CHAPTER 3

Distribution, population status and habitat preference of the eastern population of the Short-clawed Lark *Certhilauda chuana* in the Limpopo Province, South Africa

INTRODUCTION

The Short-clawed Lark *Certhilauda chuana* is a highly localised species found in two geographically isolated populations of southern Africa. A western population occurs in south-eastern Botswana with scattered records from the North West and Northern Cape Provinces and from the north-western Free State Province of South Africa (Herremans 1997). The findings though, of a recent survey of the western population of the species in South Africa by Engelbrecht *et al.* (2007), indicated a substantial reduction in this population's range when compared with that presented by Harrison *et al.* (1997). A smaller eastern population of the Short-clawed Lark is largely restricted to the Polokwane Plateau of the Limpopo Province (Barnes 2000). Clancey (1966) was the first to mention the possibility of the existence of this population of the Short-clawed Lark, and it was only much later confirmed in the literature by Tarboton *et al.* (1987). The estimated maximum range of this population is 10650km^2 of which large areas of natural habitat have been altered (Barnes 2000).

The relatively small global range and highly localised occurrence within its distribution range has resulted in the listing of the Short-clawed Lark as a species of conservation concern since the publication of the first Red Data books (Siegfried *et al.* 1976; Brooke 1984; Collar *et al.* 1994; Barnes 2000). Both Collar *et al.* (1994) and Barnes (2000) listed the species as near-threatened, largely as a result of its relatively small global range. A recent

conservation status report by Birdlife International (2004) saw the Short-clawed Lark's conservation status down-listed to the category of "least concern" as this species was not believed to approach the thresholds for the population decline criterion of the IUCN Red List, i.e. declining more than 30% in ten years or three generations (IUCN 2005). However, the eastern population of this species is protected under provincial legislation (Limpopo Environmental Management Act 7 of 2003) where it is listed under the schedule of "specially protected wild animals".

Considering the range reduction of the western population reported by Engelbrecht *et al*. (2007), it is evident that a survey of the present distribution of the smaller eastern population was imperative in order to establish whether a similar decline has occurred in the distribution range of this population. Such a survey would prove valuable to the conservation status reassessment, currently conducted by the Threatened African Birds Forum of Birdlife International (www.birdlifeforums.org). Furthermore, a thorough understanding of the species' ecological requirements and habitat preferences will be of value to such a survey.

Apart from studies by Herremans and Herremans (1992) and Herremans *et al*. (1994) on the biology of individuals from the western population and Engelbrecht's (2005) study on the breeding biology of the eastern population of the Short-clawed Lark, very little is still known about the species' general ecology. According to Brooke (1984) the species is associated with *Tarchonanthus* savanna, a fact that is questioned by Engelbrecht *et al.* (2007). Although Herremans and Herremans (1992) provided brief descriptions of habitat preferences of the western population in Botswana, no detailed studies have been carried out to determine this aspect of its ecology.

In light of the foregoing, a study was conducted to determine the present distribution, population status and habitat preference of the eastern population of the species. Knowledge of the ecological requirements of the species would provide a better understanding of the spatial and temporal patterns in the distribution of the species. This, in turn, will be invaluable for any conservation strategy for the Short-clawed Lark.

MATERIALS AND METHODS

The study area

The study was conducted on the Polokwane Plateau in the Limpopo Province of South Africa, an area of approximately 4400km^2. The Polokwane Plateau is situated at an altitude that ranges between 1150 and 1405masl and is flanked by the Wolkberg and Strydpoort mountain ranges to the south and south-west respectively. The north-eastern boundary of the plateau reaches the approximate latitude of the Tropic of Capricorn while its eastern boundary is made up of the northern Drakensberg Mountain range near the settlement of Houtbosdorp. Polokwane, the capital city of the Limpopo Province, lies roughly in the centre of the plateau. The geology of the plateau is dominated by underlying Houtrivier Gneiss, a regionally extensive granite-gneiss complex giving rise to freely draining red and yellow sandy loams of the Hutton, Glenrosa and Clovelly soil types (Grosel 2001; Baglow 2005). Other significant geographical features that form part of the southern portion of the plateau include granodiorites of the Turfloop Granite complex, quartz veining and remnants of the Pietersburg Greenstone belt (Baglow 2005). The Polokwane Plateau is situated in a summer rainfall region with a mean annual precipitation of 478mm of which 91% falls between October and April, mainly in the form of convection thunderstorms (South African Weather Service 2004) (Fig. 3.1). The study area falls within the Central Bushveld Bioregion and is dominated by the Polokwane Plateau Bushveld vegetation unit (Mucina & Rutherford 2006)

previously known as the Pietersburg Plateau False Grassland vegetation type (Acocks 1953). This vegetation type can be described as,false grassland to open savanna characterized by open clumps of woody vegetation with *Acacia tortilis* subsp. *heteracantha* and *Acacia rehmanniana* as the dominant tree element and *Themeda triandra* dominating the grass layer (Acocks 1953; Low and Rebelo 1996; Mucina & Rutherford 2006).

Ecological survey

Site selection for ecological surveys

In order to determine the preferred habitat of the species, a random sample of 40 currently occupied territories was selected. Occupied territories were located by searching for territorial males that call and display from prominent perches within their territories or by careful observation of breeding pairs carrying nesting material, prey or faecal sacs. Searches for territorial birds and nest sites were conducted during September and October 2005. This period constitutes the peak of the eastern population's pre-breeding season when there is a high call and display frequency by territorial males (Engelbrecht 2005).

Territorial males were observed over several weeks in order to determine favoured calling sites. Males also respond well to imitations of their call which facilitates locating them (J. Grosel, pers. obs.). In territories where nests were located, a random point, 10 meters from the nest was used as the reference point for the ecological survey of that particular territory. In territories where an active nest could not be located, the approximate centre point between 2 - 3 favoured calling sites was used as a representative ecological survey site (Fig. 3.2).

Of the 40 selected occupied territories, 20 were located within the Polokwane Nature Reserve (23^{o}58'S, 29^{o}28'E), an area of approximately 3200 hectares and the largest

formally protected area within the Polokwane Plateau Bushveld vegetation unit. This reserve is also considered to be the stronghold of the eastern population of the Short-clawed Lark (Engelbrecht 2005). The remaining 20 occupied territories were randomly selected within the population's present area of occurrence outside the Polokwane Nature Reserve. These sites were selected on the same basis as those within the nature reserve. In addition to the presently occupied territories, 20 control sites were included in the survey: 10 sites within the Polokwane Nature Reserve and 10 sites outside the reserve within the population's historic area of occurrence. The control sites were selected on the basis of nest sites and territories which were historically active but which no longer supported Short-clawed Larks. These localities were all active territories during the late 1990's when the first informal distribution surveys of this species were conducted around the city of Polokwane and in the Polokwane Nature Reserve (J.I. Grosel and G.D. Engelbrecht, unpublished data). Thus, the survey sites in the present study were made up of:

- Occupied territories in a protected area (*n* = 20),
- Unoccupied sites in a protected area (*n* = 10),
- Occupied territories in unprotected areas (*n* = 20), and
- Unoccupied sites in unprotected areas (*n* = 10).

Vegetation and habitat surveys

Vegetation sampling was carried out during the 2005/2006 breeding season (December to February). This period coincides with the period of highest rainfall on the Polokwane Plateau (Fig. 3.1). It is also the predominant flowering period in the study area which facilitates the identification of grass and herbaceous plant species. Plant taxonomy was based on the classification according to Gibbs Russell *et al.* (1987) and SANBI (2005). Van Wyk & Malan (1988), Von Breitenbach *et al.* (2001) and Van Oudtshoorn (2004) were consulted for plant

identification. The herbarium of the South African National Biodiversity Institute (Pretoria) was also consulted for verification of the identity of certain specimens.

Micro-habitat survey

The micro-habitat survey was conducted within a 100m^2 quadrant using the reference point as the centre of the quadrant. Within each quadrant a thorough vegetation audit was carried out. This involved the identification and referencing of all plant species within the quadrant. In addition, the grass species composition survey was recorded along four, approximately 50m transects in the four compass directions from the reference point. This was done by means of a modified wheel-point sampling method, namely the "step point" method as described by Tainton (1988). This method involves the surveyor walking along a random transect while recording the closest grass species to a mark on the tip of one shoe at every second step taken. Using this method, 100 points (25 points/transect) were taken along the four transects in every surveyed site. The grass species composition data obtained through this method was also used to determine the stage of plant succession within the survey sites and to asses the ecological status and condition of the "veld" or habitat. These assessments are particularly important in pasture and rangeland management practices such as cattle and wildlife ranching and were considered necessary as a means of relating the habitat requirements of the species to wildlife and cattle ranch managers. The plant succession stages based on grass species dominance used in the present study are pioneer, sub-climax and climax stages (Shimwell, 1971). Veld condition assessments were based on the ecological status of the dominant grass species and grouped according to Tainton (1988) as follows:

1. Decreaser species – grasses which dominate in veld which is in good condition and which decrease in abundance when the veld condition deteriorates through over- or under-utilization,

2. Increaser 1 species – grasses that increase in abundance when the veld is under-utilized,
3. Increaser 2 species – grasses that increase in abundance when the veld is overgrazed,
4. Increaser 3 species – grasses that increase in abundance when the veld is overgrazed through selective grazing.

At every step-point along the line transects, grass height was recorded by means of a 1.5m rod calibrated according to the predetermined grass height classes of:

Class 1. 0 to 50mm,

Class 2. >50 to 150mm,

Class 3. >150 to 250mm,

Class 4. >250 to 500mm, and

Class 5. >500mm.

A further 20, $1m^2$ quadrants were quantified at 5m intervals along the four transects for the following additional micro-habitat features:

1. Substrate composition, i.e. the percentage sand, loam, clay, bare rock and pebble,
2. Vegetation and substrate cover, i.e. the percentage grass, forbs/herbs, pebbles and bare ground.

The results presented by Herremans and Herremans (1992) showed negligible percentages of dry litter in Short-clawed Lark territories studied in south-eastern Botswana. Prior to the survey in the present study, the same insignificant levels were noted in occupied territories and this parameter was therefore excluded from the substrate cover parameters.

Scoring of vegetation cover was adapted from methods described by Shimwell (1971). In addition, the presence of large grazing animals (domestic or wild) was noted and the degree of grass cropping/grazing was estimated within each $1m^2$ quadrant and scored according to the following grazing classes:

Class 1. No grazing or the absence of grazers,

Class 2. Moderately grazed,

Class 3. Heavily grazed.

Macro-habitat survey

Macro-habitat features were documented in each site within a $10000m^2$ quadrant using the reference point as the centre of the quadrant. The percentage tree cover, tree height and tree crown diameter was estimated within this quadrant. Tree cover classes consisted of:

Class 1. No trees,

Class 2. >0 to 10% cover,

Class 3. >10 to 25% cover,

Class 4. >25 to 50% cover, and

Class 5. >50% cover.

Tree height and tree crown diameter were measured according to four classes:

Class 1. >0 to 1m,

Class 2. >1 to 2m,

Class 3. >2 to 4m, and

Class 4. >4m.

Within the $10000m^2$ quadrant, woody species composition was recorded along with geographical features including altitude, slope and aspect which were recorded using a

hand-held global positioning system (GPS) (Garmin 3). Additional altitude readings obtained from population distribution surveys were also included in the dataset.

Fire history at each site was documented with the aid of fire frequency statistics. This was sourced from the Fire and Disaster Management Business Unit of the Polokwane Municipality and the Polokwane Environmental Management Business Unit who have kept detailed records of all bush fires within the greater municipal district over the past decade. The fire history was categorized into 12-month time frames:

1. <12 months,
2. >12 to 24 months,
3. >24 to 48 months, and
4. >48 months prior to the survey.

An example of the field data recording sheets for the ecological study is provided in Appendix 3.1.

Statistical Analyses

All statistical analyses of data were conducted with the aid of SPSS version 14 (Norius 1994) and Microsoft Excel software packages. Phi-tests were used to determine whether significant differences occurred in geographical parameters between occupied and unoccupied territories. The Cramer's V test measures the strength of association or dependency between two (nominal) categorical variables (Cramér 1999). This test was therefore employed in order to establish whether an association exists between aspect and the occupancy of territories. T-tests were used to determine whether significant differences occurred between occupied territories and unoccupied territories for several basal cover classes. Chi-square tests were used to determine the correlation between two dichotomous

variables such as the extent of grazing between occupied territories and unoccupied territories while F-tests were applied to establish dominance of plant species within occupied versus unoccupied territories.

Survey of the extent of occurrence and area of occupancy

A survey to establish the current extent of occurrence of the eastern population was conducted during the 2003/2004, 2004/2005 and 2005/2006 early breeding seasons. The extent of occurrence is defined as "the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of the present occurrence of the taxon" (IUCN 2001). The survey period of September – October coincides with a marked increase in singing and aerial displays of male Short-clawed Larks (Engelbrecht 2005). Suitable habitat on the entire Polokwane Plateau and surrounding area was surveyed. This included all the known historic records where this species was recorded during the Southern African Bird Atlas Project (Harrison *et al.* 1997). During the survey, frequent stops were made at any form of suitable habitat, i.e. short grassed, flat, open habitat with scattered low *Acacia* trees or shrubs (Herremans & Herremans 1992). These areas would then be systematically searched on foot and all birds seen or heard calling were plotted with the aid of a GPS and transferred onto 1:50000 topographical Geographic Information System (GIS) maps.

Once the species' present extent of occurrence was established a more detailed 3-month long population census was conducted in the breeding season of 2005/2006. All locations where Short-clawed Larks were found during the above survey were mapped, imported into a GIS program and compared to similar terrain as depicted in recent aerial photographs of the study area. These images were superimposed and all additional suitable habitats within this species' area of occurrence was identified and plotted. These areas were then surveyed

intensively in order to confirm the presence and obtain an estimated population size of the species by conducting systematic searches on foot. Recordings of Short-clawed Lark calls were played at regular intervals in order to elicit responses. This method proved effective as in all areas where larks were present, responses by males to call recording play-back were almost immediate. Site positions where calling and displaying males were observed were once again recorded on a portable GPS (Garmin 3). These coordinates were imported into the Arc-view GIS software package and mapped as the area of occupancy, i.e. "the area within the taxon's extent of occurrence which it occupies" (IUCN 2001). To facilitate management of the Polokwane Nature Reserve, and to serve as a base for future monitoring, a map depicting all known territories in the reserve was also produced.

RESULTS

Ecological survey results

The eastern population of the Short-clawed Lark occurs primarily on flat to gently sloping terrain. Thirty-five (87.5%) (n = 40) and 18 (90%) (n = 20) of the occupied territories and unoccupied sites respectively had a slope of less than 10º. There was no significant difference in the slope of occupied and unoccupied sites (Phi-test = 0.04, P = 0.78). This is to be expected as the currently unoccupied sites represent areas that were suitable in the recent past and slope would be a constant parameter (Fig. 3.3). The population's present area of occupancy falls within an altitude range of 1177 to 1402 masl ($\bar{x}$ = 1316 masl). Although numerous territories occurred on gently undulating terrain, there was no association between aspect and occupancy of territories (Cramer's V = 0.33: P = 0.09). The substrate within Short-clawed Lark territories consists predominantly of red to yellow sandy loam (89%) occasionally covered with small quartz pebbles (8.5%). This species avoids sandy soils, bare rock and areas with clay substrates (Fig. 3.5).

A T-test revealed significant differences in the percentage basal cover in the $1m^2$ quadrants between occupied territories and unoccupied sites for the percentage grass cover ($P < 0.0001$), bare ground ($P < 0.0001$), and pebbles ($P < 0.05$), but not for the percentage of herbs/forbs ($P > 0.05$) (Table 3.1; Fig. 3.6). Short-clawed Larks were absent from areas where the mean projected grass cover exceeded 65%.

In currently occupied territories the mean grass height fell within Class 2, i.e. >50 to 150mm (*SD* = 0.38) as opposed to Class 3, i.e. >150 to 250mm (*SD* = 0.51) in unoccupied territories (Fig. 3.7). There was a significant difference in the mean grass height of occupied and unoccupied sites ($P < 0.0001$). The grass species composition within the 40 occupied territories was dominated by *Themeda triandra* (14.8%) followed by *Brachiaria nigropedata* (8.5%), *Eragrostis lehmaniana* (5.7%), *Tragus berterianus* (5.7%) and *Heteropogon contortis* (5.6%) (Table 3.2; Fig. 3.8a). Similarly *T. triandra* was the dominant grass species in unoccupied territories (26%) followed by *H. contortis* at 9.5% (Fig. 3.8b).

Within occupied territories the tree cover never exceeded 25% (Fig. 3.9). In 65% of the occupied territories tree cover was between 1 - 10% and in 35% of the territories, tree cover was between >10 - 25% (Fig. 3.9). The dominant woody species in currently occupied territories were *Acacia tortilis* subsp. *heteracantha* (100%), *Dichrostachys cinerea* (52.5%), *Gymnosporia senegalensis* (45%) and *Acacia rehmanniana* (40%) (Table 3.3). *Acacia tortilis* also featured as the dominant woody species occurring in unoccupied sites (62%) ($n = 20$). Two herbaceous plant species were particularly prevalent within occupied territories (Table 3.4). *Chamaecrista mimosoides* occurred in 27 (67.5%) ($n = 40$) $100m^2$ quadrants while *Geigeria burkei* occurred in 24 (60%) ($n = 40$). Herbaceous plants were not as prevalent in

unoccupied sites with the dominant species *Lippia javanica* only recorded at 7.5% of the sites (n = 20) (Table 3.4).

Short-clawed Larks prefer areas with relatively low trees and small crown diameters. A T-test revealed a significant difference between tree height ($P < 0.0001$) and tree crown diameter ($P < 0.05$) between occupied territories and unoccupied sites. In the majority of occupied territories (62.5%), the average tree height belonged to Class 2, i.e. >1 – 2m whereas in unoccupied sites the principal tree height class was Class 3, i.e. >2 – 4m (83%) (Fig. 3.10). A similar pattern was observed for tree crown diameter: within currently occupied territories Class 2 (42.5%) and Class 3 (50%) were fairly evenly matched but at the unoccupied sites Class 3 (90%) dominated (Fig. 3.10).

In all currently occupied territories the presence of large herbivores was significant and grass cropping by large grazing mammals was obvious. Short-clawed Larks preferred areas that were moderately to heavily grazed: 60% of the occupied territories fell within heavily grazed areas with 27.5% of the occupied territories occurring in terrain that was moderately grazed. In contrast, none of the unoccupied sites showed any signs of heavy grazing but at 70% of the sites no grazing was evident. The results show a significant difference in the extent of grazing between occupied territories and unoccupied sites (Chi-square = 25.950, $d.f.$ = 2, $P < 0.0001$) (Fig. 3.11).

Analysis of grass species composition data to determine succession stages of veld within currently occupied and unoccupied territories revealed that pioneer grass species were more dominant in occupied (22.5%) than in unoccupied (14%) territories ($F_{0.541}$, $d.f.$ = 58, P = 0.003) Within occupied territories sub-climax and climax species were equally dominant (38.5% and 39% respectively) but within unoccupied territories climax species were more

abundant than sub-climax species (52% and 34% respectively) ($F_{0.015}$, *d.f.* = 58, *P* = 0.001) (Fig. 3.12).

Veld condition was assessed according to the ecological status of the grass species recorded along the "step point" transects and compared in currently occupied and unoccupied territories (Fig. 3.13). Grass species which indicate under-utilization of the grass layer (Increaser 1 species) were found in 10.6% of the unoccupied sites as opposed to 1.8% in occupied territories. Species which indicate a degree of overgrazing (Increaser 2 species) were dominant in 58% of occupied territories compared to 44% of unoccupied territories.

In all occupied Short-clawed Lark territories fire had occurred within 48 months of the survey as opposed to four of the 20 at the unoccupied sites. Within unoccupied territories no burns had occurred within two years prior to the study (Phi-test = 0.481, *P* = 0.003) (Fig. 3.14).

Extent of occurrence and area of occupancy

The distribution of the eastern population of the Short-clawed Lark is patchy, following corridors and areas of suitable habitat as described above, mainly within the Polokwane Plateau Bushveld vegetation unit (Mucina & Rutherford 2006). However, pockets of isolated sub-populations were observed on the fringes of the neighbouring Mamabolo Bushveld vegetation type to the east and in the Makhado Sweet Bushveld vegetation type (Mucina & Rutherford 2006) to the north (Fig. 3.15) The northern-most records were near the settlement of Bandelierkop on the farm Joppa 473LS and on the farm Droogeloop 516LS in the Soekmekaar district.

In the present study, Short-clawed Larks were only recorded in 9 of the 15 SABAP grid squares (Harrison *et al.* 1997). Short-clawed Larks were also observed in two additional grid

squares in which they were not recorded during the SABAP. The six squares where the species was absent, 2328BB, 2328BD, 2328DD, 2329BA, 2329AC and 2329AD had very little to no evidence of suitable habitat. Short-clawed Larks were however recorded in two additional grid squares 2329DB and 2329DD albeit in very low numbers (Fig. 3.17).

In the Polokwane Nature Reserve this species is restricted to within and on the fringes of three vegetation communities namely "*Themeda triandra* false grassland with scattered bush clumps", "*Themeda triandra/Acacia tortilis* false grassland" and "Saline patches with sparse vegetation" (Grosel 2001) (Fig. 3.16). A census of occupied territories within the Polokwane Nature Reserve during the 2005/2006 breeding season showed the presence of 57 territories, of which 49 (86%) fell within or on the fringes of the abovementioned plant communities. The remaining eight territories were found in particularly well grazed, open patches of three additional plant communities namely "*Gymnosporia senegalensis* open shrubland", "*Acacia tortilis* open woodland" and "Mixed *Acacia* woodland" (Grosel 2001).

The results of the survey of the area of occupancy of the eastern populations in the 2005/2006 breeding season revealed that within the Polokwane Nature Reserve and adjacent areas the species is well represented with 80 – 100 pairs. Outside this fairly dense concentration the Short-clawed Lark occurs in scattered sub-populations in pockets of suitable habitat. The number of territories within these sub-populations was dependant on the size of the available habitat which ranged from 0.7 - 30km^2. Subsequently the numbers of pairs within these areas ranged from one to approximately 25 pairs. The results of the survey of the area of occupancy were mapped and are depicted in Figure. 3.18.

DISCUSSION

As predominantly ground-living birds of open habitats, larks occupy a wide range of habitats within this niche: from deserts to mesic savannas. Nevertheless, several species have restricted ranges, suggesting that they have very narrow habitat requirements, e.g. Red Lark *Calendulauda burra*, Barlow's Lark *C. barlowi*, Beesley's Lark *Chersomanes beesleyi*, Rudd's Lark *Heteromirafra ruddi* and the Short-clawed Lark *Certhilauda chuana*. As a result of their restricted ranges, many of these species are also species of conservation concern. Any effective conservation management plan requires a thorough understanding of the habitat preference and biological and ecological requirements of the species.

The results obtained from the current study suggest that the eastern population of the Short-clawed Lark is highly selective of habitat. They occur predominantly within the Polokwane Plateau Bushveld vegetation unit within a narrow altitudinal range of between 1170 and 1400masl, where the mean annual rainfall is 478mm. Within this vegetation type the habitat which is selected can be described as false grassland (grassland with scattered shrubs and bush-clumps) or very open savanna with short grass and small scattered trees, mainly represented by *Acacia tortilis* (Fig. 3.19a-b). *Acacia tortilis* trees and shrubs occurred in each of the 40 surveyed occupied territories which are congruent with observations made by Herremans and Herremans (1992) who found this species in 99% of 100 Short-clawed Lark territories studied in south-eastern Botswana.

The substrate in all currently occupied territories surveyed consisted of sandy loam often accompanied by small quartz pebbles scattered on the surface. The substrate colour varied between red, grey and yellow and many resident larks which had territories in areas with a distinct soil colour often showed ventral plumage resembling the substrate. This was

particularly noticeable in territories situated on Red Hutton soils where, as a result of dusting, the rust colour would be impregnated in the ventral feathers, a feature which could result in field identification difficulties.

The basal cover in Short-clawed Lark territories comprises mainly of grass (40%) which is matched in proportion by bare ground (39%) while herbaceous plants contribute 13%. The habitat study took place during the wet summer months so it would be important to note that many annual herb species would not feature in the basal cover at other times of the year. These herbs would not likely be replaced by grass after the wet season so the percentage of bare ground would thus increase proportionally during the dry winter months. Two perennial herbs *Chamaecrista mimosoides* and *Geigeria burkei* were particularly well represented in plant species audits within Short-clawed Lark territories. The soft, fibrous seeds and dry flowers of *G. burkei* and another fairly common herb, *Dicoma macrocephala* was found in the lining of the majority of Short-clawed Lark nests observed during the study. In a study to determine the habitat preference of the western population of the Short-clawed Lark in south-eastern Botswana, Herremans and Herremans (1992) found that the grass cover was only 15% with bare ground occupying 78% of 100 territories studied. These median values are significantly dissimilar to the results of the current study. It is not known at what time of the year the survey was performed or what seasonal conditions persisted during the abovementioned study, but it is likely that such a large proportion of bare ground can be attributed to a period of prolonged drought, intensely overgrazed conditions and/or areas that have experienced some degree of soil disturbance in the past, e.g. ploughing. In fact, Herremans and Herremans (1992) described the preferred habitat of the species in southeastern Botswana as 1 - 3 year fallow land. In the current study, 20 territories were surveyed outside protected areas of which 15 were situated in rural areas where traditional subsistence agricultural practices similar to that in south-eastern Botswana are performed.

Although overgrazing was evident in all 15 territories, none of the territories showed any signs of other agricultural disturbances such as ploughing. Interestingly, although some Short-clawed Larks territories bordered recently fallow land in the present study, the species was not once observed in this habitat type during this study. The relative homogenous vegetation composition and structure of recently fallow lands is unsuitable for this species as there are no small trees/shrubs for perches or herbaceous plants and grass tufts for cover or to place their nests against.

Short-clawed Larks show a preference for relatively short grass (50 - 150mm) in the majority of the occupied territories. The grass height in all occupied territories never exceeded 500mm. This is comparable with the findings of Herremans and Herremans (1992) in south-eastern Botswana where grass height in Short-clawed Lark territories was lower than 250mm and mostly less than 100mm high. In most of the territories, scattered patches of taller grass were however evident, suggesting that this species does require some degree of a mosaic of grassy habitats within what is predominantly a short-grassed environment. This requirement has also been documented in habitat preference studies of other lark species including Rudd's Lark *Heteromirafra ruddi* (Maphisa 2004), Red Lark *Calendulauda burra* (Dean *et al.* 1991) and the Eurasian Skylark *Alauda arvensis* (Chamberlain & Gregory 1999). The Short-clawed Lark avoids areas of tall, ungrazed grass or where the grass layer has not been burnt for several seasons. Such areas show a build-up of moribund material, particularly around the grass tufts resulting in a high but unproductive basal cover. Furthermore, moribund vegetation will also make foraging difficult. A combination of moderate to heavy grazing accompanied with a fire frequency of at least every three seasons appears to create a suitable grass layer structure.

Tree height, tree crown diameter and tree cover were all greater in unoccupied territories than in occupied territories. The species' preference for habitat with small trees is clearly demonstrated by the higher mean tree height and larger crown diameter in the unoccupied sites. All the unoccupied sites in the present study were occupied in the recent past, but as many of these trees are now substantially larger than 10 years ago, it appears that the mean tree height and crown diameter may have exceeded the species preference threshold.

Within occupied territories trees were small and widely scattered, an ecological feature which may have relevance to the effectiveness of aerial displays by male Short-clawed Larks during the breeding season. The display flight starts with a rapid horizontal flight with a sudden vertical ascent to between 5 - 20m followed by a nose-dive descent (Herremans *et al.* 1994). The entire display flight takes place over an area of 15 - 40m with some individuals immediately repeating such a display flight (Herremans *et al.* 1994). The efficiency and physical ability of the display flight will thus be severely compromised in areas with a dense tree cover. Males that cannot perform their display flights effectively and be noticed by females and neighbouring males will clearly be at a competitive disadvantage. However Herremans *et al*. (1994) suggest the height of the ascent seems to be related to the type of habitat: in very open vegetation 6 - 10m is the norm, but in denser *Acacia* bushveld males ascend above tree height, sometimes to over 20m. In addition to performing aerial display flights, territorial males frequently sing from elevated perches such as small trees and shrubs. Territorial advertising from a perched position may serve a dual function: i) as a visual signal and audible cue to females and neighbouring males that the territory is occupied and ii) as a vantage point to see neighbouring males and to scout the home territory for available females or trespassing males. Clearly, large, dense trees will not only impede an individual's ability to fulfill these functions properly, but an individual may also appear "lost" amongst dense stands of large trees with large crowns. In addition to this it is

also possible that the change in vegetation structure would also introduce a new suite of woodland predators, e.g. Shikra Gabar *Accipiter badius* (Gmelin, 1788), Gabar Goshawk *Melierax gabar* (Daudin, 1800) and Genets *Genetta* spp. etc. that may prey on individuals.

The ecological data obtained from historically occupied areas may provide further evidence of this species' habitat selectiveness. In many cases these "deserted" areas which once supported significant sub-populations are adjacent or very close to existing, flourishing populations. As expected the geographical features and some habitat parameters of occupied territories and unoccupied sites compare well with that of occupied territories, e.g. aspect, slope and substrate. However features which are affected by the presence or lack of environmental influences such as fire, grazing and browsing show significant differences in occupied territories compared to unoccupied sites. The evidence of the lack of grass cropping by grazing animals and fire in these unoccupied areas can be seen in the differences in grass cover, grass height, veld succession stages and general veld condition as shown in the results. The Polokwane Nature Reserve hosts a variety of large grazers including White Rhinoceros *Ceratotherium simum* (Burchell,1817), Burchell's Zebra *Equus burchelli* (Gray, 1824), Waterbuck *Kobus ellipsiprymnus* (Ogilby, 1833), Blue Wildebeest *Connochaetes taurinus* (Burchell, 1823), Red Hartebeest *Alcelaphus buselaphus* (Pallas, 1766), Tsessebe *Damaliscus lunatus* (Burchell, 1823) Gemsbok *Oryx gazelle* (Linnaeus, 1758) and Sable Antelope *Hippotragus niger* (Harris, 1838). Although the game stocking rates are fairly conservative, based on a carrying capacity of 11ha/large animal unit (LAU) (Meisner 1982; Grosel 2001), numbers are significant enough for these species to create a grass structure mosaic as a result of their individual grazing preferences. In this way areas dominated by palatable grass species are well cropped while patches of less palatable grass are not utilized to the same degree. The commercial cattle farming areas on the Polokwane Plateau have a lack of diverse grazers as compared to the Polokwane Nature Reserve.

Here, cattle are the only significant grazers and although they do reduce the grass height, the same degree of variation in grass structure is not created. Although this aspect was not quantified in this study it may bear some relevance why commercial cattle farming areas show lower Short-clawed Lark densities than wildlife areas. However, no grass structure mosaic is apparent in the rural areas on the Polokwane Plateau as a result of overgrazing by livestock, and yet relatively high numbers of Short-clawed Larks are present. The breeding success of the species in areas where subsistence agriculture is practiced is, however, very low (Herremans and Herremans 1992).

The lack of browsing animals is equally significant since within the Polokwane Nature Reserve, species such as Kudu *Tragelaphus strepsiceros* (Pallas, 1766), Impala *Aepyceros melampus* (Lichtenstein, 1812), Eland *Tragelaphus oryx* (Pallas, 1766) and Giraffe *Giraffa camelopardalis* (Linnaeus, 1758) are able to prune particularly the *Acacia* shrubs, keeping them relatively small and vulnerable to fire. Without adequate browsers, shrubs (even after a fire) are allowed to coppice and quickly grow into trees which show more tolerance to fire (Tainton & Mentis 1984).

A case study to illustrate the abovementioned aspects was borne out on the farm “Orange Grove” situated some 15km’s east of Polokwane. This cattle farm which also held fair numbers of wild ungulates supported a population of Short-clawed Lark in the late 1990’s. In 2001 the farm was sold and all the livestock and most of the game removed. Delays in the change of ownership resulted in the land not being utilized for a period of four years. At the start of the present study in 2005 not a single Short-clawed Lark was found on the farm. In 2006 the land transfer was completed and cattle were again introduced onto the farm. Short-clawed Larks were once again recorded there in early 2007.

During the distribution survey small sub-populations of Short-clawed Larks were located outside the Polokwane Plateau Bushveld within the rather atypical neighbouring vegetation types of Makhado Sweet Bushveld and Mamabolo Bushveld (Mucina & Rutherford 2006). In the Makhado Sweet Bushveld, the preferred habitat included areas where large-scale bush clearing had taken place in the distant past for crop farming. Since then much of the crop farming has given way to free range cattle farming, mainly due to water shortages. Many of these areas of cleared bushveld are now utilized as cattle grazing lands. This has lead to the creation of open scrubby thornveld with a well cropped grass layer resulting in an unnatural, yet suitable Short-clawed Lark habitat. This situation could however be regarded as a mere temporary habitat structure since the tendency with secondary succession on fallow land under heavy grazing would be for a proliferation of *Acacia tortilis,* to the extent of eventual bush encroachment (Van der Schijff 1957; Trollope 1999).

In the rural areas within the Mamabolo Bushveld vegetation unit, the natural vegetation has given way to open shrub-land with very sparse short grass as a result of severe deforestation and overgrazing by livestock (Fig. 3.20). The secondary growth of scrubby *Acacia tortilis* and the low grass height and cover has also created suitable habitat for the Short-clawed Lark. Herremans and Herremans (1992) suggested that the typical Short-clawed Lark habitat in south-eastern Botswana is recent fallow land, usually close to settlements, with some coppicing of low bushes, extensively grazed by donkeys, cattle and goats. Indications are that the dynamic consequences of continuous overgrazing within the Mamabolo Bushveld habitat will eventually also lead to the proliferation of spinescent pioneer forbs e.g. *Stoebe vulgaris* and *Schkuhria pinnata* and *Acacia tortilis* shrubs making it unsuitable for the Short-clawed Lark. During the ecological survey stage of the study it was noticed that several locations within these areas already showed signs of heavy *S. pinnata, Acacia hebeclada* and *A. tortilis* infestation (Fig. 3.19c).

Barnes (2000) estimated the maximum global range of the eastern population of the Short-clawed Lark at approximately 10650km^2. The results of the current distribution range survey showed this species to occur in only 11 quarter degree squares equating to approximately 7800km^2. Even this figure may prove inflated as in five of the grid squares the habitat was marginal, supporting very low numbers of Short-clawed Larks. It is thus reasonably safe to suggest that the eastern population of the species has an area of occurrence of less than 4254km^2. With the aid of GIS programs all occupied territories recorded during the present study were mapped, each with a generous buffer of two kilometers. Using this method the current area of occupation of the eastern population of the Short-clawed Lark was estimated to be approximately 2450 km^2.

A comparison of the results of the present study with that of the South African Bird Atlas Project (Harrison *et al.* 1997) show a significant reduction in range (from 15 to 11 quarter degree grid squares) for the eastern population. Engelbrecht *et al.* (2007) suggested that misidentification of the species could have been one of the contributing factors for a range reduction of the western population in South Africa. In that study, Short-clawed Larks were only found in six of the 29 grid squares in which the species was recorded in South Africa during the SABAP (Harrison *et al.* 1997). It is believed that erroneous reports as a result of confusion with similar species such as the Sabota Lark *Calendulauda sabota* and the Rufous-naped Lark *Mirafra africana,* both species which are commonly found alongside the Short-clawed Lark, may also have contributed to an inaccurate representation of the range of the eastern population. This is particularly evident in many of the grid squares surveyed which showed no suitable habitat for Short-clawed Larks while Sabota Larks were common. Phenotypical similarities between the two species are depicted in Figure 3.20a-b. The Short-clawed Lark shows great sexual size dimorphism (Engelbrecht 2005) and small females

could easily be confused with the Sabota Lark, particularly if the longer tail of the former species is hidden from view (Fig 3.20c). The description of the Short-clawed Lark by Maclean (1985a) is incorrect and actually matches that of a *Mirafra* lark, probably the Rufous-naped Lark. This publication was widely used by amateur volunteers participating in the SABAP period and it is suspected that many records of the Short-clawed Lark may have been misidentifications and incorrect reports.

The stronghold for the eastern population of this species is undoubtedly the Polokwane Nature Reserve, an area of 3200ha and one of only four formally protected areas on the Polokwane Plateau. The other three formally protected areas are the Moletsi Nature Reserve, Turfloop Dam Nature Reserve and Percy Fyfe Nature Reserve, none of which support viable populations of the Short-clawed Lark. Within the Polokwane Nature Reserve Short-clawed Larks are restricted to three distinct plant communities (Fig. 3.16). Even within this protected area the suitable habitat is patchy and the total surface area of suitable vegetation communities only covers approximately 330ha. Barnes (2000) estimated that between 80 - 150 birds occur in the reserve. This proved consistent with results of a Short-clawed Lark census within the reserve based on active nest sites and displaying males during the 2005/2006 breeding season. The census showed a total of 57 territories. Based on the surface area of suitable habitat, the 57 territories equate to an estimated territory size of 5.8ha which is comparable with the findings of Engelbrecht (2005) of 6 – 10ha. However, during the study, a degree of overlapping of territories was evident. This was also observed by Herremans & Herremans (1992) and Engelbrecht (2005).

Areas outside the Polokwane Nature Reserve where this species was well represented (more than 20 pairs occurring within a sub-population) were the rural areas of Mothibaskraal and Makotopong to the east of Polokwane and Bloedrivier and Moletsi north-west of

Polokwane. The farms, Duvenhageskraal 689LS, Snymansdrift 738LS, Zandrivier 742LS (south west of Polokwane) and Melkboomfontein 919LS, Kalkfontein 1001LS, De Put 918LS, Onverwacht 914LS and Majebeskraal 1002LS (all due east of the city) also hold scattered but viable sub-populations (Fig. 3.18). Based on the current survey of the area of occupancy and the territory sizes presented by Engelbrecht (2005), the effective population size of the eastern population of the Short-clawed Lark is estimated to be fewer than 380 pairs.

In conclusion, the present study presents the first detailed analyses of the habitat preference, area of occurrence, area of occupancy and estimated population size of the eastern population of the Short-clawed Lark. As with many of the range restricted lark species, the Short-clawed Lark also shows fine-scale habitat preferences within the broad, general habitat description of "open habitat, sparsely vegetated with small trees and shrubs". The results also suggest that its habitat preference is probably dictated as much by physiological requirements, e.g. short-grassed areas with bare ground for breeding and foraging, as it is by behavioural requirements, e.g. large open areas for aerial displays and small trees or shrubs for territorial calls. Moreover, the study has shown that the preferred habitat of the Short-clawed Lark can become unsuitable within a relatively short period if grazing, browsing and fire, or any combination of these, is withheld for 2 - 3 years. The species' narrow habitat requirements explains its highly localised distribution and it suggests that there must be considerable local movement within the population's area of occurrence as dynamic anthropogenic and natural ecological conditions create and destroy suitable habitat. The study also showed that previous population estimates and ranges were considerably over-estimated. Based on the findings in this study and that of Engelbrecht *et al.* (2007), a re-assessment of the present conservation status of the species should be considered as a matter of urgency.

Table 3.1. Summary of mean grass height (height classes – 1. = 0 to 50mm, 2. = >50 to 150mm, 3. = >150 to 250mm, 4. = >250 to 500mm, and 5. = >500mm) and percentage basal cover in currently occupied (*n* = 40) and unoccupied (*n* = 20) territories of the eastern population of the Short-clawed Lark (*P* = 0.05).

	Occupied	Mean	±SD	*P*
Grass height	Yes	2.40	0.38	0
	No	3.84	0.51	
Grass cover	Yes	40.71	5.60	0
	No	65.18	7.38	
Forb / herb cover	Yes	13.26	7.15	0.07
	No	10.65	3.89	
Bare ground	Yes	39.42	6.93	0
	No	20.63	6.38	
Stone / pebble cover	Yes	6.11	6.61	0.03
	No	3.45	2.62	

Table 3.2. Grass species prevalence, measured in territories of the eastern population of the Short-clawed Lark (*n* = 40). The species richness was 57 species.

Species	N/4000 strikes	Prevalence (%)
Themeda triandra Forssk.	591	14.80
Brachiaria nigropedata (Ficalho & Hiern) Stapf	340	8.51
Tragus berteronianus Schult.	231	5.78
Eragrostis lehmanniana Nees var. lehmanniana	229	5.73
Heteropogon contortus (L.) Roem. & Schult.	224	5.61
Digitaria eriantha Steud.	221	5.53
Aristida congesta Roem. & Schult. subsp. c*ongesta*	209	5.23
Eragrostis rigidior Pilg.	182	4.56
Aristida diffusa Trin. subsp. *burkei* (Stapf) Melderis	143	3.58
Melinis repens (Willd.) Zizka	139	3.48
Cynodon dactylon (L.) Pers.	113	2.83
Pogonarthria squarrosa (Roem. & Schult.) Pilg.	108	2.70
Urochloa mosambicensis (Hack.) Dandy	106	2.65
Elionurus muticus (Spreng.) Kunth	104	2.60
Aristida congesta Roem. & Schult. subsp. barbicollis	100	2.50
Eragrostis superba Peyr.	97	2.43
Eragrostis chloromelas Steud.	92	2.30
Chloris virgata Sw.	75	1.87
Eragrostis racemosa (Thunb.) Steud.	66	1.65
Aristida stipitata Hack. subsp. *graciliflora* (Pilg.)	61	1.52
Anthephora pubescens Nees	53	1.32
Eragrostis gummiflua Nees	53	1.32
Eragrostis micrantha Hack.	48	1.20
Aristida adscensionis L.	41	1.02
Microchloa caffra Nees	40	1.00
Diheteropogon amplectens (Nees) Clayton	35	0.87
Hyparrhenia filipendula (Hochst.) Stapf var. *filipendula*	29	0.72
Dactyloctenium aegyptium (L.) Willd.	28	0.70
Trichoneura grandiglumis (Nees) Ekman	26	0.65
Sporobolus nitens Stent	25	0.62
Tricholaena monachne (Trin.) Stapf & C.E.Hubb.	21	0.52
Cymbopogon excavatus (Hochst.) Stapf ex Burtt Davy	20	0.50
Aristida scabrivalvis Hack. subsp. *scabrivalvis*	16	0.40
Eragrostis viscosa (Retz.) Trin.	15	0.37
Sporobolus albicans (Nees ex Trin.) Nees	13	0.32
Hyparrhenia hirta (L.) Stapf	12	0.30
Schmidtia pappophoroides Steud.	12	0.30
Setaria sphacelata (Schumach.) Stapf & C.E.Hubb.	12	0.30
Eragrostis curvula (Schrad.) Nees	11	0.27
Eragrostis tenuifolia (A.Rich.) Steud.	10	0.25
Aristida canescens Henrard subsp. *ramosa* De Winter	7	0.17
Cymbopogon plurinodis (Stapf) Stapf ex Burtt davy	7	0.17
Eragrostis nindensis Ficalho & Hiern	5	0.12
Enneapogon scoparius Stapf	4	0.10

Species	N/4000 strikes	Prevalence (%)
Panicum maximum Jacq.	4	0.10
Perotis patens Gand.	4	0.10
Bothriochloa insculpta (Hochst. ex A.Rich.) A.Camus	3	0.07
Sporobolus fimbriatus (Trin.) Nees	3	0.07
Aristida junciformis Trin. & Rupr. subsp. Junciformis	2	0.05
Enneapogon cenchroides (Licht. ex Roem. & Schult.)	2	0.05
Andropogon eucomus Nees	1	0.02
Brachiaria serrata (Thunb.) Stapf	1	0.02
Urochloa panicoides P.Beauv.	1	0.02
Enteropogon monostachyus (Vahl) K.Schum.	1	0.02
Eragrostis inamoena K.Schum.	1	0.02
Fingerhuthia africana Lehm.	1	0.02
Eustachys paspaloides (Vahl) Lanza & Mattei	1	0.02
Triraphis andropogonoides (Steud.) E.Phillips	1	0.02
	4000	

Taxonomy and nomenclature follows that of Gibbs Russell *et al.* (1987) and SANBI (2005).

Table 3.3. Woody plant species prevalence in territories of the eastern population of the Short-clawed Lark.

Tree/shrub species	Occurrence in 40 territories	Prevalence percentage (%)
Acacia tortilis sbsp. *heteracantha* (Berch)	40	100.0
Dichrostachys cinerea (L.) Wight & Arn.	21	52.5
Gymnosporia senegalensis (Lam.)	18	45.0
Acacia rehmanniana (Schinz.)	16	40.0
Ormocarpum trichocarpum (Taub) Engl	9	22.5
Acacia hebeclada sbsp. *hebeclada* (Berch.)	7	17.5
Ehretia rigida (Thunb.)	6	15.0
Rhus lancea L.f.	6	15.0
Aloe marlothii (A. Berger)	5	12.5
Lycium spp.	5	12.5
Clerodendrum glabrum E.Mey	4	10.0
Diospyros lycioides sb sp. guerkei (Kuntze)	4	10.0
Sclerocarya birrea sbsp. *caffara* (Sond.)	4	10.0
Ziziphus mucronata Willd.	4	10.0
Carissa bispinosa (L.) Desf.	2	5.0
Vangueria infausta Berch.	2	5.0
Rhus pyroides (Berch.)	2	5.0
Combretum molle R.Br.	2	5.0
Ximenia americana L. var. americana (Welw.)	2	5.0
Acacia permixta (Burtt Davy.)	1	2.5
Pappea capensis Eckl. & Zeyh.	1	2.5
Euphorbia ingens E. Mey.	1	2.5
Acacia nilotica sbsp. k*raussina* (Benth.)	1	2.5
Elaeodendron transvaalensis (Burtt Davy.)	1	2.5
Grewia villosa Willd.	1	2.5
Acacia karoo (Hayne.)	1	2.5
Acacia caffra (Thunb.)	1	2.5
Acacia robusta sbsp. *robusta* (Berch.)	1	2.5
Erythrina lysistemon (Hutch.)	1	2.5
Gymnosporia buxifolia (L.) Szyszyl.	1	2.5
Boscia albitrunca (Berch.)	1	2.5
Ximenia caffra (Sond.)	1	2.5

Taxonomy and nomenclature follows that of Gibbs-Russell *et al.* (1987) and Von Breitenbach *et al.* (2001).

Table 3.4. Herbaceous plant species prevalence, measured in territories of the eastern population of the Short-clawed Lark.

Species	Occurrence per 40 survey sites	Prevalence (%)
Chamaecrista mimosoides (L.) Greene	27	67.5
Geigeria burkei Harv. subsp. *burkei* var. *burkei*	24	60.0
Acrotome angustifolia G.Taylor	18	45.0
Commelina africana L. var. africana	18	45.0
Ipomoea obscura (L.) Ker Gawl. var. *obscura*	18	45.0
Hermannia depressa N.E.Br.	17	42.5
Lippia javanica (Burm.f.) Spreng.	17	42.5
Monsonia burkeana Planch. ex Harv.	17	42.5
Dicerocaryum eriocarpum (Decne.) Abels	16	40.0
Schkuhria pinnata (Lam.) Cabrera	16	40.0
Monsonia angustifolia E.Mey. ex A.Rich.	14	35.0
Aloe greatheadii Schönland var. *greatheadii*	13	32.5
Hypoxis iridifolia Baker	12	30.0
Dicoma macrocephala DC.	11	27.5
Indigofera daleoides Benth. ex Harv.	11	27.5
Cleome rubella Burch.	10	25.0
Gazania krebsiana Less. subsp. *serrulata* (DC.) Roessler	10	25.0
Indigofera filipes Benth. ex Harv.	10	25.0
Solanum panduriforme E.Mey. ex Dunal	10	25.0
Crotalaria burkeana Benth.	9	22.5
Ipomoea bathycolpos Hallier f.	9	22.5
Oxygonum sinuatum (Hochst. & Steud. ex Meisn.) Dammer	9	22.5
Crabbea angustifolia Nees	8	20.0
Dicoma anomala Sond. subsp. *anomala*	8	20.0
Indigofera comosa N.E.Br.	8	20.0
Tagetes minuta L.	8	20.0
Vernonia galpinii Klatt	8	20.0
Cucumis zeyheri Sond.	7	17.5
Senecio inaequidens DC.	7	17.5
Sida dregei Burtt Davy	7	17.5
Crotalaria distans Benth. subsp. *distans*	6	15.0
Hibiscus trionum L.	6	15.0
Indigofera hedyantha Eckl. & Zeyh.	6	15.0
Indigofera setosa N.E.Br.	6	15.0
Indigofera melanadenia Benth. ex Harv.	6	15.0
Jatropha latifolia Pax var. latifolia	6	15.0
Crotalaria podocarpa DC.	5	12.5
Merremia palmata Hallier f.	5	12.5
Tephrosia longipes Meisn. subsp. *longipes* var. *longipes*	5	12.5
Vernonia sutherlandii Harv.	5	12.5
Aptosimum transvaalense F.E.Weber	4	10.0
Cissus quadrangularis L. var. *quadrangularis*	4	10.0

Species	Occurrence per 40 survey sites	Prevalence (%)
Felicia muricata (Thunb.) Nees subsp. *muricata*	4	10.0
Gladiolus permeabilis D.Delaroche	4	10.0
Kyphocarpa angustifolia (Moq.) Lopr.	4	10.0
Raphionacme hirsuta (E.Mey.) R.A.Dyer	4	10.0
Solanum elaeagnifolium Cav.	4	10.0
Aloe zebrina Baker	3	7.5
Becium obovatum (E.Mey. ex Benth.) N.E.Br. subsp. obovatum	3	7.5
Indigofera setosa N.E.Br.	3	7.5
Lantana rugosa Thunb.	3	7.5
Ledebouria revoluta (L.f.) Jessop	3	7.5
Striga asiatica (L.) Kuntze	3	7.5
Striga elegans Benth.	3	7.5
Zinnia peruviana (L.) L.	3	7.5
Aerva leucura Moq.	2	5.0
Asparagus suaveolens Burch.	2	5.0
Blepharis transvaalensis Schinz	2	5.0
Commelina erecta L.	2	5.0
Crotalaria schinzii Baker f.	2	5.0
Euphorbia groenewaldii R.A.Dyer	2	5.0
Ledebouria ovatifolia (Baker) Jessop	2	5.0
Striga bilabiata (Thunb.) Kuntze subsp. Bilabiata	2	5.0
Tephrosia capensis (Jacq.) Pers. var. angustifolia E.Mey.	2	5.0
Tephrosia elongata E.Mey. var. elongata	2	5.0
Ziziphus zeyheriana Sond.	2	5.0
Bidens pilosa L.	1	2.5
Aptosimum elongatum Engl.	1	2.5
Anthericum transvaalense Bak.	1	2.5
Blepharis subvolubilis C.B.Clarke	1	2.5
Boophone disticha (L.f.) Herb.	1	2.5
Bulbostylis humilis (Kunth) C.B.Clarke	1	2.5
Chlorophytum fasciculatum (Baker) Kativu	1	2.5
Clematis oweniae Harv.	1	2.5
Cleome monophylla L.	1	2.5
Craterocapsa tarsodes Hilliard & B.L.Burtt	1	2.5
Wahlenbergia caledonica Sond.	1	2.5
Haplocarpha nervosa (Thunb.) Beauverd	1	2.5
Huernia transvaalensis Stent	1	2.5
Indigofera cryptantha Benth. ex Harv.	1	2.5
Leucas neuflizeana Courbon	1	2.5
Lippia rehmannii H.Pearson	1	2.5
Merremia pinnata (Hochst. ex Choisy) Hallier f.	1	2.5
Momordica repens Bremek.	1	2.5
Oldenlandia herbacea (L.) Roxb. var. herbacea	1	2.5
Orbeopsis lutea (N.E.Br) Leach subsp. Lutea	1	2.5
Oxalis depressa Eckl. & Zeyh.	1	2.5
Plexipus hederaceus (Sond.) R. Fernandes	1	2.5
Scilla nervosa (Burch) Jessop	1	2.5
Trachyandra asperata Kunth var. *asperata*	1	2.5

Species	Occurrence per 40 survey sites	Prevalence (%)
Selago densiflora Rolfe	1	2.5
Senecio latifolius DC.	1	2.5
Striga gesnerioides (Willd.) Vatke	1	2.5
Tulbaghia acutiloba Harv.	1	2.5
Vernonia oligocephala (DC.) Sch.Bip. ex Walp.	1	2.5
Walafrida densiflora (Rolfe) Rolfe	1	2.5

Taxonomy and nomenclature follows that of Gibbs Russell *et al.* (1987) and SANBI (2005).

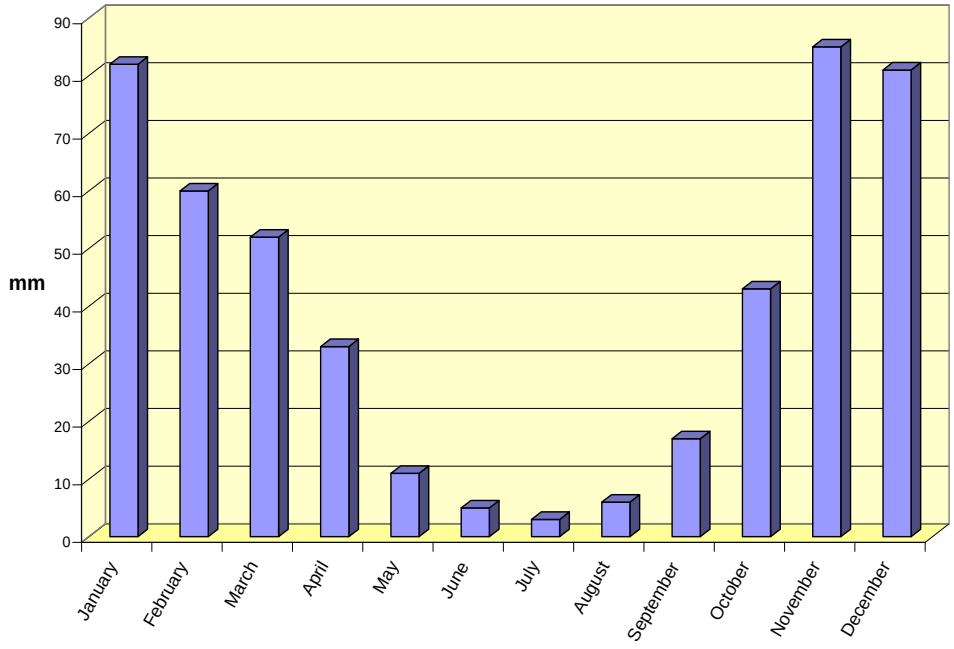

Fig. 3.1. Average monthly precipitation (1975-2004) for the greater Polokwane area recorded at the Polokwane/Gateway International Airport weather station - 0677802 BX (South African Weather Service, 2004).

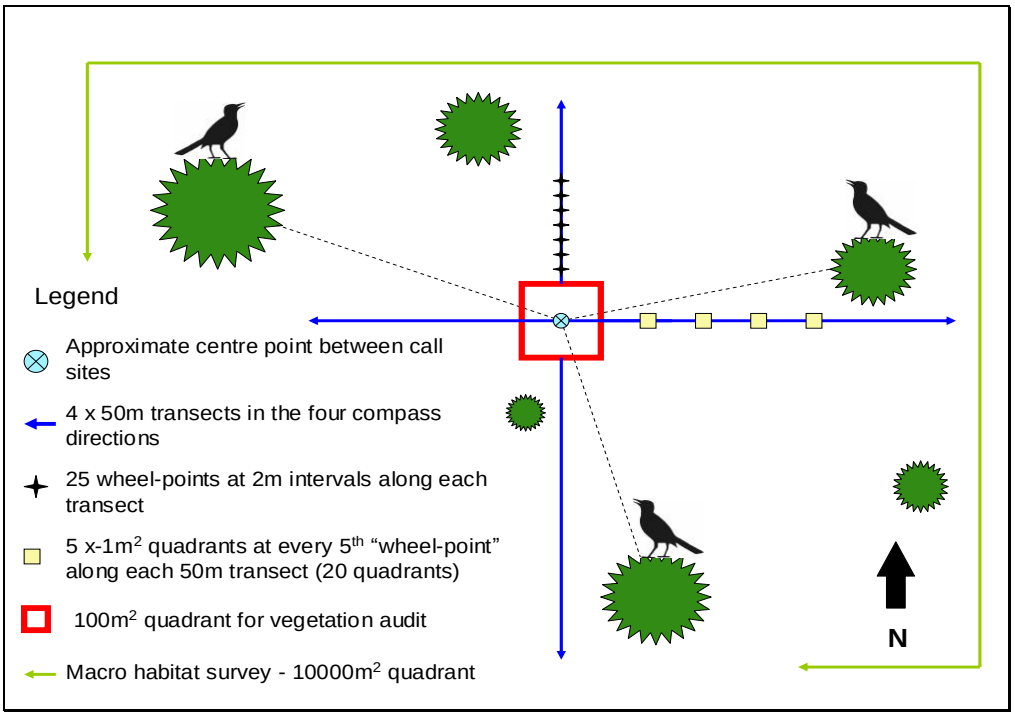

Fig. 3.2. Schematic representation of site selection and survey methodology for macro- and micro-habitat analysis.

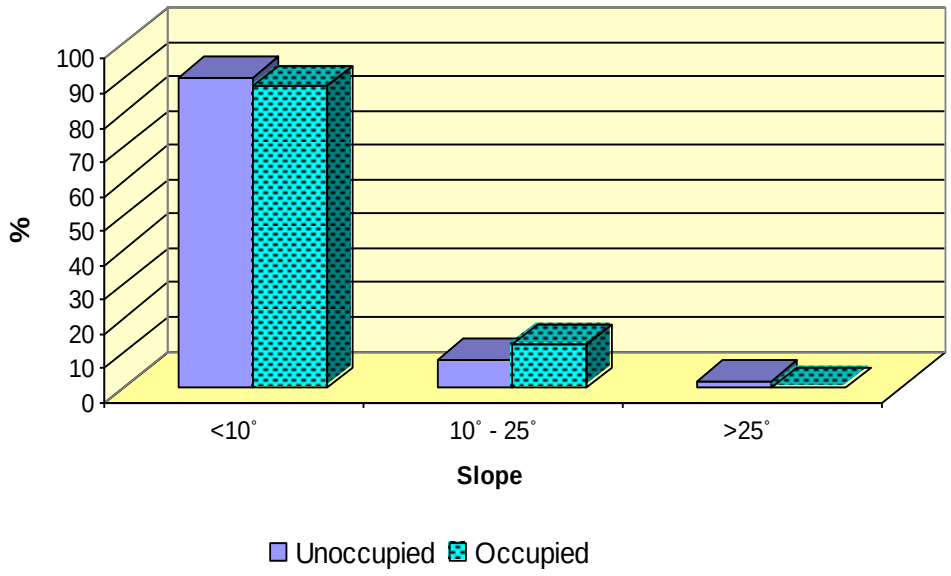

Fig. 3.3. The percentage of occupied territories (*n* = 40) and unoccupied sites (*n* = 20) of the Short-clawed Lark showing different degrees of slope.

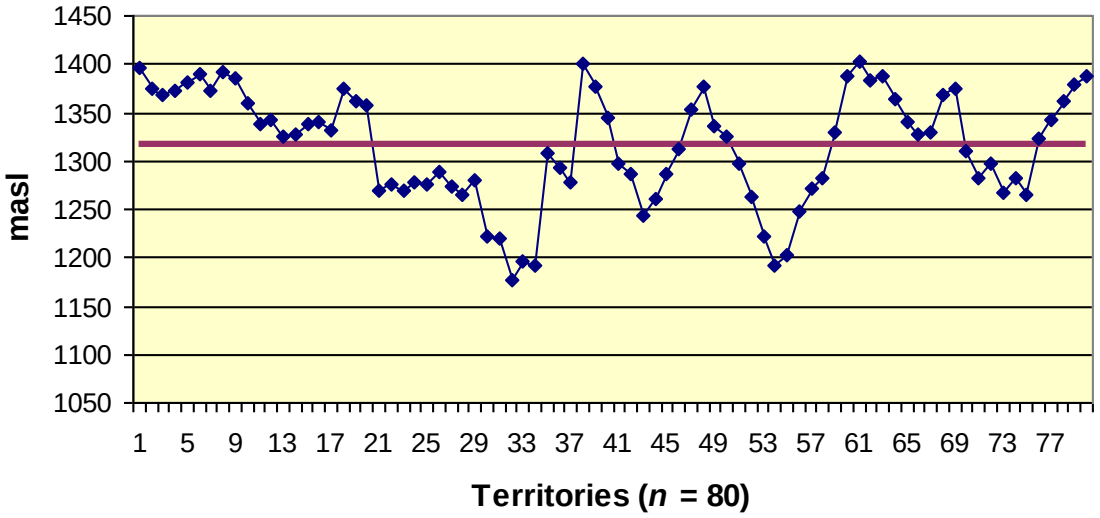

Fig. 3.4. A representative sample of altitudes recorded in the territories of Short-clawed Larks from the eastern population.

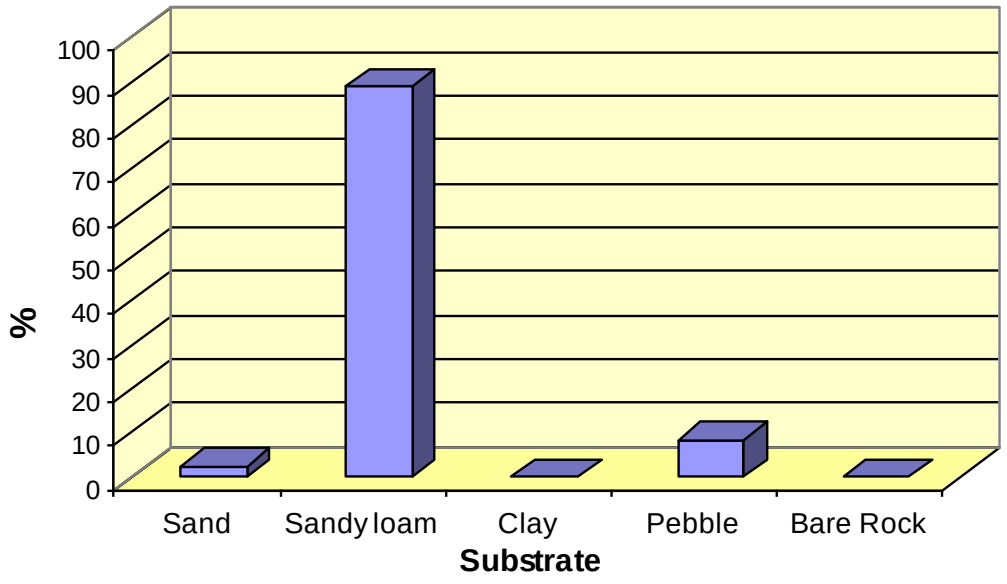

Fig. 3.5. The percentage of Short-clawed Lark territories (*n* = 40) showing their preference for substrate composition.

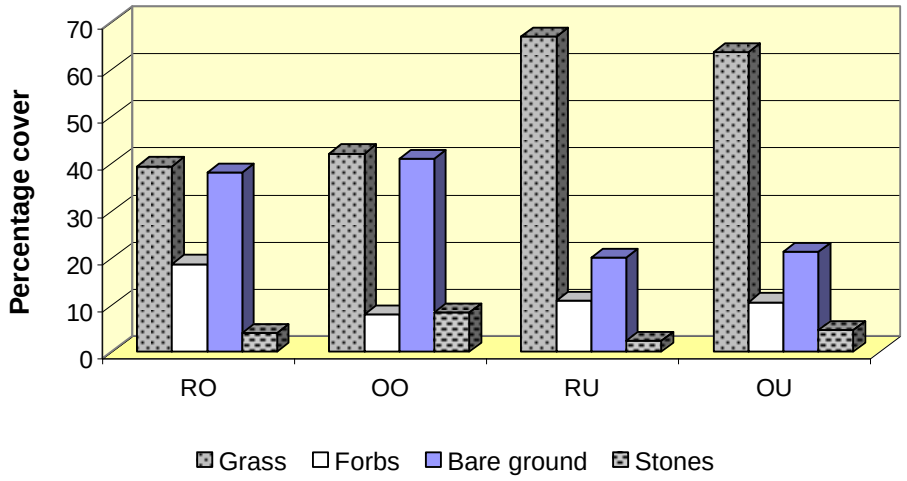

Fig. 3.6. Mean percentage ground cover in occupied territories and unoccupied sites of the Short-clawed Lark, where RO = Occupied lark territories within the Polokwane Nature Reserve (*n* = 20), OO = Occupied territories outside protected areas (*n* = 20), RU = Unoccupied sites in the Polokwane Nature Reserve (*n* = 10) and OU = Unoccupied sites outside protected areas (*n* = 10).

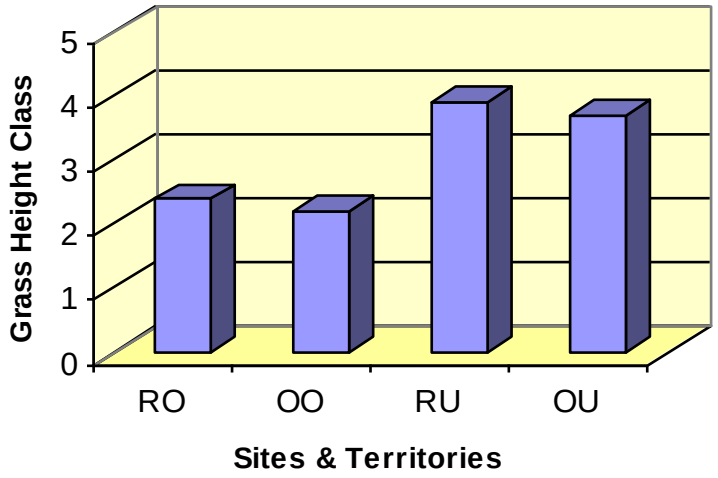

Fig. 3.7. Mean grass height in occupied territories and unoccupied sites of the Short-clawed Lark. Grass height classes: Class 1 = 0 to 50mm; Class 2 = >50 to 150mm; Class 3 = >150 to 250mm; Class 4 = >250 to 500mm and Class 5 = >500mm. The four site categories are; RO = Occupied lark territories within the Polokwane Nature Reserve (*n* = 20), OO = Occupied territories Outside protected areas (*n* = 20), RU = Unoccupied sites in the Reserve (*n* = 10) and OU = Unoccupied sites Outside protected areas (*n* = 10).

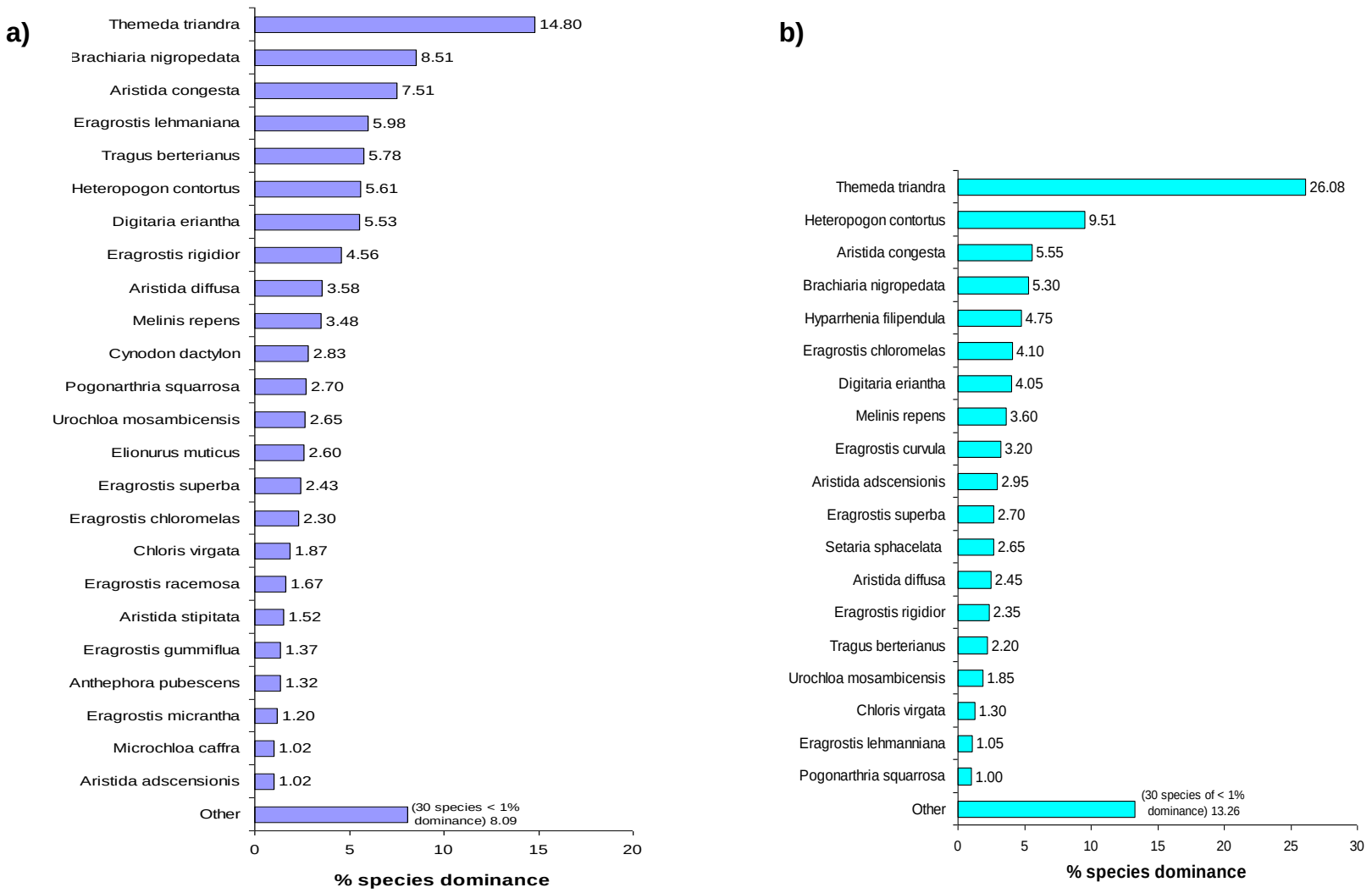

Fig. 3.8. Grass species dominance in a) occupied territories (*n* = 40) and in b) unoccupied territories (*n* = 20) of the Short-clawed Lark from the eastern population.

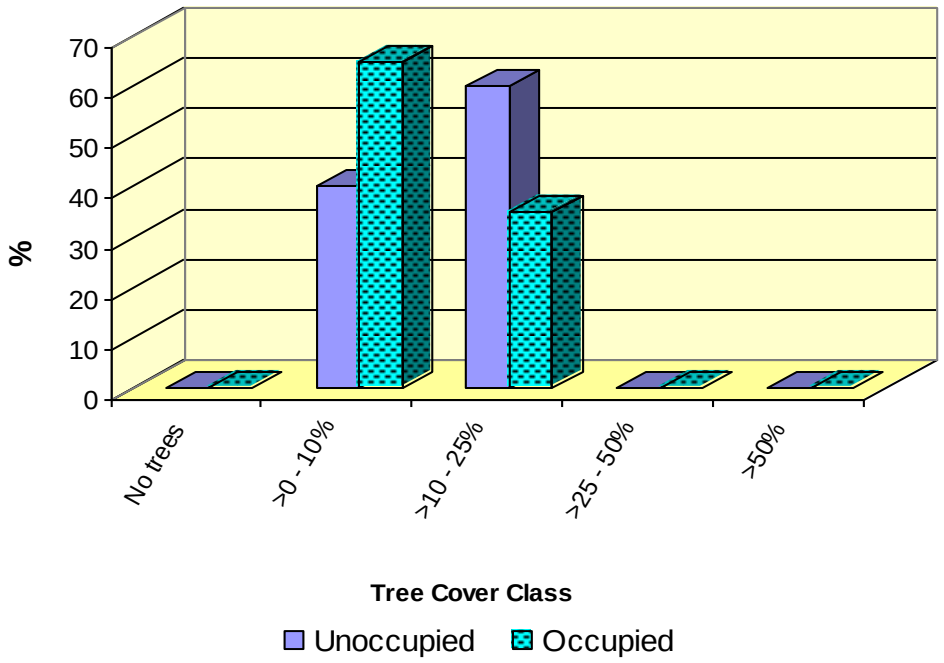

Fig. 3.9. Mean percentage tree cover in occupied territories (*n* = 40) and unoccupied sites (*n* = 20) of the eastern population of the Short-clawed Lark.

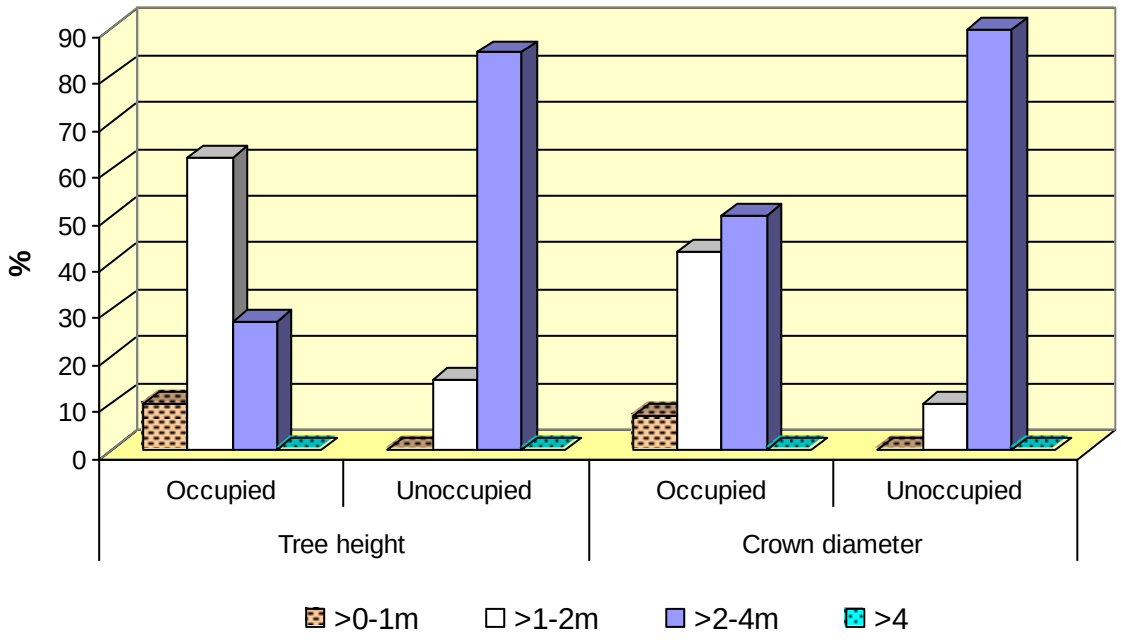

Fig. 3.10. Mean percentage tree height and tree crown diameter within occupied territories (*n* = 40) and unoccupied sites (*n* = 20) of the eastern population of the Short-clawed Lark.

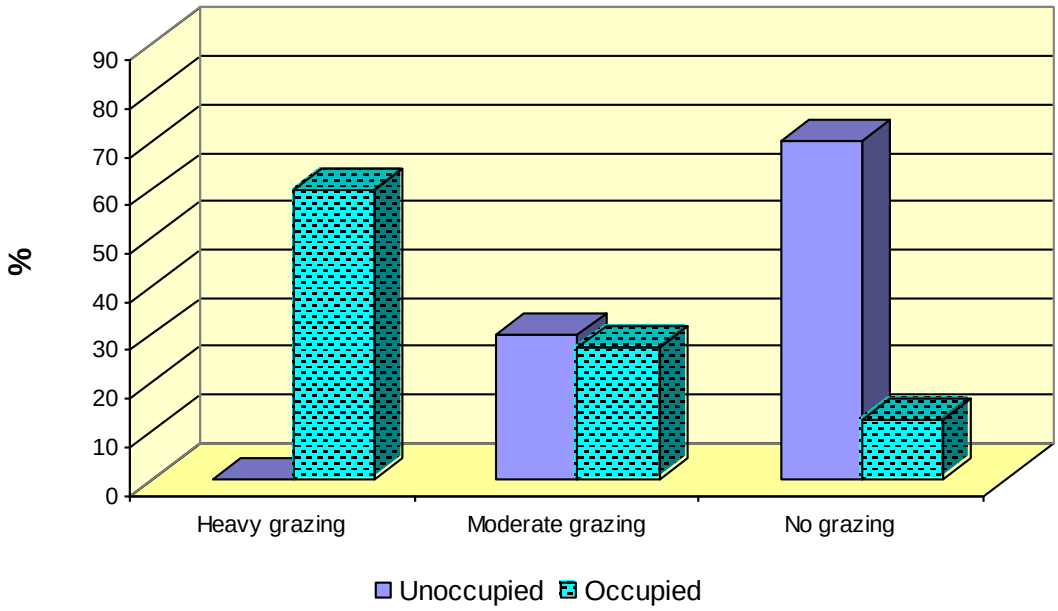

Fig. 3.11. The percentage of occupied territories (*n* = 40) and unoccupied sites (*n* = 20) of the Short-clawed Lark showing different degrees of grazing.

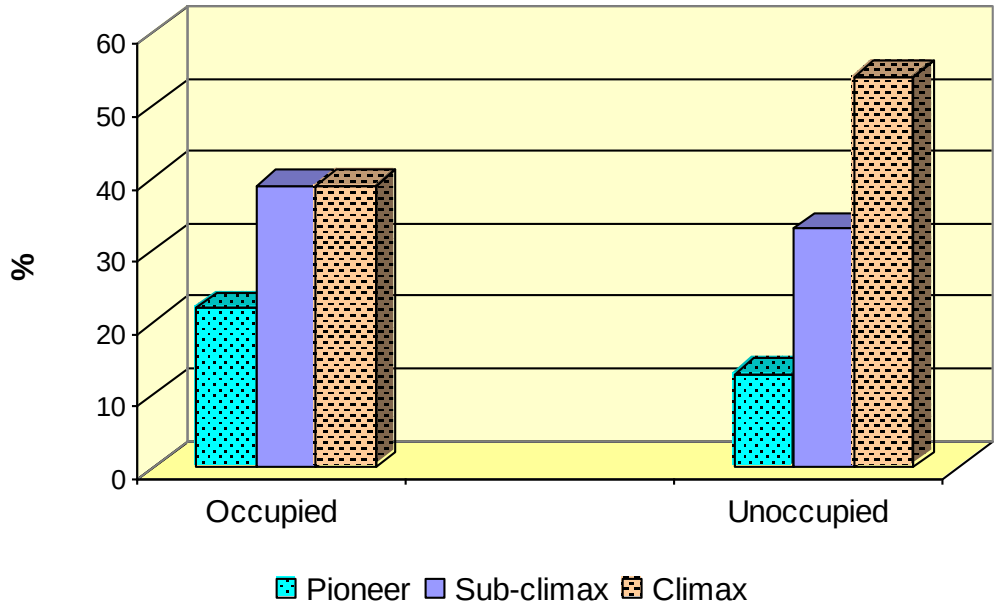

Fig. 3.12. The percentage of occupied territories (*n* = 40) and unoccupied sites (*n* = 20) of the Short-clawed Lark showing different levels of habitat succession based on grass species abundance.

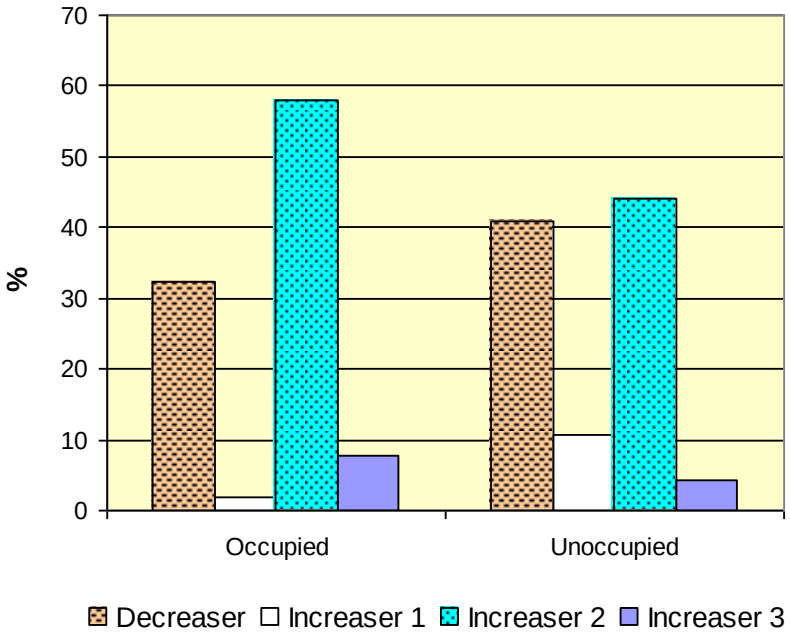

Fig. 3.13. The percentage of occupied territories (*n* = 40) and unoccupied sites (*n* = 20) of the Short-clawed Lark showing the mean ecological status based on grass species prevalence and composition.

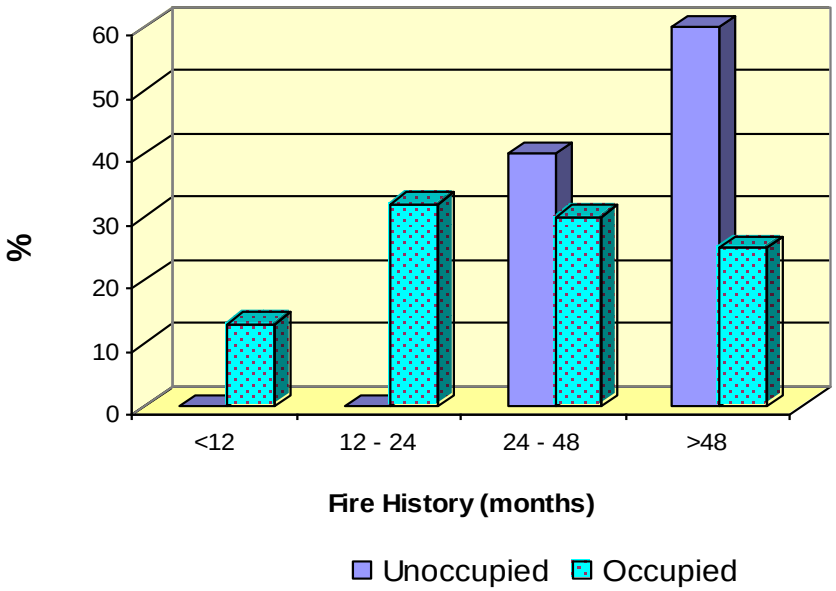

Fig. 3.14. The percentage of occupied territories (*n* = 40) and unoccupied sites (*n* = 20) of the Short-clawed Lark showing its fire history. Classes represent the history of fire occurrence prior to the survey date, categorized into 12-month time frames.

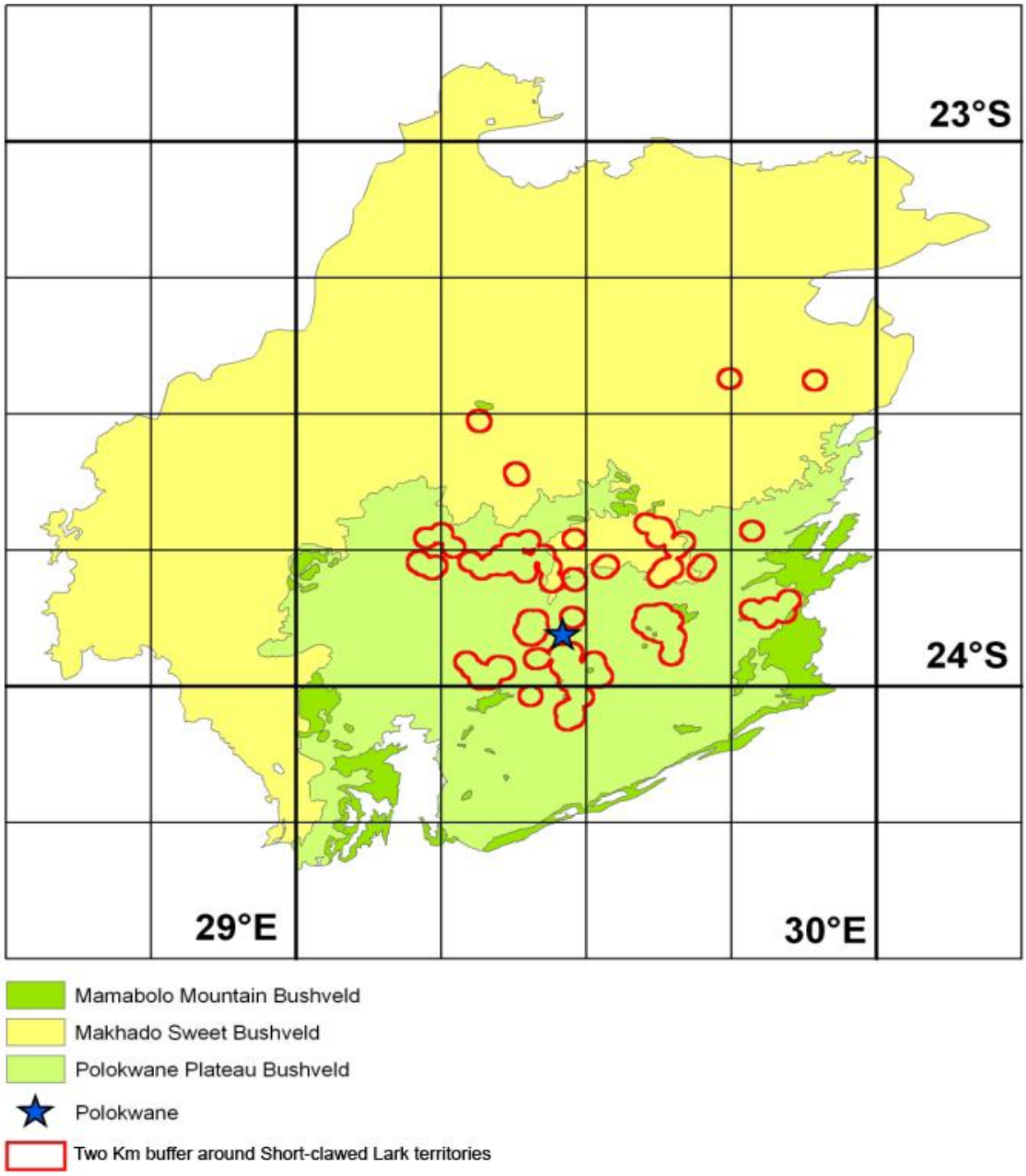

Fig. 3.15. The present area of occupancy of the eastern population of the Short-clawed Lark within the Polokwane Plateau Bushveld, Mamabolo Bushveld and Makhado Sweet Bushveld vegetation units (Mucina & Rutherford 2006).

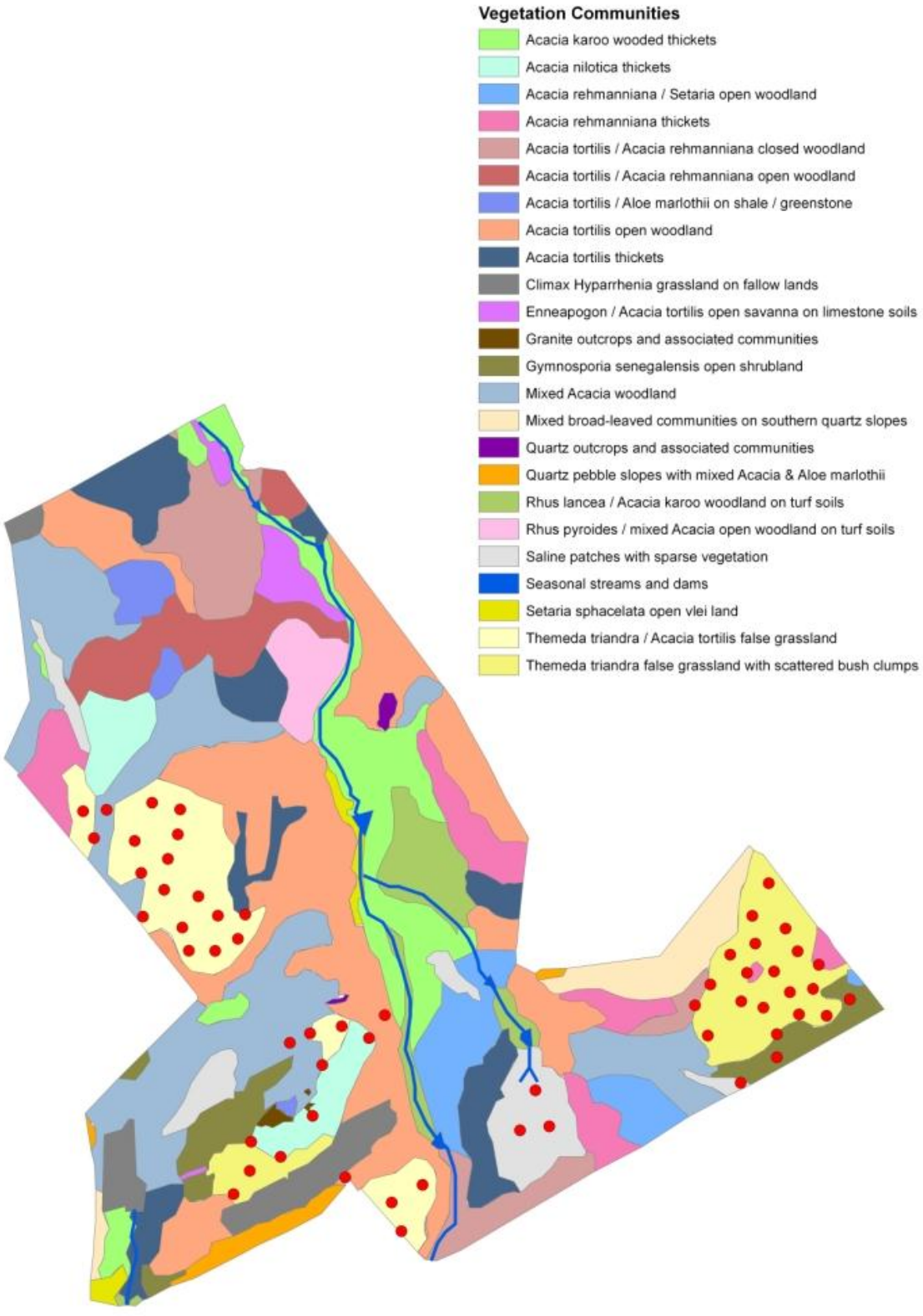

Fig. 3.16. Locations of 57 occupied Short-clawed Lark territories recorded during the 2005/2006 breeding season within relevant vegetation communities of the Polokwane Nature Reserve.

Fig. 3.17. The distribution of the eastern population of the Short-clawed Lark during the South African Bird Atlas Project 1 (left) compared to the results of the current distribution survey (right).

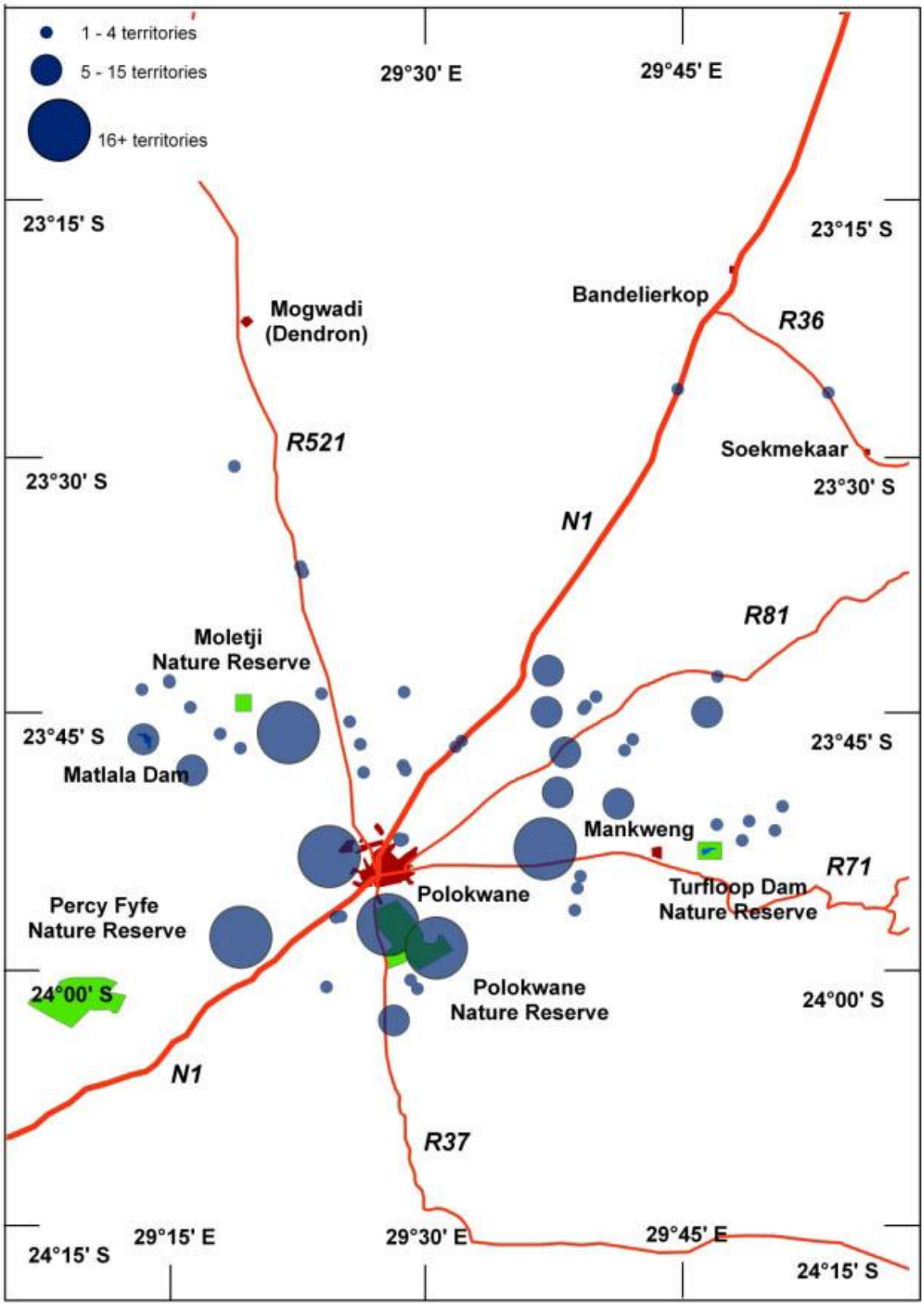

Fig. 3.18. Population estimates of the eastern population of the Short-clawed Lark across its present area of occurrence.

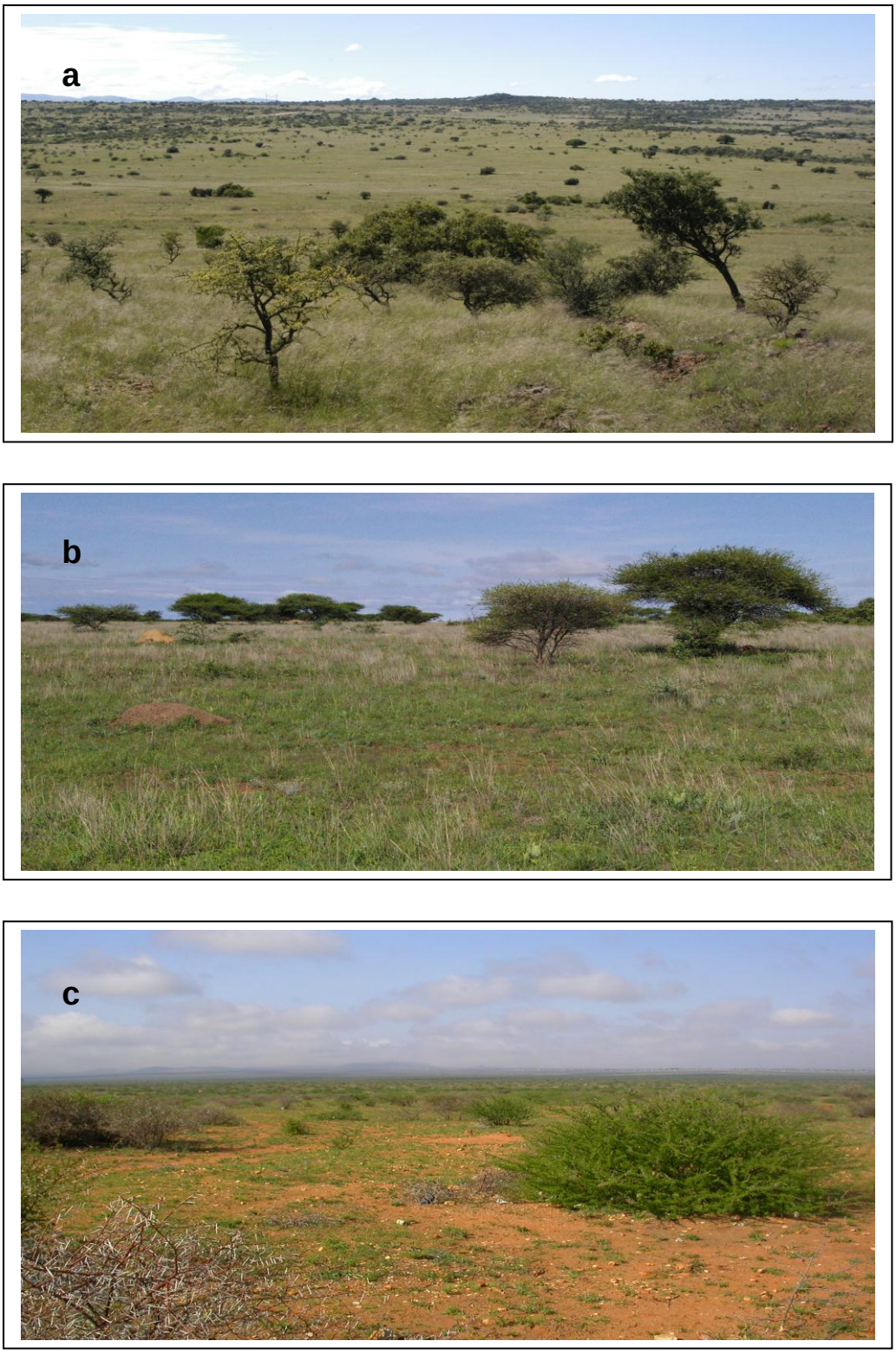

Fig. 3.19. Photographs of suitable Short-clawed Lark habitat a) within the Polokwane Nature Reserve and b) and on the farm Snymansdrift 738LS, west of Polokwane City. Photograph c) shows *Acacia hebeclada* and *A. tortilis* shrub encroachment in the rural areas of Mothibaskraal (east of Polokwane) as a result of deforestation and overgrazing.

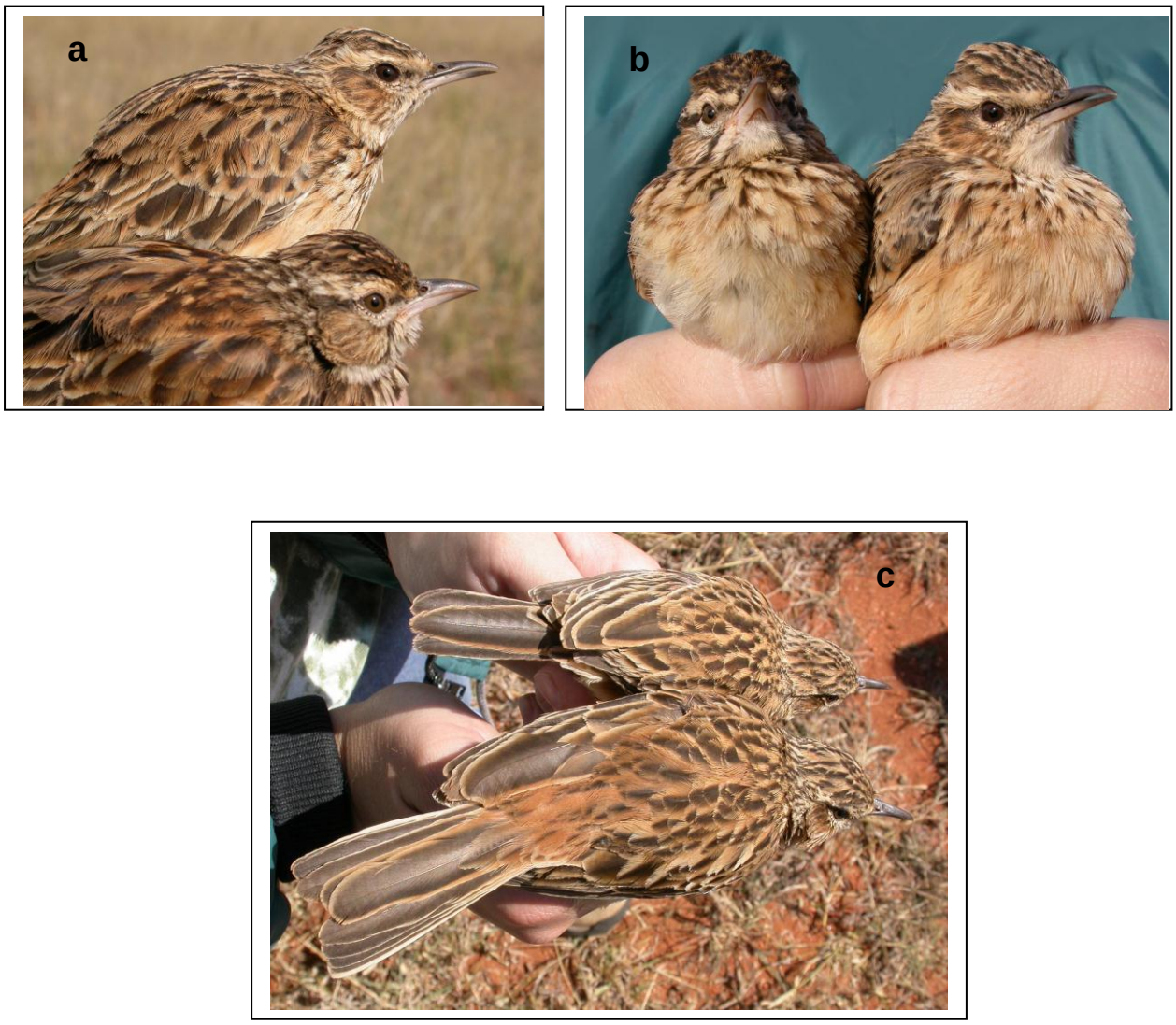

Fig. 3.20. Photographs showing some of the phenotypic similarities in plumage and shape between the Short-clawed Lark *Certhilauda chuana* and the Sabota Lark *Calendulauda sabota.* Photograph A) - Short-clawed Lark above, Sabota Lark below. Photograph B) - Sabota Lark left, Short-clawed Lark right. Photograph C shows the distinct sexual size dimorphism of the Short-clawed Lark with the much larger male below.