengths of the large and small intestine were comparable in length to those of grouse of similar body mass (450-550g) (Leopold, 1953). However, the length of the large intestine for Redwing Francolins in Mpumalanga grasslands was greater than that for Redwing from large-scale protected grasslands of the KwaZulu Natal Drakensberg (mean = 916mm, n = 22; Mentis & Bigalke 1981a). Furthermore, the significant increase in the length of the caecum in birds from grazed/burned grasslands supports the hypothesis of Leopold (1953) and Moss (1972a) that the intake of more fibrous, less nutritious, food may cause increases in caecum length in gallinaceous birds. This increased length of the caecum observed in Redwing Francolin from these habitats suggests that food plants are of lower nutritional quality and quantity in grazed/burned habitats where birds have to digest food plants of greater volume and higher fibre content.

Environmental fluctuations in the highland grasslands of Mpumalanga, in terms of intense grazing and annual burning, are such that populations are generally well below the potential carrying capacity (see Chapter 1). However, food can seldom account wholly for the declines of a given population because neither mortality nor recruitment is dependent on food-supply alone (Newton 1980). Modifications in behaviour in response to changing food and cover quantity, quality, or availability have more subtle effects on reproduction and spacing. Low availability of suitable nesting cover in grazed/burned grasslands effectively reduces the potential production and recruitment of Redwing Francolin populations since they prefer taller vegetation close to surface water (see Chapter 3).

Previous studies on grouse species showed a marked decline in breeding density, breeding success, clutch size, brood production rate, nesting survival and chick survival where the habitat was of insufficient quantity and quality (e.g. Moss 1968; Miller *et al.* 1970; Panek 1977; Watson & O'Hare 1979; Watson *et al.* 1984; Rands 1986b; Rands 1987; Baines 1996; Badyaev *et al.* 1996). Furthermore, the numbers of high-quality sites that can potentially produce a large number of offspring are relatively low and widespread in the study area. Birds are forced to occupy sub-optimal habitats as most suitable habitats fall in the range of territorial coveys. Generally, environments with very dilute concentrations of high-quality habitats (in this case food and cover) have relatively low population sizes (Pulliam & Danielson 1991) that are limited by the amount of suitable nesting and foraging habitat - essentially influencing production, recruitment and survival.

Chapter 5

Haematozoa of Redwing and Greywing Francolin

Summary

Blood smears collected from 28 Redwing Francolin *Francolinus levaillantii* and nine Greywing Francolin *F. africanus* from three montane grassland habitats in the highlands of Mpumalanga Province from August 1996 to March 1997 were examined for haematozoa parasites. Three haematozoans were identified of which *Leucocytozoon macleani* and microfilaria were the most common and *Trypanosoma avium* the least common. The incidence of infections were higher in Redwing Francolin (64.3%) than in Greywing Francolin (11.1%). Francolins collected in grasslands which had been exposed to higher grazing pressures and more frequent burning had a higher prevalence of blood parasites. Infections with *L. macleani* were significantly ($P < 0.01$) greater in commercially grazed and frequently burnt grassland habitats than in less intensively utilised grasslands. Incidence of infection by haematozoa was inversely related to population density of Redwing Francolin. Haematozoan infections with the parasites observed in thus study, do not seem to pose any threat to population densities of these two grassland francolins within the study region.

Introduction

Since the first report of a protozoan from the blood of birds by Danilewsky in 1885, there has been a constantly growing list of host species infected by parasitic haematozoa (Bennett *et al.* 1992). Gamebirds are known to be affected by various species of blood protozoa (Huchzermeyer 1987; Earlé *et al.* 1991; Bennett *et al.* 1992; Earlé, Little & Crowe 1992; Earlé & Little 1993). Like competition and predation, parasites are now seen to operate in a density-dependent manner and so serve to regulate the density of their hosts (Anderson & May 1978; Dobson & Hudson 1986). Considering the commercial importance of gamebirds in terms of gaining additional income for landowners from hunting operations, all factors which potentially concern the management of these birds and the regulation of their numbers should be investigated. Furthermore, the influence of habitat quality and prevalence of haematozoan parasites in relation to host population density has not been investigated.

The aim of this Chapter was to compare blood parasite loads in populations of Redwing Francolin *Francolinus levaillantii* and Greywing Francolin *F. africanus* in three highland grassland habitats in Mpumalanga Province, South Africa.

Methods

Blood smears were collected from Redwing (n = 28) and Greywing Francolin (n = 9) from three grassland habitats in the Dullstroom and Lydenburg districts between August 1996 and March 1997. Habitat-A is managed with a triennial burning programme and supports no commercial grazing. Habitat-B follows a biennial burning programme and has been rested from cattle grazing for four years. Habitat-C is exposed to annual burning and high stocking rates with sheep.

Blood was obtained from the hearts of freshly shot birds. The blood smears were air-dried and fixed with absolute methanol before being stained with 4% Giemsa solution for 50 minutes. The smears were examined microscopically and the blood parasites identified.

The population densities of grassland francolin were estimated by the method described by Mentis & Bigalke (1985). Birds were located using English pointers, identified and counted and an estimate of density per ha (*D*) obtained by applying the index of abundance (*I*), or birds found per minute of searching, to the following equation:

$$D = 0.023 + 0.376\,I \text{ (Mentis \& Bigalke 1985)}$$

Results

The prevalence of haematozoan parasites was highest in grasslands exposed to high grazing pressures and more frequent burning practices (Table 5.1), with habitat-C having the highest frequency of birds infected (88.9%). A total of 56.8% of all francolin sampled were infected. Three haematozoan parasites were identified (Table 5.1) of which *Leucocytozoon macleani* and microfilariae were the most common and *Trypanosoma avium* the least common. Infections with *L. macleani* were significantly higher ($\chi^2 = 8$, d.f. = 2, $P < 0.01$) in habitat-C exposed to intensive grazing and frequent burning than in habitats A or B. Only two birds from habitat-C, were infected by two haematozoan species.

Table 5.1. Comparison of the prevalence of infection (%) by haematozoan parasites in Redwing and Greywing Francolin from three habitats in montane grasslands in Mpumalanga Province.

	Grassland habitats								
	A n = 14		B n = 14		C n = 9		Total n = 37		
Parasite species	#	%	#	%	#	%	#	%	Significance*
Leucocytozoon	1	7.1	1	7.1	7	77.8	9	24.3	$P < 0.02$
Trypanosoma	0	0	2	14.3	1	11.1	3	8.1	$P > 0.05$
Microfilaria	3	21.4	4	28.6	2	22.2	9	24.3	$P > 0.05$
Total infected	4	28.5	7	50	8	88.9	37	56.8	

Habitat A = triennial burning, no commercial grazing
Habitat B = biennial burning, rested for past four years
Habitat C = annual burning, high sheep stocking rates
n = number of birds sampled
# = number of birds infected
* Chi-square goodness of fit test (Yate's correction)

Population densities of Redwing Francolin dropped steadily from habitats A to C (Fig. 5.1). However, Greywing Francolin densities were similar over all three study sites. Levels of infection were inversly related to population densities of Redwing Francolin with highest infection rates in francolins from habitat-C (Fig. 5.1). Haematozoa were far more prevalent in Redwing Francolin (64.3%) than in Greywing Francolin (11.1%).

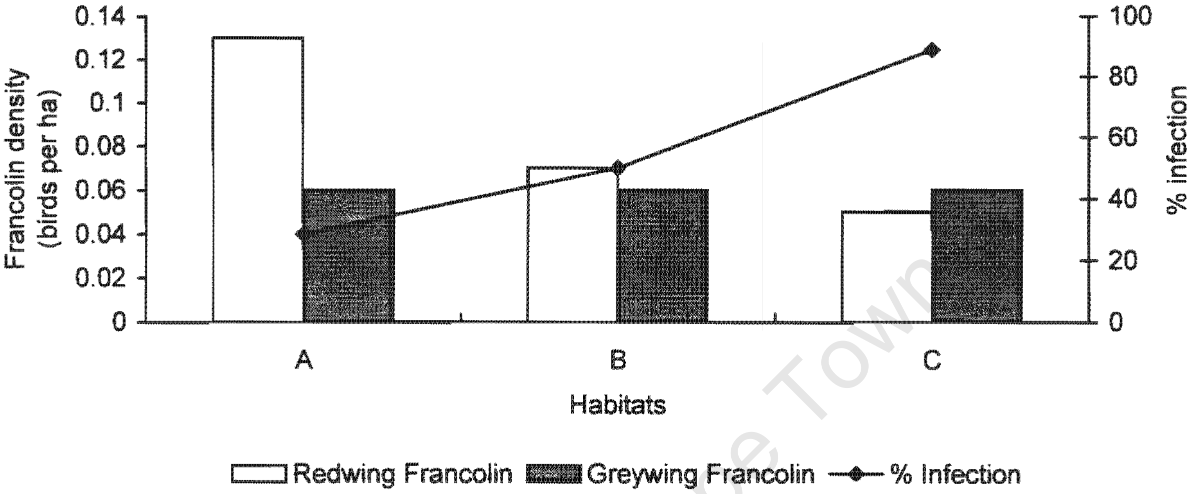


Figure 5.1. Population densities of Redwing Francolin and Greywing Francolin with respective percentage of haematozoan infection over three study sites in Mpumalanga Province.

Discussion

The higher incidence of blood parasite infections in birds occupying grasslands exposed to more frequent burning and higher livestock stocking rates might be related to francolin population density. With lower bird densities as a result of habitat degradation (see Chapter 1), the availability of suitable hosts is reduced and therefore the prevalence of infection greater. Furthermore, grasslands exposed to commercial grazing may be more suitable in terms of sustaining higher numbers of parasite-transmitting vectors, e.g. blood-sucking black flies (Diptera: Simuliidae) (Bennett *et al*. 1992).

Infections with *L. macleani* have also been observed in Greywing Francolin (Earlé *et al*. 1992; Bennett *et al*. 1992), Cape Francolin *F. capensis*, Natal Francolin *F. natalensis* and Rednecked Francolin *F. afer* (Earlé & Little 1993). *Leucocytozoon* spp.

are host family specific and transmission is by ornithophilic black flies (Diptera: Simuliidae) (Threlfall & Bennett 1989; Bennett *et al.* 1992; Earlé, *et al.* 1992). The abundant small streams and hilly terrain in the study area would be ideal for the breeding of these vectors. (Earlé *et al.* 1991). Earlé *et al.* (1991) observed highest frequencies of *Leucocytozoon* infections in various host bird species during the winter season (June - Oct.) in the Lydenburg district. Sampling of grassland francolin over this period may reveal higher infection rates than observed in the current study.

Few *Trypanosoma* spp. are known to be host specific (Threlfall & Bennett 1989) and most, e.g. *Trypanosoma avium*, have a wide range of hosts. Few studies have been conducted on the life cycles and vectors of these blood parasites due to the problem that most of the species are highly pleomorphic (Bennett *et al.* 1994). The low infection levels of *Trypanosoma* spp. observed in the study area may be attributed to (a) low occurrence of the species or (b) the difficulty of detecting trypanosomes in blood smear preparations (Bennett *et al.* 1992). A centrifuge technique such as the hematocrit centrifuge, is required to assess the prevalence of these parasites reliably (Bennett 1962). *T. avium* has also been recorded in Greywing Francolin (Earlé *et al.* 1992), Natal Francolin (Earlé & Little 1993), Helmeted Guineafowl and Orange River Francolin *F. levaillantoides* (Bennett *et al.* 1992).

The other frequently occurring group of blood parasites is the microfilariae of the Filroidea representing the larval stage of roundworms (Nematoda) (Oosthuizen & Markus 1967; Threlfall & Bennett 1989). Adult worms can directly reduce the survival and reproductive output of wild gamebird species (Hudson 1986; Hudson & Dobson 1988). Microfilariae can only be specifically identified when associated with the adult worm. Therefore, no attempt has been made to summarise the species of microfilariae recorded from avian hosts (Bennett *et al.* 1992). However, many of these parasites appear to be dependent upon vector transmission to hosts (Earlé *et al.* 1992).

As is the case with this study, Earlé & Little (1993) found *Leucocytozoon* spp. and microfilariae to be amongst the commonest parasites occurring in eight gamebird species in southern Africa. However, parasitic infections with these two parasites produce a relatively benign course of infection in wild populations of gamebirds. The same applies to *Trypanosoma* spp. which do not appear to cause gross pathological effects in bird species (Bennett *et al.* 1992). Haematozoan infection in Redwing Francolin and

Greywing Francolin do not seem to pose any threat to population densities within the study region.

SECTION 2

THE SWAINSON'S SPURFOWL

"It does not appear to extend its range much south of the northern slopes of the Magaliesberg near Rustenburg but does a good deal of damage among the Marpela grain fields of the natives in the upper Zambesi"

Stark (1906)

Chapter 6

Population distribution and habitat-use

Summary

Counts on Swainson's Spurfowl *Pternistis swainsonii* were made during 1998 – 1999 within an intensive, fine-grained, agricultural landscape to estimate population parameters, seasonal dispersion and habitat preferences. Radio-transmitters were fitted to four birds to note habitat use and home ranges within the summer breeding season. During winter, population densities peaked and birds exploited agricultural crops extensively. At the onset of spring, densities dropped as birds paired to establish non-overlapping breeding territories over a number of habitats with apparently sufficient cover and 'natural' food. Expanding grazed grassland appears to be the greatest threat to Swainson's Spurfowl due to a lack of cover and food. The matrix of habitats within the landscape plays important roles in the success of this opportunistic spurfowl. Agricultural crops in the winter sustain the population until the following summer when natural savanna and ungrazed grasslands provide complementary foraging, nesting and roosting sites.

Introduction

There are few countries on Earth that have not experienced extensive and major transformations of their landscapes as a result of agriculture (McIntyre & Barrett 1992). Since these anthropogenic transformations change the availability of habitats, the populations of a given species in any particular habitat may be altered (Pulliam & Danielson 1991). This has formed the basis of many species - specific studies centering on their population dynamics. Although the importance of environmental patchiness is commonly accepted, little attention has been given to multiple habitat use by animals (Law & Dickman 1998), particularly of more common species in a fine-grained habitat mosaic.

Results from Europe point to widespread reduction of bird populations for many species and across many countries. Most striking has been the reduction of once common and widespread species, especially in western Europe, and this reduction is primarily attributable to intensified agriculture (Bibby 1999). Gamebirds, in this part of the world, are no exception and populations of Hazel Grouse *Bonasa bonasia*, Capercaillie *Tetrao urogallus*, Black Grouse *Tetrao tetrix* and Grey Partridge *Perdix perdix* have experienced population declines and/or severe range reductions (Perrins 1992; Klaus 1994; Panek 1997; Marshall & Edward-Jones 1998). Moreover, many gamebird species are habitat specialists and a reduction in the availability of specific habitat types has led to a further increase in the number of globally threatened Asiatic partridges, many of which are single-country endemics and are confined to small areas of relictual, natural habitat (Rands 1992). However, a number of species have benefited from this increased intensification in agriculture, specifically species that are habitat generalists that can exploit the diversity within fine-grained habitat mosaics.

One such gamebird that has done this is Swainson's Spurfowl *Pternistis swainsonii* which has increased in both population and its distributional range in southern Africa during the last 50 years (Little & Crowe 2000). The ability of this opportunistic gamebird to exploit agricultural crops and benefit from the fine-grained habitat mosaic created by this form of land management, has led to increased numbers even within previously unsuitable habitat (Mentis 1970; Milstein & Wolff 1987; Milstein 1989; Pero 1996; Little 1997; Little & Crowe 2000).

The aims of this Chapter are to ascertain the importance of each habitat (cotton, maize, grazed grasslands, ungrazed grasslands, thornveld and islands of relictual natural habitat) individually and collectively within the landscape mosaic. Specific focus will be placed on population densities, seasonal movements and overall habitat preferences of Swainson's Spurfowl. This should allow the identification of factors that may contribute to the overall success of this species within a highly transformed landscape.

Methods

Population studies on Swainson's Spurfowl were conducted during 1988 – 1999 within a 1 345 hectare area within the Springbok Flats, Northern Province.

Population densities

Counts of spurfowl were conducted monthly with the aid of pointer dogs between 06H00 and 11H00. Habitat types were categorized according to the dominant land-use: crop agriculture (cotton and maize), grasslands (grazed and ungrazed) and savanna (large tracts of thornveld and isolated patches of thornveld 'islands' on the periphery or within croplands). Each habitat category was surveyed by means of widely spaced, non-overlapping, transects to prevent double counting. Note was made of the counting period, number of birds per covey, locality of birds and number of young birds per brood.

Home range and radio tracking

Four Swainson's Spurfowl were trapped in November and December (summer) 1999 by means of baited walk-in traps and mist-nets. The abundant food resource within the study area coupled with time-constraints prevented any further birds to be trapped. An unknown predator took one bird fitted with a transmitter. Trapped birds were fitted with a 2.9g (0.49% body mass, mean body mass of 100 birds sampled over study region = 596g) necklace radio-collar (Biotrack Co. Ltd; Kenward, 1987a) which gave an effective ground to ground range in the 148 MHz band of 500 - 1200m using a Yaesu radio receiver and a four-element hand-held Yagi antenna.

Directional radio fixes were obtained by three-point triangulation. On moving to the triangulation intersection plot, a small 15cm vertical antenna (Yaesu) was fitted onto the receiver which gave a more accurate (to within 10m) close-up directional and distance estimation plot. Each fix was plotted on a 1:10 000 aerial photograph of the study area and note made of the habitat-type the fix was taken in. For each radio-tagged bird, fixes were taken approximately ever two hours over a ten-day period. The home range study was conducted in summer (December - January) during the breeding season when most birds are in pairs and male birds had established breeding territories.

The Range IV program (Kenward 1990) was used to calculate the following home ranges: the minimum convex polygon (MCP), or so-called minimum area polygon (Mohr 1947) enclosing 95% of radio locations, the harmonic-mean area using isopleths limited by the isoline which enclose 95% of radio locations (Dixon & Chapman 1980), and the Kernel analysis home range with the same 95% isoline (Worton 1989).

Habitat analyses

The proportion of each habitat category within the study area was calculated by superimposing a 1 x 1cm grid (100 x 100m = 1 hectare) over a 1:10 000 aerial photograph and counting the blocks (hectares) each habitat type falls in. Edge habitat is defined as the linear interface ($1m^2$) between two habitat types and calculated by measuring the centimeters on the periphery of each habitat and converting this to hectares ($1cm^2 = 10000\ m^2 = 1$ hectare).

Data analyses

Correlation analyses were performed between population density and covey sizes over months of the year and between mean population densities within habitats and the mean number of birds on the edge habitat. Regression analyses were performed for climatic variables (rainfall) against population densities, covey size and the presence of chicks over all months of the year and between the percentage of edge habitat against the percentage of birds found in edge habitat. *t*-Tests were performed to note significant difference between population densities of birds between habitat types.

Due to the small sample size of birds radio-tracked ($n = 4$), a simple procedure of habitat preference (Jacobs Preference Index, Jacobs 1974) was employed in place of a more acceptable habitat utilisation procedure such as the compositional analyses of habitat use described by Aebischer, Robertson & Kenward (1993). The shortcoming of Jacobs preference index is that it does not allow for significance testing whereas compositional analyses described by Aebischer *et al.* (1993) does. Jacobs preference index is calculated as follows:

$$P = (R_1/R_2 - A_1/A_2) / (R_1/R_2 + A_1/A_2)$$

where P = Jacobs' preference index, R = number of radio fixes, A = area of habitat, 1 = for a particular habitat, 2 = for all habitats or all fixes.

Results

Seasonal population trends

The population increased in dispersion at the onset of the breeding season, evidenced by the overall decline in the number of birds as coveys break-up to form pairs (correlation of density & covey size: $r = 0.570$, $P < 0.05$) (Fig. 6.1). These pairs then dispersed to establish breeding territories at the onset of the first summer rains in August. Furthermore, density, covey size and the presence of chicks were significantly correlated with the onset of summer rainfall (rainfall vs. density: $F_{1.10} = 5.37$, $r^2 = 0.349$, $P < 0.05$; vs. covey size: $F_{1.10} = 11.68$, $r^2 = 0.539$, $P < 0.01$; vs. chicks: $F_{1.10} = 5.10$, $r^2 = 0.338$, $P < 0.05$). Birds again regrouped into coveys following the summer breeding (April) and the overall population climbed to a point higher than the previous season as a result of recruitment from the recent breeding activity.

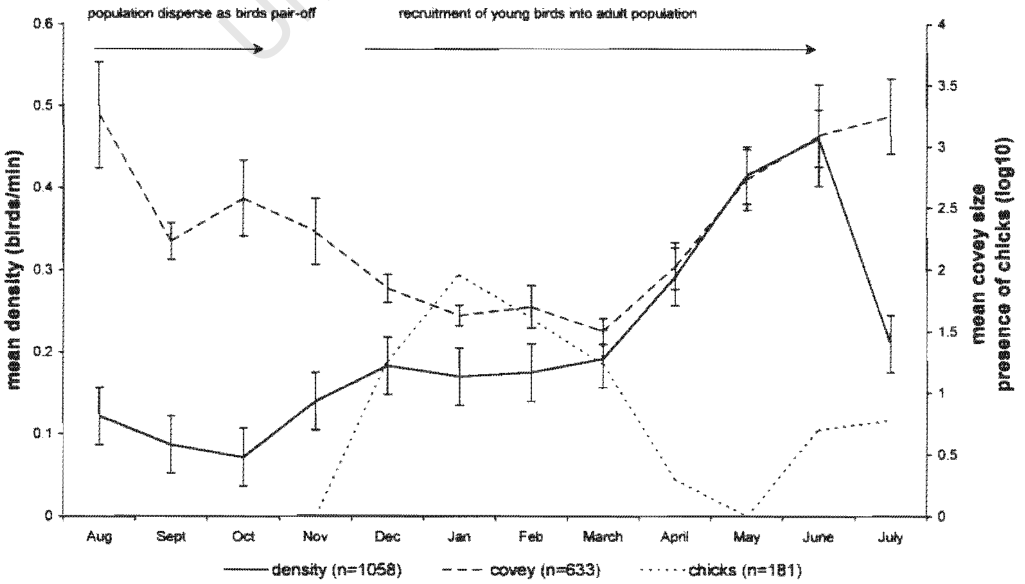


Figure 6.1. Mean population density, covey size and presence of chicks of the Swainson's Spurfowl

Seasonal changes in the dispersion of birds was also closely associated with the utilisation of crop agriculture. During the period when croplands were cleaned and planted (August – March) the numbers of birds associated with the crop agriculture were at there lowest. Once the crop (cotton and maize) became established and cover appeared to be sufficient, spurfowl utilised this resource extensively (Fig. 6.2). The analyses of the crops collected from birds within the study area, as part of another study (see Chapter 8), support this conclusion since the presence of maize seeds increased during May – September. The population density of birds within savanna (thornveld, islands and grasslands) stayed relatively consistent throughout the year with a slight increase in numbers following the breeding season (Fig. 6.2). The intake of wild grass and weed seeds was most prevalent during the early rainfall months (August – November) when weed and grass plants were abundant and producing large numbers of seeds (see Chapter 8.

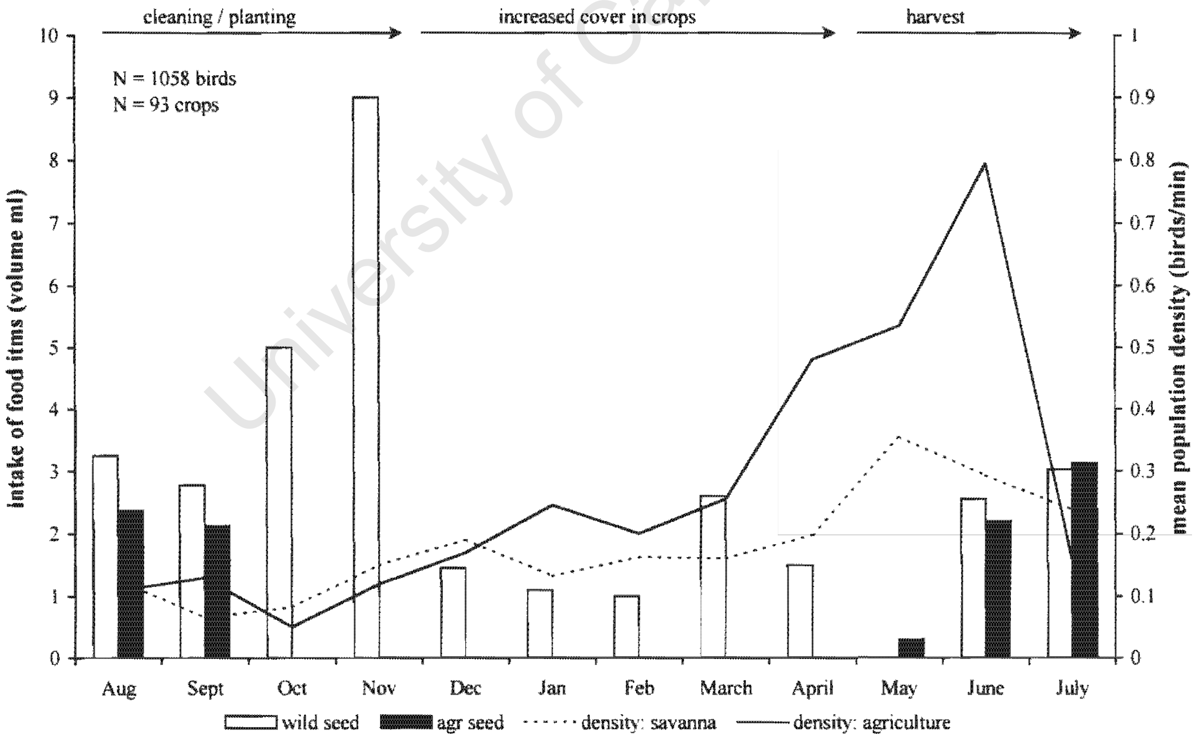


Figure 6.2. Population density of Swainson's Spurfowl within savanna habitat (grassland, thornveld and island) and in agricultural lands (cotton and maize) in relation to the intake of food items (wild and agricultural seeds).

Habitat preferences

Agricultural crops (cotton and maize) held the highest densities of Swainson's Spurfowl, both in winter and summer (Fig. 6.3). Grazed grasslands had the lowest densities of spurfowl and the number of birds in this habitat were significantly lower than the numbers of birds observed in ungrazed grasslands (grazed: mean = 0.113 birds/min; ungrazed: mean = 0.22 birds/min, $t = 2.64$, $P < 0.05$), thornveld (mean = 0.232 birds/min, $t = 2.74$, $P < 0.05$) and maize habitats (mean = 0.245 birds/min, $t = 2.10$, $P < 0.05$). Grazed grassland was the only habitat in which densities were higher in the summer than in winter.

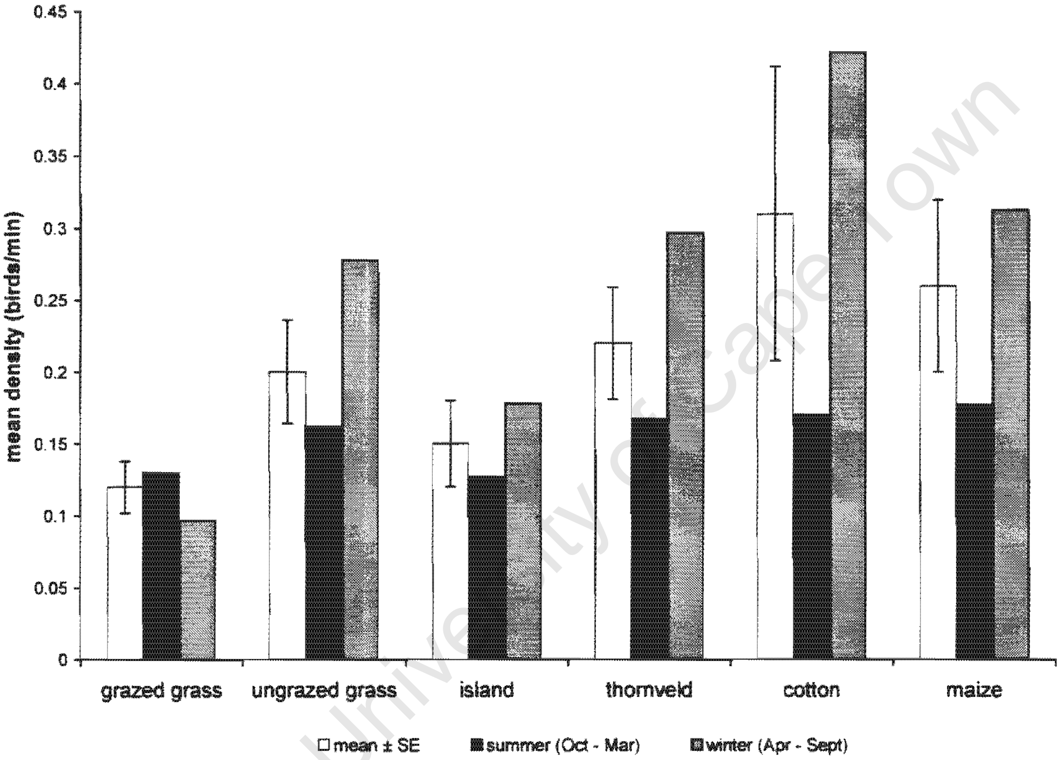


Figure 6.3. Summer, winter and mean (± standard error) population density of Swainson's Spurfowl within the various habitats in the study area.

The mean density of spurfowl within all habitats was significantly positively correlated with the number of birds utilising the edge habitat ($r^2 = 0.712$, $P < 0.05$). Forty eight percent out of the 1113 birds counted was found on the edge of habitats. The percentage of edge habitat available was positively correlated with the percentage of birds utilising the edge over all habitats ($F_{1,4} = 16$, $r^2 = 0.80$, $P < 0.05$) (Table 6.1). Maize and cotton had the highest percentage of birds utilising the edge habitat, whereas ungrazed grass had the lowest.

Table 6.1. Density of Swainson's Spurfowl utilising edge habitat in relation to population density and the total amount of habitat available against the total amount of edge habitat available.

	$\bar{X}$ birds/ habitat	$\bar{X}$ birds edge	% birds edge	% edge (ha)	habitat (ha)	edge (ha)
ungraz. grass	18.29	5.36	31	20.1	375	75.5
grazed grass	8.78	2.56	33	26.6	267	70.9
island	12.75	6.88	42	34.2	92	31.5
thornveld	20.82	10.64	52	28.5	218	62.2
cotton	23.71	13.14	55	33.7	206	69.5
maize	23.0	18.40	73	47.1	187	88.1
Total	1113	546	48	31.7	1345	397.7

Table 6.2. (a) Home ranges (hectares) enclosing 95% of radio locations and (b) habitat available and habitat utilisation of four radio-tracked Swainson's Spurfowl.

(a)	MCP	Harmonic	Kernel	mean	covey size
covey 1	7.30	12.89	11.81	10.66	3
covey 2	5.03	16.93	12.69	11.55	4
covey 3	1.80	2.38	1.92	2.03	1
covey 4	3.50	3.82	3.64	3.65	1
mean	4.41	9.01	7.52	6.98	2.3

(b)	hectares available	% habitat used	number fixes	Jacobs preference	rank
cotton	64.5	19.1	50	-0.23	3
maize	21.9	16.6	34	0.1	1
grassland	37.5	37.1	37	-0.56	4
islands	11	25.9	46	0.06	2

Radio-tracking and habitat use

The mean home range of four radio-tracked birds was 6.98 hectares (SE = 1.22), but varied between 4 and 9 hectares depending on the type of home-range analyses employed (Table 6.2). Covey size was significantly correlated with mean home-range size ($r = 0.970$, $P < 0.05$), i.e. larger coveys had larger home ranges. The birds within coveys 1 and 2 had, at this stage, not yet paired-off whereas a male and female from coveys 3 and 4 respectfully had formed pair-bonds. Bird 3 (male) established himself within an island of thornveld on the periphery of a cotton field and moved little within the 10 days during which observations where made. Bird 4 (hen) moved freely within the male's established territory, but never ventured far into the territories of bordering males.

The total area for the home-range analyses, as defined by the outer most radio-location points, totaled 134.9 hectares for all four coveys. Cotton was the most prevalent habitat followed by grassland, maize fields and islands of thornveld (Table 6.2). Grassland was the habitat used most extensively (37.1%). However, most fixes were in the cotton habitat (50). Jacobs preference index ranked maize the most favoured habitat followed by thornveld islands, cotton and grasslands.

Daily activity patterns were divided into three classes: early morning (05H00 – 08H00), midday (08H00 – 15H00) and late afternoon (15H00 – 18H00). The highest proportion of fixes in the grassland was in the early morning and lowest at midday, with numbers increasing again into the late afternoon (Fig. 6.4). The opposite was true for islands within which the largest number of fixes was during midday. Birds were most common in maize and cotton fields towards late afternoon.

Discussion

Gamebird enthusiasts have noted declines in populations of grassland francolins (*Francolinus* spp.) (Berry & Crowe 1985; see Chapter 1) and even Helmeted Guineafowl (*Numida meleagris*) (Milstein & Wolff 1987; Pero & Crowe 1996; Malan 1998) in southern Africa. Conversely, some spurfowls (*Pternistis* spp.), particularly Swainson's Spurfowl, have thrived and benefited extensively from crop agriculture. The ability of this gamebird to adapt to intensively transformed habitat lies in its competence as a generalist, exploiting a wide variety of habitats at different times of the year.

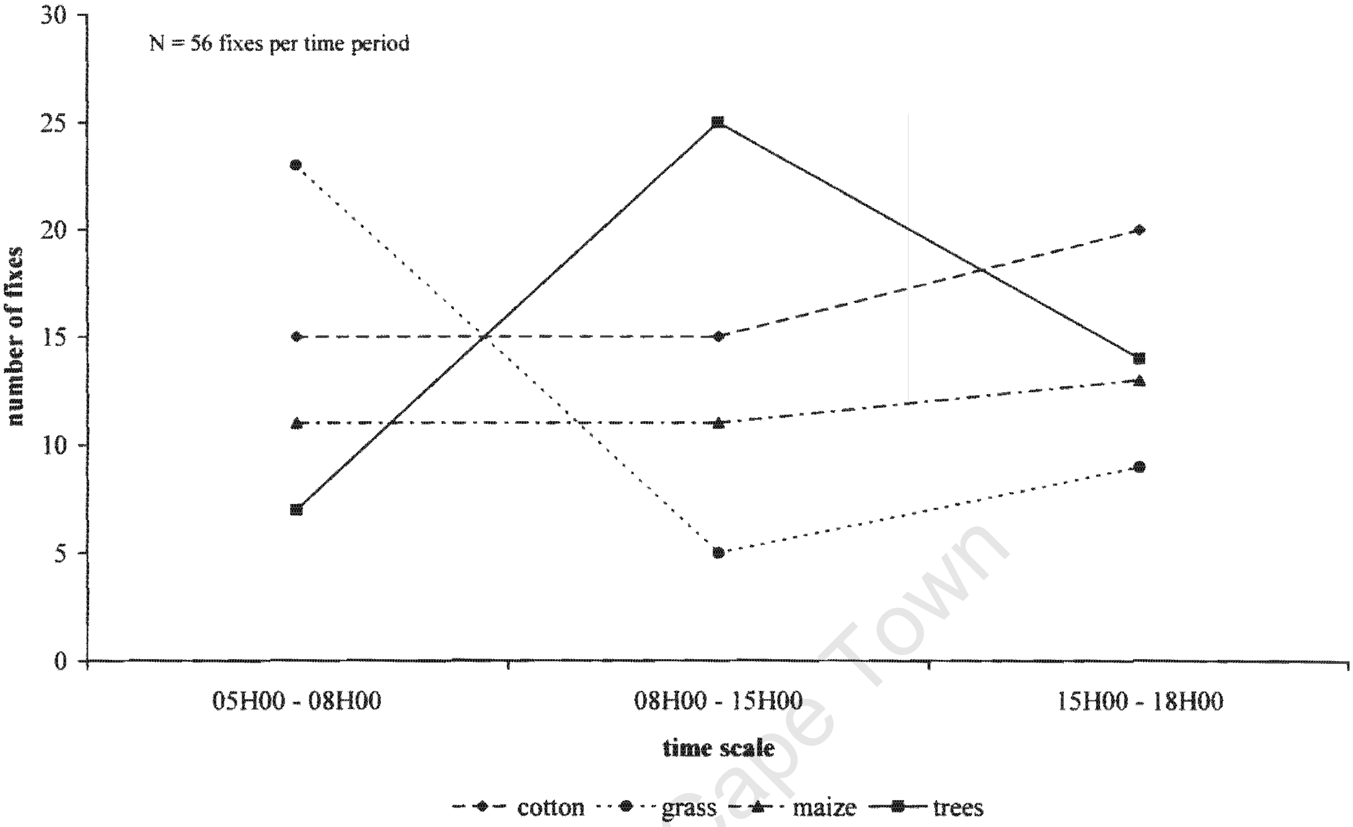


Figure 6.4. Number of radio-fixes for four radio tracked Swainson's Spurfowl within three time zones: morning (05H00 – 08H00), midday (08H00 – 15H00) and afternoon (15H00 – 18H00).

Population trends and local movements

There was evidence of local movements over the landscape with spurfowl being only sedentary and highly territorial in the summer when breeding. During winter, birds regrouped and congregated on the fringes of crop fields to exploit waste grain and weeds (Fig. 6.3, Table 6.2). During summer, birds dispersed over a wider range of habitats and establish breeding territories. Increased grazed grassland appears to be the greatest threat to Swainson's Spurfowl. In this habitat, both the availability of food in the form of weed and grass seeds as well as sufficient cover is diminished and populations of Swainson's Spurfowl within heavily grazed grasslands in Botswana have declined considerably as a result of intensive and extensive grazing practices (Little 1997; Herremans 1998).

The distribution of Swainson's Spurfowl seems to be closely associated with the availability of favoured food items. The largest proportion of agricultural seeds was ingested in the winter months and the largest proportion of weed seed, green material and invertebrates are ingested in the summer (see Chapter 8). These food preferences coincide with seasonal availability of wild seed and crop seed. Each habitat (savanna, grassland and crop agriculture) provides a complementary important source of nutrients at different quantities throughout the year. The birds appear to follow this availability of food and large tracts of a single habitat would thus be less beneficial for Swainson's Spurfowl than a finer grained habitat mosaic that provides the bird with less distance to forage, roost and seek shelter.

Habitat requirements

The importance of sufficient drinking water for Swainson's Spurfowl has been emphasized (Clancey 1967; Crowe, Keith & Brown 1986; Johnsgard 1988; McGowan 1994). However, open bodies of drinking water were relatively scarce within the study area and movements to and from water holes were infrequent and the birds seldom drank (Skead 1975). Therefore, the lack of easy access to drinking water does not seem to pose any great threat to the specific habitat requirements for this spurfowl. Furthermore, the radio-tracking results presented here demonstrate that Swainson's Spurfowl roosts in grasslands and not in trees as previously thought (Stark 1906; Clancey 1967). Sufficient roosting and breeding cover in dense grassland appears to be an important prerequisite for healthy populations. The highest proportion of radio fixes within grassland was in the early morning when birds where still on their roosts then again in the late afternoon when they returned back to grassland to roost. Foraging activity was most prevalent in the early morning and late afternoon. The island habitats, consisting of isolated stands of indigenous trees, are important landscape components providing shelter and cover during the midday heat. The fine-grained habitat matrix comprising thornveld, grassland and crop agriculture contributes to the daily routine of Swainson's Spurfowl, generally more so within the winter and summer seasons (Figs 6.2, 6.3, 6.4; Table 6.2).

Grasslands and, to a lesser extent, savanna and thornveld islands provide important breeding habitats for spurfowl during summer, whereas the croplands of cotton and maize are important sink habitats during winter (Fig. 6.3). Because a territory is usually a pre-requisite for breeding, territorial behaviour in Swainson's

Spurfowl's breeding season can limit the density of potential breeders (Newton 1992). These breeding territories are non-overlapping, and birds excluded from suitable breeding habitat are unlikely to have a successful breeding season. Hence, the availability of source breeding habitats would influence reproduction and recruitment directly, no matter how much sink habitat is available. The majority of nests for the Swainson's Spurfowl was located in grasslands (55.6%) followed by thornveld (29.6%) (see Chapter 7). Therefore, open areas of ungrazed grassland, field verges and islands should be sufficient to warrant suitable breeding habitat for a number of territorial pairs. These field verges (or ecotones) are made up of pockets of thornveld and grassland (savanna) and are commonly core areas (Bingham & Noon 1997) within the home-range of breeding pairs. They are also relatively small (2 to 4 ha), and are dependent on the quality of the habitat. An increase in the availability and quality of nesting habitat has been shown to increase the breeding population, breeding success and survival of hatchlings for a number of upland gamebird species in Britain (see Rands 1988). Currently, much of the field verges of croplands are grazed in summer and burnt shortly prior to the spring rains within the Springbok Flats, effectively reducing the availability of territories and suitable nesting habitat.

The scale of the habitat mosaics used by different species depends on both their home range size and particular resource requirements (Law & Dickman 1998). Non-breeding spurfowl occurring in larger family groups or coveys utilise a large expanse of the landscape and the position of their core areas is not as important as it is during the breeding season. Here home ranges can be as large as 17 ha and individual birds may travel further afield to exploit crops.

Conclusions

The ability of Swainson's Spurfowl to capitalize on each habitat seasonally within the matrix has promoted its success as a bird associated with agricultural areas. Indeed, it has also allowed it to expand its distribution range into transformed habitats resulting from crop agriculture in many previously unsuitable regions of southern Africa. Furthermore, it is a species that has not only a broad ecological niche but is also able to utilise resources that are commonly available (weed seed, grass seed and cereal seed) within southern Africa – a recipe for a species that is not only locally abundant, but has the potential to be widespread (Gaston, Blackburn & Lawton 1997). However, intensified agriculture frequently leads to the simplification of the agricultural landscape (Panek 1997). Enlarging arable, weed-free fields, reducing the variety of crops, improving the efficiency of harvesting methods, reduces the availability of permanent cover and food (through the more intense application of herbicides and insecticides). This 'modern' more efficient form of agriculture leads to the simplification of the landscape, reducing the number of niches available to birds (Fuller *et al.* 1995) and can lead to a population decline in this currently successful gamebird. To avoid this, the mosaic within the transformed habitat should be managed to maintain heterogeneity with a patchwork of relic savanna and grassland.

Chapter 7

Breeding behaviour and seasonality of Swainson's Spurfowl

Summary

Data were collected from the literature for southern Africa and from reliable unpublished reports, nest record cards and field observations for the Springbok Flats, Northern Province, on the breeding activity of Swainson's Spurfowl *Pternistis swainsonii* and are analyzed to establish breeding seasons and nesting behaviour within southern Africa. Breeding (egg laying), male gonadal development, changes in population density and covey size (pairing behaviour) are all significantly correlated with rainfall. Peak breeding activity is from January - April in South Africa, February - May in Zimbabwe and March to June in Botswana. Egg laying has been recorded in all months of the year and sporadic egg laying in winter is most likely the result of aseasonal rainfall. Mean clutch size is 5.2 eggs/hen (n = 140); eggs are incubated by the hen for 23 days; and hatching success and chick survival are 69.4%.

Introduction

Swainson's Spurfowl *Pternistis swainsonii* is a monogamous, ground nesting phasianid with an extended breeding season in southern Africa (Little & Crowe 2000). This highly successful gamebird, which has extended its range considerably in recent years, is claimed to breed throughout the year and even perhaps twice in one year (Mentis 1970; Johnsgard 1988; Milstein 1989). However, peak breeding months vary throughout southern Africa (Little & Crowe 2000).

The aims of this Chapter are to:

1. collate the literature available on breeding activity of Swainson's Spurfowl within southern Africa with specific reference to the Springbok Flats region in the Northern Province, South Africa,
2. investigate timing of breeding, courtship and nesting behaviour, and
3. discuss what bearing these results have on management practices and the timing of wingshooting.

Methods

Nesting data for Swainson's Spurfowl were collated from the published literature, reliable unpublished reports and nest record cards available from the Avian Demography Unit, University of Cape Town. Field observations were made during 1988 - 1999 on a number of farms within the Springbok Flats.

Density of adult birds, covey sizes and presence of chicks was recorded with the aid of pointer dogs. Age of chicks was estimated by observing flight behaviour and plumage development: 1-14 day old birds did not fly and had downy heads, 14-28 day old birds were capable of flutter-flight and the downy head was still visible, and older birds (>28 days) flew strongly and had little or no down. The age of chicks was backdated to time of hatching and laying (incubation period 23 days, Brain & Brain 1970; Milstein & Wolff 1987; Komen 1991).

Seasonal gonadal development was monitored by collecting specimens throughout the year within the study area and measuring the anterior-posterior length of the larger testis (usually the left one) for males and for females, the diameter of the largest follicle.

Rainfall data were obtained from the South Africa Weather Bureau, Pretoria and extracted from the station: Tuinplaas (24°54'S and 28°45'E) for the period 1989 – 1999.

Results

Timing of breeding

Data for a total of 1 366 clutches were pooled from published sources (Benson 1963; Brooke 1971; Wolff 1977; Liversidge 1987; Hartley & Mundy 1992; Skinner 1997;) and from nest record cards to establish peak breeding months within southern Africa (Fig. 7.1).

Egg-laying for Swainson's Spurfowl in southern Africa occurs primarily during February – May. In the former Transvaal (Gauteng and Northern Provinces) nesting is earlier (January - April) and, in Zimbabwe, slightly later (mid February - mid May). Birds in the Springbok Flats tend to breed even earlier, November - January. There are limited nest records for all months of the year, with the fewest for late winter and early spring (July – October). In Botswana, peak monthly egg laying occurs during March - June (Skinner 1997, values not given, n = 48 records).

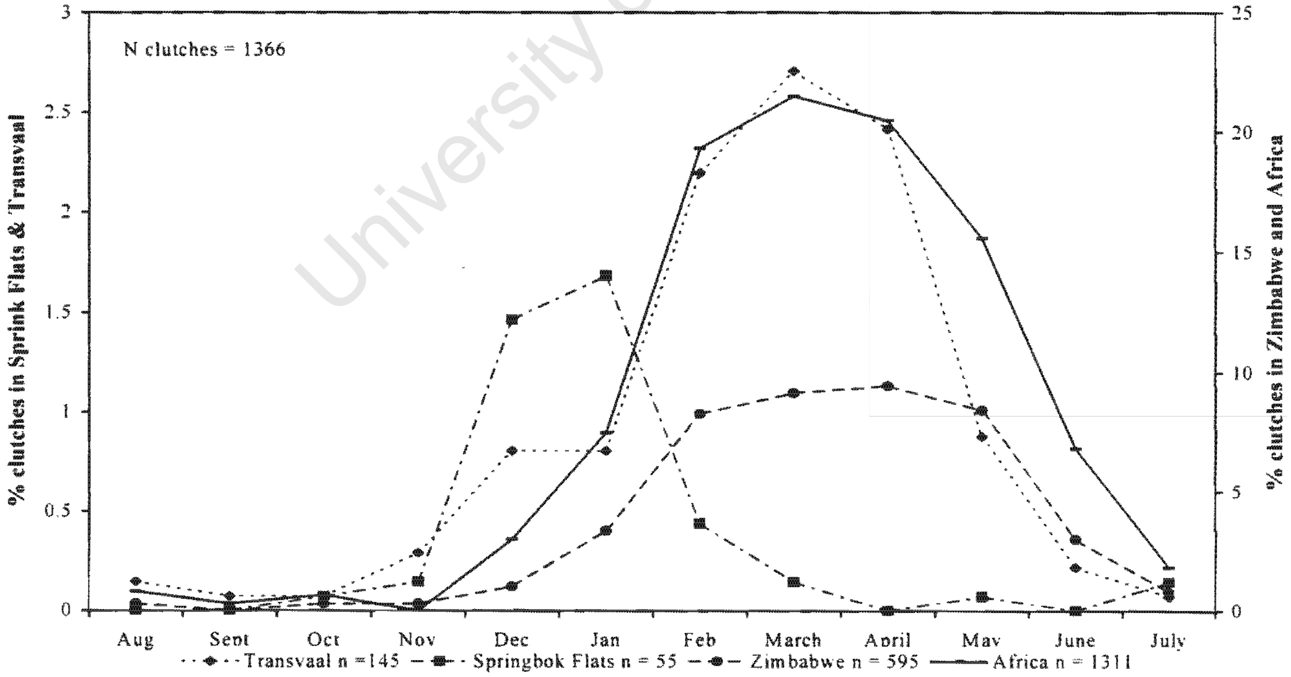


Figure 7.1. Egg laying activity of Swainson's Spurfowl within southern Africa

The onset of breeding is closely correlated with rainfall, with the prevalence of chicks increasing sharply shortly after the spring rains (Fig. 7.2). Chicks were also observed in mid-winter following aseasonal rainfall in late autumn.

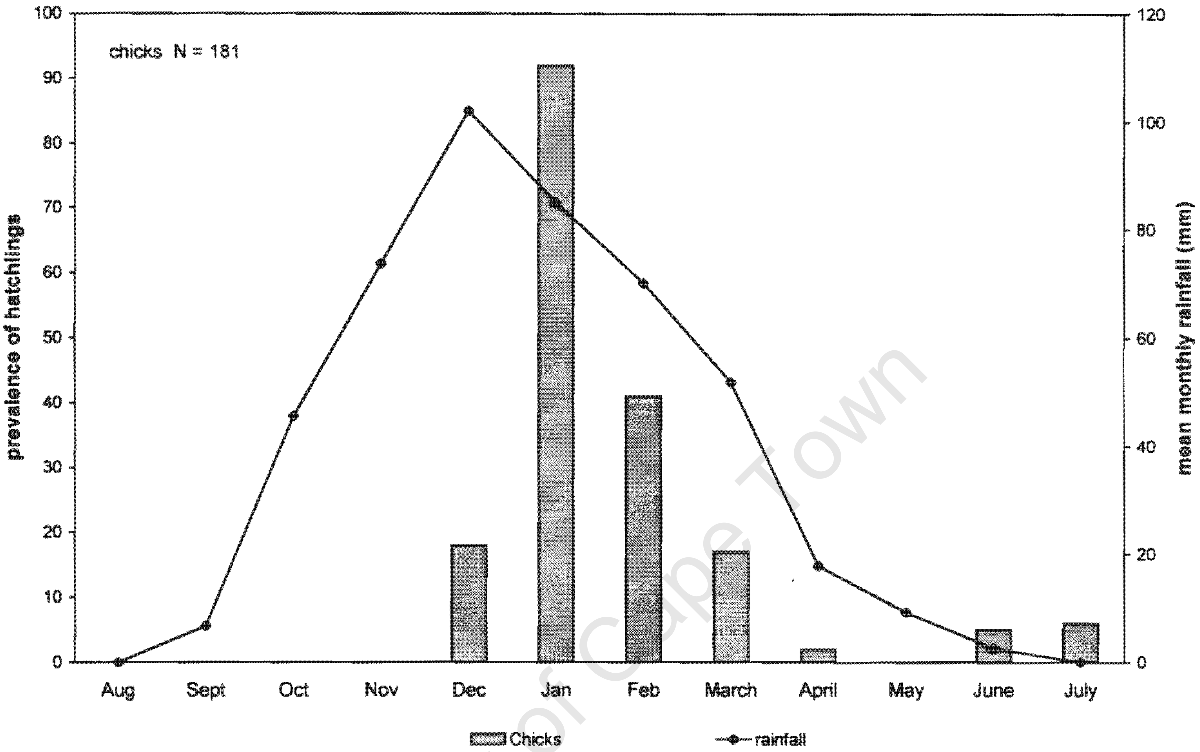


Figure 7.2. Presence of Swainson's Francolin chicks and mean annual rainfall (1989 – 1999) within the Springbok Flats

The breeding season is also reflected in male and female gonadal development (Fig. 7.3). The enlargement of female ovarian follicles slightly preceded that of male testes. However, gonadal development for both sexes initiated after the first rains in spring and this association with rainfall is significant for the males ($r = 0.769$, $P < 0.001$), but not females ($r = 0.421$, $P > 0.05$).

Nesting, clutch size and incubation

Of the 270 nest record cards analyzed, only 54 describe nesting habitat. Of these, 55.6% were located in grassland, 29.6% within or on the fringes of a low-lying bush or thicket and 14.8% within fallow cultivated land. The nest is a hollowed-out cup in the ground 170 – 180 mm diameter and 50 - 60 mm deep lined with grass.

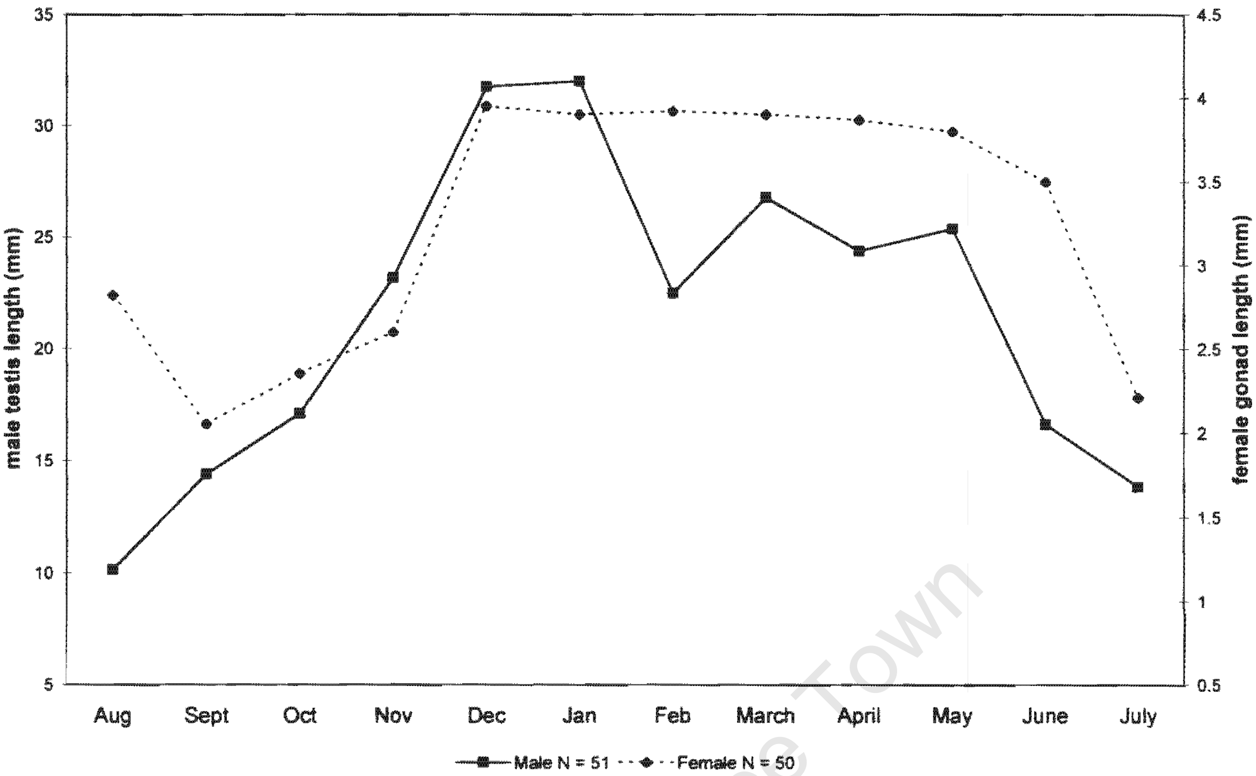


Figure 7.3. Monthly male (testis) and female (ovary) gonadal development of Swainson's Spurfowl within the Springbok Flats.

Where grass cover appears to be limiting, hens will hollow out the center of a large tuft of grass leaving a thin wall of grass for concealment.

The mean clutch size was 5.2 eggs per hen (SD = 2.21; range = 1 – 12; n = 140). Mean egg dimensions (n = 14) were obtained from Vincent (1945) and from the nest record cards (n = 114) with an overall mean length of 43.5 mm and diameter of 35.0 mm (SD = 2.0 and 1.31; range = 38 – 47 x 32 - 38; n = 128). It has been proposed that this spurfowl might lay more than one clutch per season (Mentis 1970; Johnsgard 1988; Milstein 1989). However, there is no reliable evidence to support this statement. Moreover, Swainson's Spurfowl has been found to "dump" eggs in the nests of other galliforms (Brain & Brain 1970) or in the nests of conspecifics (Grimes 1976).

Reported incubation periods vary from 21 to 23.4 days (Brain & Brain 1970; Milstein & Wolff 1987; Johnsgard 1988; Milstein 1989; Komen 1991; Little & Crowe 2000) with 23 days being the most likely. This is because Swainson's Spurfowl eggs are significantly larger than those of other smaller francolin species whose eggs had a shorter incubation period of about 21 days (Milstein & Wolff 1987).

A very broad hatching success and brood survival can be derived from the nest record cards if one considers the mean clutch size per hen and the mean number of chicks observed per hen over years and over large geographical range. For the nest record cards, the mean number of chicks/hen was 3.61 for 131 broods. This is fairly close to the 3.18 chicks/hen observed in the Springbok Flats for 57 broods. Considering the mean clutch size was 5.2 eggs/hen, this is a hatching success and chick survival of 69.4% of all eggs laid. No decline in the size of the brood against their estimated age was observed for the Swainson's Spurfowl in the study area. Mortality within the brood, is, therefore, regarded as minimal.

Adult pairing and nestling behaviour

At the onset of the spring rains, coveys break up and males and females start pairing off. The correlations between population density and covey size against rainfall are both significant (population: $r = -0.591$, $P < 0.05$; coveys: $r = -0.734$, $P < 0.01$) as well as for covey size and population density ($r = 0.570$, $P < 0.05$). The breakdown of coveys leads to a population dispersal as pairs spread out to establish breeding territories (Fig. 7.4). In late summer and early autumn, birds again regroup and the population climbs to a point higher than that of the previous winter as a result of the latest recruitment from breeding activity.

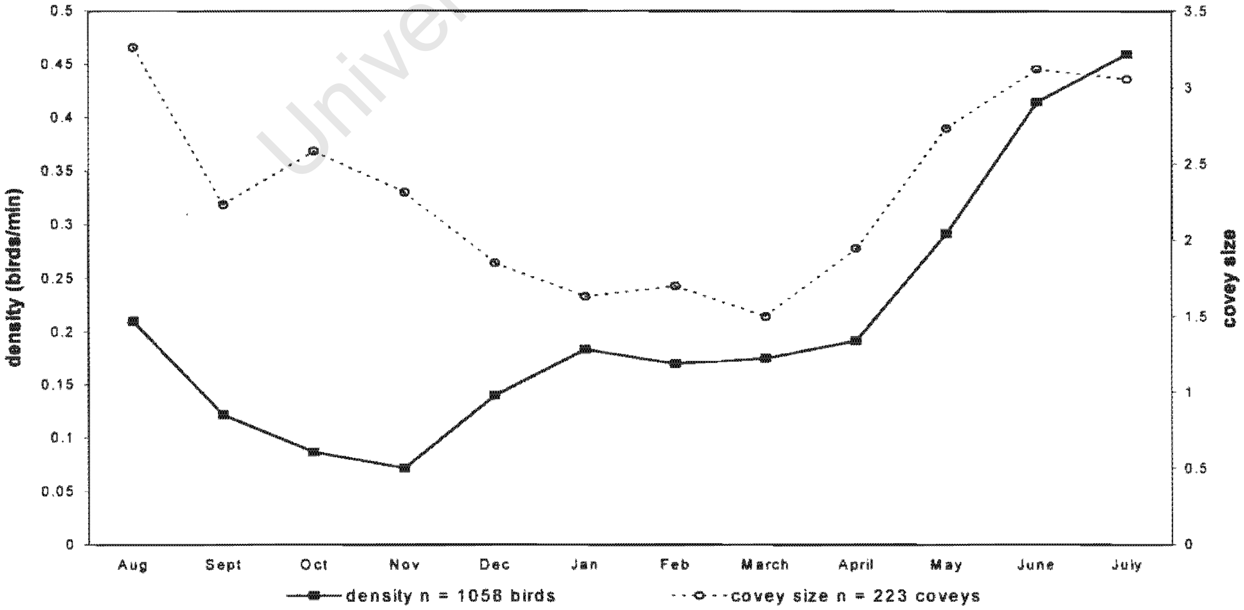


Figure 7.4. Relationship between population density and covey size (pairing behaviour) for Swainson's Spurfowl in the Springbok Flats.

Van Niekerk (1983) described the courtship behaviour of Swainson's Spurfowl. However, territory size and home range of the adult breeding pair as well as post-fledgling development and independence are poorly documented.

A radio transmitter fitted to a single adult male bird within the breeding season, that forms part of another study (see Chapter 6), indicated a small territory of about 3 ha. Hens were free to criss-cross this territory, but not that of other adult males. As hens entered the male territory, the male assumed courtship display. Male birds thus appear to seek territories within suitable habitat in terms of sufficient food and cover to attract females. These habitats were frequently small patches of savanna 'islands' (thornveld and grass) within or on the fringes of agricultural land.

Hatchlings were all observed within or on the fringe of dense cover. The mean number of adults observed per brood was 1.28 (n = 57 broods). Of these 73.7 % (42 observations) of broods were accompanied by the hen only. Chicks observed with two or more adults were all over the age of four weeks. Sub-adult birds (less than 6 months old) lack the deeper red facial skin and legs are of a lighter brown and not the dark brown/black of adults (Clancey 1967). These sub-adults were independent at approximately 12 weeks and roamed freely through the home ranges of other coveys, often joining up with other sub-adult birds. It is presumed that these sub-adult birds are capable of breeding within their first year. Analyses of male and female gonadal development supported this hypotheses where 12 sub-adult birds (8 males and 4 females) showed signs of testicular and follicle enlargement, at the level of adult gonadal development for that time of year.

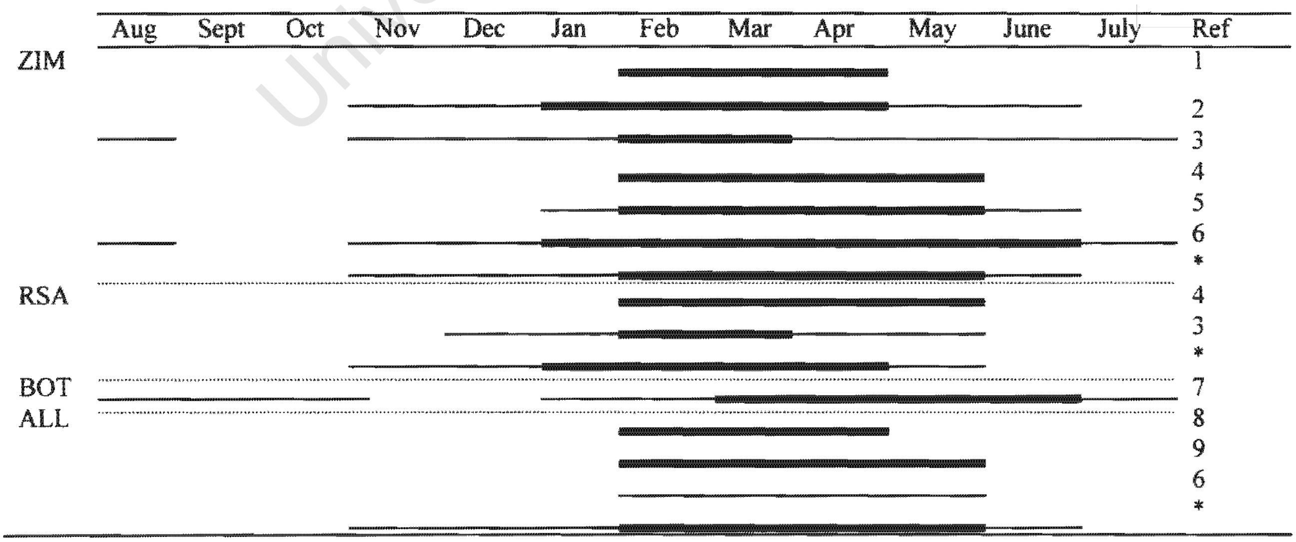
Discussion

The success of this spurfowl can, in part, be attributed to its ability to nest within virtually any environment (as long as sufficient cover is available), lay reasonably large clutches (mean 5.2 eggs/hen) and have a high hatching success and brood survival (69.4%). The extended breeding season coupled with high nesting success and the ability of birds to become sexually active within their first year, can produce large numbers of birds. These adapt well to transformed habitats closely associated with agricultural practices. The plasticity of its breeding activity can be regarded as one of the key components contributing the species' invasive capabilities.

Although evidence from the literature suggests that Swainson's Spurfowl can breed in all months of the year, peak egg laying months vary little within the southern Africa and sporadic nesting activity is probably the result of isolated, aseasonal bursts of rainfall within the winter months. The general tendency is for Swainson's Spurfowl to breed earlier within South Africa (January - April), slightly later in Zimbabwe (February - May) and the latest within Botswana (March - June) with a general peak in February - May within southern Africa (Table 7.1).

Swainson's Spurfowl within the higher-lying regions of South Africa, such as Gauteng Province, tend to breed earlier than birds in the low-lying, lower rainfall regions of the Northern Province, South Africa, and areas of southern Zimbabwe (Kruger 1981). It seems that rainfall, as in Helmeted Guineafowl (*Numida meleagris*) (Crowe & Siegfried 1978; Little & Crowe 2000), is the prime driving force behind the onset of breeding. Lower rainfall, delayed rainfall and sporadic rainfall can lead to the pattern of variable breeding activity observed within southern Africa.

Table 7.1. General breeding season of Swainson's Spurfowl within Zimbabwe (ZIM), South Africa (RSA), Botswana (BOT) and southern Africa (ALL) (─) and peak breeding months (━) sourced from the following publications: 1. Benson (1963), 2. Clancey (1967), 3. Johnsgard (1988), 4. Little (1997), 5. Hartley & Mundy (1992), 6. Maclean (1985), 7. Skinner (1997), 8. Tarboton *et al.* (1987), 9. Little & Crowe (2000) and * this study.



Food availability has long been said to be one of the prime driving forces behind the onset of breeding (Marshall 1951) and the successful development of hatchlings.

Many species of galliform chicks feed solely on invertebrates for the first two weeks of their lives (Savory 1977; Green 1984; Rands 1985, 1986b). In turn, the causal relationship between climatic variables and the breeding season has been linked to food availability and, in particular, arthropod abundance (Crowe 1978; Berry & Crowe 1985; Liversidge 1987; Little & Crowe 1993b). The amount of protein reserve in the bodies of birds, especially that of the female needed to produce eggs, plays a role in determining the breeding season and the success of the population as a result of breeding success (Earlé 1981). The analyses of 94 crops, that forms part of another study (see Chapter 8), indicated a 7.8% increase in the intake of arthropods during the summer months (refer to figure 8.1, Chapter 8), with termites and worms being the most favoured items ingested following good rains. The analyses of a single crop of a chick of approximately six weeks of age contained only wild grass seeds. It is suggested, therefore, that young are fully capable of digesting highly fibrous material slightly prior to or at 1.5 months of age. The analyses of a crop of a hen shot in August, just prior to the main breeding season, indicated remains of a number of eggshells, ingested perhaps to obtain calcium necessary for the production of healthy eggs.

Management implications and wingshooting seasons

Management of habitat to promote optimal breeding conditions relate to the availability of suitable cover. Territorial males occupy small areas that can provide the hen with suitable breeding conditions, hatchlings with cover to escape predators, and food for both. A small-scale habitat mosaic of agriculture coupled with islands or corridors of suitable 'natural' grassland or savanna, will provide breeding pairs and hatchlings with this food, cover and refuge.

In general, wingshooting should be designed to take the harvestable surplus shortly after the breeding season but delayed long enough to enable young to develop and for the population to re-group in coveys. The recommended hunting season for Swainson's Spurfowl in South Africa is from June to October, in Zimbabwe from July to October and Botswana from August to November.

Chapter 8

Diet of Swainson's Spurfowl

Summary

Swainson's Spurfowl *Pternistis swainsonii* is a highly opportunistic gamebird that has extended its range considerably in recent years throughout southern African as a result of its ability to capitalize on agricultural habitats. The analyses of crop contents from 94 birds collected within savanna, cotton and cereal (maize and sunflower) environments revealed a greater preference for grass seed (49.7%) in terms of numbers ingested. However, agricultural seed (mostly maize) made up the largest volume observed in crops (38.6%). The largest amounts of grass and agricultural seed were consumed during the winter months and the largest proportion of weed seed, green material and invertebrates was taken during the summer months. Termites were the most favoured invertebrates ingested and the greatest number and volume of invertebrates were observed in the crops of birds from the cereal habitats. The number and availability of invertebrate species is reflected within the specific habitat where birds were collected. The intestinal length of birds from cereal habitats was significantly shorter than that of birds collected in the savanna habitats ($P < 0.05$). Distribution and abundance of Swainson's Spurfowl follows the planting and harvesting of crops and the availability of specific food items.

Introduction

Habitat quality has formed the focus of many ecological studies within which possible correlations between birth rates, death rates, immigration and emigration of animal populations and the availability of essential resources (food, nesting cover and safe refuge) are investigated. Indeed, a sound knowledge of what constitutes high quality habitat involves the prediction or explanation of fluctuations within and between populations. Much of this evidence underpinning such studies has come from close correlations between bird densities and food supplies (see Newton 1980). More specifically, the availability of food and the specific quality thereof can influence reproductive output, emigration rates and spacing behaviour in gamebirds such as the Red Grouse *Lagopus lagopus scoticus* (Moss 1972b; Watson & O'Hare 1979; Watson, Moss & Parr 1984; Watson, Moss, Rothery & Parr 1984). Moreover, food has been suggested to be the single most important limiting factor for gamebirds in South Africa (Wolff & Milstein 1987). Locally, extensive burning and intensive grazing of upland grasslands reduces the availability of foraging habitat for the Redwing Francolin *Francolinus levaillantii* (see Chapters 1 & 4) because excessive defoliation of grasslands reduces the availability of food and foraging cover. When this occurs in a more widespread scale it effectively reduces the range of the species in many parts of South Africa (Little & Crowe 2000).

Conversely, Swainson's Spurfowl *Pternistis swainsonii* has extended its range considerably in recent years (Milstein & Wolff 1987; Pero 1996; Little & Crowe 2000), mostly as a result of the expansion of agriculture (specifically cereal crops) throughout much of southern Africa (Mentis 1970; Milstein 1989; Little 1997). Furthermore, Swainson's Spurfowl is perceived to be a "pest" by crop farmers due to its digging out sprouting maize seedlings (Stark 1906; Clancey 1967; Mentis 1970; Kruger 1981; Crowe, Keith & Brown 1986; Milstein 1989; Little & Crowe 2000).

The aims of this Chapter are to determine the feeding preferences of Swainson's Spurfowl, through the analyses of crop contents, within an agricultural environment. These results will hopefully help to improve the understanding of its habitat preferences and the implications to crop damage.

Methods

Crops were collected from 94 Swainson's Spurfowl over a two year period (1998 – 1999) from birds sampled over a number of habitats varying in land management ranging from crop and pasture farming to game farming.

Crop contents were separated into six food classes (grass seed, wild seed, agricultural seed, corms, green material and arthropods). Food items from each crop were counted and measured volumetrically by water - displacement method (to the nearest 0.01 ml) per food class. The percentage intake of food items was related to the habitat where the bird was collected to ascertain the availability of food diversity and food preferences. Agricultural habitats where the dominant farming practice was the planting of crops (maize, sunflower and millet) are collectively termed cereals. Where birds where sampled in natural vegetation (a combination of grassland and woodland), the habitat is collectively termed savanna.

Since the composition and amount of food eaten affect intestinal length in gallinaceous birds (Leopold 1953; Moss 1972a), the lengths of the large intestine, small intestine and combined length of both caecae were measured to the nearest millimeter.

The population density of adult birds was estimated over a number of habitats with the aid of pointer dogs and forms the basis of another study (see Chapter 6). Rainfall data were obtained from the South African Weather Bureau, Pretoria, for the station Tuinplaas (24°54'S and 28°45'E) for the period 1989 – 1999 to note any correlations between the intake of food items and the amount of precipitation.

Data analyses

A MANOVA test was used to investigate differences in the intake of food items between habitats. If the MANOVA was significant ($P < 0.05$), single one-way ANOVA's were used to note which food class varied in terms of numbers and volume across the habitats. A Newman-Keuls test was then employed to distinguish for post hoc comparisons. The data was $\log_{10}$ transformed to improve normality and reduce heteroscedasticity. *t*-Tests were finally employed to compare means amongst those food items that were shown to differ significantly (from post hoc comparisons), between male and female birds and between the relative length of intestines. Multivariate analyses of food items ingested between birds and between habitats were performed using the cluster analysis (CLUSTER) program in the PRIMER software package (Plymouth Marine Laboratory, U.K.) to determine possible similarities between the intake of food items of birds within specific habitats. Briefly, food item data was summarized in a triangular matrix of similarities between all sites, using the Bray-Curtis similarity coefficient (Bray & Curtis 1957). Results of this procedure are displayed as a dendrogram that reflects the hierarchical relationships of food items, using group-average linking.

Results

Food preferences

In terms of numbers, grass seed was the most favored item ingested (49.65%) followed by weed seed (28.09%). However, agricultural seeds (mostly maize and sunflower) made up the greatest volume (38.6%) of food items due to their larger size (Fig. 8.1). Arthropods, green material and corms made up the remainder of food items ingested, but only accounted for 7.5% of the total numbers and 13.4% of the total volume.

A greater proportion (numbers) of grass and agricultural seed were ingested during the winter months (May - August, n =79 crops) and a greater proportion of weed seed, arthropods and green material was ingested during the summer months (September - April, n = 14 crops) (Fig. 8.1).

MANOVA test of the crop contents over the 94 crops analysed was significant ($P < 0.001$). Results from the one-way ANOVA's indicated significance only for the number and volume of grass seed, weed seed and agricultural seed in the crops of birds from the cereal, cotton and savanna habitats (Table 8.1). Crops from birds collected within savanna habitat held the largest percentage of grass seeds followed by birds collected in cotton habitat (Fig. 8.2). The amount of grass seed in the crops of birds collected in savanna was significantly higher than the grass seed from birds foraging in cereal habitat ($t = -3.33$, $P < 0.01$). Weed seed was most common in birds from cotton habitat followed by birds collected in savanna. Weed seed from crops from birds collected in cereal habitat was significantly lower than that in crops of birds from the cotton ($t = -5.06$, $P < 0.001$) and savanna habitats ($t = -3.30$, $P < 0.01$). Grass seed and weed seed formed the bulk of the crop contents of birds collected in cotton and savanna habitats. Agricultural (maize and sunflower) and grass seed formed the bulk of the crop contents from birds in the cereal habitats. Green material was most prevalent in crops collected in cotton lands followed by cereal habitats, and significantly lower in the savanna ($t = 2.32, P < 0.05$) than in the cotton habitats. Arthropods were more abundant in the crops of birds collected in the cereal followed by savanna habitats.

The similarity between the relative intake of food items within the crops of birds collected was analyzed using multivariate analyses (Bray-Curtis similarity). Both the amount of arthropods and green material were commonly found together in crops and were also associated with birds that had ingested relatively large amounts of agricultural seeds within cereal habitats (Fig. 8.3). A further similarity was found between the intake of grass seeds and weed seed which were often taken together within the savanna and cotton habitats.

The relative intake of food items (both in number and volume) between male and female birds differed little with the exception of a significantly higher volume of weed seed taken by females ($t = 2.24, P < 0.05$) (Table 8.2).

Population density in relation to habitat

Generally, the population of Swainson's Spurfowl on the Springbok Flats increases at the onset of winter (April - May) when birds regroup into coveys following the breeding season by incorporating young birds into the population. During the high rainfall summer months (September – March), the population disperses to establish breeding territories and pairs (Fig. 8.4). In late winter and spring (July – August), lands are cleared to prepare for the summer planting of crops. At this time, birds utilise the periphery of fields. As the crop becomes more established, and hence provides more foraging cover during the summer, birds venture deeper into the fields and populations reach a peak when cereal crops mature at the onset of the harvest when waste grain lies on the ground (March - May). Cotton is harvested slightly later and birds utilise this habitat extensively due to abundant weed seed and cover until it too is harvested in late winter (July).

Table 8.1. (A) numbers and (B) volume of food items ingested by Swainson's Spurfowl within cereal, cotton and savanna habitats.

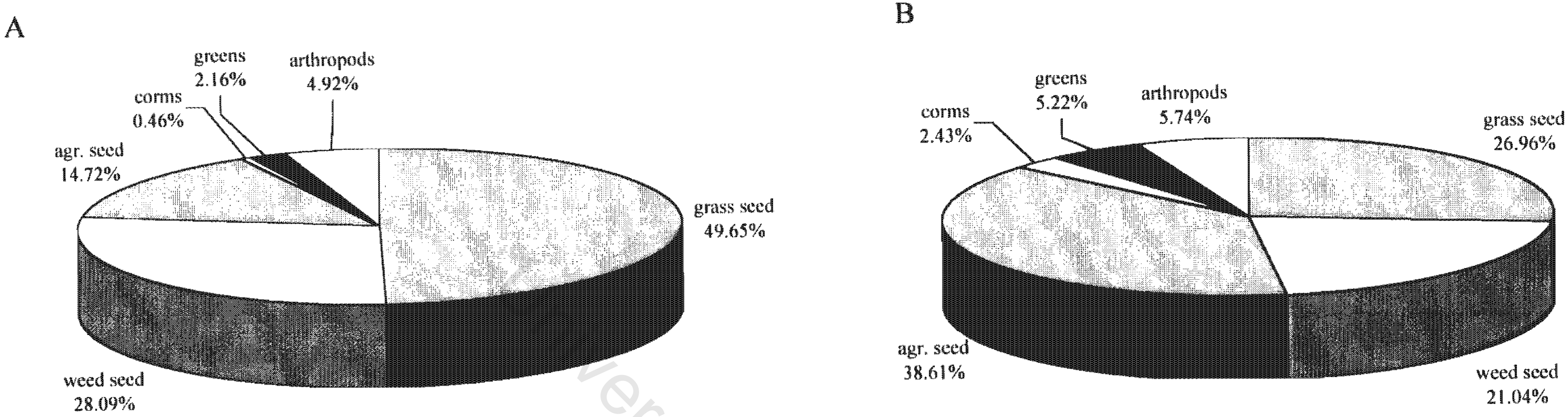
(A) numbers

	cereals			cotton			savanna			all groups			one-way ANOVA	
	mean	SD	N	mean	SD	N	mean	SD	N	mean	SD	N	*F*	*P*
grass seed	34.9	62.1	51	71.8	127.9	17	98.4	105.3	26	59.1	93.0	94	4.379	0.015 *
weed seed	11.9	28.3	51	68.1	63.1	17	53.1	80.1	26	33.5	58.5	94	10.476	0.000 *
agric. seed	28.5	27.2	51	0.0	0.0	17	7.4	37.9	26	17.5	30.6	94	62.912	0.000 *
corms	1.0	0.5	51	0.5	1.3	17	1.4	4.4	26	0.5	2.4	94	2.389	0.097
greens	2.2	4.5	51	4.9	6.4	17	1.7	2.5	26	2.6	4.6	94	2.036	0.136
arthropods	5.8	20.3	51	2.8	7.0	17	8.1	21.8	26	5.9	19.0	94	0.187	0.830

(B) volume

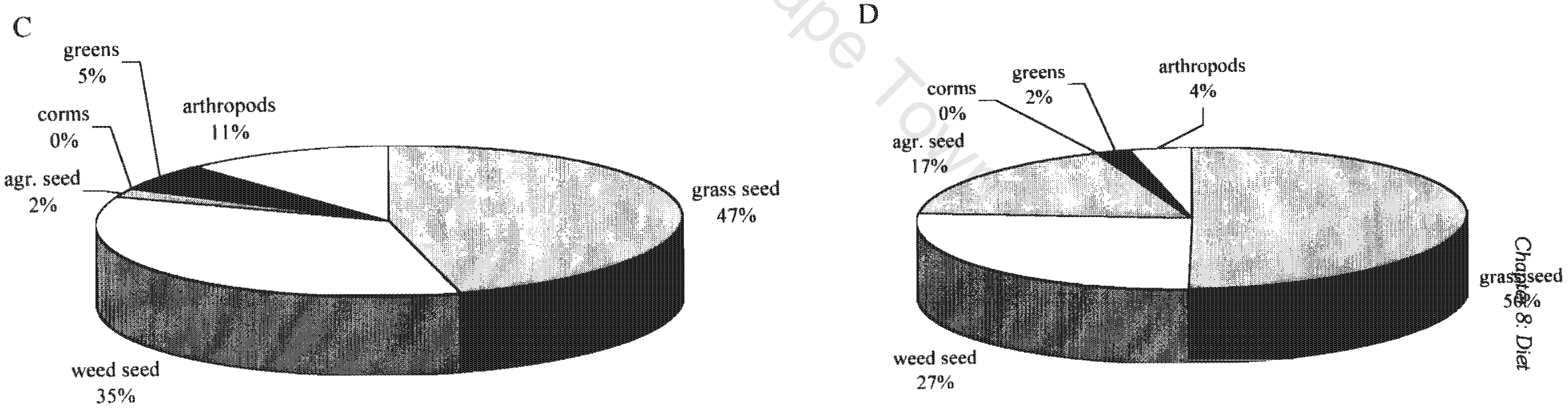
	cereals			cotton			savanna			all groups			one-way ANOVA	
	mean	SD	N	mean	SD	N	mean	SD	N	mean	SD	N	*F*	*P*
grass seed	1.0	2.0	51	1.7	3.7	17	2.9	4.3	26	1.7	3.2	94	4.955	0.009 *
weed seed	0.4	0.9	51	2.8	3.2	17	2.1	3.7	26	1.3	2.6	94	11.844	0.000 *
agric. seed	4.3	3.3	51	0.0	0.0	17	0.1	0.5	26	2.4	3.2	94	69.148	0.000 *
corms	0.1	0.3	51	0.1	0.3	17	0.3	1.4	26	0.1	0.8	94	1.265	0.287
greens	0.2	0.5	51	0.5	0.7	17	0.4	0.6	26	0.3	0.6	94	1.731	0.183
arthropods	0.3	1.0	51	0.3	0.6	17	0.4	1.1	26	0.4	0.9	94	0.122	0.885

* ANOVA significance at $P < 0.05$, shaded values indicate significant difference using Newman-Keuls test



% numbers

% volume



summer

winter

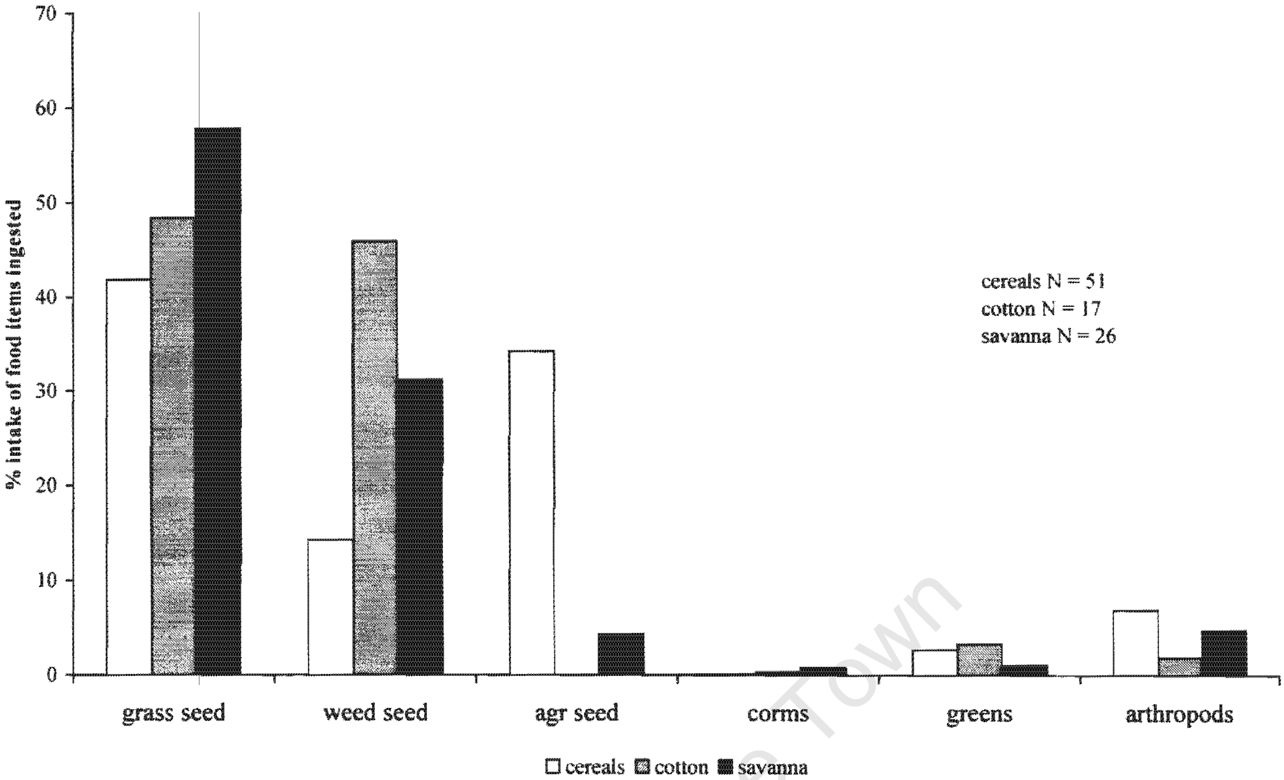


Figure 8.2. The percentage intake (numbers) of food items within the crops of Swainson's Spurfowl from cereal, cotton and savanna habitats.

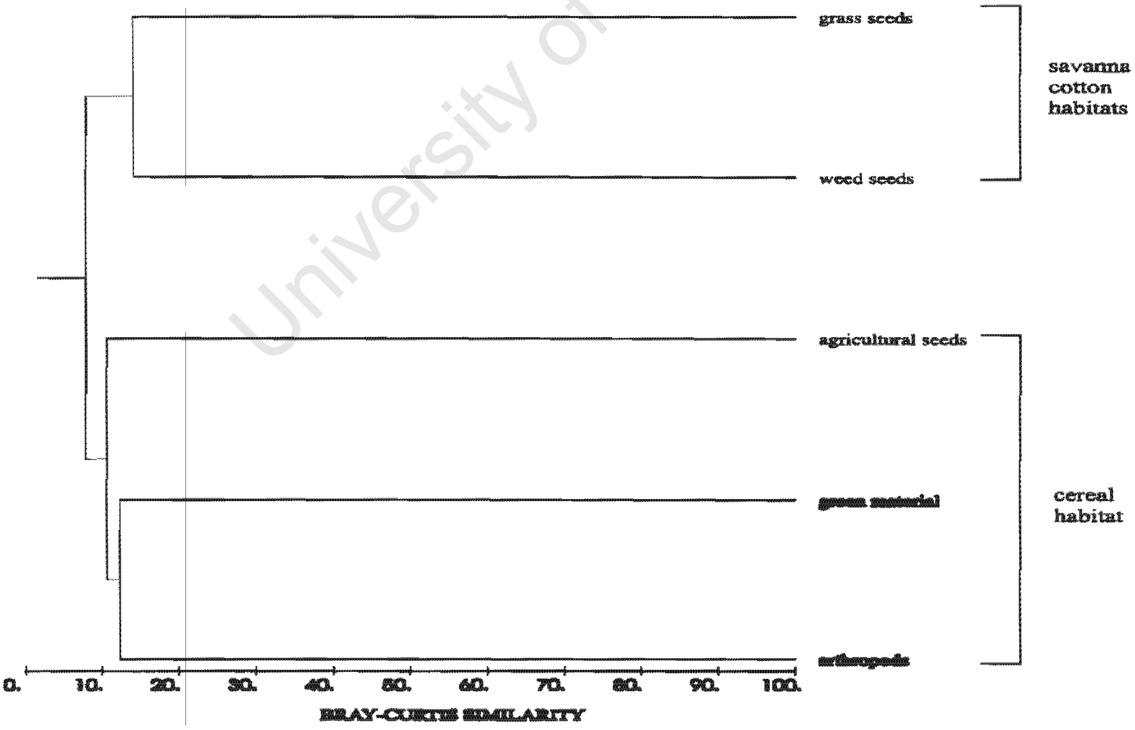


Figure 8. 3. Bray-Curtis similarity between the contents of crops according to habitat.

Table 8.2. Intake of food items in terms of numbers and volume between male (M, n = 48) and female (F, n = 46) Swainson's Spurfowl in the Springbok Flats.

	grass seed		weed seed		agric seed		corms		greens		invertebrates	
	F	M	F	M	F	M	F	M	F	M	F	M
NUMBERS												
mean	63.5	55	34	32.9	20.2	15	0.43	0.66	3.39	1.79	4.76	6.92
SE	14.94	12.80	9.21	8.23	4.38	2.59	0.32	0.39	0.81	0.49	1.83	3.27
VOLUME												
mean	1.66	1.63	1.33*	0.41*	2.45	2.28	0.48	0.24	0.37	0.27	0.41	0.29
SE	0.43	0.52	0.39	0.14	0.51	0.46	0.03	0.16	0.09	0.08	0.14	0.09

* significantly different means (*t*-Test: $P < 0.05$)

The onset of the breeding season, the planting and harvesting of crops are all dependent on the timing of rainfall. During the drier winter months, the food from croplands (maize, sunflower and cotton) plays an important part in carrying the birds through to the following summer when they then utilise a wider variety and greater abundance of wild seed in the form of grass seeds, weed seed, greens and arthropods.

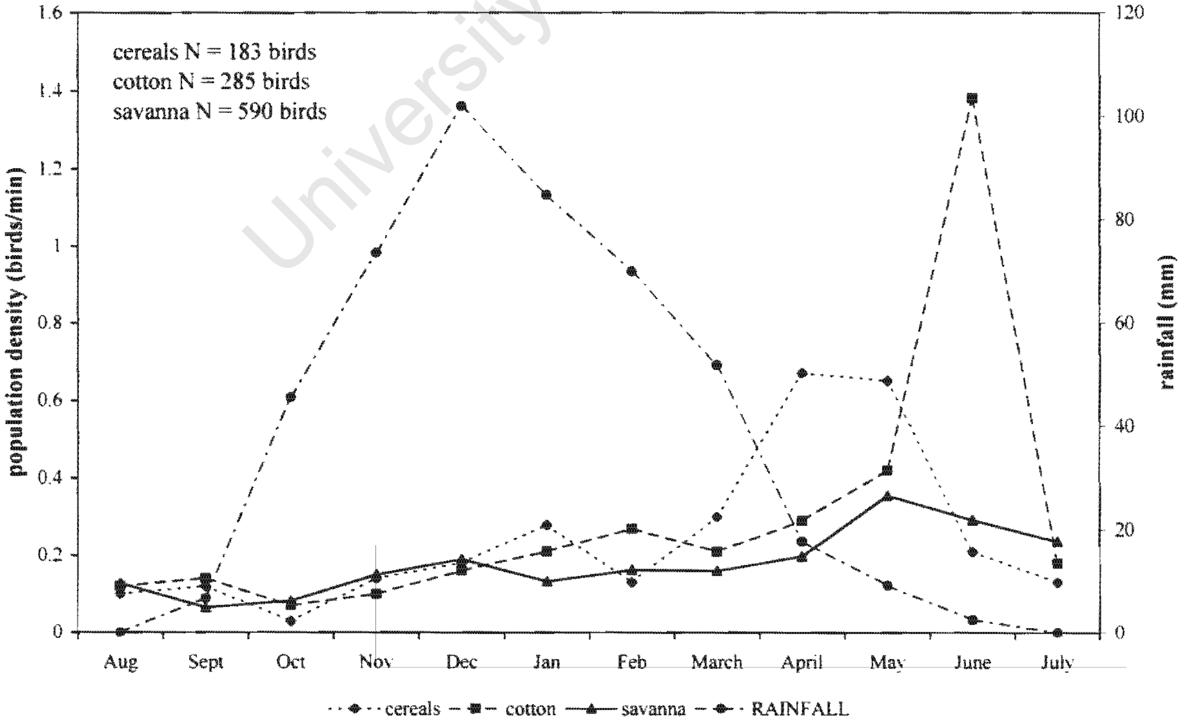


Figure 8.4. Mean monthly population density (birds/min) of Swainson's Spurfowl within cereal, cotton and savanna habitats.

Invertebrate preference and abundance

Of the 94 crops analyzed, only 35 (37.2%) contained invertebrates (37.2%). Termites were the most favored invertebrates followed by worms and then beetles and ants (Fig. 8.5). Due to their larger size, worms and beetles constituted a greater volume than termites. Other invertebrate species ingested include grasshoppers (1), millipedes (1), moths (1), ticks (1) and spiders (2).

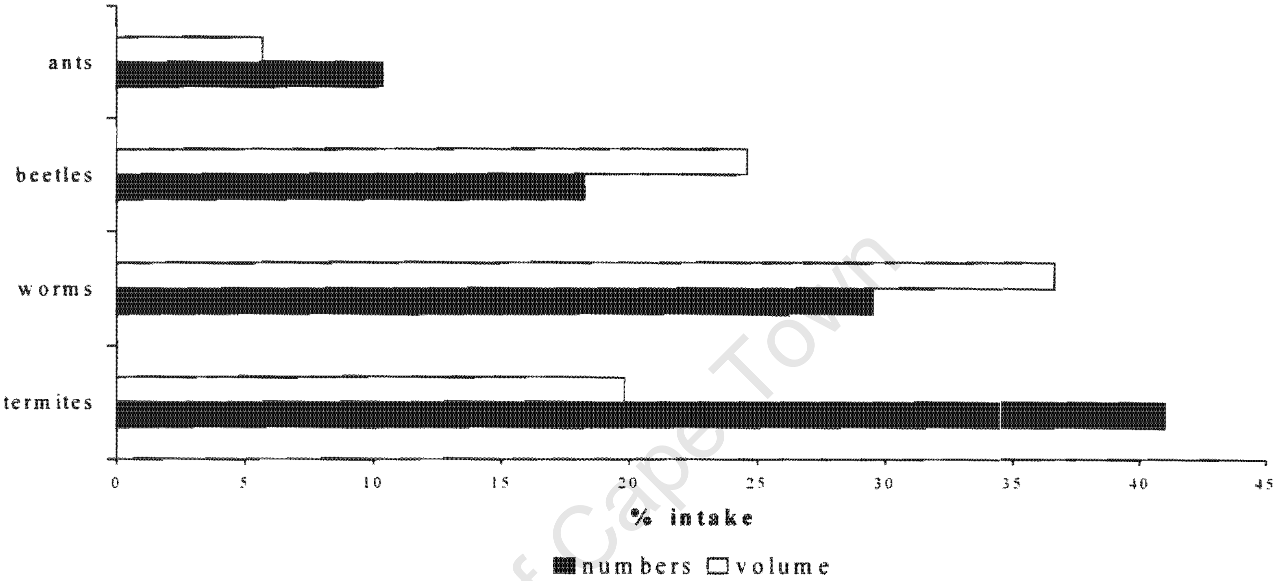


Figure 8.5. Percentage intake of the total number and volume of invertebrate species found within crops of Swainson's Spurfowl.

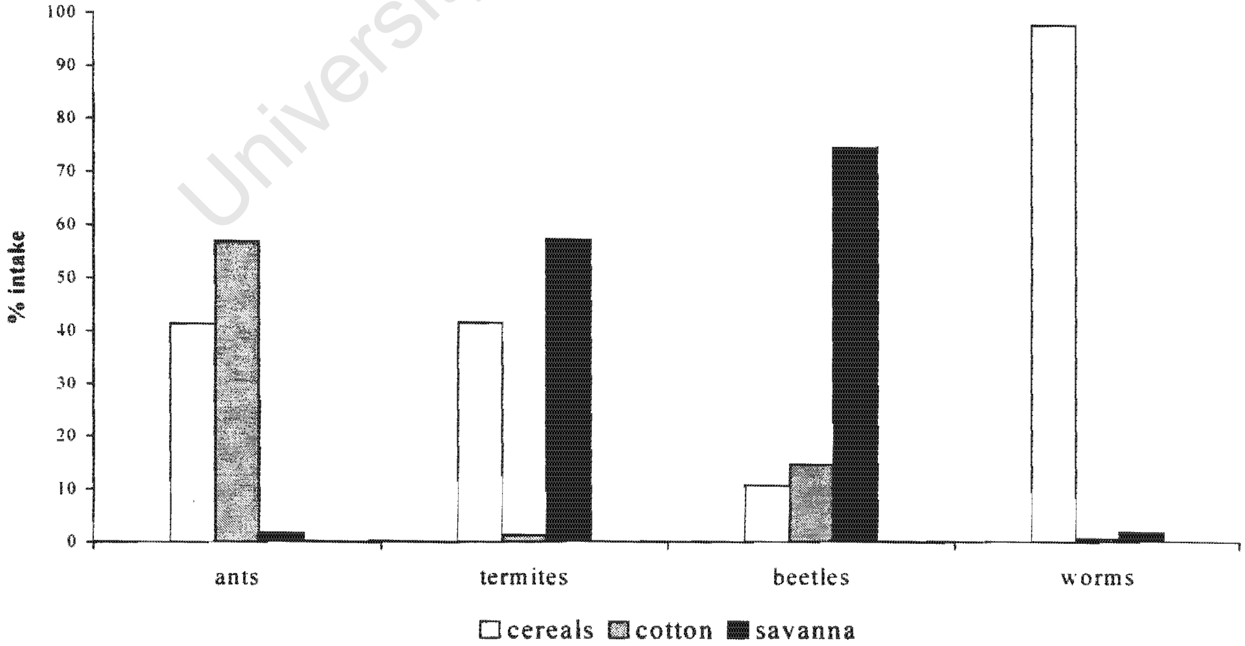


Figure 8.6. Percentage intake of the total number of invertebrate species found within crops of Swainson's Spurfowl with the various habitats.

The largest number and volume of invertebrates was ingested within the cereal habitat (293 individuals, 16.8 vol.), followed by the savanna habitat (211 individuals, 10.4 vol.) and the cotton habitat (56 individuals, 6.1 vol.). Worms were the most favored invertebrates ingested within the cereal habitat followed by termites, ants and beetles (Fig.8.6). Numerically, ants were the most favored food item in the cotton habitat followed by beetles, termites and then worms. Within the savanna habitat, termites were the most favored invertebrates followed by beetles, worms and ants. Each of the three habitat classes provide a variable source of invertebrates; crops from cereal habitats had a higher abundance of worms, ants predominated in cotton habitat and termites and beetles in savanna.

Variation in intestine length

The small intestines from birds collected within the cereal habitat were significantly shorter than those from birds collected in both cotton ($t = -2.56$, $P < 0.05$) and savanna habitat ($t = -3.25$, $P < 0.01$). The combined ceacae of birds collected within the savanna habitat was significantly longer than that of birds from both cereal ($t = -3.92$, $P < 0.001$) and the cotton habitat ($t = -2.84$, $P < 0.01$) (Table 8.3). The overall gut length of birds collected within the cereal habitat was the shortest, but was only significantly shorter ($t = -2.85$, $P < 0.01$) than the length of the gut from birds collected within savanna habitat.

Table 8.3. Mean intestinal lengths for Swainson's Spurfowl collected in various habitats on the Springbok Flats

	small int.	large int.	comb. ceacae	overall
CEREALS				
Mean	66.87*	7.39	22.48	96.72
N	34	34	36	33
SE	1.48	1.45	0.56	2.31
COTTON				
Mean	73.28	6.42	22.98	102.64
N	17	18	19	17
SE	1.94	0.24	0.52	2.44
SAVANNA				
Mean	74.56	6.32	25.58*	106.45*
N	26	26	26	26
SE	1.89	0.17	0.68	2.49

* significantly different means (*t*-Test, $P < 0.05$)

Discussion

Crop contents

The results presented above suggest that Swainson's Spurfowl is a highly opportunistic feeder that adapts well to modified habitats, exploiting waste grain and wild pioneer weed and grass seeds that sprout up in disturbed habitats. Its foraging movements correspond with the availability of food and sufficient cover to exploit that food resource. Birds were even observed to forage at night when daily temperatures were excessively high.

Within the early summer months, birds concentrate foraging activities where food and sufficient cover are readily available, i.e. within the canopy of the savanna habitats or on the fringes of croplands. It is during summer when most of the seasonal pioneer weed and grass seeds are abundant and there is also a proliferation of green material and invertebrates. Food taken during summer months has a higher percentage of protein than agricultural seed (Grafton 1970; Potts 1971; Savory 1977) and both food sources are important in terms of successful egg production and chick survival (Dahlgren 1990). However, the percentage of crops that contained insects within the summer months was lower than might be expected (37.2%). This may be a consequence of the extensive use of herbicides and insecticides to control plant pests and weeds during summer, as has been found in Britain (Rands 1985, 1986b; Potts 1986; Sotherton & Robertson 1990). It is only within the savanna environment or on the fringes of agricultural lands that the numbers of insects may be sufficient (Panek 1997).

During winter months, when the amount of green material and insects are lower, birds exploit the waste grain within the crop-lands and this food source makes up the bulk of items ingested in terms of volume (38.6%). These results are similar to the unpublished findings of Kruger (1981) who found that agricultural seeds made up 30% of the crop mass but only 4.1% of number of items ingested. Most of this utilisation is in the harvesting period when seeds are easily accessible on the ground. It is this ability of the birds to exploit agricultural seed in the winter months that helps to carry the population over to the next summer. During these winter months, much of the savanna habitat is extensively grazed and food resources are limited.

The diversity of habitats is reflected within the crops of birds sampled. Savanna and cotton habitats reflect higher proportions of grass and weed seed and were rich in ants, termites and beetles. The cereal habitats reflect the high intake of agricultural seed and worms.

Intestinal, gut and caecae lengths

This diversity is also reflected within the gut length of birds associated with these specific habitats. The shorter lengths of the small intestine from birds collected on or within close proximity of cereal habitats give indication to a food resource containing a higher protein value. This was also reflected in the longer ceacae and gut lengths of birds collected within the savanna habitat, possibly indicating an ingestion of more fibrous foods of lower nutritional value. If we accept the hypothesis of Leopold (1953) and Moss (1972a) that ingestion of food of better quality (higher protein value) causes birds to have a shorter intestinal length, cereal habitats are the most beneficial to Swainson's Spurfowl in terms of food quality. However, with increased application of herbicides and insecticides along with more efficient harvesting methods, cereal fields now contain very low densities of weed seeds, invertebrates and waste grain, all important components of the summer and winter diet of Swainson's Spurfowl. Furthermore, these habitats are not available to birds throughout the year and accessibility to a variety of suitable alternatives is important in keeping healthy populations. A matrix of small-scale habitats, improving the overall heterogeneity of the land, would give birds the benefit of food diversity where each habitat has a predominance of one or another food source important for survival.

Pests or assets

Although there was evidence that spurfowl were utilising sprouting maize seedlings, the amount taken was less than has been suggested by various authors (Stark 1906; Clancey 1967; Mentis 1970; Kruger 1981; Crowe, Keith & Brown 1986; Milstein 1989; Little & Crowe 2000). It has been speculated that Swainson's Spurfowl digs out young maize seedlings only in search of cutworm larva which may thus be beneficial to farming (Dickin 1992). In many instances, waste grain is not collected from the field following a harvest and goes to waste. This waste grain is the bulk of the agricultural food utilised by

Swainson's Spurfowl during the winter months and there is no evidence that the bird can justly be branded as a serious agricultural pest. On the contrary, the amount of annual weed, grass and other pioneer seedlings coupled with the high intake of invertebrates, such as worms, ingested within crop fields make up for any perceived damage that may have been caused by this spurfowl.

Dependence on water

Although the diversity of habitats within close proximity to one another is important to Swainson's Spurfowl, watering points were scarce and the population seemed unaffected by the low availability of drinking water and, as such, is not a crucial factor in terms of Swainson's Spurfowl survival (Skead 1975).

Implications on range expansion

The massive expansion of Swainson's Spurfowl southwards, particularly into KwaZulu-Natal, the southern Free State and the Northern Cape can be attributed partly to introduction by humans (Pero 1996; Little & Crowe 2000; A. Harvey pers. comm.). However, once established within these crop-farming environments, this gamebird thrives, particularly where there is a mosaic of natural and cereal habitats that fulfill its feeding and breeding requirements. Furthermore, there is a general population decline within the "francolins" (Milstein & Wolff 1987), such as the Redwing *F. levaillantii* (see Chapter 1; Little 1997), Orange River *F. levaillantoides* and Shelley's Francolins *F. shelleyi* (Little & Crowe 2000), and a population increase within the "spurfowls" such as Swainson's and Natal *Pternistis natalensis* Spurfowls. Characteristic of the francolins is the ability to utilise sub-terrain bulbs and corms, a specialized diet where the food plant availability and diversity are susceptible to intense pasture farming such as grazing and burning (see Chapters 1 & 4). On the contrary, spurfowls adapt well to agriculture and the majority of their diet consists of surface foods such as seeds and berries. The successful adaptation of these birds can, at most, be attributed to their diet and feeding habitats.

Chapter 9

Haematozoan parasites in the Swainson's Spurfowl

Summary

Blood smears were collected from 105 Swainson's Spurfowl *Pternistis swainsonii* between 1998 and 1999 from various agricultural habitats within the Springbok Flats region of the Northern Province, South Africa. These smears were examined for haematozoan parasites. Two haematozoans were identified from two individuals. Both *Leucocytozoan* and *Haemoproteus* spp. identified were found individually within each host at low levels of infestation. The remarkably low level of infestation by avian haematozoa Swainson's Spurfowl from the Springbok Flats is probably due to low numbers or even the absence of suitable vectors (e.g ornithophilic blackflies) within the study region. If so, this is possibly a result of unsuitable conditions for such vectors, e.g. a lack of natural bodies of open water, rivers and streams.

Introduction

Swainson's Spurfowl *Pternistis swainsonii* is probably the most common gamebird within savanna and thornveld biotopes of South Africa and has recently expanded its range into much of the grassland habitats of the Free State and KwaZulu-Natal Provinces. This expansion has been facilitated by agricultural practices, particularly those relating to farming with cereal crops (Mentis 1970; Milstein & Wolff 1987; Milstein 1989; Pero 1996; Little 1997; Little & Crowe 2000;).

In recent years, this spurfowl has become a commercially important gamebird, particularly within Gauteng and Northern Provinces where populations are high and have adapted well to transformed habitats (Little & Crowe 2000). One possible factor, which might limit the populations of this gamebird, is infestation by parasites. Indeed, empirical data and controlled experiments have shown that parasites can directly reduce the condition, survival and reproductive output of game species, and their indirect effects can lead to reduced competitive ability of the host as well as increase its vulnerability to predators (Hudson & Dobson 1988). Furthermore, the extent to which these parasite can reduce host populations depends on the pathogenicity of the parasite.

The aims of this Chapter are to ascertain the level of infestation and to identify the species of haematozoan blood protozoa within a population of Swainson's Spurfowl between habitats and seasons within agricultural habitats of the Springbok Flats, Northern Province, South Africa.

Methods

Blood smears were collected between 1998 and 1999 from the hearts of 105 freshly shot birds. They were air-dried and fixed with absolute methanol before being stained with 4% Giemsa solution. The smears were examined microscopically and the presence of parasites related to the time of year and the habitat in which birds were collected.

Results

Of the 105 blood smears analyzed, only two specimens were infested with protozoan parasites. A *Leucocytozoan* spp. was evident in the blood taken from a single male spurfowl collected in February 1999 and a *Haemoproteus* spp. located in a smear from a hen collected in August of the same year. The levels of infection within both cases were very low. The prevalence of infection within the entire sample made up only 1.91%. Both infested specimens were collected in thornveld habitat bordering agricultural lands (maize and cotton).

Discussion

Both species of blood protozoa found in the blood of the Swainson's Spurfowl have previously been found within this species (Oosthuizen & Markus 1967; Thomas & Dobson 1975; Earlé & Little 1993). Both *Haemoproteus* and *Leucocytozoon* species can only be transmitted to their vertebrate hosts through the agency of sporozöite from appropriate vectors (Bennett *et al.* 1992).

The most commonly encountered avian blood parasites found in sub-Saharan African birds belong to the genus *Haemoproteus* (Threfall & Bennett 1989; Bennett *et al.* 1992). The general vector for this genus of protozoa are the ornithophilic biting midges of the genus *Culicoides* (Diptera: Ceratopogonidae) (Threlfall & Bennett 1989). Only *Haemoproteus columbae* is transmitted by hippoboscid flies. *Leucocytozoon* parasite species were further recognized as the second most frequently encountered group within sub-Saharan birds (Bennett *et al.* 1992). This species is host family specific and are transmitted by ornithophilic blackflies (Diptera: Simuliidae) (Threlfall & Bennett 1989).

Both *Leucocytozoon* and *Haemoproteus* species produce a rather benign course of infection and do not pose any great threat to Swainson's Spurfowl populations within the Springbok Flats. Only *Leucocytozoon* species observed in ducks (*L. simondi*), turkeys (*L. smithi*) and chickens (*L. caulleryi*) have been shown to produce high mortalities in domestic flocks (Herman 1968; Bennet *et al.* 1992). However, *Haemoproteus* species have been known to cause extensive muscle necrosis in vertebrate hosts (Becker 1959) and, in the case of high levels of infection, general body condition and quality of the meat can be affected seriously (Earlé, Little & Crowe 1992).

Why such low levels of infestation?

The overall lack of avian haematozoa within the Swainson's Spurfowl of the Springbok Flats is probably the result of low numbers or even the absence of suitable vectors which, in turn, are usually restricted by geographic and climatic conditions (Pierce 1989). Both fly vectors of the protozoan species identified within this study rely heavily on rainfall and running water (Pierce 1989; Earlé *et al.* 1991) and infection with *Haemoproteus* and *Leucocytozoon* species occurred within the rainfall season. Furthermore, open bodies of water in the form of streams or natural dams are a rarity within the study area. The eradication of malaria in the early 1940s opened up the Springbok Flats to large-scale settlement and intensive farming (Tarboton 1987) and may have contributed to the elimination of or influenced ornithophilic vector populations.

Chapter 10

Other birds and habitat:
The Steenkampsberg and the Springbok Flats

Summary

The presence, diversity and species richness of birds were investigated within the montane grasslands of the Steenkampsberg, Mpumalanga Province and the savanna/agricultural habitat of the Springbok Flats, Northern Province to note the influence habitat transformation, through agriculture (pasture and crop farming), has had on bird communities. Density and the species richness of grassland birds in general were negatively correlated with grazing intensity. Nineteen bird species (including five threatened species) were confined to essentially pristine grassland and were never observed in grazed/annually burned grasslands. There were two assemblages of grassland bird species that appear to be indicative of the intensity of habitat utilisation. Populations of grassland birds in the Steenkampberg are becoming increasingly dependent on isolated patches of pristine grassland and are threatened by management involving annual burning and high stocking rates on a landscape scale. Within savanna habitats, bird species diversity and richness were highest within remnant habitats of thornveld (savanna) scattered within intensive agriculture lands. Of the 82 species recognized within the savanna habitat, thornveld was dominated by insectivores whereas grasslands, cotton and maize habitats where dominated by granivorous bird species. Three assemblages of birds, based on their presence, were identified and indicative of habitat transformation via agriculture. The protection of grasslands in the Steenkampsberg and remnant savanna in the Springbok Flats are highlighted as important priority habitats for the preservation of avian communities.

Introduction

Habitat fragmentation can put plant and animal populations in jeopardy, both at the species and community levels (see Folse 1982; Erdelen 1984; Morrison 1986; Hockey *et al.* 1988; Knopf *et al.* 1988; Harrison *et al.* 1994; Allan *et al.* 1997). Bird distributions, in particular, seem to be influenced strongly by vegetation composition and structure (Liversidge 1962; Folse 1982; Knopf *et al.* 1988). However, little research has been done in South Africa which describes changes in bird densities and assemblages where the dominant vegetation is highland grassland, containing a matrix of anthropogenically transformed and pristine ecosystems. Furthermore, the effects on bird populations as a result of intense habitat transformation, through agriculture, have not been investigated within a South African savanna ecosystem. Indeed, these transformed habitats can be exploited by birds in a range of ways (McIntyre & Barrett 1992), since they appear to define their niches largely in terms of habitat structure (Wiens 1973). Therefore, the mere presence of birds, or assemblages of birds, can be used effectively as crude indicators of changes in the structure of the environment (Morrison 1986).

The aims of this Chapter are to ascertain the relative changes within grassland and savanna bird assemblages (diversity and species richness) within various pristine and transformed within the highland grasslands of the Steenkampberg (Mpumalanga) and the savanna of the Springbok Flats (Northern Province).

Methods

Overall distribution of grassland birds

Overall bird diversity was estimated at nine study sites during francolin counts. There are a range of diversity indices that weigh the contributions of species according to some measure of abundance, usually discounting rare species to some degree (Hurlbert 1971). However, owing to difficulties in counting both francolins and other birds simultaneously, overall bird diversity and composition were measured by simply noting which species were present, thus giving an equal weight to all taxa (Erdelen 1984; Schluter & Ricklefs 1993).

Overall distribution of savanna birds

Overall bird species presence and diversity were estimated at six study sites representing various habitats on the farms Mooigelegen and Conteberg in the Springbok Flats between September and October (spring) 1998. At least three replicate sample transects of 3 hours each were performed over each site noting species present and number of individuals per species. Both species richness and species diversity were calculated for each habitat. Each species within each habitat was further assigned to food classes based on its dietary preferences to determine feeding community preferences within habitats.

Data analyses

Programs from the Statgraphics (Anon. 1986) statistical package were used to perform regression analysis to determine relationships between grazing intensity and grassland bird species richness for birds in the Springbok Flats. Multivariate analyses of bird species encountered at the study sites were performed using the cluster analysis (CLUSTER) and non-metric multi-dimensional scaling (MDS) programs in the PRIMER software package (Plymouth Marine Laboratory, U.K.) to determine possible non-random assemblages of birds.

Results

Highland grassland birds

Of the 105 species of grassland birds (Maclean 1985) observed in the Steenkampsberg (Appendix 10.1), 87 were recorded at one or more of the nine study sites. Conserved and farmed sites had 57 species (65.5%) in common, 19 species were observed only at conserved sites, and 11 were observed exclusively at farmed sites (Appendix 10.1). The species richness of grassland birds declined steadily within sites with increasing grazing intensity ($r^2 = 0.68$, $P < 0.05$, $y = 0.18 + 1.3x$).

Eleven of the 15 threatened bird species (Brooke 1984) which occurred in the study area were observed solely in the protected study sites (Table 10.1). The Wattled Crane *Bugeranus carunculatus*, Black Harrier *Circus maurus*, Pallid Harrier *Circus macrourus*, Stanley's Bustard *Neotis denhami* and Yellowbreasted Pipit *Anthus chlois*, all threatened species (Brooke 1984), and a further 14 bird species were never observed at such 'farmed' sites. Only three threatened species, the Southern Bald Ibis *Geronticus calvus*, Cape Vulture *Gyps coprotheres* and Blue Crane *Anthropoides paradiseus*, readily exploited intensely grazed (<5 ha/LAU) and burnt farmland.

Table 10.1. Species richness of grassland birds within Mpumalanga Province

	No grassland species	Number. endemics	Number threatened
conserved	77	11	11
grazed	69	10	9

The study sites form two groups characterized by distinctive bird assemblages (Fig. 10.1 a and b; Appendix 10.1). Sites comprising group 'a' experience triennial or biennial burns and, at most, relatively low grazing intensity (>5 ha/LAU). Sites forming Group 'b' are burned annually and are grazed intensively.

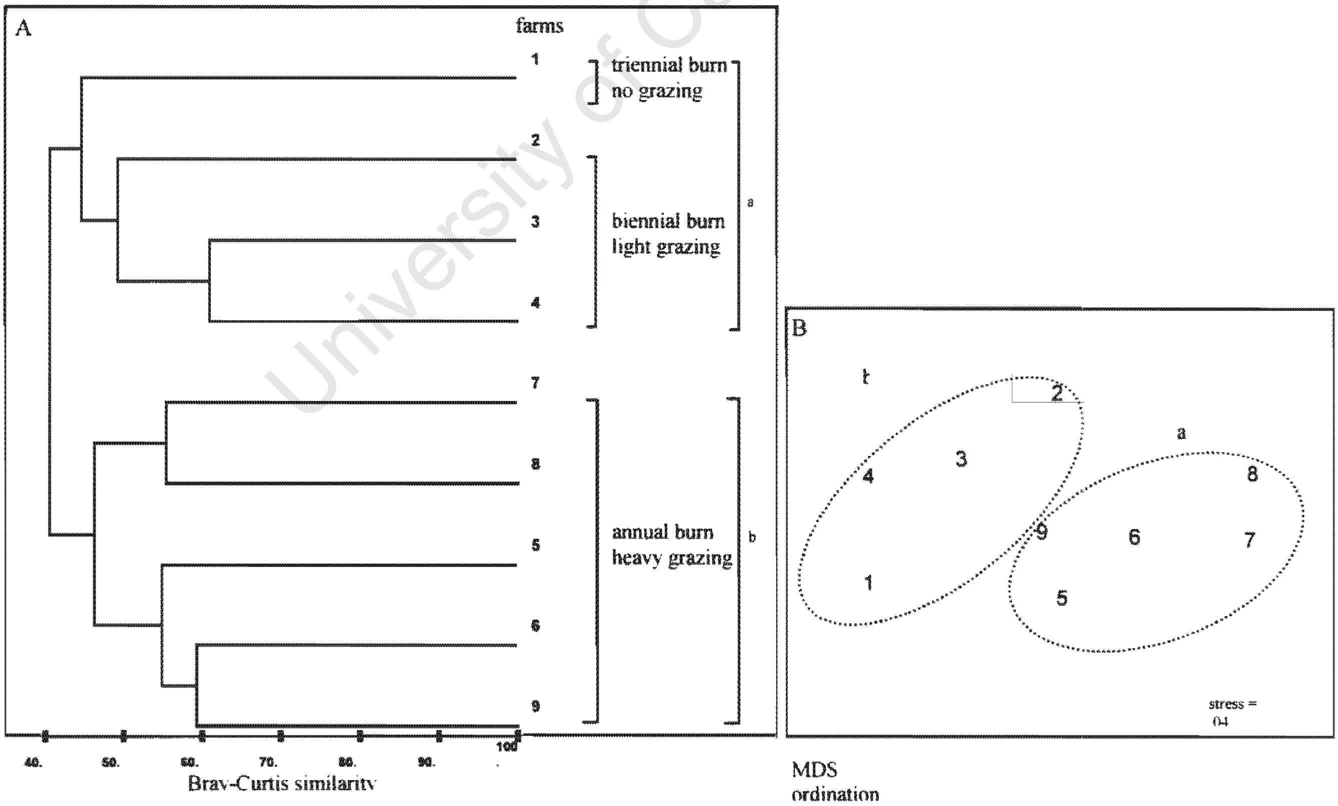


Figure 10.1. Dendrogram of Bray-Curtis percentage similarities in bird assemblage structure within the study sites (A) and mutidimensional scaling ordination between sites (MDS) (B) for birds in the Steenkampsberg grasslands.

Savanna birds

Three assemblages representing 82 species were recognized within the six study sites or habitats (Fig. 10.2). Species common to assemblage A commonly occur within both the thornveld and island habitats. Species common to assemblage B represent the grassland and cotton habitats. The species within assemblage C were unique to the maize habitat.

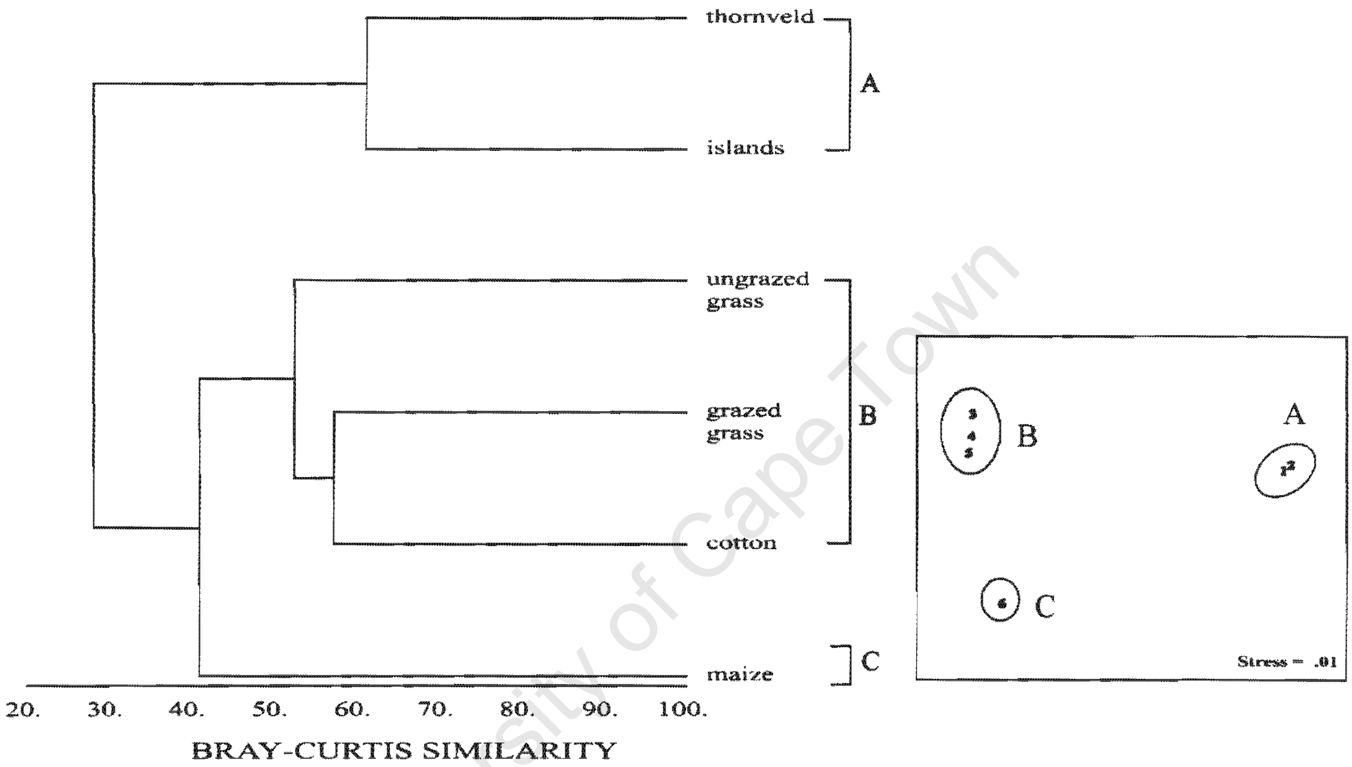


Figure 10.2. Similarity between habitats based on species presence within the savanna habitat of the Springbok Flats

Both species richness and diversity were highest in the islands (small remnants of natural vegetation bordering or within agricultural lands) followed by the thornveld habitats. Maize and cotton (croplands) had the lowest richness and diversity of bird species (Fig. 10.3).

The species of birds within each assemblage, as identified in Figure 10.2. were grouped according to their feeding preferences (Table 10.2): granivores/fruit/nectar (G), insectivores (I), omnivores (O) and raptorial (R). Assemblage A (birds within the thornveld and islands) were dominated by insectivores, assemblage B (birds within the grasslands and cotton) were dominated by granivores and closely followed by insectivores, assemblage C (birds within the maize) were dominated by granivorous species followed closely by omnivorous species.

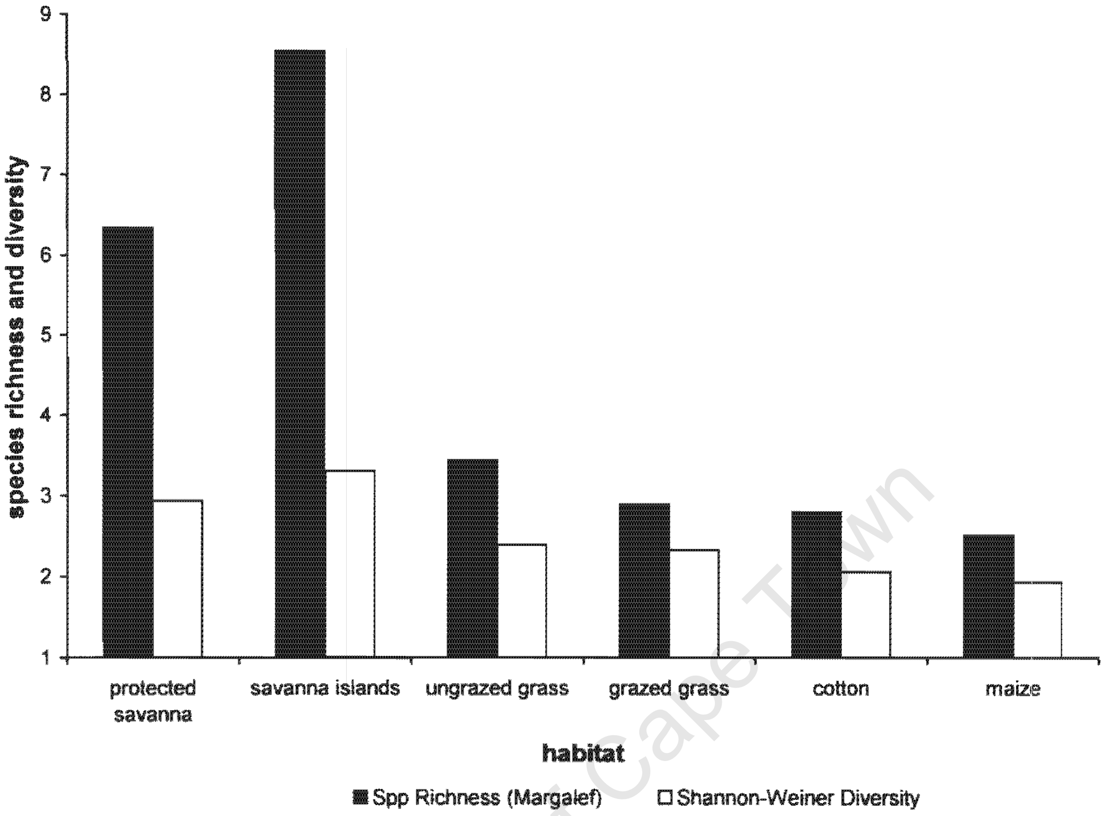


Figure 10.3. Species richness and diversity of birds within the savanna/agricultural habitat of the Springbok Flats

Table 10.2. Percentage of bird species within each assemblage based on their food preferences within the Springbok Flats

	Assemblage		
	A	B	C
granivores	27.12	35.29	47.06
insectivores	45.76	32.35	5.88
omnivores	22.03	26.47	41.18
raptorial	5.08	5.88	5.88
specific spp.*	41	8	9
total spp	88	60	17

* specific to assemblage

A comprehensive species list of birds identified within the savanna habitat of the Springbok Flats is given in Appendix 10.2, noting their foraging class and assemblage presence.

Discussion

There is often a core of characteristic species in a bird assemblage of a particular habitat that appears to be sensitive to habitat transformation, fragmentation and the character of the surrounding environment (Cody 1993). Moreover, changes within this core assemblage should, in turn, give an indication of changes in habitat structure and/or functioning. The relationship between bird assemblages and vegetation structure may, however, be complex and modification of the structural complexity of the habitat (i.e., species composition, biomass, cover etc.) could be detrimental to habitat-specific bird assemblages if the habitat is no longer of sufficient quality to maintain healthy populations (Morrison 1986). Thus, the bird species composition of these habitats may not reflect the "true" species common to an undisturbed, unmodified environment.

The Steenkampsberg grasslands

The conservation importance of these highland grasslands is highlighted by the fact that one of the seven South African hot-spots of botanical endemism and diversity is centered on the escarpment in Mpumalanga (Cowling & Hilton-Taylor 1994), and overlaps with one of the four 'Endemic Bird Areas' in South Africa identified by the International Council for Bird Preservation (ICBP, 1992).

With this in mind, species within both assemblages recognized in Figure 10.1 are strongly influenced by changes (or the lack thereof) in pristine grassland habitat or vegetation structure and should be detectable within the beta component of species diversity. In fact, some threatened species (e.g. Southern Bald Ibis and Blue Crane) appear to benefit from current pasture farming operations within the region. However, modified habitats are lower in overall species richness, number of endemic and threatened species.

Considering that only 2% of the grassland biome in South Africa is protected (Siegfried 1992) there is cause for serious concern. Highland grasslands exposed to moderate to low grazing levels (> 5 ha/LAU) in combination with biennial burning, are few and far between. They are thus prone to local species extinctions due to stochastic demographic and environmental events (Hanski & Gilpin 1991). Indeed, threatened species, e.g. the Wattled Crane, Black Harrier, Pallid Harrier, Stanley's Bustard and Yellowbreasted Pipit, which are localized in habit or are dependent on undisturbed grassland and associated wetlands systems for survival, must experience range reduction and possible local extinction. Of these species, the Black Harrier and Yellowbreasted Pipit are endemic to South African grassland and should receive special conservation attention.

The Springbok Flats savanna

If one considers the thornveld habitat as that which best represents the 'original' veld structure of the Springbok Flats, it holds both the highest avian diversity and species richness. It, therefore, has a high priority for conservation in terms of bird species composition, particularly for arboreal insectivorous birds. However, up until 1987, none of this Springbok Flats veld type was conserved and only 0.28% is currently under protection. Furthermore, it is estimated that 92% is transformed (Macdonald 1989; Rebelo 1997).

The importance of these remnant savanna habitats (thornveld and islands) is highlighted in their role as "source habitats" whereby they function as important breeding sites for a number of species that may well utilise the neighboring grassland and crop habitats. Moreover, these remnant patches of savanna play an important role in the formation of ecotones or edge habitat utilised by a diversity of birds, particularly the Swainson's Spurfowl. The establishment of game farms for personal pleasure or for the tourism market would justify, financially and ecologically, the preservation of these habitats and by so doing indirectly preserve those species associated with these remnant savanna habitats.

Conclusions

The grasslands of the Steenkampsberg were both higher in their resident species richness and number of endemic and rare bird species than the savanna habitat of the Springbok Flats. Although the two ecosystems vary to a large degree in their structure and function, the massive transformation via agriculture of the savanna habitat in the Springbok Flats may contribute to a large extent to the overall demise of bird species that had evolved to survive in an undisturbed savanna environment. Although the montane grasslands of the Steenkampsberg hold a larger percentage of avian 'specialists', that may be more sensitive to habitat degradation, the remnant bird populations within the thornveld of the savanna should receive a greater degree of conservation attention than is currently implemented if these communities are to be preserved.

Both the Redwing Francolin and the Swainson's Spurfowl utilise land that is not intensively managed (ungrazed, infrequently burnt grasslands in the case of the Redwing and ungrazed pastureland with no crop agriculture in the case of the Swainson's) for roosting and breeding. Furthermore, these habitats play a fundamental role in the survival and success of both gamebird species. Greater preservation of these habitats would not only boost their populations, but also have spin-offs for possible wingshooting operations and a means by which the landowner can recoup revenue lost from alternative farming activity.

Appendix 10.1.

Species list of grassland birds (Maclean 1985) occurring in Steenkampsberg, their conservation status (Brooke 1984) and endemism to South Africa. (Siegfried 1992).

Common name	**Scientific name**	**Conservation status**	**Endemis**	**Assemblage**
Cattle Egret	*Bubulcus ibis*			1 & 2
White Stork	*Ciconia ciconia*			1
Black Stork	*Ciconia nigra*	threatened		
Southern Bald Ibis	*Geronticus calvus*	globally threatened	*	2
Hadidah Ibis	*Bostrychia hagedash*			1 & 2
Egyptian Goose	*Alopochen aegyptiacus*			1 & 2
Yellowbilled Duck	*Anas undulata*			1 & 2
Spurwinged Goos	*Plectropterus gambensis*			1
Secretary Bird	*Sagittarius serpentarius*			1 & 2
Cape Vulture	*Gyps coprotheres*	threatened	*	2
Yellowbilled Kite	*Milvus migrans*			1
Blackshouldered Kite	*Elanus caeruleus*			1 & 2
Black Eagle	*Aquila verreauxii*			1
Martial Eagle	*Polemaetus bellicosus*			2
Broun Snake Eagle	*Circaetus cinereus*			
Steppe Buzzard	*Buteo buteo*			1
Jackal Buzzard	*Buteo rufofuscus*		*	1 & 2
Redbreasted Sparrowhawk	*Accipiter rufiventris*			1 & 2
Black Sparrowhawk	*Accipiter melanoleucus*			2
Pallid Harrier	*Circus macrourus*	threatened		1
Black Harrier	*Circus maurus*	threatened	*	1
Gymnogene	*Polyboroides typus*			1
Eastern Redfooted Kestrel	*Falco amurensis*			2
Rock Kestrel	*Falco tinnunculus*			1 & 2
Greywing Francolin	*Francolinus africanus*		*	1 & 2
Redwing Francolin	*Francolinus lavaillantii*			1 & 2
Swainson's Spurfowl	*Pternistis swainsonii*			1 & 2
Common Quail	*Coturnix coturnix*			1
Helmeted Guineafowl	*Numida meleagris*			1 & 2
Kurrichane Buttonquail	*Turnix sylvatica*			1
Wattled Crane	*Bugeranus carunculatus*	globally threatened		1
Blue Crane	*Anthropoides paradiseus*	globally threatened	*	1 & 2
Crowned Crane	*Balearica regulorum*	threatened		1
Striped Flufftail	*Sarothrura affinis*	threatened		1 & 2
Kori Bustard	*Ardeotis kori*	treatened		
Stanley's Bustard	*Neotis denhami*	threatened	*	1
Crowned Plover	*Vanellus coronatus*			1 & 2
Blacksmith Plover	*Vanellus armatus*			1 & 2
Wattled Plover	*Vanellus senegallus*			1 & 2
Ethiopean Snipe	*Gallinago nigripennis*			1 & 2
Spotted Dikkop	*Burhinus capensis*			1
Rock Pigeon	*Columba guinea*			1 & 2
Redeyed Dove	*Streptopelia semitorquata*			1 & 2
Cape Turtle Dove	*Streptopelia capicola*			1 & 2
Laughing Dove	*Streptopelia senegalensis*			1 & 2
Namaqua Dove	*Oena capensis*			
Grass Owl	*Tyto capensis*	threatened		1
Marsh Owl	*Asio capensis*			1
Cape Eagle Owl	*Bubo capensis*			1 & 2
Spotted Eagle Owl	*Bubo africanus*			
Black Swift	*Apus barbatus*			1
Alpine Swift	*Apus affinis*			1
Hoopoe	*Upupa epops*			2
Ground Woodpecker	*Geocolaptes olivaceus*	threatened	*	1 & 2

Longbilled Lark	*Mirafra curvirostris*			1
Redcapped Lark	*Calandrella cinerea*			1 & 2
European Swallow	*Hirundo rustica*			
Whitethroated Swallow	*Hirundo albigularis*			
Greater Striped Swallow	*Hirundo cucullata*			
Banded Martin	*Riparia cincta*			1
Black Sawwing Swallow	*Psalidoprocne holomelas*			1 & 2
Black Crow	*Corvus capensis*			1 & 2
Groundscraper Thrush	*Turdus litsitsirupa*			2
Cape Rock Thrush	*Monticola rupestris*		*	1 & 2
Sentinel Rock Thrush	*Monticola explorator*		*	1 & 2
Mountain Chat	*Oenanthe monticola*			1 & 2
Buffstreaked Chat	*Oenanthe biasciata*	threatened	*	1 & 2
Anteating Chat	*Myrmecocichla formicivora*			1 & 2
Stonechat	*Saxicola torquata*			1 & 2
Yellow Wabbler	*Chloropeta natalensis*			
Willow Wabbler	*Phylloscopus trochilus*			1
Grassbird	*Spenoeacus afer*			2
Fantailed Cisticola	*Cisticola juncidis*			1 & 2
Ayres' Cysticola	*Cisticola ayresii*			1 & 2
Palecrowned Cysticola	*Cisticola brunnescens*			1
Wailing Cysticola	*Cisticola lais*			1 & 2
Levailliant's Cysticola	*Cisticola tinniens*			1 & 2
Spotted Prinia	*Prinia maculosa*			
Longtailed Wagtail	*Motacilla clara*			2
Cape Wagtail	*Motacilla capensis*			1
Ritchards Pippet	*Anthus novaeseelandiae*			1 & 2
Plainbacked Pippet	*Anthus leucophrys*			1 & 2
Yellowbreasted Pipit	*Anthus chloris*	globally threatened	*	1
Orangethroated Longclaw	*Macronyx capensis*			1 & 2
Fiscal Shrike	*Lanius collaris*			1 & 2
Bokmakkirie	*Telophorus zeylonus*			1 & 2
Pied Starling	*Spreo bicolor*		*	1 & 2
Redwinged Starling	*Onychognathus morio*			1 & 2
Gurney's Sugarbird	*Promerops gurneyi*			1
Malachite Sunbird	*Nectarinia famosa*			1
Greater Doublecollard Sunbird	*Nectarinia afra*		*	
Black Sunbird	*Nectarinia amethystina*			1 & 2
Masked Weaver	*Ploceus velatus*			1 & 2
Red Bishop	*Euplectes orix*			1
Golden Bishop	*Euplectes afer*			1
Yellowrumped Widow	*Euplectes capensis*			1 & 2
Redcollard Widow	*Euplectes ardens*			1
Longtailed Widow	*Euplectes progne*			1 & 2
Common Waxbill	*Estrilda astrild*			1 & 2
Swee Waxbill	*Estrilda melanotis*			
Quail Finch	*Ortygospiza atricollis*			1
Pintailed Whydah	*Vidua macroura*			1
Black Widowfinch	*Vidua funerea*			
Cape Bunting	*Emberiza capensis*			
Rock Bunting	*Emberiza tahapisi*			1 & 2

Appendix 10.2. Species list of birds identified on Mooigelegen and Conteberg (Almac Farm) in the Springbok Flats savanna.

Common name	**Scientific name**	**Foraging class**	**Assemblage***
Arrowmarked Babbler	*Turdoides jardineii*	I	A
Pied Barbet	*Lybius leucomelas*	I	A
Chinspot Batis	*Batis molitor*	I	A
Goldenbreasted Bunting	*Emberiza flaviventris*	I	A
Kori Bustard	*Ardeotis kori*	O	B
Kurrichane Buttonquail	*Turnix sylvatica*	O	B/C
Blackthroated Canary	*Serinus atrogularis*	G	C
Bully Canary	*Serinus sulphuratus*	G	B
Streakyheaded Canary	*Serinus gularis*	G	A
Anteating Chat	*Myrmecocichla formicivora*	I	B
Desert Cisticola	*Cisticola aridula*	I	A/B
Fantailed Cisticola	*Cisticola juncidis*	I	A/B
Rattling Cisticola	*Cisticola chiniana*	I	A/B
Burchell's Coucal	*Centropus superciliosus*	R	C
Longbilled Crombec	*Sylvietta rufescens*	I	A
Cape Dikkop	*Burhinus capenis*	O	A
Laughing Dove	*Streptopelia senegalensis*	G	A/B/C
Namaqua Dove	*Oena capensis*	G	A/B/C
Forktailed Drongo	*Dicrurus adsimilis*	I	A/C
Cattle Egret	*Bubulcus ibis*	I	B
Burntnecked Eremomela	*Eremomela usticollis*	I	A
Cut-throat Finch	*Amadina fasciata*	G	A
Melba Finch	*Pytilia melba*	G	A/B/C
Quail Finch	*Ortygospiza atricollis*	G	B/C
Redheaded Finch	*Amadina erythrocephala*	G	A/B/C
Scalyfeathered Finch	*Sporopipes squamifrons*	G	A/B/C
Chestnutbacked Finchlark	*Eremopterix leucotis*	O	B/C
Bluebilled Firefinch	*Lagonosticta rubricata*	G	A
Jameson's Firefinch	*Lagonosticta rhodopareia*	G	A
Paradise Flycatcher	*Terpsiphone viridis*	I	A
Coqui Francolin	*Francolinus coqui*	O	A
Crested Francolin	*Francolinus sephaena*	O	A
Swainson's Spurfowl	*Pterenistis swainsonii*	O	A/B/C
Egyptian Goose	*Alopochen aegyptiacus*	O	C
Gabar Goshawk	*Micronisus gabar*	R	B/C
Helmeted Guineafowl	*Numida meleagris*	O	A/B/C
Grey Hornbill	*Tockus nasutus*	O	A
Yellowbilled Hornbill	*Tockus flavirostris*	O	A
Redcapped Lark	*Calandrella cinerea*	O	C
Sabota Lark	*Mirafra sabota*	O	A/C
Grey Lourie	*Corythaixoides concolor*	O	A
Redfaced Mousebird	*Colius indicus*	G	A/B
Speckled Mousebird	*Colius striatus*	G	A
Neddicky	*Cisticola fulvicapilla*	I	A
Blackheaded Oriole	*Oriolus larvatus*	I	A
Pearlspotted Owl	*Glaucidium perlatum*	R	A
Whitefaced Owl	*Otus leucotis*	R	A
Grassveld Pipit	*Anthus cinnamomeus*	I	B/C
Rock Pigeon	*Columba guinea*	G	C

Crowned Plover	*Vanellus coronatus*	I	B/C
Tawnyflanked Prinia	*Prinia subflava*	I	A/B/C
Puffback	*Dryoscopus cubla*	I	A
Redbilled Quelea	*Quelea quelea*	G	C
Heuglin's Robin	*Cossypha heuglini*	I	A
Kalahari Robin	*Erythropygia paena*	I	A/B
Whitebrowed Robin	*Erythropygia leucophrys*	I	A
Whitethroated Robin	*Cossypha humeralis*	I	A
Lilacbreasted Roller	*Coracias caudata*	I	A
Crimsonbreasted Shrike	*Laniarius atrococcineus*	I	A
Whitecrowned Shrike	*Eurocephalus anguitimens*	I	A
White helmet Shrike	*Prionops plumatus*	I	A
Yellowthroated Sparrow	*Petronia superciliaris*	O	A
Black Sparrowhawk	*Accipiter melanoleucus*	R	C
Glossy Starling	*Lamprotornis nitens*	O	A/B
Wattled Starling	*Creatophora cinerea*	O	B
Stonechat	*Saxicola torquata*	I	B
Marico Sunbird	*Nectarinia mariquensis*	O	A
Whitebellied Sunbird	*Nectarinia talatala*	O	A
Threestreaked Tchagra	*Tchagra australis*	R	A
Titbabbler	*Parisoma subcaeruleum*	I	A
Redeyed Turtle Dove	*Streptopelia semitorquata*	G	C
Ringnecked Turtle Dove	*Streptopelia capicola*	G	A/B
Barred Warbler	*Camaroptera fasciolata*	I	A
Blackcheeked Waxbill	*Estrilda erythronotos*	G	A
Blue Waxbill	*Uraeginthus angolensis*	G	A
Common Waxbill	*Estrilda astrild*	G	B
Orangebreasted Waxbill	*Sporaeginthus subflavus*	G	B
Violeteared Waxbill	*Uraeginthus granatinus*	G	A/B
Masked Weaver	*Ploceus velatus*	G	A
Pintailed Whyda	*Vidua macroura*	O	C
Redbilled Woodhoopoe	*Phoeniculus purpureus*	I	A
Cardinal Woodpecker	*Dendropicos fuscescens*	I	A

- Foraging class: insectivore (I), granivore (G), omnivore (O), raptorial (R)

Chapter 11

Wingshooting strategies and management of Redwing Francolin and Swainson's Spurfowl

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Summary

The results of the research underpinning this dissertation demonstrate that populations of Redwing Francolin in the Mpumalanga study area outside of protected grasslands are not sufficiently large and seasonally productive to withstand sustained wingshooting. To increase numbers of Redwing Francolin to levels which can be utilised sustainably, landowners/managers should burn grasslands only on a biennial cycle and reduce grazing by domestic livestock drastically following a camp-rotation system, or exclude it altogether. If populations of Redwing are raised to levels that can withstand wingshooting, intensive pre-seasonal surveys of the locations and abundance of birds should be done, since coveys are small and may be shot out entirely. Even in such situations, wingshooting should not exceed 20% of the population.

Swainson's Spurfowl within the Springbok Flats is sufficiently abundant and productive to warrant annual harvesting. The Swainson's Spurfowl is more productive than the Redwing Francolin and wingshooting should not exceed 30% of the population. However, overgrazing and large-scale tracks of agricultural land are the main threats to this spurfowl. Landowners should strive to increase the availability of nesting and roosting habitat by not grazing or burning field verges and constructing 'islands' of natural habitat within and between agricultural lands.

Introduction

Management plans for the biologically sustainable and commercially viable utilisation of gamebirds like the Redwing Francolin and Swainson's Spurfowl need to produce two key products: quality habitat and sufficiently abundant francolin/spurfowl. This requires an understanding of and ability to manipulate key factors that control the population of these two gamebirds.

Management recommendations for the Redwing Francolin

The Redwing Francolin is a montane grassland specialist and, as discussed in Chapter 1, is sensitive to even low levels of habitat manipulation involving burning and grazing. Management plans thus should focus on grassland restoration – to provide a habitat as close as possible to that of the pristine, *Themeda* veld type in the Steenkampsberg.

Limitations to francolin populations and sustainable use

A combination of environmental factors contributes towards the depressed populations of Redwing Francolin in agricultural pasture farms in the Dullstroom district (Fig. 11.1). Low availability of suitable nesting habitat for breeding hens coupled with high mortality of young chicks reduces overall recruitment to the adult Redwing population. Low and patchy food availability and cover influence population dispersion and home-range size, restricting small coveys to isolated patches of nutrient-rich habitat in grazed grasslands within which food diversity, abundance and quality play major roles in regulating covey size, spacing and home-range. Parasitic infestations are more prevalent in populations of Redwing associated with these patchy, fragmented habitats and may limit populations by making them more vulnerable to predation.

Populations of Redwing and Greywing Francolin on commercial farmland in the Dullstroom, Belfast and Machadadorp districts are currently not sufficiently high to warrant sustainable wingshooting. Where populations are sufficiently high to warrant shooting, off-take should be designed to take the harvestable surplus as soon as possible after it has been produced, and early enough not to interfere with breeding in the following season (Mentis & Bigalke 1973). This implies that wingshooting is best done from 15 April to 15 July. However, since Redwing covey sizes tend to be small and no more than 20% of the population should be harvested per year in order to mirror natural mortality (Little & Crowe 1993b), wingshooting should be designed to take the entire covey for hunter satisfaction. Unlike Greywing, where management is designed to harvest 40% of a covey, local populations of Redwing would have to be resuscitated through immigration from adjacent, unshot areas. This form of management would require intensive counts prior to the hunting season and shortly after the breeding season to estimate harvestable numbers and bag-limits for the upcoming season.

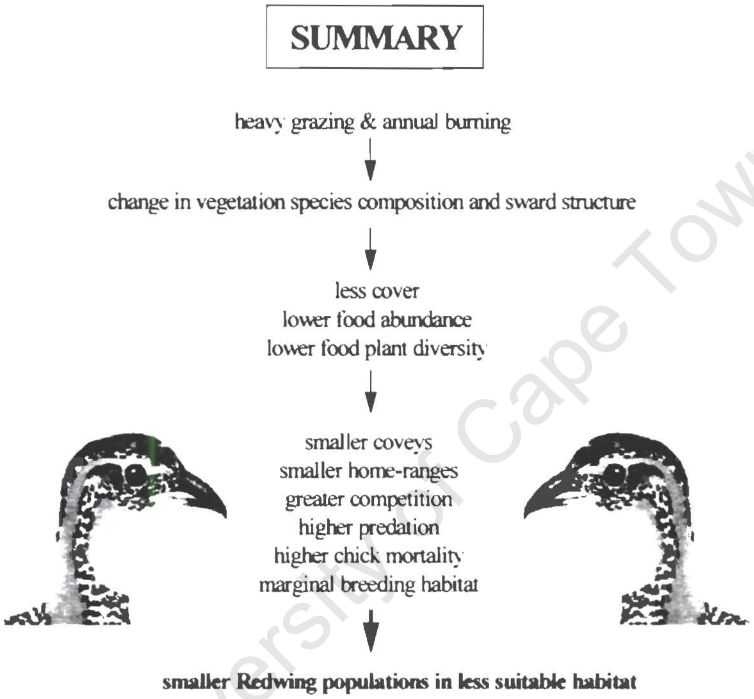

Figure 11.1. Summary of factors resulting in the overall population decline of the Redwing Francolin within grazed grasslands on the Steenkampsberg, Mpumalanga Province

Grassland management

Looking at the problem from another perspective, it is possible to consider a high density of Redwing Francolins (> 0.1 birds per ha) to be a reliable indicator of 'good' grassland condition. Thus, management of grassland employed to promote Redwing numbers should also benefit those species of plants and animals which also require a relatively undisturbed environment, and enhance the overall conservation status of highland grasslands on the Mpumalanga escarpment.

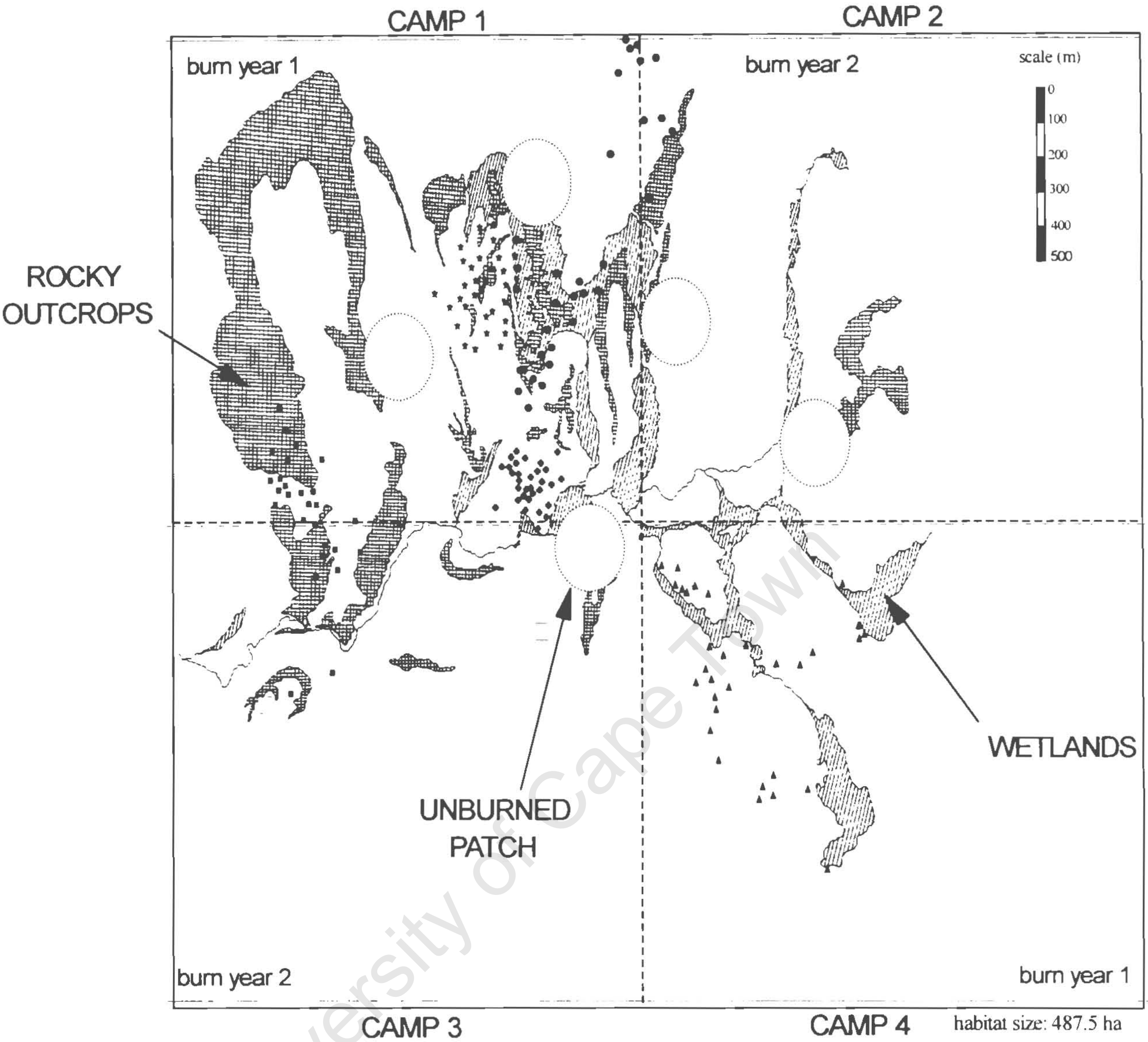

Figure 11.2. Proposed grassland habitat management plan to promote Redwing Francolin numbers. Each camp is burnt every second year and small areas (ellipses) are left unburned where grassland, wetland and rocky outcrop habitats co-occur and can provide breeding habitat. This map is taken from one of the study habitats in the Redwing Francolin home range study (see Chapter 2).

The management principles offered here complement those recommended by Mentis & Bigalke (1973). They presuppose that land is farmed and that Redwing Francolin constitute only a secondary by-product on the farm. Since the immediate effects of clean-burning large expanses of grassland are detrimental to Redwing, the landowner should, in applying spring burns, develop a mosaic so that adjoining camps are not burnt in the same year (Figure 11.2). Furthermore, burning should be biennial and patches of unburned, ungrazed grassland should be available to provide suitable habitat for nesting, feeding and shelter. Burning of these camps and patches should not be simultaneous. The siting of these patches should take into account habitat preferences for Redwing as well as home range size. A combination of a 5 ha patch over wetland, rocky and grass habitat would be ideal. Ten 5 ha patches would constitute a 50 ha protected area on the farm with the potential to accommodate between 40 and 50 Redwing and numerous other threatened grassland species reliant on preserved habitat. Furthermore, intensive pasture farming should be supplemented by other economically viable activities such as trout farming to reduce the impact of overgrazing in the region.

Many farmers within the Steenkampsberg and the Dullstroom region in particular have reduced stock farming or eliminated it all together in favour of ecotourism and trout farming. In many of these cases, farms are large and a 3000 hectare farm can accommodate up to 300 Redwing Francolin at a density at or above 0.1 birds/ha if commercial stock farming is excluded (see chapter 1). In this instance, the landowner can provide up to three shoots and, at a harvest rate of 20%, offer 60 birds per season at a bag limit of 20 birds per shoot for three to four guns at a time. Currently, hunters pay up to R1000 each for a shoot, the farmer can thus generate between R9000 and R12000 per season. This excludes other hospitality-related services such as meals and accommodation. The majority of these trout farms provide up-market accommodation and the combination of revenue from wingshooting and fishing outweigh commercial stock farming. Verloren Vallei Nature Reserve situated outside of Dullstroom, a state-owned Mpumalanga Parks Board run reserve, has adapted the commercial wingshooting approach and gained substantial revenue over the past three years from commercial Redwing Francolin hunting operations. This RAMSAR declared site now ploughs back this revenue into its prime objective of wetland and associated biodiversity conservation.

Management recommendations for the Swainson's Spurfowl

Unlike the Redwing Francolin, the Swainson's Spurfowl is an opportunist species with a wide tolerance of, and even an attraction to, habitat transformed by agriculture. However, any form of landscape management that is extreme or large-scale can limit populations.

Limitations to Spurfowl populations and sustainable use

Relatively few environmental factors contribute to depressed populations of Swainson's Spurfowl (Fig. 11.3). The most severe are overgrazing and large-scale agriculture. This form of management reduces the accessibility and increases the fragmentation of suitable habitat along the landscape. As a result, birds have to travel larger distances to and from roosting and feeding sites. Cover is probably the most important habitat component for this spurfowl as birds use of the 'edge' or ecotone extensively between fields and on field verges. Remove this cover and the landscape becomes 'ecologically unavailable' for this bird. Furthermore, birds may then congregate in the less available 'hot-spots' which meet cover and food requirements. These birds are prone to over-shooting and represent the majority of the population within the surrounding district.

However, the populations of Swainson's Spurfowl within the Springbok Flats are currently sufficiently high to warrant sustainable wingshooting and, like the Redwing, off-take should be designed to take the harvestable surplus (no more than 30%) of the population shortly after the breeding season. As discussed under Chapter 7, it is recommended that the wingshooting season should be run from June to October in the Springbok Flats.

Savanna management

It takes very little to increase populations of the Swainson's Spurfowl relative to measures necessary to resuscitate Redwing Francolin populations. This spurfowl adapts well to transformed habitats and can serve well as a co-product of agriculture if wingshooting operations are to be implemented. However, the scale of landscape farming should be reduced to increase the availability of nesting and roosting habitat. Furthermore, this habitat (thornveld, ungrazed grassland and field verges) forms an important foraging habitat in the summer months when the availability of croplands are reduced.

Farmers should strive to establish small-scale field verges within and on the perimeter of agricultural lands. Furthermore, these ecotones should not be grazed or burnt in spring or summer and preferably be connected to one another. Provided all the

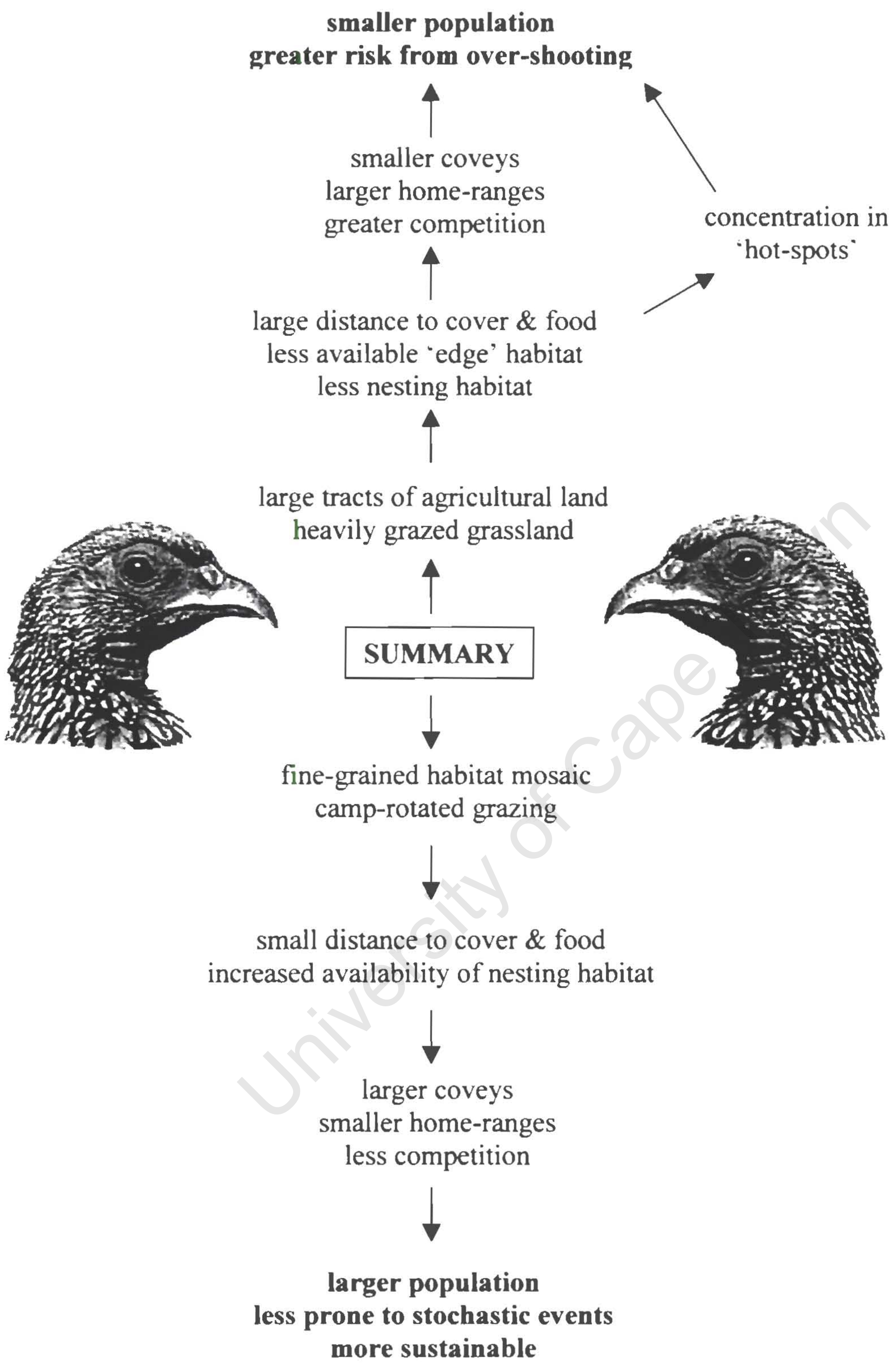

Figure 11.3. Summary of environmental factors contributing towards the overall population decline and population increase of Swainson's Spurfowl in the Springbok Flats.

birds requirements are met (foraging, roosting and shelter), home-range size should decrease and more coveys will be able to utilise a smaller area. Male birds take up small-scale territories (*ca* 2 ha) at the onset of the breeding season. The best territories are taken first; i.e. those that provide the pair with suitable nesting and foraging cover – other pairs will move off in search of suitable territories and, if not available, may not breed or have reduced breeding production. These breeding territories are non-overlapping and birds will be excluded from breeding if the habitat is unsuitable. Once again, the more fine-scaled the habitat mosaic, the more beneficial to the Swainson's Spurfowl.

SYNTHESIS

'Who can explain why one species ranges widely and is very numerous, and why another allied species has a narrow range and is rare?'

Charles Darwin (1859)

This study was undertaken to assess the status of the Redwing Francolin *Francolinus levaillantii* in the pastoral grasslands of the eastern Mpumalanga escarpment and the Swainson's Spurfowl *Pternistis swainsonii* in the Springbok Flats southern district of the Northern Province where much of the land is under crop agriculture. Previous studies on the Redwing Francolin focused on the population of birds within the protected grasslands of the KwaZulu Natal Drakensberg where the habitat is free from intensive pasture farming and frequent controlled burns. The status of the Redwing Francolin within privately owned farmland, particularly within the montane grasslands of Mpumalanga Province, has not been assessed scientifically. The Swainson's Spurfowl is wingshot (= gamebird hunting with shotguns) extensively within the Springbok Flats and is regarded, by many farmers, as a 'pest' to their agricultural crops. However, there are no published studies of the population biology, estimates of numbers and impact this bird has on cereal crop agriculture. The reasoning behind its apparent population increases, gradual range expansion southwards and ability to adapt within intense agricultural environments have not been verified. Moreover, the potential for wingshooting and value of these two species as economic co-products of agriculture is unknown.

Anthropogenic changes to the structural complexity of the landscape, primarily through farming activity, have led to changes in the abundance and distribution of both the Redwing Francolin and Swainson's Spurfowl.

The conservation implications of the Redwing Francolin study are profound, in that a bird considered indicative of the sour grassland biome, along with many rare and endangered grassland birds, is becoming scarce and vulnerable as a result of severe habitat degradation through over-utilisation of grasslands. In the few protected grassland areas remaining, Redwing populations are healthy and grassland bird species richness is higher. The transformation or modification of such grasslands is effected by varying degrees of grazing by stock and burning which have modified the variegated nature of the montane grasslands on the eastern Mpumalanga escarpment, directly affecting the abundance of the Redwing Francolin. The interface between intensive management (> 15 ha / large animal unit, annual burning) and less intensive management was indicated by a decline in Redwing numbers from a potentially harvestable surplus (> 0.1 birds/ha) to well below this threshold in heavily utilised grasslands. Furthermore, coveys within these grazed grasslands were smaller and further spaced from one another. A number of environmental factors working independently or in consort are responsible for the observed population declines of Redwing on commercial pasture farms.

Nesting production involved a mean clutch size of 4.3 eggs per hen at a 69.3% probability of nesting success and 2.98 chicks per hen are produced per season. All nests were located within rank grass close to surface water, a potential habitat constraint when grasslands are exposed to intense grazing and burning at the onset of summer. Furthermore, if these grasslands were degraded, survival rates of chicks dropped by 36% within the first four weeks after hatching. This supports the hypothesis that food and/or cover are limiting.

Home ranges of birds within commercially grazed grasslands, where coveys were smaller, were constrained and restricted to isolated patches of habitat where cover and food requirements were met. Furthermore, grass cover and the availability and diversity of Redwing food plants decreased significantly within grazed grasslands exposed to annual burning. Within these grazed grasslands, the prevalence of blood parasites was higher where levels of infection were inversely related to the population densities of francolin.

Conversely, the Swainson's Spurfowl has extended its range considerably in recent years, primarily as a result of the expansion of agriculture throughout much of southern Africa. Populations within the intensively farmed savanna habitat of the Springbok Flats are stable and have adapted well to transformed habitats and are sufficiently high to warrant sustainable wingshooting. The study region is used widely for the cultivation of crops (72% of the area) and is highly transformed (92%) from the original savanna biotopes. The success of the species as a whole can be attributed to its wide resource usage, mobility and adaptive capabilities.

This spurfowl relies heavily on the variegated nature of the transformed habitat, exploiting cereal crops extensively in the winter and reverting back to the utilisation of more natural thornveld and grasslands for foraging and breeding in the summer. Birds dispersed at the onset of the first spring rains (August) to establish, non-overlapping, breeding territories in the remnant patches of savanna habitat (grassland and thornveld) where the utilisation of both wild grass and weed seeds made up the bulk of food ingested. Although the intake of agricultural seeds (maize and sunflower) made up the bulk of food items ingested within the winter months, little evidence was found that Swainson's Spurfowl actively forages for planted seedlings and, in so doing, causes extensive damage to planted crop lands.

On a local scale, Swainson's Spurfowl is a highly mobile species with large numbers of birds congregating on the fringes of agricultural lands to exploit waste grain and retire to the grasslands and savanna to roost. Although agricultural lands held the highest numbers of birds, the percentage of birds utilising the ecotone between natural and agricultural land was substantial (45% of total population) and birds never ventured far for cover. This was highlighted in the finding that large expanses of grazed grasslands hold the lowest densities of spurfowl. The limited availability of natural savanna habitat could further reduce the potential number of Swainson's Spurfowl in terms of restricting breeding and roosting habitat and, as such, hold the greatest threat to this highly opportunistic gamebird.

The success of the species is further highlighted in that it has an extended breeding season in southern Africa and has the ability to breed throughout the year, even in response to sporadic winter rainfall. Furthermore, nesting success and production was high (69.4%) and there was little evidence of significant mortality due to predation or some form of habitat constraint to hatchlings. Moreover, infection with blood protozoa was negligible and the prevalence of infection was only 1.91% (two individuals from a sample of 105 birds), probably due to the unsuitability of the habitat in providing appropriate conditions for promoting the number of vectors that carry bacteria and viruses to birds. The population, in general, is under no threat and is extending southwards in response to increased farming activity into previously unsuitable habitat.

The success of one species and the progressive decline of the other can be attributed to their respective resource breadth and resource availability or niche breadth which measures the range of physical conditions or habitat used by a species (Gaston, Blackburn & Lawton 1997). As Brown (1984) states, and as is the case for the Swainson's Spurfowl, a species that has a broad environmental tolerance and is able to use a wide range of resources will, in so doing, achieve high local densities and will be able to survive in more places and hence over a larger area. However, a species comparable to the Redwing Francolin that have a narrow environmental tolerance and are able to use only a narrow range of resources will be unable to attain the densities and distribution achieved by the generalist. Furthermore, species such as the Swainson's Spurfowl that are both locally abundant and widespread utilise resources which are themselves locally abundant and widespread, whilst the resources utilised by the Redwing Francolin (geophytes: bulbs and corms) are restricted to certain habitats which, in turn, restricts the movements and population of this gamebird.

Populations of grassland birds within the Steenkampsberg grasslands are becoming increasingly dependent on isolated patches of pristine habitat and are threatened by management involving annual burning and high stocking rates on a landscape scale. Within these grasslands, two assemblages of grassland bird species appear to be indicative of the intensity of habitat utilisation and species richness was closely associated with population levels of Redwing Francolin. Within savanna habitats, three assemblages of birds, based on their presence, were identified and indicative of habitat transformation via agriculture. Bird species diversity and richness were greatest within remnant habitats of thornveld (savanna) scattered within intensive agriculture lands. The protection of grasslands in the Steenkampsberg and remnant savanna in the Springbok Flats are highlighted as import priority habitats for the preservation of avian communities.

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