van Niekerk *Avian Res (2017) 8:11*
DOI 10.1186/s40657-017-0069-2

Avian Research

RESEARCH

Open Access

Orange River Francolins (*Scleroptila levaillantoides*) persist in fragmented Highveld farming landscapes, South Africa

Johann H. van Niekerk*

Abstract

Background: How do Orange River Francolins (*Scleroptila levaillantoides*) adapt to an intensive farming landscape with grass (grazing) camps and crop cultivation? To answer this question, a study was carried out in south-east of Johannesburg in South Africa to clarify the interaction of francolins with a landscape consisting of land use mosaics.

Methods: A transect-road of 45 km was traversed weekly during November 2015–October 2016 through flat maize (*Zea mays*) and cattle (*Bos primigenius*) grazing fields. Francolins were counted in three land use mosaic types along the transect-road (including the road): grass camps on both sides of the road (grass/grass edges); arable fields on both sides (arable/arable edges) and arable land on one side with grass camps on the opposite side of the road (arable/grass edges).

Results: Francolins used all three mosaic types, but the arable/arable edges were least frequented. Nonetheless, the arable/arable edges played an important part: francolins, including females with chicks, moved along the arable/arable edges, which enabled contact between sub-populations, and the arable/arable edges provided temporary cover (e.g. stubble and maize plants) and ploughed firebreaks to forage (e.g. for bulbs).

Conclusion: Cultivation of crop within grasslands does not constrain breeding, movement and habitat use by the Orange River Francolin. For conservation purposes it is critical that the fine-scale mosaic of grazing and cultivation areas remain intact.

Keywords: Agriculture, Edge habitat, Management, Mosaics, Orange River Francolin, *Scleroptila levaillantoides*

Background

Habitat fragmentation is the breaking apart of continuous habitat, such as grasslands, into distinct "land use parcels". According to Bennet and Saunders (2010), fragmentation reveals three interrelated processes: a reduction of pristine habitat, partitioning of remaining habitat into portions of the original vegetation and the introduction of new portions such as cultivation and roads. Accordingly, grass-living francolins such as the Orange River (*Scleroptila levaillantoides*), Red-winged (*S. levaillantii*) and Grey-winged (*S. afra*) Francolins increasingly face the prospect of habitat fragmentation as pristine grassland landscapes are encroached by cultivation, cut grass and livestock grazing in South Africa (Little et al. 1993; Little 1997; Jansen et al. 1999; Hockey et al. 2005; Crowe 2009). Scientists are constantly looking for ways to balance food security for a growing human population with biodiversity conservation as more farmland surface is required for grain and beef production (Firbank et al. 2008).

Of the 308 Galliformes species, 70 (23%) are on the IUCN Red List (2016) of globally threatened species. Hunting and trapping are considered the biggest threats, and cultivation and livestock farming are the next. Habitat modification by intensive agriculture was considered an important reason why populations of the Red Grouse (*Lagopus scoticus*) and the Black Grouse (*Lyrurus tetrix*) in Europe and the Prairie Grouse (*Tympanuchus cupido*)

*Correspondence: thirstland2@gmail.com
Department of Environmental Sciences, College of Agriculture and Environmental Science, University of South Africa, PO Box 392, Pretoria 0003, South Africa

in North America have declined (McGowan et al. 2012). In the KwaZulu-Natal Province of South Africa, the Coqui Francolin (*Peliperdix coqui*) contracted its range due to habitat fragmentation and the transformation of grass camps to sugarcane (*Saccharum officinarum*) production (Van Niekerk and Van Ginkel 2003; Davies 2015). The conservation status of the Orange River Francolin can change very quickly to extinction should a few years of consecutive overgrazing take place, even on otherwise well managed grassland (Little 2016). In my previous work, I investigated if the Orange River Francolin adapt to an intensive farming landscape consisting of roads, grass camps for livestock grazing and crop cultivation (Van Niekerk 2012a, 2016; Little 2016). It has been demonstrated that agricultural activities may provide benefits for the survival of the Orange River Francolin, provided they are managed properly. This is in accordance with the finding of Goijman et al. (2015) that a positive relationship exists between bird species diversity and habitat heterogeneity in agricultural landscapes. Aspects which proved beneficial in this regard were a diversity of crops and pastures with patches of natural areas. Vickery et al. (2009) described the importance of arable edges (ploughed strips along cultivation that are not sown) as an important focal area to conserve farmland birds and suggested that arable edges can provide invertebrates and seeds for gamebird chicks. Gothier et al. (2014) found that a multi-dimensional approach that includes strict control of agro-chemicals and the protection of natural patches becomes an important target to conserve birds on farmland. Arable edges are potentially important micro-habitats (within cultivation and grazing landscapes) of Highveld farms that can allow them to be managed with positive outcomes for gamebirds (Vickery et al. 2009; Van Niekerk 2016).

On the South African Highveld, Orange River Francolins are exposed to mechanised maize production, grass fodder (cut grass) and intensive livestock grazing (Milstein and Wolff 1987; Viljoen 2005). In and around the study area four cattle (*Bos primigenius*) feedlots have expanded their cattle herds by between 20 and 40% during the past 10 years (average of 3% per annum) from 150,000 to about 230,000 head of cattle (Van Niekerk unpublished). This increase is supported by surrounding farmers that provide grass fodder and maize (*Zea mays*) for silage and 6-month old calves from the grass camps to the feedlots. These activities encroach on the natural habitat of the Orange River Francolin.

Previous research on the Orange River Francolin in this study area demonstrated that this francolin survived in pristine grass camps that were left among cut grass camps (fodder) (Van Niekerk 2012a). The birds were recorded on cut grass but avoided it during the breeding season, which indicated the importance of natural grass camps for reproduction. Furthermore, if it had not been for unmodified areas on farms, Orange River Francolin populations would have been reduced, if not locally extinct (Van Niekerk 2012a). This present study was conducted in the same farming community, but additional important dimensions were added which should be taken into consideration to formulate enhanced management strategies (Viljoen 2005; Berruti 2011).

Whereas previous research was limited to one farm of 158 ha that consisted mainly of cut grass and game farming, the current study was conducted along a transect-road of 45 km which consisted of expanses of maize cultivation and livestock grazing (Van Niekerk 2012a). This transect-road provided an opportunity to assess how the Orange River Francolin use edges of land use mosaics through a larger area. Regular traversing through agricultural regions throughout the Highveld during the past 20 years has invariably revealed Orange River Francolin coveys (groups of francolins) along the edges of arable land during winter, which justified a study to determine why and when the Orange River Francolin uses these edges.

The purposes of this current study were: (1) to assess the impact of fragmentation on habitat-use by Orange River Francolins; (2) to evaluate how francolins adapt to a farming landscape that changes seasonally as a result of ploughing, planting, harvesting and grazing; (3) to demonstrate the benefits and limitations of edges along land use mosaics; and (4) to present conservation management targets (Ausden 2004).

Methods

Study area

The study area comprised a 45-km road across flat maize and cattle grazing fields south-east of Johannesburg in South Africa (hereafter 'the transect-road') (Fig. 1). This route was selected since it is a typical sample of the type of agricultural landscape across the Highveld where these birds occur which stretches across three provinces. This transect-road started in a southwards direction from the farm Elandsfontein near Heidelberg (26.086915°S, 27.709002°E) to the farm Dekuilen (26.825455°S, 28.263140°E), then eastwards towards the N3 road near Grootvlei (26.820093°S, 28.322534°E). The vegetation units are Eastern temperate freshwater wetlands, Soweto Highveld, Carletonville dolomite, Tsakane clay and Rand Highveld grass camps, plus Gauteng shale and Gold Reef and mountain bushveld on the hills (Mucina and Rutherford 2006). Summer rainfall varies between 700 and 750 mm per annum (Chittenden et al. 2012).

Fig. 1 Google map showing a typical configuration of grass camps, arable fields (mainly maize) and roads in the study area that were traversed to determine how the Orange River Francolin (*S. levaillantoides*) interacted with fragmented land "parcels". The *white lines* indicate the positions (and widths) of the open strips/fire break along maize field, fire breaks along the edges of grass camps and the road seams which occurred along the transect. The open strips of arable land (10 m wide) often have intermittent weed patches during winter. These strips are also often left open through ploughing and burning to create firebreaks. The transect-road, seams, fire breaks and open strips constitute the study area where francolins were counted (Van Niekerk 2016)

Data collection

To determine how francolins interact with different land uses in a landscape of livestock grazing and arable land, the transect-road was traversed on a weekly basis to count and observe the behaviour of francolins. The intersection of three land forms, namely grass camps, arable land and roads revealed three practical mosaics in which francolins could be counted: (1) where arable land occurred on opposite sides of the transect-road; (2) where arable land occurred on one side of the transect-road and a grass camp on the opposite side; and (3) where grass camps occurred on both sides of the transect-road. Since the francolins were counted in the edges of these three land use mosaics, they are henceforth respectively referred to as arable/arable, arable/grass and grass/grass edges (Table 1).

The transect-road refers to a public farm road (~10 m wide) with grassy seams (~5 m wide) on either side of the road, plus the open strips (~10 m wide) along arable land (90% covered with maize production) or firebreaks (~10 m wide) along grass camps, all of which are aligned parallel to the road (Fig. 1). The width of this study area was ~40 m (~20 m on either side of the centre of the road). An edge (through mosaics) in this paper refers to the road, seams, firebreaks and the open strips along arable land. The open strips are found along arable edges and serve as fire breaks and similarly the edges of grass camps are also ploughed or burnt to form fire breaks. In addition the open strips along arable land are unplanted to enable tractors to turn around during planting but often become invaded with patches of weeds and grass during early winter.

The study started with a pilot phase from December 2014 to October 2015 by traversing the transect-road weekly to determine whether francolins occurred in the edges of all three land use mosaics. The follow-up survey was conducted from November 2015 to October 2016 to gather data on habitat use by francolins (rate of occurrence), demographic data (e.g. age classes and group sizes) and to record behavioural aspects. Francolins beyond 20 m from the centre of the road were not recorded because they were outside the predetermined edge. The presence of francolins in the edges was used as an indicator of which land uses were used/avoided and how francolins interacted with "parcels" of the farming landscape.

Travelling at 50 km/h in a high vehicle (165 cm from ground level to eye level) proved effective to observe francolins with or without binoculars (when close by) by one observer only. Once a covey was sighted, the vehicle was brought to a standstill to record the birds (e.g. numbers and behaviour). A set route was traversed along the edges of the three land use mosaics (Fig. 1). Travelling was done in one direction only, the first 30 km during the late afternoon from 17:00 to 17:45 and the next 15 km in the morning from 07:00 to 07:30. During a previous study on these francolins nearby and the pilot study that foresaw this survey along the transects, it was experienced that the birds did not change their habitat-use patterns during the day. Their presence in the same habitat, whether it was morning or late afternoon, was highly predictable. The francolins were most active during these times, emerging from cover to feed (Van Niekerk 2012a). No surveys were conducted on rainy days and the sun

Table 1 Monthly Orange River Francolin (*S. levaillantoides*) counted in the edges of three land use mosaics in the study area during November 2015–October 2016

Months	Grass/grass	Arable/arable	Grass/arable
Nov			
Birds	2	0	5
Weeks	3	3	3
Mean/wk	0.66	0	1.66
Dec			
Birds	7	0	0
Weeks	2	2	2
Mean/wk	3.5	0	0
Jan			
Birds	0	0	0
Weeks	4	4	4
Mean/wk	0	0	0
Feb			
Birds	1	1	1
Weeks	4	4	4
Mean/wk	0.25	0.25	0.25
Mar			
Birds	3	6	2
Weeks	5	5	5
Mean/wk	0.6	1.2	0.4
Apr			
Birds	7	6	2
Weeks	3	3	3
Mean/wk	2.33	2	0.66
May			
Birds	17	3	6
Weeks	6	6	6
Mean/wk	2.83	2	1
June			
Birds	8	1	20
Weeks	5	5	5
Mean/wk	1.6	0.2	4
July			
Birds	14	1	3
Weeks	4	4	4
Mean/wk	3.5	0.25	0.75
Aug			
Birds	9	2	5
Weeks	4	4	4
Mean/wk	2.25	0.5	1.25
Sept			
Birds	7	11	11
Weeks	3	3	3
Mean/wk	2.33	3.66	3.66
Oct			
Birds	6	7	12
Weeks	3	3	3
Mean/wk	2	2.3	4

Birds, total number of francolins counted for month; weeks, number of weeks surveyed/month; mean/wk, mean number of birds counted per week

did not obscure the observer's visibility since observations were mostly done downwards from a relatively high vantage point. The road seam of about 5 m on either side of the road and the 10 m wide open strip along arable land or ploughed firebreak along grass camps ensured that only francolins within the edges (including road and seams) of the three land use mosaics were counted. The length of the edges of separate grass camps and arable lands along the transect-road was measured using Google Maps. A 1:50,000 topographical map was used to determine the distances francolins moved along arable edges away from the nearest grass camps.

The visibility of the francolins was good based on a number of factors. During ploughing, sowing and during early plant growth (October–March) farmers had cleared the fields of any vegetation (e.g. weeds and stubble). Furthermore, from April to September the francolins were clearly visible below tallish maize plants or among stubble (after harvesting). Open strips were invariably left on the sides of arable land and were often ploughed to serve as firebreaks throughout the year. The grass camps were grazed throughout the year, which kept the density relatively low, and grasses were medium height, making francolins detectible from a high vehicle. Some patches of tall, thick grass were found along the road in ditches and culverts, but francolins generally avoided lower lying moist areas and the road seams were constantly cut for cattle fodder (Van Niekerk 2011).

All the coveys sighted and the number of birds in a covey was recorded and the surrounding habitat of each sighting was described. In other words, was the bird (or covey) situated in an edge with grass on both sides of the road, or in an edge with grass on one side and arable land across the road or in an edge with arable land on both sides of the road? The birds (or coveys) recorded under maize cover or sighted in grass camps were described as such. It was not possible to distinguish between adults and fully grown sub-adults, but coveys with two adults and chicks or juveniles were regarded as family coveys. Males have spurs providing a reliable indicator of sex (Madge and McGowan 2002; Little 2016). A fixed point was selected 2 km off the transect-road into grass camps to record territorial calls (Van Niekerk 2012c). This point was visited weekly from 17:45 to 18:00 in the late afternoons and again from 6:00 to 7:00 in the mornings. This point was selected on the basis that it was a large unmodified grass camp with only a narrow entry road. The mean length of grass camp edges along the road was compared to the mean length of arable land edges along the road and was calculated from Google maps. It was important to determine if contact between individuals (e.g. young male and female) from two sub-populations is possible if they were separated by maize fields. Since the edges of arable land was not occupied by francolins throughout the year, as they were in grass camps during early summer, the distance francolins moved along arable edges after breeding was assumed to be a good measure of how far these birds could move.

Statistical analysis

The data comprised counts, grouped by three land use mosaics (edges) across 49 weeks (weekly counts during 12 months). The zero-inflation model coefficient (ZIM, "pscl" package) was chosen to provide a comparable statistical prediction of the number of francolins in the grass/grass, arable/grass and arable/arable edges since it is used for count time series with excess zeros. ZIM indicated the significance of predicting excess zeros along with their standard errors, *z*-scores and *p* values (Lambert 1992). ANOVA (single factor) was used to determine and compare mean covey sizes in the different habitats. Chi square was used to determine whether covey sizes may have been significantly larger at different times of the year. The data were not distributed normally (Shapiro–Wilk test for normality; $W = 0.898386$; $p < 0.01$). Data were square-root transformed (0.5 was added to each number before transformation) which did not violate normality or homoscedasticity. For Chi square purposes the data were multiplied by 10 to achieve a value >5. ANOVA single factor was also used to compare mean distances of edges along grass camps and arable fields. The data were not distributed normally (grass camps $W = 0.880605$, $p < 0.01$; arable land $W = 0.716455$, $p < 0.01$). All measurements were log-transformed (base 10) which did not violate normality and homoscedasticity (R and Excel in Gardener 2012).

Results

Covey sizes

A total of 186 francolins were counted in 87 coveys, with a mean covey size of 2.13 birds. The mean covey sizes in the respective edges of the mosaics were not significantly different: 2.02 ($n = 40$, range 1–4, SD = 1.23) for the grass/grass edges; 2.53 ($n = 15$, range 1–9, SD = 2.22) for the arable/arable edges and 2.09 ($n = 32$, range 1–8, SD = 1.64) for the arable/grass edges (ANOVA single factor; $F = 0.8617$, df = 35, $p = 0.431$). Mean covey sizes were not statistically different over months ($\chi^2 = 10.429$, df = 11, $p = 0.4923$) (Fig. 2).

Distances of edges

The mean length of grass camp edges along the road (689.4 m, $n = 29$, SD = 426.4, range 152–2200 m) was significantly less than the mean length of arable land edges (1310.2 m, $n = 16$, SD = 1169.3, range 190–5000 m) (ANOVA: $F = 5.647$, df = 43, $p = 0.02$).

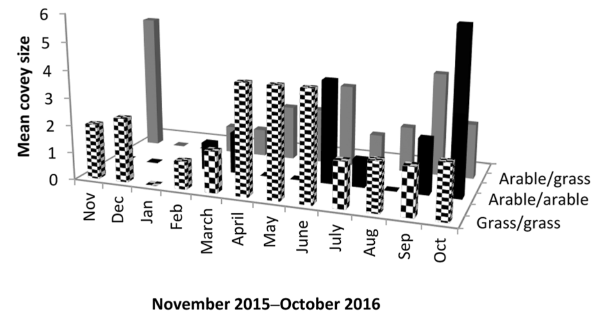

Fig. 2 The mean monthly covey sizes of the Orange River Francolin (*S. levaillantoides*) in the edges of three land use mosaics during November 2015–October 2016

Habitat-use

Compared to the arable/arable edges, the grass/grass edges increased the odds of seeing a francolin by 83.3% (ZIM coefficient = −1.792, $p = 0.001$), and grass/arable edges increase the odds of seeing a francolin by 66.0% (ZIM coefficient = 1.080, $p = 0.027$).

Francolins were recorded in arable/grass edges throughout the year, except during December and January, when they were restricted to breeding territories in grass camps (Table 1). Six coveys were recorded walking across the road from grass into maize cover, and four coveys were recorded walking from maize cover to grass camps during the winter (May–June). Four coveys moved into stubble from the grass camps after harvesting and two coveys were also recorded moving from grass camps into soya bean (*Glycine max*) fields during winter.

Arable/arable edges were used during all months of the year except during November–January. This was when ploughing and sowing took place (Table 1). The average distance francolins were recorded from nearest grass camps into arable/arable edges was 265.6 m ($n = 9$, SD = 183.6 and range 20–600 m). During June, two coveys were recorded feeding on waste grain, parts of weed plants and scratching for comers and bulbs in the road between two arable lands. During August and September, two coveys were recorded foraging in freshly ploughed black turf soil, retrieving bulbs and corms in the edges of arable land. Moving deep into arable/arable edges from nearby grass camps was an established pattern. When I approached the francolins they either squatted in available cover on the edges or ran into maize cover nearby.

Francolins were observed in grass/grass edges throughout the year except during December (Table 1). During December–February two or three territorial males, separated by about 250 m between them, called every morning (6:00–7:00) and every evening (17:30–18:30) during the weekly visit at a fixed observation point deep into grass camps (2 km from any edge). The absence of males on the edges during breeding suggests that males withdraw from the edges deep into grass camps for breeding. In the territory of one of these males, 5-day-old chicks were seen crossing an open patch with the covey.

Twelve different coveys were recorded with offspring, being separated by 5–10 km along the transect-road. One covey with chicks and seven coveys with juveniles were recorded during November 2015–July 2016 and two coveys with chicks and two coveys with juveniles were recorded during September 2016–October 2016. Overall, four coveys with offspring (33.3%) occurred in grass/grass edges, four coveys with offspring (33.3%) occurred in arable/arable edges and four coveys with offspring (33.3%) were in arable/grass edges. One of the coveys in the arable/arable edges had four chicks (<10 days old) but was more than 400 m from the nearest grass camp. The only form of cover was weeds and patches of grass in the seams.

Territorial behaviour

During August to February, 10 territorial calls (vocal interplay between two or more males) took place in the edges of grass camps (grass/grass and grass/arable edges). Two territorial fights were recorded in the open road; one in a grass/grass edge and another in the edge between arable land and a grass camp. In one, with five francolins, two males took part in a skirmish. Within the group two rivals faced one another frontally by bobbing their upper bodies towards one another repeatedly, chased one another for short distances of about 10 m, and jumped into the air as they pecked at one another while feathers flew. In one case in August, the chaser flew after a submissive challenger over a distance of 70–100 m into a maize field and then sat among the dry maize plants. In both cases two or three females stood nearby these clashes as onlookers.

Discussion

The overall mean covey size of 2.13 in this survey was slightly smaller than the mean covey size of 2.4 for the previous survey, but the mean covey size of 2.5 for arable land in the transect-road exceeds both slightly (Van Niekerk 2012c). In both surveys natural grass, among cultivation, was determined to be an important prerequisite for breeding and edge habitat (previously defined as an ecotone) re-emerged as an important habitat for francolins (Van Niekerk 2012a). The visibility of francolins and subsequent low counts recorded during January and February may have been compromised to some extent by taller and denser grass along the edges since farmers could not get in with tractors and mowers to cut the grass during continuous rain. However, the previous study in the same study area, conducted with playbacks, supports the conclusion that Orange River Francolins were absent from the edges of farm roads during the breeding season (Van Niekerk 2012a, b).

Although grass/grass edges revealed most francolins counted throughout the year, fragmentation of pristine grasslands with roads, seams, firebreaks and arable edges encouraged the francolins to make use of these open modified edges. Furthermore, this habitat-use pattern manifested in a spatio-temporal manner. The birds were essentially restricted to grass camps during the breeding season from September to March to provide the incubating hen and subsequent chicks with optimal concealment with insects and grass seeds to feed on (Little 2016). Once their chicks were strong enough to move over longer distances, the francolins ventured into arable/arable and arable/grass edges. Here the francolins were able to scratch in soft arable soils for food and also consume parts of weed plants, corms, bulbs and grass seeds (Little 2016). Fallen waste grain was also consumed along these edges. It was clear that dense ground cover, which is naturally provided to these birds by grass, did not play such a critical role during their presence in edges from March to April where maize was planted. Instead, the francolins squatted in weeds and maize plants when the birds were disturbed by an intruder (e.g. human). The edges of arable fields were also relatively actively used by francolins from August to September, when the fields have been ploughed leaving freshly ploughed edges to scratch in for food. This is also the time when young males gather in groups in open edges competing for territorial supremacy through physical clashes (Van Niekerk 2012c).

Francolins benefit from arable edges (a product of fragmentation) in a number of ways (Goijman et al. 2015); (1) weed, soya bean and maize plants provided cover in the edges of arable land so that the francolins could move into these habitats to feed unhindered by predators; (2) open edges probably provided space for marginal francolins which otherwise would have perished due to competition should they have remained in the grass camps during a time when chicks are growing up; (3) arable edges, especially when ploughed, provide food in the form of pieces of weed plants, corms, bulbs and fallen grain which were not found in grass camps (Little 2016). Since the grass camps were grazed quite heavily by cattle limited grass seeds were available for food during late winter which is a period when the francolins moved into arable edges to supplement their diet; (4) the maize fields between grass camps probably provided a buffer between territorial males as these males are actively attracted towards each other by territorial calls in unvaried grass camps (e.g. no buffers such as cultivation) which is the root cause of physical clashes (Van Niekerk 2012c). Such clashes could prolong for 2 weeks or so and be interruptive to the point that actual breeding is spoiled should the males be in easy reach of one another (Van Niekerk 2012b); (5) edges provide open space for territorial disputes between young males that enable the fittest to be separated from weaker males and which leads to subsequent pairing as females stood close by during these encounters probably attracted to the strongest males; (6) the edges along maize fields could possibly also provide additional breeding habitat for francolins as one hen with small chicks were recorded in an arable edge far from grass camps; (7) the edges along maize fields could also be corridors that encourages young males and females from distant coveys (on either sides of large maize fields) to pair which is necessary to maintain genetic diversity in the population (Segelbacher et al. 2003). Comparing the mean distances of the edges of arable land (190 m upwards) with the mean distances francolins were observed away from the nearest grass camps (265.5 m) into arable/arable edges, it is evident from the overlap that sub-populations from opposite sides of an arable land could meet halfway along the edges of arable land; and finally (8) the edges along maize fields provide a corridor with some cover to conceal the birds when they move from one grass camp along an arable edge to another grass camp. This is especially relevant during August–September when the adjacent maize fields are open due to ploughing and preparation for planting which temporarily leaves large blocks without any cover (Bennet and Saunders 2010).

The presence of francolins in modified landscape enables the land owner or conservationist to implement conservation strategies (Ausden 2004). Since the francolins used artificial cover such as maize, soya bean and weed plants, it is possible to rehabilitate dilapidated old arable fields by planting low growing shrubs and by sowing grass seeds. Grass must not be too dense otherwise it will prevent the francolins from moving on feet through it (Van Niekerk 2012a). However, the option to rehabilitate old fields will only work if natural francolin populations are close by so that the birds could populate these areas naturally. Edges can be managed by burning the ground cover when the birds are not present and by ploughing the edges (which are usually done for fire breaks), both of which will encourage foraging (Van Niekerk 2012a). Arable edges could also be sown lightly (a few seeds in patches here and there) with grass seeds to encourage the growth of wild seeds for food. Importantly, empty poison containers and the spilling of agrochemicals must be prohibited in these edges along arable fields. Edges can be used to count the francolins, especially forming population trends over a number of years and to assess breeding success as hens and chicks were not shy to move into open edges.

The removal of grass cover in grass camps by accidental burning, which invariably occurs in August coinciding with breeding, will be detrimental to local francolin populations if these fires are widespread. Therefore firebreaks are necessary to prevent the spreading of fires. Furthermore, good planting practices are required to increase grain productivity on existing land in order to prevent the encroachment of more arable land into existing grass camps that will reduce the surface area of natural grass. Such improvements include the use of improved cultivars for better crop production, concentration of fertilizers in the root zone and the retention of soil moisture through correct contouring.

Conclusions

It is critical for the survival of the Orange River Francolin to keep the relative ratio of grazing to cultivation patches with roads on farms unchanged. Given the need for beef and maize for human consumption, these configurations should not change. Where farmland is mismanaged (e.g. overgrazing, lack of veld fire control, the creation of fallow land or where agrochemicals are used recklessly), it will impact negatively on Orange River Francolin populations. Finally, Orange River Francolins are resilient and live in grass camps and along arable land. The cultivation of crop within grasslands does not constrain breeding, movement and habitat use by the Orange River Francolin.

Competing interests
The author declares that he has no competing interests.

Received: 4 February 2017 Accepted: 27 April 2017
Published online: 12 May 2017

References

Ausden M. Habitat management. In: Sutherland WJ, Newton I, Green RE, editors. Bird ecology and conservation. Oxford: Oxford University Press; 2004. p. 329–69.
Bennet AF, Saunders DA. Habitat fragmentation and landscape change. In: Sochi NS, Ehrlich P, editors. Conservation biology for all. Oxford: Oxford University Press; 2010. p. 88–106.
Berruti A. The AGRED guide to gamebird management in South Africa. Houghton: AGRED; 2011.
Chittenden H, Allan D, Weiersbye I. Roberts geographic variation of Southern African birds. Cape Town: John Voelcker Bird Book Fund; 2012.
Crowe TM. Management of Southern African gamebirds: opportunities and threats. In: Cederbaum CB, Faircloth BC, Terhune TM, Thompson JJ, Carroll JP, editors. Gamebirds 2006: quail VI and Perdix XII. 31 May–4 June 2006. Athens: Warnell School of Forestry and Natural Resources; 2009.
Davies GBP. Decrease of Coqui Francolin *Peliperdix coqui* (Aves: Phasianididae) in southern KwaZulu-Natal, South Africa. Novitates. 2015;37:47–53.
Firbank LG, Petit S, Smart S, Blain A, Fuller RJ. Assessing the impacts of agricultural intensification on biodiversity: a British perspective. Philos Trans. 2008;363:777–87. doi:10.1098/rstb.2007.2183.
Gardener M. Statistics for ecologists using R and Excel. Exeter: Pelargic Publishing; 2012.
Goijman AP, Conroy MJ, Bernardos JN, Zaccagnini ME. Multi-season regional analysis of multi-species occupancy: implications for bird conservation in

agricultural lands in East-Central Argentina. PLoS ONE. 2015;10:e0130874. doi:10.1371/journal.pone.0130874.
Gothier DJ, Ennis KK, Farinas S, Hsieh H, Iverson AL, Barbary P, Rudolphi J, Tscharntke T, Cardinale BJ, Perfecto I. Biodiversity conservation in agriculture requires multi-scale approach. Proc R Soc Lond Biol B. 2014;281:20141358.
Hockey PAR, Dean WJR, Ryan PG. Roberts birds of Southern Africa. 7th ed. Cape Town: Trustees of the John Voelcker Bird Book Fund; 2005.
IUCN. The IUCN red list of threatened species (version 2016-3). 2016. http://www.iucnredlist.org/. Accessed 27 Apr 2017.
Jansen R, Little RM, Crowe TM. Implications of grazing and burning of grasslands on the sustainable use of francolins (*Francolinus* spp.) and on overall bird conservation in the highlands of Mpumalanga Province, South Africa. Biodivers Conserv. 1999;1999(8):587–602.
Lambert D. Zero-inflated poisson regression, with an application to defects in manufacturing. Technometrics. 1992;34:1–14.
Little RM, Gous RM, Crowe TM. The distribution and abundance of Grey-wing Francolin, *Scleroptila africanus*, on the Stormberg Plateau, Eastern Cape province, South Africa, in relation to diet and substrata. Ostrich. 1993;64:105–14.
Little RM. Orange River Francolin *Francolinus levaillantoides*. In: Harrison JA, Allen DG, Underhill LG, Herremans M, Tree AJ, Parker V, Brown CJ, editors. The atlas of Southern African birds, vol. 1. Johannesburg: BirdLife South Africa; 1997. p. 286–7.
Little R. Terrestrial gamebirds and snipes of Africa. Johannesburg: Jacana Media; 2016.
Madge S, McGowan PJK. Pheasants, partridges and grouse. London: Christopher Helm; 2002.
McGowan PJK, Owens LL, Grainger MJ. Galliformes science and species extinctions: what we know and what we need to know. Anim Biodivers Conserv. 2012;2:321–31.
Milstein PS, Wolff SW. The oversimplification of our francolins. S Afr J Wildl Res. 1987;1:58–65.
Mucina L, Rutherford MC, editors. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia; 2006.
Segelbacher G, Höglund J, Storch I. From connectivity to isolation: genetic consequences of population fragmentation in capercaillie across Europe. Mol Ecol. 2003;12:1773–80.
Van Niekerk JH. Habitat-use and range contraction of Swainson's Spurfowl at the Krugersdorp Game Reserve. Ostrich. 2011;82:43–7.
Van Niekerk JH. Habitat use by Orange River Francolin *Scleroptila levaillantoides* on farmland in the Heidelberg district, South Africa. Ostrich. 2012a;83:43–9.
Van Niekerk JH. Vocal behaviour of Orange River Francolin *Scleroptila levaillantoides* based on visual and sound-playback surveys. Ostrich. 2012b;83:147–52.
Van Niekerk JH. Notes on behavioural ecology of Orange River Francolin *Scleroptila levaillantoides* on farmland in the Heidelberg district, Gauteng province, South Africa. Ostrich. 2012c;83:55–8.
Van Niekerk JH. Hierarchical analysis of Swainson's Spurfowl *Pternistis swainsonii* habitat use on Highveld maize and livestock farms. Ostrich. 2016;87:231–40.
Van Niekerk JH, Van Ginkel CM. Notes on the behavioural ecology of Coqui Francolin in the Rustenburg district, South Africa. S Afr J Wildl Res. 2003;2003(33):59–62.
Vickery JA, Feber RE, Fuller RJ. Arable field margins managed for biodiversity conservation: a review of food resource provision for farmland birds. Agric Ecosyst Environ. 2009;133:1–13.
Viljoen PJ. AGRED's gamebirds of South Africa. Houghton: African Gamebird Research Education and Development Trust; 2005.