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First evidence of breeding and eastward range expansion of the Mediterranean short-toed lark (*Alaudala rufescens*) in King Abdulaziz Royal Reserve, Saudi Arabia

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Abstract. *Al-Asmari HA, Chedad A, Al-Qahtani AM, Alshammari NM, Altalhi MH, Alzahrani AS, Alkhamis HH, Alowaifeer AM, Alrefaei AF. 2025. First evidence of breeding and eastward range expansion of the Mediterranean short-toed lark (*Alaudala rufescens*) in King Abdulaziz Royal Reserve, Saudi Arabia. Biodiversitas 26: 4048-4056.* We report the first confirmed breeding records of the Mediterranean short-toed lark (*Alaudala rufescens*) in the King Abdulaziz Royal Reserve (KARR), eastern Saudi Arabia. Field surveys conducted during the winter and spring of 2025 documented territorial pairs and fledglings, indicating successful local reproduction. Based on observed chick development and known incubation and fledging periods, egg-laying likely began in mid-March, with juveniles still present in late May, suggesting a prolonged breeding period under favorable spring conditions. This represents a notable eastward expansion of the species' known breeding range, previously limited to western and northern Saudi Arabia, and may drive by ecological or climatic factors such as increased aridity tolerance or changes in habitat availability. Seasonal monitoring revealed high winter abundance (2,387 individuals) followed by a marked decline in spring (296), including an estimated 90 breeding pairs, 45 juveniles, and 70 fledglings, highlighting both temporal dynamics and the effectiveness of mobile transects in detecting desert bird populations. The species displayed notable trophic flexibility: while nestlings fed primarily on soft-bodied invertebrates, adults consumed a broader omnivorous diet including insects and plant matter. These results illustrate the ecological adaptability of *A. rufescens* and emphasize the importance of continued monitoring in arid environments to track range shifts and inform conservation strategies. Additionally, our study confirms the presence of a resident breeding population in the northern sector of the King Abdulaziz Royal Reserve, coexisting with a winter migratory group.

Keywords: Alaudidae, arid habitats, distribution, Mediterranean short-toed lark

INTRODUCTION

Birds are widely acknowledged as effective bioindicators because fluctuations in their population size, reproductive success, and behavioral patterns often mirror the ecological condition of their habitats (Harisha and Hosetti 2009; Schrag et al. 2009; Zhang and Ma 2011; Egwumah et al. 2017; Kurniawan and Ontarian 2017). Additionally, climate change exerts substantial impacts on avian species, particularly by altering their breeding phenology and shifting the distribution of species with narrow geographic ranges (Badis et al. 2024).

Primarily due to their high sensitivity to agricultural conversion, grasslands are among the most vulnerable ecosystems on Earth. Alarmingly, only about 5% of their total area is currently under formal protection, making them the least protected habitat type worldwide (Brooks et al. 2004). As a consequence, grassland bird populations have experienced steeper declines than most other avian groups across North and South America (With et al. 2008; BirdLife International 2010), as well as Europe (Chamberlain and Fuller 1999). This pattern extends to other regions with similar habitats. Owing to these widespread and ongoing declines, grassland birds have been designated as a conservation priority by Birdlife International.

The Alaudidae, sometimes known as larks, are passerine birds in the Sylvioidea superfamily (Alström et al. 2013). This family includes around 100 species distributed across six continents, with the highest diversity found in Africa (hosting nearly 80% of all species) and Eurasia (approximately 40%, with some overlap with Africa). Globally, the family is divided into 24 genera, including the genus *Alaudala*, which encompasses five recognized species (BirdLife International 2022; Gill et al. 2024). In Saudi Arabia, 15 lark species have been recorded across a variety of habitats (Ghamdi et al. 2020), among which is the Mediterranean short-toed lark (*Alaudala rufescens*).

Larks inhabit a wide range of open habitats, including sandy and stony deserts, steppes, tundras, and savannahs (de Juana et al. 2004). Over the past six decades, the number of recognized lark species has increased by nearly 30%, from 76 species listed by Peters (1960) to approximately 100 in recent classifications (Gill et al. 2024). This significant rise is largely due to advances in molecular and vocal analyses, which have revealed considerable cryptic diversity within the family. As a result, several taxa once regarded as subspecies have been elevated to full species status based on consistent genetic, vocal, and morphological differences (Ryan et al. 1998; Ryan and Bloomer 1999; Alström et al. 2023; Guillaumet et al. 2005, 2006, 2008). Notably, most lark species exhibit cryptic plumage, with a strong correlation between their overall coloration and the substrate of their native habitat (Donald et al. 2017).

The Mediterranean short-toed lark is a steppe specialist passerine with a wide distribution across the southern Palearctic, extending from the Canary Islands to northeastern China (del Hoyo and Collar 2016; Christidis 2018; de Juana and Suárez 2019). In North Africa, the species shows a heterogeneous distribution: it is widespread in the Moroccan steppes, rare in Algeria, and relatively common in Tunisia and Egypt. In the Middle East, including Saudi Arabia, it has been reported as scarce to locally common (de Juana et al. 2021). Although detailed population estimates are lacking in much of its range, the global number of mature individuals is believed to exceed 500,000, with total estimates ranging from 500,000 to 999,999 (de Juana and Suárez 2020; BirdLife International 2022, 2025). Previously, *A. rufescens* was considered conspecific with the Urkestan Short-toed Lark (*A. heinei*) and the Asian Short-toed Lark (*A. cheleensis*), under the name Lesser Short-toed Lark (*Calandrella rufescens*). These three taxa were separated following detailed studies that analyzed differences in plumage, morphology, vocalizations, behavior, ecology, and genetic markers (Alström et al. 2021). Molecular phylogenetic analyses led to their reclassification from *Calandrella* to the re-established genus *Alaudala* (Alström et al. 2013). The accepted English name for *A. rufescens* is now the Mediterranean short-toed lark (BirdLife International 2022; Gill et al. 2024).

Traditionally, the breeding range of this species was considered to extendas far east as western Iran and Iraq (Cramp 1988; Porter and Aspinall 2010). However, its breeding status within the Arabian Peninsula, particularly in central and eastern Saudi Arabia, has remained uncertain, with previous observations being anecdotal, scattered, and largely lacking direct evidence of nesting or reproduction (Jennings 2010; BirdLife International 2025). This absence of confirmation has created a clear gap in the species' known breeding distribution.

This study documents the first confirmed breeding of the Mediterranean short-toed lark in central–eastern Saudi Arabia, within the King Abdulaziz Royal Reserve (KARR), where ~90 breeding pairs and numerous juveniles and fledglings were recorded during winter–spring 2025. These records verify local reproduction and point to a recent expansion of the species' breeding range into the interior of the Arabian Peninsula. As a steppe specialist with an important role in fragile desert ecosystems, the presence of *A. rufescens* at KARR underscores the conservation value of arid steppe habitats in Arabia, which may increasingly be used for breeding under ongoing regional climatic and ecological change. This finding is relevant to conservation planning, as steppe habitats and their specialist birds face growing pressures from agricultural intensification and habitat fragmentation (Hofer et al. 2024). The aim of this study is to document this first breeding record at KARR and outline its implications for Palearctic range dynamics.

MATERIALS AND METHODS

Study area

The King Abdulaziz Royal Reserve (KARR), established in 2018 and recently added to the IUCN Green List in 2025, is located roughly 70 km north of Riyadh and covers an area of 28,345 km² across the Riyadh and Eastern Provinces of Saudi Arabia. The reserve has a hot desert climate characterized by extremely hot, dry summers (June-September) and mild, wet winters (November-April), occasionally punctuated by periods of heavy rainfall (Almazroui et al. 2012). The region receives an average annual precipitation of 66 mm (Climate Data 2025), with temperatures ranging from 6.7°C in winter to 42.8°C in summer, and occasionally surpassing 50°C (Weather Spark 2025). According to the Köppen-Geiger climatic classification, the area is classified as a hot desert (World Bank 2024) (Figure 1).

Data collection

To verify the presence of the Mediterranean short-toed lark in the King Abdulaziz Royal Reserve, occurrence data were collected from 20 January to 26 May 2025 using the Progressive Frequency Sampling method (*Échantillonnage Fréquentiel Progressif*, EFP) (Blondel 1975; Bendjoudi et al. 2013; Chedad et al. 2021). Seasonal surveys were conducted in two phases: winter (20 January-20 February) and spring (27 April-26 May), with approximately 9-10 hours of observation per day. Each survey day included 5 hours of morning observation (starting at sunrise) and 5 hours in the evening (ending at sunset). The fieldwork was conducted across various habitat types (including rawdhats, gravel plains, wetlands, palm groves, valleys, and ravines) ensuring representative spatial coverage. The elevation in these areas ranged between 277 and 638 meters.

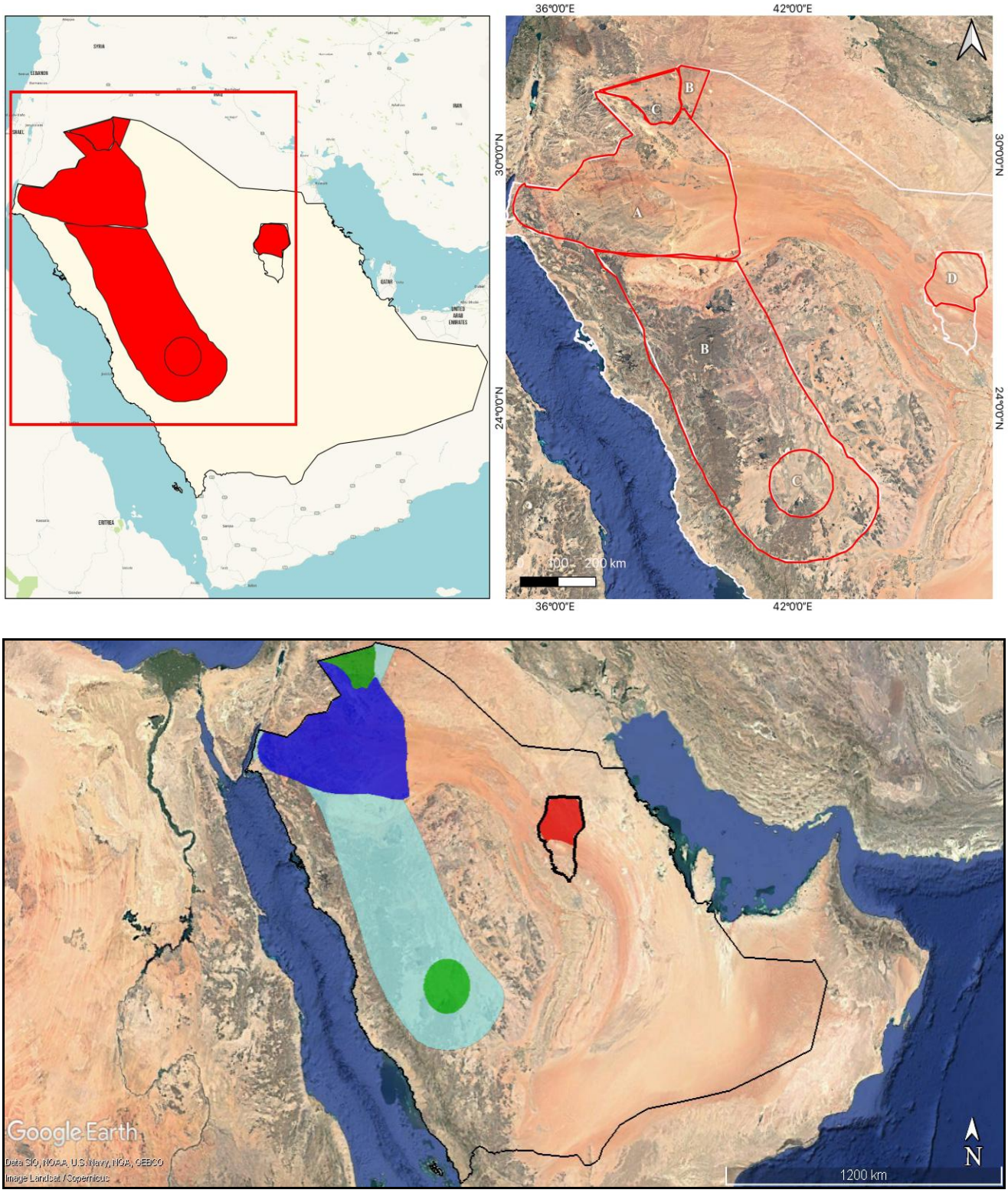

Figure 1. Map showing previous and updated distributions of the Mediterranean short-toed lark (*Alaudala rufescens*) in Saudi Arabia (A. Dark blue: Non-breeding; B. Light blue: Passage; C. Green: Resident; D. Red: Breeding expansion)

Observations were made through direct sightings using a Sony A7R V digital camera equipped with a 200-600 mm lens, supplemented by 10×42 binoculars. Breeding activity was confirmed based on multiple direct indicators, including repeated observations of adult larks feeding fledglings, territorial behavior, and presence of recently fledged juveniles showing limited flight ability. Although nests were not located, the presence of dependent chicks at

different developmental stages, as well as parental care behavior such as food provisioning and alarm calling, provided strong evidence of local breeding. All sightings were geo-referenced, and photographs were taken to document behaviors and age classes, which were determined based on plumage, body size, and other morphological traits, with juveniles defined as birds with fresh juvenile plumage, shorter wings, and a less-developed tail, subadults showing a mix of juvenile and adult plumage with intermediate size and feather development, and adults having full adult plumage and fully developed body size and tail feathers. In our study, we also employed the line transect survey method to cover a broader range of habitats within the reserve. Transects were designed to connect fixed observation points while traversing a variety of environments, including areas of human settlement, waste disposal sites, overhead powerline corridors, and bird stopover and migration stations. Each transect began at the edge of the fixed-point observation zone to avoid data duplication. Observations were conducted on both sides of the transect by two separate teams one monitoring the right side of the vehicle and the other the left within a variable detection width ranging from 250 to 500 meters, depending on the terrain and habitat type. To maximize observation accuracy, vehicle speed was maintained between 25 and 35 km/h, with regular stops approximately every 10 km to allow for detailed scanning using binoculars and cameras. This method is particularly well suited to open and expansive landscapes. The data collected through these transects provide valuable insights into species distribution and abundance within the study area, relying on the assumption that all birds present along the transect path can be detected (Buckland et al. 2005; Chandler 2019).

The data were analyzed using descriptive statistics to summarize total counts and seasonal distributions. Relative abundance for each habitat type was calculated as the proportion of individuals observed relative to the total number of birds recorded. Seasonal comparisons between winter and spring were performed to assess changes in habitat use, population structure, and age class composition. All analyses were conducted in R statistical software (version 4.3.0) to ensure reproducibility and transparency.

RESULTS AND DISCUSSION

During the study period from 20 January 2025 to 26 May 2025, 79 fixed observation points and 102 mobile transects were established and distributed across the entire territory of the reserve over the course of the two study seasons.

Habitat use

During the winter season, a total of 2,387 individuals of the species were recorded across the King Abdulaziz Royal Reserve, comprising 255 individuals from 7 fixed points and 2,132 from 23 mobile transects. These data highlight the superior efficiency of mobile transects, particularly in detecting species across heterogeneous landscapes or when bird density is spatially variable. A sharp decline was observed in the spring, with only 296 individuals detected (98 at 9 fixed locations and 188 along 16 transects), indicating a dramatic 88% reduction in overall abundance. This seasonal contrast reflects broader ecological processes, including migration dynamics, breeding behavior, and changes in detectability or habitat suitability.

From a habitat perspective, five of the twelve biotopes in the reserve showed notable winter occupancy, with Gravel Plains and Khabbab hosting the majority of birds 55.4% and 29.2%, respectively. These biotopes function as key winter refuges, likely due to favorable microclimatic conditions and resource availability during the harsher months. Similar seasonal aggregations in arid and semi-arid systems have been linked to resource pulses, such as rainfall and vegetation greening, which drive habitat selection (Letnic and Dickman 2006). Secondary habitats such as Natural Grasslands, Rocky Plateau, and Al-Rawdah/Al-Faydha played a lesser yet ecologically meaningful role.

Spring data revealed a notable redistribution of individuals across habitats. While overall numbers declined, Gravel Plains and Khabbab experienced the steepest reductions (-94.1% and -96.8%, respectively), indicating that their ecological suitability is highly seasonal. Conversely, Al-Rawdah/Al-Faydha and Rocky Plateau increased in relative importance, hosting 25.9% and 22.0% of spring individuals, respectively (Figures 3.A and 3.B). Natural Grasslands also gained relevance, increasing from 6.7% to 17.1%. These shifts suggest that certain habitats provide more stable or buffered microenvironments during warmer months potentially due to greater vegetation complexity, shade availability, or moisture retention (Figure 2). This pattern supports previous research highlighting the buffering role of habitat structure for bird persistence under extreme conditions in arid environments (Tews et al. 2004; Selwood et al. 2015).

The observed seasonal variations align with broader ecological principles. As emphasized by Samraoui et al. (2023), organismal movement is fundamental to both ecology and evolution, and understanding the selective forces shaping spatial population structures is essential for conservation. The dramatic shifts in abundance and habitat preference underscore the influence of multiple factors environmental, biological, historical, and anthropogenic on species distribution, as outlined by Lomolino et al. (2006). Moreover, these findings support the concept of migration as an evolutionary adaptation that enables species to exploit fluctuating resources and avoid temporarily adverse conditions (Dingle and Drake 2007). Recent empirical studies further emphasize the role of fine-scale habitat complexity in supporting arid-zone bird diversity and facilitating seasonal redistribution (Bird et al. 2014).

In particular, the consistent role of Al-Rawdah/Al-Faydha across seasons highlights its potential as a refuge habitat, offering year-round stability amidst a broader landscape of seasonally variable habitats. This distinction between permanent and temporary habitat roles carries important implications for conservation planning, emphasizing the need to protect them to maintain overall

ecological functionality and support species with diverse movement strategies, including partial or complete migrants.

Habitat structure plays a pivotal role in mediating reproductive success. Open habitats with sparse vegetation are often favored by steppe birds, as they enhance predator detection and foraging efficiency while reducing ambush risk (Martínez-Morales 2005). However, such open environments can also expose nests to aerial or opportunistic predators, especially where ecological imbalances or human disturbances alter predator populations. From a biogeographical perspective, species such as the Mediterranean short-toed lark and Thekla's Lark are recognized as key indicators of steppe habitat integrity. In Catalonia (NE Spain), for example, around 1,000 pairs of the Mediterranean short-toed lark are distributed across two fragmented populations one in Lleida province and another in the Ebro Delta separated by over 100 km (Gordo and Antón 2021). Such spatial fragmentation emphasizes the importance of landscape-scale conservation strategies to maintain connectivity and suitable breeding grounds for these habitat specialists.

Nesting observations

Despite thorough field efforts, no nests containing eggs were found during the study. This absence is likely due to a combination of factors, including the vast survey area, dense vegetation hindering visual detection, and potentially low nesting density. These challenges are common when studying cryptic, ground-nesting birds in arid environments and do not necessarily indicate a lack of nesting activity. Similar difficulties in nest detection have been widely reported in steppe birds, particularly under dense herbaceous cover or patchy terrain (Suárez and Manrique 1992).

A total of 296 individuals were documented, including approximately 90 breeding pairs, 45 juveniles, and 70 fledglings. The relatively low number of fledglings observed, compared to what would be expected based on the apparent adult population, suggests substantial reproductive losses—possibly due to predation or ecological constraints. As with many Alaudidae, the Mediterranean short-toed lark is vulnerable to a wide range of predators, including corvids, mammals, and reptiles (Suárez and Manrique 1992; Suárez et al. 1993; Yanes et al. 1996; Hódar 2006; Bravo et al. 2020). Predator composition appears to vary across sites and years (Suárez et al. 2005), indicating that predation risk is not uniform but context-dependent.

Studies in similar habitats have identified domestic dogs (*Canis familiaris*) and red foxes (*Vulpes vulpes*) as primary nest predators, along with snakes (various species), ocellated lizards (*Timon lepidus*), hedgehogs (*Erinaceus europaeus*), and Iberian grey shrikes (*Lanius meridionalis*) (Suárez and Manrique 1992; Yanes 2000). The consistent identification of multiple predator species reinforces the notion of high predation pressure on open-nesting steppe birds. This pressure likely drives the evolution of highly concealed nest placement and selective habitat use—strategies that, while enhancing nest survival, also complicate detection during field studies (Tieleman et al. 2008). Moreover, meta-analyses suggest that ground-nesting birds in Mediterranean and steppe ecosystems show significantly lower nesting success than shrub- or cavity-nesting species, largely due to predation pressure (Kubelka et al. 2018, 2019). In addition, high ambient temperatures may further reduce breeding success, particularly in habitats with sparse vegetation cover, where microclimatic buffering is limited.

Morphologically, adults are well-camouflaged, displaying sandy and pale brown plumage with fine streaks and spots suited to arid environments. Juveniles exhibit even denser and darker spotting, enhancing concealment in rocky or sandy terrain. Chicks are covered in speckled down that provides both thermal insulation and effective camouflage, which are key to survival in open habitats (Figures 3.E and 3.F).

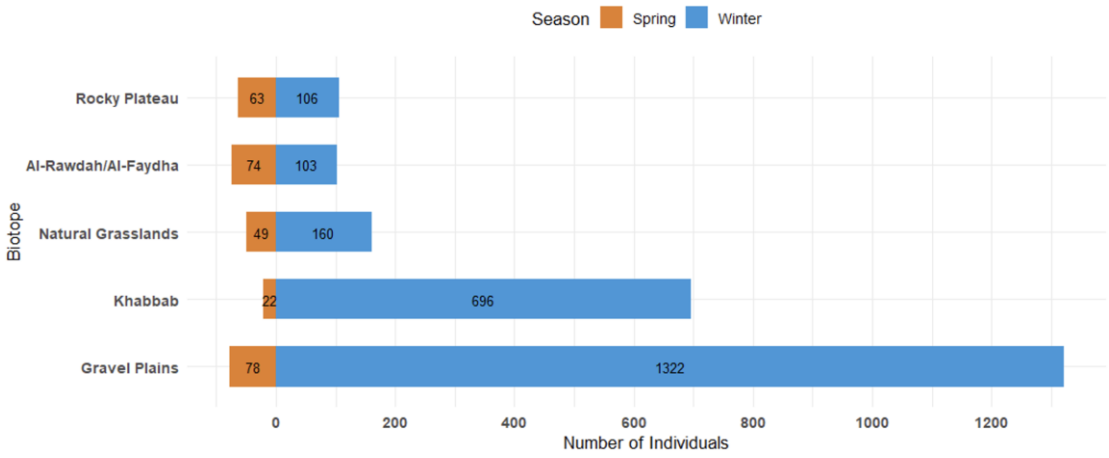

Figure 2. Seasonal variation of abundance across biotopes

Figure 3. Mediterranean short-toed lark (*Alaudala rufescens*). A-B: Species' biotope, C-D: Individuals foraging, E: Juveniles, F: Fledgling

Breeding behavior

Based on an estimated incubation period of 13-14 days and a fledging period of approximately 15 days (Suárez et al. 2009), along with the observation of fledged juveniles approximately 10 days post-fledging, egg-laying likely began in mid-March. This timing is consistent with phenological data across the species' range. In the Atlantic Sahara, breeding begins as early as January and can continue through late April (Bergier et al. 2022); in the Canary Islands, it mainly occurs from February to May, with some broods extending into June (Martín and Lorenzo 1981). In North Africa, including Morocco, Algeria, and Tunisia, egg-laying generally occurs from early April to early June (Heim de Balsac and Mayaud 1962; Bergier et al. 2022), while in southeastern Spain (Almería), breeding typically begins in late March or early April and extends into June (Suárez et al. 2005, 2009).

Field observations conducted in early May revealed active parental care, with adults feeding their offspring at various developmental stages-from dependent nestlings to fledglings capable of short flights. This behavioral evidence confirms ongoing reproductive activity and provides a snapshot of the breeding timeline. In total, 296 individuals were recorded (approximately 90 pairs), including 45 juveniles and 70 fledglings. Such diversity in developmental stages suggests a prolonged and possibly asynchronous breeding season, likely shaped by local environmental factors such as temperature variability and prey availability.

Feeding strategies during this period reflect notable ecological flexibility. Nestlings and young fledglings were primarily fed soft-bodied invertebrates such as caterpillars and larvae, which are rich in protein and easy to digest. As the juveniles mature, their diet diversifies, signaling a progressive shift toward foraging independence. Adults exhibit an omnivorous diet, favoring ground-dwelling arthropods (beetles, ants, butterflies, spiders, and grasshoppers) while also consuming seeds or plant matter opportunistically when insect prey is scarce (Figures 3.C and 3.D). This trophic adaptability is critical for coping with seasonal and spatial fluctuations in food availability, especially in resource-limited steppe environments.

Diet composition was assessed through direct visual observation, a method particularly effective in open habitats where foraging behavior is easily observable. Unlike more invasive or delayed methods such as fecal or pellet analysis, visual observation allows for real-time documentation of prey capture and feeding patterns (Blagosklonov 1987; Chedad et al. 2021), contributing to a more accurate ecological profile of the species.

In Saudi Arabia, the species exhibits both resident breeding and winter-visiting statuses, reflecting its adaptive strategy to local environmental conditions. According to BirdLife International (2022), resident behavior has been documented in the western region, particularly in Taif, as well as in the northern region, specifically in Turaif.

Evidence of fledging

The presence of fledged juveniles observed in the field, particularly the 70 fledglings recorded in May, provides direct evidence of successful reproduction during the season. Some fledglings were already capable of short flights, while others remained dependent on parental provisioning. The observation of this range of

developmental stages confirms both the reproductive viability of the local population and the ongoing success of at least a subset of nesting attempts. When considered alongside the total count of 296 individuals and 45 juveniles, the age structure of the population suggests a staggered and extended fledging period, likely reflecting environmental heterogeneity and asynchronous nesting cycles. Such temporal spreading of fledging is a known reproductive strategy in open-habitat passerines to mitigate predation risk and buffer environmental unpredictability (Halliwell et al. 2023). This strategy may increase reproductive success by spreading predation risk and optimizing chick development in relation to fluctuating food resources.

However, the total number of fledglings remains relatively low compared to the number of adult pairs, implying that post-hatching mortality (possibly due to predation, harsh climatic conditions, or food scarcity) remains a significant limiting factor. Study such as those by Halliwell et al. (2023) on whinchats *Saxicola rubetra* on forest passerines show that fledglings are especially vulnerable in their first two weeks, with survival often linked to vegetation structure and foraging conditions.

These observations reinforce the importance of microhabitat features, such as vegetation cover and prey density, in shaping fledgling survival. Species like the Golden-winged warbler *Vermivora chrysoptera* (Peterson et al. 2016) demonstrate that fledglings preferentially select microhabitats with intermediate vegetation density, providing both cover and prey accessibility.

Despite these challenges, the confirmation of fledged young in various developmental stages suggests that suitable conditions exist locally to support breeding and recruitment. This underlines the conservation value of structurally heterogeneous habitats, as emphasized by multiple post-fledging survival studies (Cox et al. 2014; Peterson et al. 2016). Maintaining such features is key to enhancing juvenile survival and population persistence.

In contrast, in central and eastern Saudi Arabia, the species was previously considered only a rare winter visitor, with a single record in April 1999 between 1999 and 2009 (Jennings et al. 2009). However, our study confirms the presence of a resident breeding population in the northern sector of the King Abdulaziz Royal Reserve, alongside a winter migratory group. This finding represents a significant extension of the known breeding range and underscores the species' regional conservation importance

In conclusion, the confirmed range expansion and breeding activity of the Mediterranean short-toed lark in the northern sector of the King Abdulaziz Royal Reserve represent an important observation for avian conservation in Saudi Arabia. These observations provide vital insights into the species' shifting distribution and reinforce the ecological importance of the reserve as a reproductive refuge within arid steppe habitats. The presence of juveniles and recently fledged young highlights successful breeding, yet the relatively low fledgling-to-pair ratio suggests high post-hatching mortality, likely due to predation or environmental constraints. These findings emphasize the need to incorporate breeding performance into long-term biodiversity monitoring frameworks and align well with national wildlife policies under Saudi Arabia's Vision 2030. To ensure population sustainability, targeted monitoring during the breeding season, refined nest detection techniques, and habitat-specific management strategies (particularly those enhancing microhabitat quality for fledglings) are strongly recommended.

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