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# THE USE OF LARKS *ALUADIDAE* AS A BIO-INDICATOR OF HABITAT QUALITY IN KUWAIT

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## ABSTRACT

Protected areas are generally designed with the aim of providing improved habitat for species that live and breed in them. The aim of this study was to examine the extent to which habitat protection is influencing the Kuwait avifauna, and to assess the conservation benefits. Using the lark species as a measurable indicator of habitat quality, we compared species richness and density between protected and non-protected areas. We found significant differences between lark density and species richness in protected, non-protected and arable lands. Density of larks was very low in non-protected areas, being about one individual $km^{-2}$. Skylark density in protected areas was up to 200 times that in the comparable adjacent non-protected areas where lands are used for camping, grazing and hunting. In the semi protected arable area, the Pivot farm, crested lark density was 80 individuals $km^{-2}$, which is 3 times their density in fully protected areas. Arable lands can form important alternative habitats for breeding larks, especially in more arid years.

The results showed a remarkable impact of human activities on non-protected areas. A national action plan is highly recommended to preserve natural habitats and rehabilitate ecosystems by reviewing and controlling hunting, grazing, camping, and land use. Greater hoopoe larks and bar-tailed larks are becoming threatened species in Kuwait and the previous categorization as 'low concern species' according to IUCN is now not compatible with their current scarcity. The decline in lark numbers indicates the requirement for an action plan to safeguard and secure their natural habitats.

**KEYWORDS:** Lark Species, Distribution, Habitat, Abundance, Density, Protected Area

## INTRODUCTION

Kuwait is a harsh environment for birds since the climate is extreme and many areas are effectively desert. This presents considerable challenges to breeding birds. Furthermore, the country is relatively small, and the suitable land is heavily used for human activities. It is recognized that it is important to conserve natural habitats, but protected areas are limited to one large and four small reserves. It is important that we have a good understanding of the effectiveness of such protection, and of the best ways of protecting and monitoring change in the ecosystems represented. Indicator species are a useful tool in this context, and it is well proven that birds are good bio-indicators of the health of ecosystems (Martin & Possingham 2005).

Avifauna forms a major component of Kuwait wildlife; 365 avian species have been recorded in Kuwait State

(Kuwait Environment Protection Society 2007) in spite of its small area and harsh climate. Furthermore, eight globally threatened bird species visit Kuwait: socotra cormorant *Phalacrocorax nigrogularis*, lesser kestrel *Falco naumanni*, saker falcon *Falco cherrug*, egyptian vulture *Neophron percnopterus*, greater spotted eagle *Aquila clanga*, eastern imperial eagle *Aquila heliaca*, houbara bustard *Chlamydotis undulata*, and Basra reed-warbler *Acrocephalusgriseldis* (IUCN 2008). However, despite the large number of recorded bird species, only 24 of them are known to breed, of which 8 species breed regularly while others probably only breed occasionally when they mate in the country during winter visits (Evans 1994).

The yearly loss of resident breeding species in Kuwait may be more than can be compensated for by immigration of breeders from other areas, due to continuous land degradation and habitat destruction. On the other hand, it is impossible to declare all the important bird sites in the country as protected areas, so it is necessary to secure bird habitat by good planning and management. However, ecological habitats and their biota are exposed to degradation due to human population growth and urban expansion. In addition, uncontrolled degradation is accompanied with the difficulty of evaluating the real value of biodiversity and low public awareness.

Avian population dynamics are influenced by natural and anthropogenic factors. Due to climatic change, habitat quality can alter and reduced food abundance will constrain breeding. For example, in 1985, when there was little rain and many plants were damaged by severe cold in Kuwait, crested lark *Galeridacristata*, temminck's horned lark or horned lark *Eremophilabilopha*, black-crowned sparrow lark *Eremopterixnigriceps* and thick-billed lark *Rhamphocorisclotbey* did not breed. However, they did resume breeding when then weather conditions became suitable (Clayton & Wells 1987). Decline of avian populations induced by natural factors such as climatic changes, predation and diseases is still moderate in Kuwait and considered much less of a threat in comparison to non-natural factors (land use) which alters habitat and may lead to irreversible declines.

Larks *Aluadidae* form the bulk of the desert breeding species in Kuwait. Larks are usually shrub steppe species (Laiolo & Tella 2006 a) and only a few species can breed in the desert ecosystem. Larks possess a number of characteristics that enable them to be used as indicators of habitat integrity (Martin & Possingham 2005). They are relatively well studied and widespread, and can play an important role as natural indicators of habitat biodiversity, and maintaining their numbers is likely to require protection of important habitats (Evans 1994).

Larks are passerines, and in Kuwait are widespread and found typically in sparse steppe vegetation lands. They are highly abundant in the Mediterranean and low latitude regions. Even though they are classified as low concern species (IUCN 2001), their populations have declined in recent decades and some species such as Dupont's lark *Chersophilusduponti* have been identified as nationally threatened in some European countries. Eleven out of 15 European lark species visit Kuwait during migration seasons (IUCN 2001), but only four of them have been recorded as breeding: 1) greater hoopoe lark *Alaemonalaudipes*, 2) crested lark, 3) bar-tail lark *Ammomanescinctura*, and 4) black-crowned sparrow lark or black-head finch lark (Gregory 2005). These larks are considered as resident, spending all year in the State of Kuwait, where they have adapted to the desert environment.

Other larks such as, short toed larks *Calandrellabrachydactyla*, lesser short toed lark *Calandrellarufescens*, desert lark *Ammomanesdeserti*, dunes lark *Certhilaudaerythrochlamys* and horned lark stay as visitors in fall and spring and breed occasionally when they find suitable circumstances (Gregory 2005). There are no breeding records for skylarks in Kuwait; they are only visitors (Al-Ghanem& Al-Shehabi 2006).

Such threats as are evident in Kuwait appear to be widespread and occur in other countries. The population density of skylarks *Alaudaarvensis* has declined in Great Britain over the last four decades (Chamberlain *et al.* 1999). Crested Larks were known to be abundant in Central Europe in the middle ages (1200-1280). Their population in Switzerland declined dramatically after 1920 and the last breeding attempt occurred in 1991 (Hegelbach*et al.* 2003). In Kuwait, crested lark numbers have greatly reduced since 1979 prior to which it had been seen everywhere in huge assemblages; for example, a thousand individuals were recorded in Ahmadi city in 1953 (Gregory 2005).

This study investigated the distribution of larks in relation to land use patterns in protected and non-protected areas of Kuwait. This was done to gauge the threats to biodiversity, and the efficacy of current conservation measures. I also investigated their adaptation to Kuwait's semi-arid climate.

## METHODS

### Study Area and Sites

The study area was located in open and protected areas north and west of Kuwait City and surveyed during winter and summer 2008-09. Selected areas were two protected areas: Sabah Al-Ahmed Natural Reserve (SAANR), 330km$^2$ in area; and Kabd Scientific Research Station (Kabd), 40km$^2$ in area; and two unprotected areas of similar landscape (behind Sabah Al-Ahmed Natural Reserve (B-SAANR), area 80km$^2$; and an area adjacent to Kabd Scientific Research Station (R-Kabd), 40km$^2$ in extent. The general landscape was characterized by short sparse bushy and grassy desert plants. Grazing, hunting and camping are forbidden in the protected areas whereas they are permitted in unprotected ones. I also sampled a semi-protected agricultural area, the Pivot farm (Pivot), 8km$^2$ in extent. The Pivot farmland contains 19 irrigated circular crops varying in radius from 0.5-0.9km, used mainly to grow seasonal leafy and cereal crops (foliage 80%, barley 10%, maize 10%). The pivot owner's camel and sheep herds graze continuously in the farmland.

We estimated bird species richness and abundance using distance sampling. Line transects were undertaken by driving slowly (<10km/h) along predetermined fixed routes and recording birds that were seen on either sides of that route. The transect length varied from 10-25km according to the relative site areas. Birds flying over the census area were included. To determine the exact perpendicular distance of recorded birds from the transect lines (in meters) I used a Bushnell Yardage Pro Sport 450 Laser Rangefinder (ranging accuracy ±0.9m). Each site was sampled in the morning (after sunrise and before midday) on between 4 and 6 visits. Fieldwork was conducted in winter from 20 December 2008 to 10 January 2009 to provide non-breeding season counts, and in spring from 1$^{st}$ March to 30$^{th}$ May 2009 to give breeding season counts, with 4 to 6 visits for each area in each season.

The data recorded were bird species, their group size and the distance of the individual or group from transect.

### Study Species

The study examined the total avifaunal species richness and abundance in the five study areas. But, particularly the focus is on resident breeding larks species; greater hoopoe lark *Alaemonalaudipes*, crested lark, bar-tailed lark *Ammomanescinctura*, and black-crowned sparrow-lark *Eremopterixnigriceps* and visitor larks; short toed larks *Calandrellabrachydactyla*, lesser short toed lark *Calandrellarufescens*, desert lark *Ammomanesdeserti*, dunn's lark *Eremalaudadunni*, temminck's lark *Eremophilabilopha* and skylark *Alaudaarvensis*.

**Statistical Analysis**

Bird richness (number of species) and abundance (number of individuals within each species) were counted for the five sites. Population density of bird species were estimated using the Distance software (Distance 5.0) (Fuller *et al.* 2008 and Thomas *et al.* 2010) fitting different detection function models. Detection functions account for the fact that the probability of seeing birds will likely decline with their perpendicular distance from transect, but the rate of decline may vary with the behaviour of the bird species, and the nature of the vegetation cover. To fit a detection function requires a certain minimum number of encounters, greater than 40 encounters is recommended (an encounter is defined as the single observation of an individual or group of individuals). Several detection models can be set up and run easily using different subsets of the data. The four detection models are: 1) uniform, 2) half-normal, 3) negative exponential and 4) hazard rate. Then, one of three adjustments: 1), Cosine, 2) Simple polynomial, and 3) Hermit polynomial are chosen to generate the analysis of data in the Distance program. The combination of 4 detection models with 3 adjustments gives 12 possibilities of detection models that an observer can use. Furthermore, the observer can use a data filter option to analyse his/her data by truncating part of the data. Data Filters enable observers to try different truncation distances in order to examine the effects of exact data intervals and excluding some extended intervals. However, the truncate option must be used cautiously with a clear understanding of the data and possibilities of misleading outcomes (Buckland *et al.* 2001). The candidate models should also be selected upon specific criteria, such as goodness of fit (especially near zero distance).

Using this approach enabled me to take account of the fact that the probability of detecting birds might vary with species and habitat. The best detection model, g(y) is the one that has the lower Akaike's Information Criterion (AIC). I also calculated the mean group size of each species. Species with rare or few encounters could not be used to estimate density, but were used to determine avifauna richness in each area.

Density of greater hoopoe larks and bar-tailed larks were very low so in order to exceed the recommended minimum number of encounters required to conduct the Distance estimation, they have been merged with other species but analysed as stratified species. Stratified analysis helps to measure the density of every named species by using one detection function for all included species. Hence, it is important to choose species that have similar detection functions to generate the analysis. In my case, I used all larks' species together except for crested lark and skylark species whose encounter numbers alone exceeded 40.

## RESULTS

**Detection Functions**

The best detection functions for specific species such as crested lark or skylark varied from one site to another according to the vegetation cover. Non-protected areas had higher detection probabilities than protected areas due to the reduced vegetation cover of the former Figures 1 and 2. Probabilities of observing larks in protected areas declined rapidly with distance but stayed constant or decreased only slightly with distance in non-protected areas. Detection functions for observing crested larks approached zero after 30m in the Pivot due to dense vegetation cover, while declining to zero only beyond 50m and 60m in SAANR and Kabd, respectively as mentioned in Figure 1.

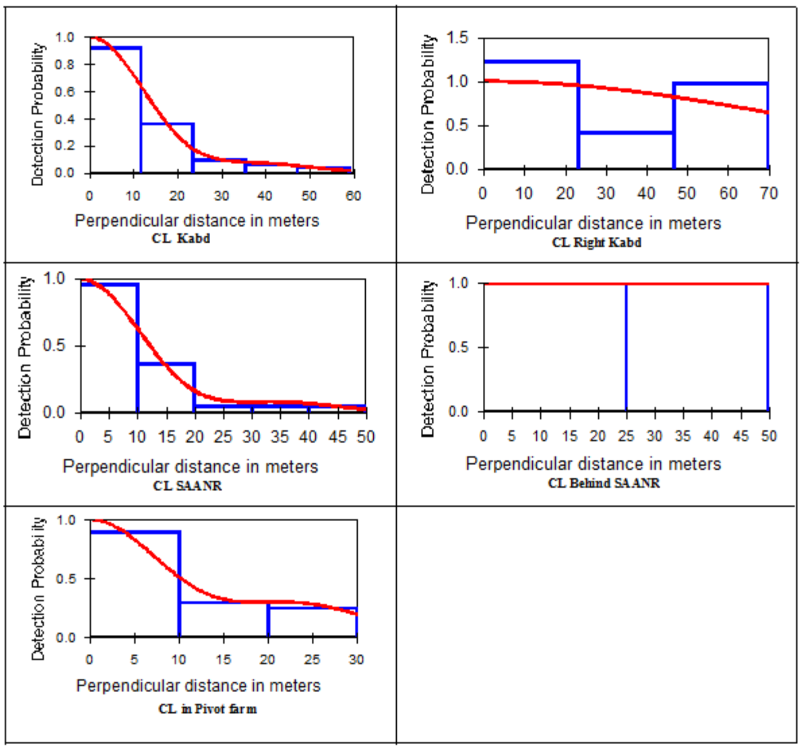


**Figure 1: Detection Functions of Crested Larks CL in the Five Studied Areas. Probabilities of Observing Larks in Protected Areas (SAANR & Kabd) and Farmland (Pivot) Declined Rapidly with Distance but Stayed Constant or Decreased Only Slightly with Distance in Non-Protected Areas (B-SAANR & R-Kabd). Non-Protected Areas had Higher Detection Probabilities than Protected Areas Due to the Reduced Vegetation Cover of the Former**

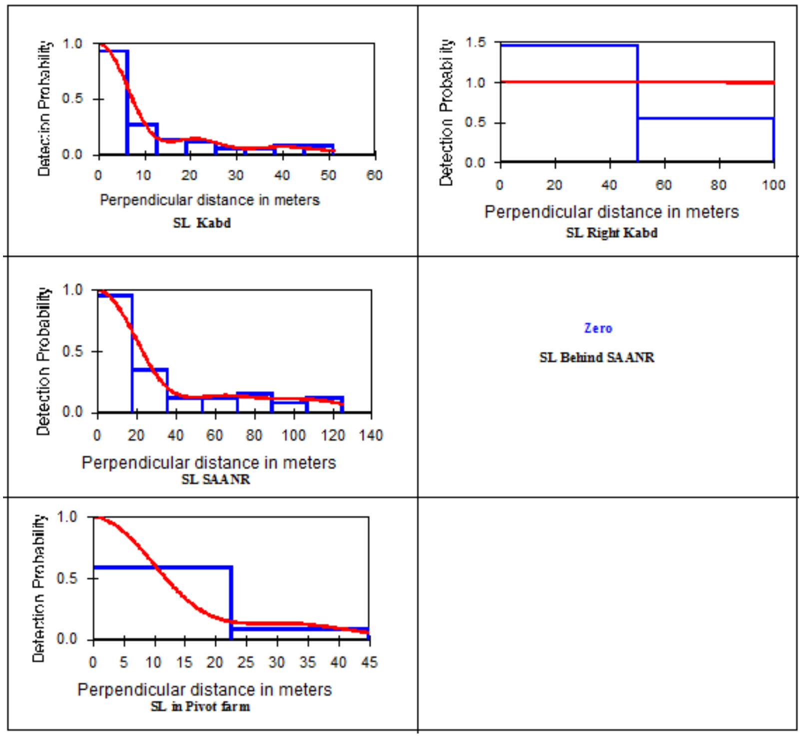


**Figure 2: Detection Functions of Skylarks (SL) in the Five Studied Areas. Probabilities of Observing Larks in Protected Areas (SAANR & Kabd) and Farmland (Pivot) Declined Rapidly with Distance but Stayed Constant or Decreased Only Slightly with Distance in Non-Protected Areas (B-SAANR & R-Kabd). Non-Protected Areas had Higher Detection Probabilities than Protected Areas Due to the Reduced Vegetation Cover of the Former**

More birds were encountered in protected areas during the bird count survey. Protected areas have higher bird species encounters (per survey transect) than non-protected areas Table 1 and 2. In the non-breeding season, encounters of crested larks in Kabd was more than double in R-Kabd, whereas its encounter rate in SAANR was 8 times higher than B-SAANR. In the breeding season, encounter numbers of crested larks in Kabd was equal to R-Kabd while it increased dramatically in SAANR to 21 times higher than B-SAANR.

**Table 1: Bird Species Encounters per Survey during Dec-Jan 2008-09. Each Survey Comprised 4 Traverses of Transect**

| Pivot (10 km) | B-SAANR (25 km) | SAANR (25 km) | R-Kabd (20 km) | Kabd (20 km) | Area Length / Species |
|---|---|---|---|---|---|
| 29 | 4 | 32 | 32 | 81 | Crested lark |
| 8 | 0 | 49 | 11 | 64 | Skylark |
| 0 | 0 | 0 | 0 | 3 | Short-toed lark |
| 0 | 0 | 0 | 0 | 41 | Black crown sparrow lark |
| 0 | 0 | 19 | 0 | 10 | Bar-tail lark |
| 0 | 0 | 6 | 0 | 0 | Greater hoopoe lark |

**Table 2: Bird Species Encounters per Survey during Mar-May 2009. Each Survey Comprised 4 Traverses of Transect**

| Pivot (10 km) | B-SAANR (25 km) | SAANR (25 km) | R-Kabd (20 km) | Kabd (20 km) | Area Length / Species |
|---|---|---|---|---|---|
| 240 | 4 | 87 | 32 | 30 | Crested lark |
| 1 | 0 | 23 | 11 | 15 | Skylark |
| 0 | 0 | 2 | 10 | 0 | Short-toed lark |
| 0 | 0 | 0 | 6 | 9 | Black crown sparrow lark |
| 0 | 0 | 5 | 0 | 2 | Bar-tail lark |
| 0 | 0 | 5 | 0 | 0 | Greater hoopoe lark |

The lower AIC value for detection models g(y) for protected areas and sometimes for non-protected areas were Hazard rate models with cosine, simple polynomial or hermite polynomial adjustments. While AIC supported the choice of Hazard function, other measures of goodness of fit suggested this function led to over estimation of the density of some bird species. Empirical investigation of the density of territorial species such as crested larks and greater hoopoe larks were not compatible with the estimated density generated by the Hazard rate model regardless of the adopted adjustment model. The inadequacy of the Hazard rate models was also revealed by the huge confidence intervals generated in comparison to the half normal. Hence, I excluded Hazard rate models and chose the detection model listed in Tables 3 and 4.

**Table 3: Detection Functions Used in the Studied Areas**

| Species | Area | Type | Detection function |
|---|---|---|---|
| CL | B-SAANR | Simple polynomial | Uniform |
| CL, SL, ShtL, BtL, HL | SAANR | Cosine | Half Normal |
| CL, SL, ShtL, BcSL, BtL | Kabd | Cosine, hermite polynomial | |
| CL, SL | Pivot | Cosine | |
| CL, SL, ShtL, BcSL | R-Kabd | Cosine | |

**Table 4: Density of Passerine Birds per Square Kilometer**

| Season | U 95% | L 95% | Density | AIC | Detection Function/ Adjustment | Area |
|---|---|---|---|---|---|---|
| Winter | 39 | 18 | 26 | 1338.70 | Half normal-cosine | SAANR |
| Spring | 86 | 35 | 55 | 2811.77 | Half normal-cosine | SAANR |

**Table 4: Contd.,**

| | | | | | | |
|---|---|---|---|---|---|---|
| Winter | 517 | 268 | 372 | 2319.35 | Half normal-cosine | Kabd |
| Spring | 171 | 80 | 117 | 2094.89 | Half normal- hermite polynomial | Kabd |
| Winter | 495 | 179 | 298 | 987.57 | Half normal-cosine | Pivot |
| Spring | 388 | 171 | 258 | 3034.56 | Half normal-cosine | Pivot |
| Winter | 64 | 0.5 | 5.6 | 137.76 | Uniform- simple polynomial | B-SAANR |
| Spring | 2 | 0.5 | 1 | 110.46 | Uniform- simple polynomial | B-SAANR |
| Winter | 38 | 14 | 23 | 904.48 | Half normal-cosine | R-Kabd |
| Spring | 2.6 | 0.3 | 1 | 86.95 | Half normal-cosine | R-Kabd |

Breeding and non- breeding seasons did not affect the detection model itself but suggested different adjustments. Half normal was the best candidate detection function for protected areas SAANR &Kabd and the arable land, the Pivot. Non-protected areas B-SAANR and R-Kabd have different detection functions. For both seasons, the best representative detection function for B-SAANR was the Uniform detection function with simple polynomial adjustment. Whereas half normal detection function was used for R-Kabd.

Richness and abundance of lark species were less than expected in most study areas. Only crested larks and black-head finch larks were present in abundance. Crested larks were restricted to SAANR and Pivot while black-crowned sparrow larks were abundant in Kabd.

In non-protected areas only crested larks were seen occasionally, but their densities were very low, only about two individuals in ten $km^2$ square kilometers. Lark density was very low in non-protected areas especially B-SAANR compared with the protected areas Figure 3. B-SAANR was the poorest area where all larks were absent except very low numbers of crested larks. In winter, the highest lark density was in Kabd, being about 228 larks in a $km^2$. Density of skylarks had dropped dramatically seven times and thirty one times in Kabd and Pivot respectively by the summer season.

The arable area, Pivot Farm, had the highest density of crested larks in both winter and summer 68 and 118 individuals in $km^2$ respectively. Density of crested larks in Pivot during winter was twice what it was in Kabd and 14 times that in SAANR. Crested lark density increased in SAANR and Pivot but decreased in Kabd in summer.

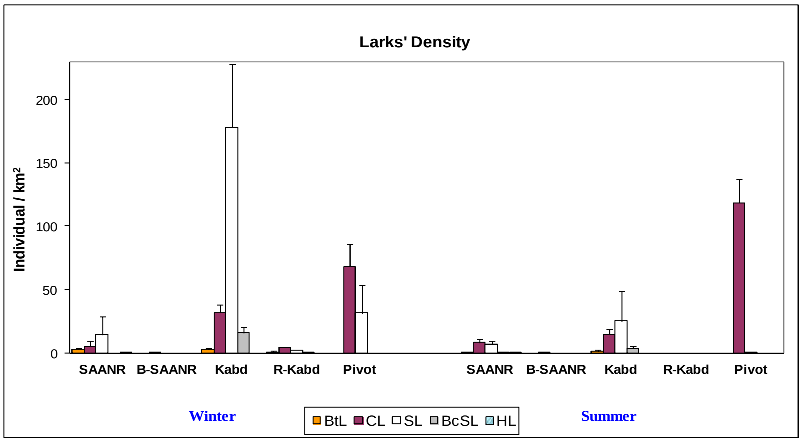


**Figure 3: Density of Different Lark Species in the Five Studied Areas, BtL: Bar-Tail Lark, CL: Crested Lark, SL: Skylark, BcSL: Black-Crown Sparrow Lark, HL: Greater Hoopoe Lark**

Greater hoopoe larks were seen in SAANR only. Their density was very low in the winter and summer season. Black-crowned sparrow larks were observed in Kabd only with low density 4-16 individuals in square kilometers. Bar-tail larks occurred in SAANR and Kabd, but their densities reduced by 40-50% in summer.

Abundance of lark species differed among the studied areas. SAANR has four species of larks: bar-tail lark, crested lark, skylark and greater hoopoe lark. Kabd also had four species of larks similar to SAANR, but instead of greater hoopoe lark it was inhabited by black-crowned sparrow lark. The Pivot had only two species of larks. Skylarks accounted for 64% of larks in SAANR during winter and 43% of larks in summer. In Kabd, skylarks formed the highest proportion of larks in both winter and summer seasons 78% and 56% respectively. In the Pivot, crested larks represented the majority of larks throughout the year. Crested lark density increased from 69% in winter to about 100% in summer.

## DISCUSSIONS

Habitats in Kuwait are heavily influenced by human activities. It is recognized that it is important to conserve natural habitats, but protected areas are limited to one large and four small reserves. It is important that we have a good understanding of the effectiveness of such protection, and of the best ways of protecting and monitoring change in the ecosystems represented. Indicator species are a useful tool in this context (Caro &O'Doherty 1999, Fleishman 2005), and it is well proven that birds are good bio-indicators of the health of habitat ecosystems (Haila 1985, Gregory *et al.* 2003, Gregory *et al.* 2005, Martin & Possingham 2005) and grassland integrity (Browder *et al.* 2002).

This study showed that there were significant differences between richness and density of larks in protected and non-protected areas and also between different protected areas.

An obvious conclusion from the results was the important role of protected areas in the conservation context. As an example, larks' species abundance and density in SAANR were remarkably higher than B-SAANR Figure 4 and 5. Density of crested larks in SAANR was higher than B-SAANR 4 and 9 times during winter and summer respectively. Furthermore, all other larks' species were absent in B-SAANR area in both breeding and non-breeding seasons. Presence of crested larks in B-SAANR was temporary and might be affected by the proximity of niche areas of crested larks in SAANR protected area. However, the few encounters of crested larks in B-SAANR were correlated with accidental foraging in the border of SAANR protected area. The group size of most encounters of crested larks was one individual. Absence of territories, mating signs and nests of crested larks in B-SAANR were a strong evidence of its lower habitat quality.

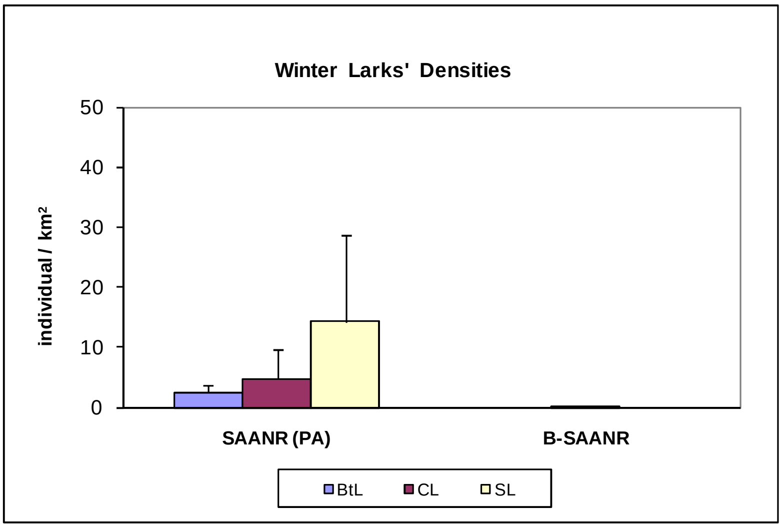


**Figure 4: Density of Lark's Species in Protected Area SAANR and Non-Protected Area B-SAANR during Winter, Non-Breeding Season**

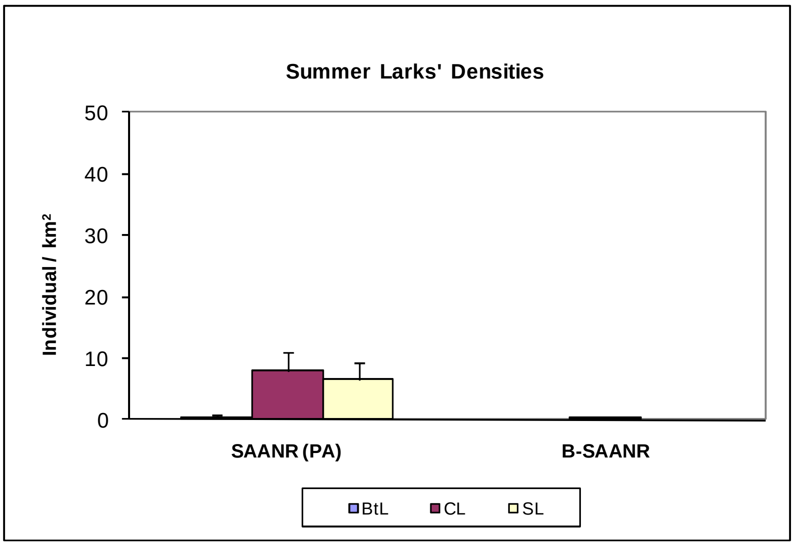


**Figure 5: Density of Lark's Species in Protected Area SAANR and Non-Protected Area B-SAANR during Spring and Early Summer, Breeding Season**

A remarkable difference between larks' density in Kabd and R-Kabd during winter and summer Figure 6 and 7 was evident. Density of skylarks in Kabd was higher than R-Kabd by 170 times during winter. Black-crown sparrow larks and bar-tail larks densities in Kabd were 40 and 20 times higher than R-Kabd during winter respectively. During summer, this difference declined especially for skylarks species which start migrating out of Kuwait after spring. However, density of larks in Kabd was also higher than R-Kabd in summer where skylarks and crested larks density were 30 and 20 times higher than R-Kabd respectively.

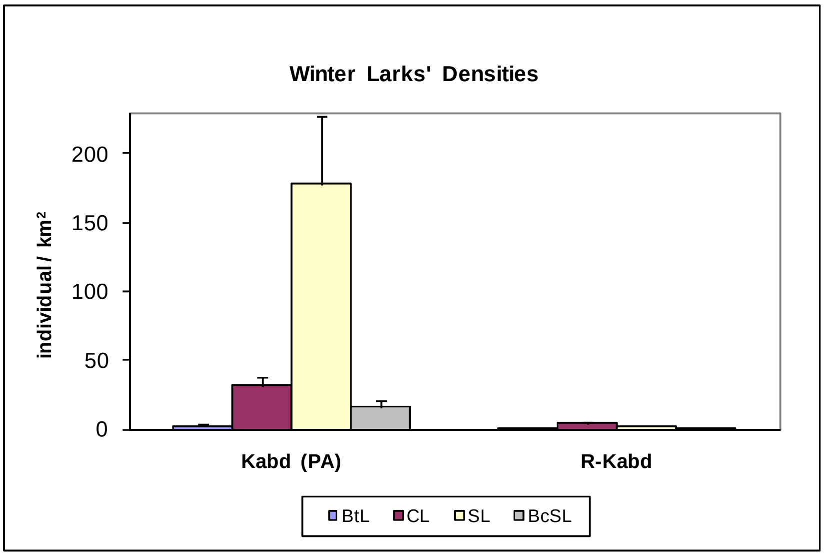


**Figure 6: Density of Lark's Species in Protected Area Kabd and Non-Protected Area R-Kabd during Winter, Non-Breeding Season**

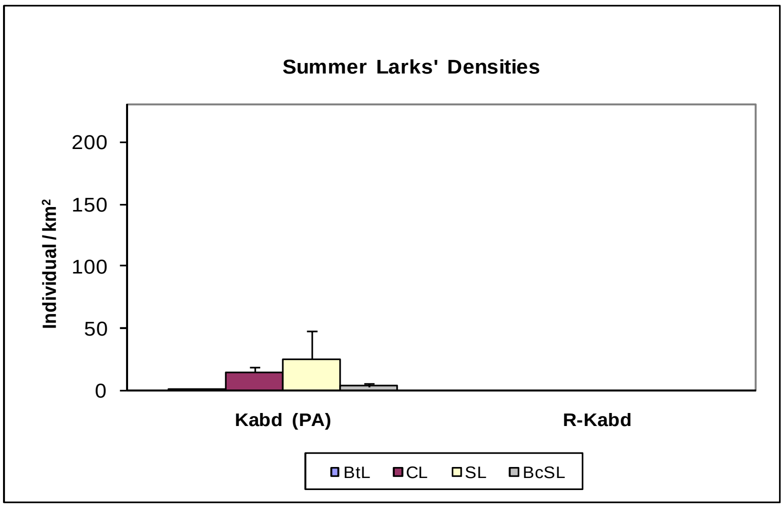


**Figure 7: Density of Lark's Species in Protected Area Kabd and Non-Protected Area R-Kabd during Spring and Early Summer, Breeding Season**

Short-toed lark, lesser short-toed lark and skylark were winter visitors. Desert larks were rare in the study areas. Greater hoopoe lark, crested lark, bar-tail lark and black-head finch lark were resident species spending all the year in the country, where they are adapted to the desert environment. Greater hoopoe lark and bar-tail lark were solitary species foraging and seeking shade alone. Greater hoopoe larks were only found in SAANR, where habitat was open with sparse vegetation cover, notably sandy shrubby and grassy habitats. The vegetation cover is very dense (mostly alfalfa and barley crops) in the Pivot, in comparison to SAANR, and may not suit the greater hoopoe lark's demands. Greater hoopoe larks prefer sparse vegetation cover where they have better foraging access and ability to escape from predators. Some species of *Alaudidae* and ground foragers flee from predators instead of hiding (Wirsing*et al.* 2010). Accordingly, these species prefer stubble fields, short sparse vegetation cover, heath, moorlands, or till lands rather than dense vegetation cover or hedges (Eraud & Corda 2004, Gregory & Baillie 1998) because these all offer high visibility, which facilitates predator detection. Hence, the Pivot farm habitat is suitable for some larks but not for greater hoopoe larks.

Fruits of permanent native plants such as *Citrus citrollus*, which is similar to watermelons, supply greater hoopoe larks with water until mid-summer reducing (but not eliminating) their need to approach water holes. Absence of greater hoopoe larks in Kabd and Pivot may be due to the absence of these plants from these habitats.

Bar-tailed larks occurred in SAANR and Kabd, inhabited ridges with steep slopes. All observations of bar-tailed and greater hoopoe larks comprised only one or two individual records. Bar-tailed larks were not observed around water holes throughout the year, even during summer. Hence, they may drink water from remote sites, or their water demand is low.

In Pivot, fresh vegetation cover (crops) and available water encouraged numerous crested larks to inhabit and breed in such habitats. Aridity of protected areas due to rainfall shortage during 2008-09 discouraged crested larks and other larks from inhabiting these areas during the breeding season. Bird encounter rates in non-protected areas decreased with distance from protected areas. Thus, the few bird species that were recorded in non-protected areas were likely there due to the proximity to protected areas rather than to actual features of the unprotected habitats, which as discussed in the methods shared their broad physical features with protected areas.

Density of skylarks had dropped dramatically (between seven and thirty fold in Kabd and Pivot respectively) by the summer season. This may be due to immigration, where they did not breed in Kuwait, remaining only as a migratory visitor species.

Both crested larks and black-crowned sparrow larks were water-dependent species, but black-crowned sparrow larks may be moreso. Black-head finch larks perhaps preferred Kabd due to its site which is near to some farms rather than SAANR that is located in remote desert far from arable lands. The black-head finch lark is considered as a breeding species in Kuwait. But, there are no data available on their density in Kuwait. Available data are only associated with its presence or nest records in some farms or protected areas (Gregory 2005).

Greater hoopoe larks and bar-tailed larks were observed most often in open desert lands and absent in arable lands, whereas crested larks were abundant in both environments. Larks' encounter numbers were very low in non-protected areas. The study showed a remarkable difference between larks' density within protected and non-protected areas. Non-protected areas were vacant of most larks and other bird species due to habitat degradation (overgrazing and camping) and hunting. The scarcity of greater hoopoe larks and bar-tailed larks in Kuwait is not compatible with IUCN categorization as merely species of low concern. This study suggests greater hoopoe larks density is very low, being seen only in one protected area, SAANR. Abundance of crested larks was less than expected (IUCN 2008) and lower than recorded in the literature (Gregory 2005). The population of crested larks is expected to decline as a consequence of urban expansion, hunting and habitat degradation. This decline in larks' population density indicates the need for an action plan to secure natural habitats.

In conclusion, conservation of natural habitats and biodiversity should be treated as a priority issue in Kuwait national strategy. Human activities should be controlled in order to save habitat lands. It is important to evaluate the effectiveness of protection, and monitoring change in the ecosystems represented. In this context, health of habitat ecosystems and grassland integrity can be measured by good bio-indicator species such as birds.

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