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Original Article

Morphology, Diet Composition, Distribution and Nesting Biology of Four Lark Species in Mongolia

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Abstract

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We aimed to enhance existing knowledge of four lark species (Mongolian lark, Horned lark, Eurasian skylark, and Lesser short-toed lark), with respect to nesting biology, distribution, and diet, using long-term dataset collected during 2000–2012. Nest and egg measurements substantially varied among species. For pooled data across species, the clutch size averaged 3.72 ± 1.13 eggs and did not differ among larks. Body mass of nestlings increased significantly with age at weighing. Daily increase in body mass of lark nestlings ranged between 3.09 and 3.89 gram per day. Unsurprisingly, the majority of lark locations occurred in steppe ecosystems, followed by human created systems; whereas only 1.8% of the pooled locations across species were observed in forest ecosystem. Diet composition did not vary among species in the proportions of major food categories consumed. The most commonly occurring food items were invertebrates and frequently consumed were being beetles (e.g. Coleoptera: Carabidae, Scarabaeidae, and Curculionidae) and grasshoppers (e.g. Orthoptera: Acrididae), and their occurrences accounted for 63.7% of insect related food items. Among the five morphological traits we measured, there were significant differences in wing span, body mass, bill, and tarsus; however tail lengths did not differ across four species.

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Introduction

The larks (*Alaudidae*) are a speciose family of small to medium-sized, cryptically plumaged, primarily terrestrial passerines (de Juana *et al.*, 2004). The family Alaudidae is comprised of 5 genera with 9 species of larks currently recognized in Mongolia (Gombobaatar & Monks, 2011). In Mongolia, larks are found in a wide variety of habitats ranging from deserts to steppes and high altitude mountainous areas. While the Mongolian lark and horned larks are resident breeders, lesser short-toed lark and Eurasian skylarks are considered as breeding visitor (Gombobaatar & Monks, 2011). Red (*Vulpes vulpes*) and corsac foxes (*V. corsac*), Halys viper (*Gloydius halys*) prey upon eggs and young chicks in the nests (Gantulga, 2006; Gombobaatar & Gantulga, 2008). They are one of main prey items of the raptors particularly saker falcon (*Falco cherrug*; Gombobaatar, 2013).

The global population of four larks are approximately 10 million – 1 billion mature individuals within estimated ranges of 26–33 million km^2 (BirdLife International, 2013); however, there are no population estimates for these species in Mongolia. Although the four lark species are subject to habitat loss and degradation by livestock, steppe fire, drought and mining, they have been assessed as a Least Concerned by IUCN regional assessment owing to its common occurrence and wide distribution across Mongolia (Gombobaatar & Monks, 2011). Specific conservation measures have not been implemented for those species and approximately 6.3–12.9% of their ranges in Mongolia occur within protected areas. The population trends of the lark species appear to be stable, with the exception of the lesser short-toed lark, which is unknown (Gombobaatar & Monks, 2011).

The majority of ornithological research on larks in Mongolia to date focused on resolving taxonomic debates and the description of new species or subspecies (but see Mainjargal, 2005, 2007; Gantulga, 2006). A thorough understanding of biology and ecological requirements is essential for effective management of a species and also for conservation planning. Larks are some of the most mobile passerines and most species are nomadic or migratory to varying extents. This makes it difficult to study their biology and ecology. In this study we aim to address these shortcomings by collating and supplementing all existing knowledge of the species and by presenting new information about various aspects of the breeding biology and ecology of four lark species (Mongolian lark *Melanocorypha mongolica,* Horned lark *Eremophila alpestris*, Eurasian skylark *Alauda arvensis*, and Lesser short-toed lark *Calandrella rufescens*) across their entire ranges in Mongolia.

Study area. Larks prefer open, structurally simple environments with low vegetation, scattered trees and a large amount of bare ground. These habitats allow larks to forage on foot in search of prey and seeds (de Juana *et al.,* 2004). The study area is characterized by gently rolling hills, broad, flat plains (altitude 600–2000 m) and sparsely scattered small ponds and springs. The climate is continental with long, cold winters (January mean = –30^{0}C) and short, warm summers (July mean = 20^{0}C). Warm-season precipitation occurs mainly during summer months (June – August), and overall annual precipitation is generally between 200 and 300 mm (Gunin *et al*., 2000). The steppe is homogeneous in terms of both its topography and vegetation community. Steppe vegetation is mostly dominated by grasses (*Stipa* spp., *Cleistogenes* spp., and *Leymus* spp.), forbs (*Artemesia* spp., *Allium* spp., *Astragulus* spp.), and *Carex* spp. sedges. A few shrubs (*Caragana* spp., and *Prunus* spp.) are present and trees (*Ulmus* spp.) are rare, occurring in isolated pockets (Gunin *et al*., 2000; Tong *et al*., 2004). Mongolia's steppe is one of the world's largest remaining intact grasslands and harbors the greatest concentration of wild ungulates in Asia (Schaller, 1998). Nomadic pastoralists live throughout the region, and tend horse, goats, sheep, cattle, and camels. The biomass production of the Mongolian steppe is the basis for the nutrition of millions of livestock, which in turn are the livelihood basis of the country's rural population.

Materials and Methods

Nests of the four species were searched for throughout the breeding season at each study site. The nest-searching effort was, as far as possible, similar for every study field over the season. Nests were found both by searching the study area systematically and by observing parental cues (e.g. adults carrying nesting materials and food to nestling) during the nestling period. When a nest containing eggs was found, the following data were recorded: clutch size, egg length and width using a digital caliper (0.1 mm). Clutch size was calculated as the sum of eggs and newly hatched chicks in the nest at the time it was found, which was within a day of hatching. It was assumed that eggs were not predated singly. A total of 37 eggs from 9 Eurasian skylark nests, 32 eggs from 9 Mongolian lark nests, 22 eggs from 6 Horned lark nests and 15 eggs from 5 Lesser short-toed lark nests were measured. In addition, diameter and depth of all nests (n = 31) for each species were measured using a ruler (0.1 mm). To understand growth rate of chicks, body mass of nestlings was measured on daily basis until they leave the nest, using portable digital scale (to the nearest 0.1g).

Mist nets were set opportunistically along drainages and other narrow areas deemed appropriate to catch birds. The net was set and then checked at least once an hour. All captured birds were banded with an aluminum band. Birds were identified by age and sex using plumage, breeding condition, feather wear and molt limits (DeSante *et al*., 2008). A total of 540 adult birds were captured and measured for morphological characteristics. We measured tail length, wing span (to the nearest 1 mm by using a ruler), tarsus length, beak (to the nearest 1 mm by using a caliper), and body mass (to the nearest 0.1g).

Diet composition was determined by analysis of stomach contents for 170 birds (i.e. 81 Eurasian skylark, 49 Horned lark, 26 Mongolian Lark, and 14 Lesser short-toed larks). Birds were collected during 1976–2012, with permission from the Institute of Biology, Mongolian Academy of Sciences. Our sampling efforts were confined mostly to spring, summer, and early autumn seasons across years. Stomachs were placed in 70% alcohol and labeled. In the laboratory, their contents were sorted, counted, and identified to order or family level. Frequency of occurrence was calculated as the proportion of stomachs a given category expressed as a percentage of the total number of stomachs analyzed. Three main groups of food items were distinguished in the diet of larks such as plant seeds, insects, and others (i.e. stone and sand particles).

We recorded the locations of lark sightings opportunistically and those of birds captured in mist-netting. During 2000–2012, we opportunistically collected a total of 364 locations for Eurasian skylark, 458 locations for Mongolian lark, 375 locations for Horned lark, and 64 locations for Lesser short-toed lark. To determine habitat preference, we overlaid GPS locations of larks onto the ecosystem map (21 ecosystems) produced by World Wildlife Fund for Nature's Mongolia Program Office (WWF Mongolia, 2010) using ArcGIS 10.0 (Fig. 1). Using extraction tool in the Spatial Analyst toolbox, ArcGIS 10.0 we extracted ecosystem values for each locations. We further classified the ecosystem map into 7 natural zones such as an aquatic (perennial rivers and floodplains), desert (semi-desert and true desert), forest (boreal coniferous and sub-boreal mixed forests), high mountains (Alpine meadow, high mountain steppe, and sub-alpine woodland), human created systems (agricultural land and industrial and urban areas), patch ecosystems (closed depressions, salt banks, intermittent rivers and ephemeral channels, and sand dunes), and steppe (desert steppe, dry steppe, meadow steppe, and moderate dry steppes).

Clutch size, nest and egg measurements were tested for differences among species using one-way ANOVA. Mean value of each measurements (e.g. clutch size, measurements of nest and egg dimensions) for each nests were included in the analyses as an unit. We also used one-way ANOVA to compare the morphological traits (tail length, wing span, tarsus, beak, and body mass) among lark species. The morphological measurements further compared between sexes using *t*-test to determine if there is sexual dimorphism exists. Linear regression was used to examine the nature of the relationship between nestling body mass (e.g. growth rate) and age at weighing. Using regression equation, we calculated daily body mass gain in lark nestlings for each species. Relationships between nestling growth rates and clutch size, and nest dimensions were also examined using linear regression to determine if growth rates of nestlings associated to food limitation (e.g. higher clutch size experience slower growth rate due to greater food limitation) or nest predation risk (e.g. larger nest size cause

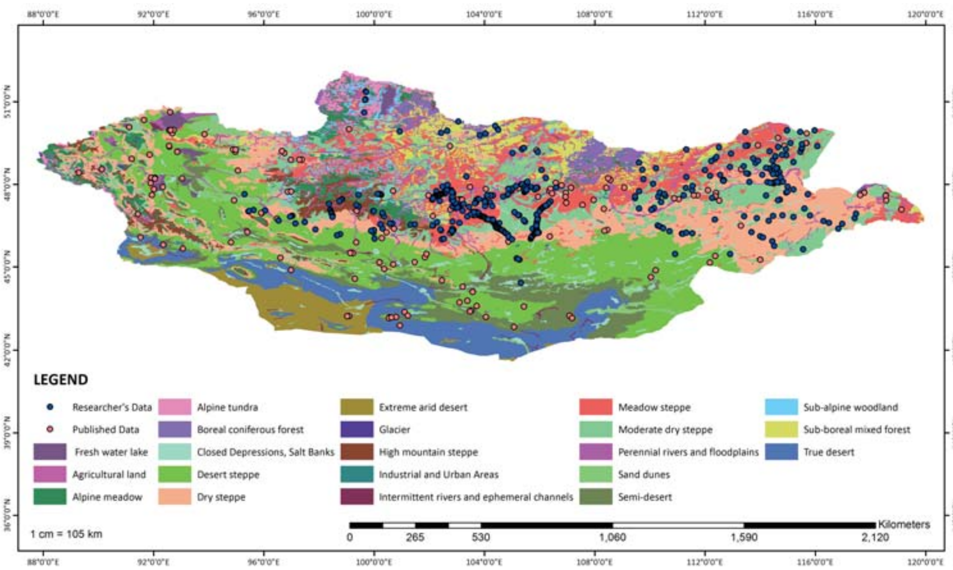

Figure 1. Distribution of larks overlaid onto the ecosystem map in Mongolia.

increased delectability to predators; Martin *et al*., 2011). We tested whether locations of each species occurred more frequently than expected by chance in different natural zones using chi square test (Sokal & Rohlf, 2000). Diet composition of four species tested for difference using the chi square test as well. For all measurements, means are reported with standard deviation (SD). All statistical analysis was done using MINITAB 16.0 statistical software.

Results

Nest diameter was substantially varied among lark species (df = 26, F = 25.71, p < 0.001). Similarly, there was a significant difference in average nest depth among larks species (df = 25, F = 5.68, p < 0.005), with greatest for Horned lark (5.70 ± 0.68 mm) and smallest for Eurasian skylark (3.60 ± 1.77 mm). Interestingly, an average diameter of Horned lark nests were the smallest, but were the greatest in depth among four species (Fig. 2). The clutch size was averaged 3.72 ± 1.13 eggs (range = 1 – 5, n = 108) for four larks (Mongolian lark: 3.56 ± 1.51, Eurasian skylark: 4.11 ± 1.17, horned lark: 3.67 ± 0.52, and lesser short-toed lark: 3.40 ± 0.89), and did not differ among species (df = 28, F = 0.53, p < 0.66). There were, however, significant differences in mean lengths (df = 28, F = 32.06, p < 0.001) and widths (df = 28, F = 24.12, p < 0.001) of eggs among species (Fig. 3). A linear regression revealed that the mean clutch size did not associate with adult body mass (r^2 = 0.03; n = 4, p = 0.93) of four larks.

Body mass of lark nestlings increased significantly with age at weighing (Lesser short-toed lark, r^2=0.90, p < 0.001, mass = 0.85 + 2.24 days; Mongolian lark, r^2=0.98, p < 0.001, mass = – 0.08 + 3.97 days; Horned lark, r^2=0.99, p < 0.001, mass = 0.481 + 2.75 days; Eurasian skylark, r^2=0.99, p < 0.001, mass = 0.591 + 2.92 days; Fig. 4). Daily increase in body mass of lark nestlings calculated from the regression equations was averaged 3.43 ± 035 g/day (Lesser short-toed lark 3.09g/day; Mongolian lark 3.89 g/day; Horned lark 3.23 g/day; Eurasian skylark 3.51 g/day, respectively). Across larks species, there was no relationship between nestling growth rates and clutch size (r^2 = 0.05; n = 4, p = 0.76). However, the growth rate positively associated with the diameter of lark nests among species (r^2 = 0.81; n = 4, p < 0.05). In other words, growth rates (i.e. daily increase in body mass) of nestlings were higher for the larks that built nests with larger diameters (e.g. a risk of delectability to predators is greater).

The number (proportion) of the lark locations occurred in different ecosystems shown in Table

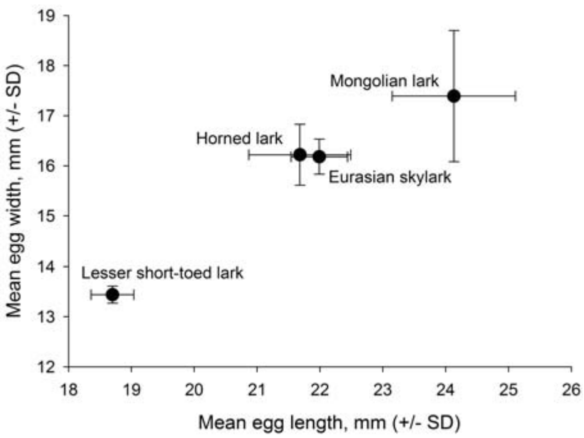

Figure 3. Mean (± SD) lengths and widths of all eggs measured for four species of larks in Mongolia

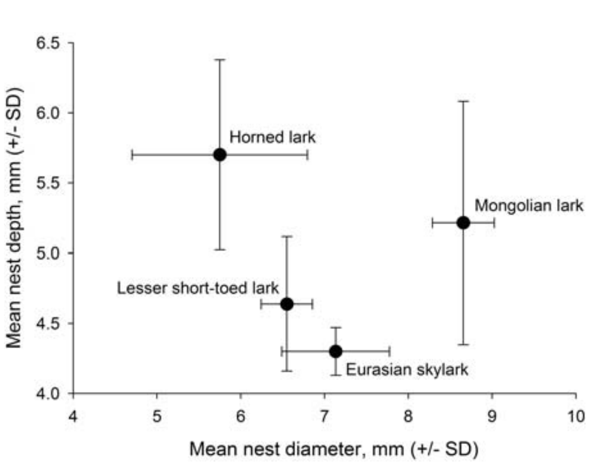

Figure 2. Mean (± SD) diameters and depths of all nests measured for four species of larks in Mongolia

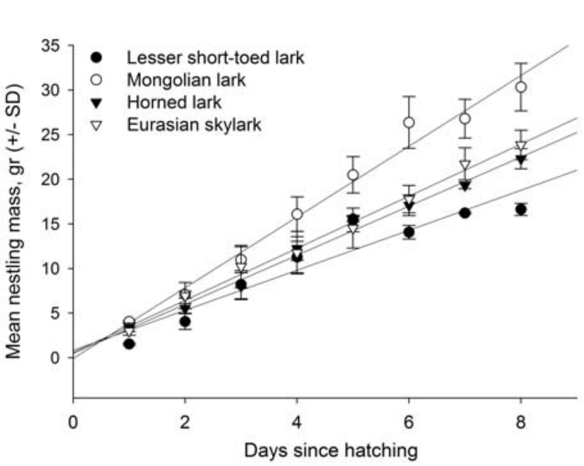

Figure 4. Nestling growth rates of four larks in Mongolia

Table 1. Distribution of larks in relation to different habitas in Mongolia.

Habitats	Mongolian lark	Horned Lark	Eurasian skylark	Lesser short-Toed lark	Total
Aquatic	23 (5.0)	22 (5.9)	26 (6.9)	3 (4.7)	92 (5.9)
Desert	9 (2.0)	21 (5.7)	3 (0.8)	24 (37.5)	65 (4.2)
Forest	7 (1.5)	6 (1.6)	9 (2.4)	0 (0.0)	28 (1.8)
High mountain	21 (4.6)	14 (3.8)	7 (1.9)	4 (6.3)	56 (3.6)
Human created systems	72 (15.7)	30 (8.1)	64 (17.1)	14 (21.9)	221 (14.1)
Patch ecosystems	14 (3.1)	16 (4.3)	11 (2.9)	4 (6.3)	55 (3.5)
Steppe	312 (68.1)	261 (70.5)	255 (68.0)	15 (23.4)	1050 (67.0)
Sum	458	370	375	64	1567

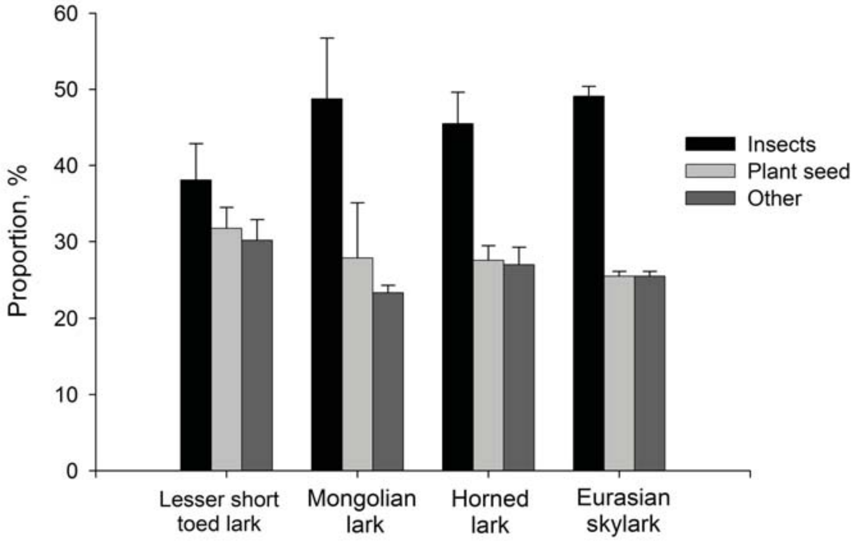

Figure 5. Diet composition of four lark species in Mongolia.

1. The majority of lark locations occurred in steppe ecosystems for all species (e.g. 68.0–70.5%), with the exception of the Lesser short-toed lark (Table 1). For pooled data across four species, the majority of locations were observed in steppe ecosystem (67.0%), followed by human created systems (14.1%); whereas only 28 locations (e.g. 1.8% of the total) were observed in forest ecosystem (Table 1, Fig. 1). Lark locations occurred more than expected in steppe zone as oppose to the other natural zones (χ^2 = 121.6, *df* = 18, $p < 0.001$).

Diet composition did not vary among species in the proportions of major food categories consumed (χ^2 = 3.67, *df* = 6, p = 0.72; Fig. 5). The most commonly occurring food items were insects (Lesser short-toed lark 38.1%, Mongolian lark 48.76%, horned lark 45.5%, and Eurasian sky lark 49.10%), followed by plant seeds (Lesser short-toed lark 31.7%, Mongolian lark 27.9%, horned lark 27.5%, and Eurasian sky lark 25.4%), and others (Lesser short-toed lark 30.2%, Mongolian lark 23.4%, horned lark 27.0%, and Eurasian sky lark 25.4%; Fig. 5). All lark species frequently consumed beetles (e.g. Coleoptera: Carabidae, Scarabaeidae, and Curculionidae) and grasshoppers (e.g. Orthoptera: Acrididae), and the occurrence of these insects was 63.7% of insect related food items.

A clear sexual dimorphism observed for Horned larks as males had greater wing span (t = -4.74, $p < 0.001$), longer tail (t = -3.41, $p < 0.001$), and heavier body mass (t = -2.07, $p < 0.04$; Table 2). Among the five morphological traits, only body mass were differed between sexes for Mongolian lark (t = -2.27, $p < 0.007$) and Eurasian skylarks (t = -1.94, $p < 0.02$), and males weighed were heavier than females for both species. However, none of traits did not differ between male and female individuals of the Lesser short-toed lark (Table 2). When we compare these five morphological traits among four lark species, there were significant

Table 2. Sex-specific comparison of morphological measurements (all measurements represented in cm, except the body mass which is represented in gram) for four species of larks in Mongolia.

Species	Measurements	Female		Male		Difference	
		Mean + SD	n	Mean + SD	n	*t*	*p*
Horned lark	Wing span	30.20 + 3.65	29	32.84 + 1.59	60	–4.74	0.001**
	Body mass	30.15 + 3.14	32	31.81 + 3.91	61	–2.07	0.04*
	Bill	9.00 + 2.64	3	9.87 + 0.64	8	–0.94	0.18
	Tarsus	2.30 + 0.72	3	1.92 + 0.12	8	1.54	0.07
	Tail	6.76 + 0.89	15	7.70 + 0.80	25	–3.41	0.001**
Mongolian lark	Wing span	38.56 + 2.46	25	39.40 + 2.21	58	–1.53	0.06
	Body mass	53.21 + 8.06	29	56.58 + 5.69	61	–2.29	0.007**
	Bill	1.64 + 0.16	9	1.54 + 0.18	16	1.32	0.09
	Tarsus	2.45 + 0.11	9	2.38 + 0.28	16	0.68	0.25
	Tail	7.81 + 0.59	16	7.69 + 0.55	36	0.69	0.27
Eurasian skylark	Wing span	33.06 + 1.77	23	33.64 + 1.96	38	–1.15	0.12
	Body mass	34.30 + 4.13	25	37.65 + 7.97	41	–1.94	0.02*
	Bill	13.12 + 4.10	25	12.17 + 2.71	42	1.13	0.13
	Tarsus	2.26 + 0.02	25	2.33 + 0.26	41	–1.14	0.12
	Tail	6.69 + 0.35	25	6.78 + 0.53	39	–0.8	0.21
L. short-toed lark	Wing span	29.58 + 1.94	19	29.66 + 2.31	37	–0.14	0.45
	Body mass	23.63 + 2.26	22	24.35 + 1.89	41	–1.34	0.09
	Bill	–	1	9.00 + 0.00	3	–	–
	Tarsus	–	1	1.90 + 0.26	3	–	–
	Tail	6.51 + 0.55	18	6.53 + 0.40	27	-0.09	0.46

differences in wing span (F = 4.54, p < 0.005), body mass (F = 3.2, p < 0.02), bill (F = 6.05, p < 0.001), and tarsus (F = 3.04, p < 0.03): however mean tail lengths did not differ among species (F = 2.08, p = 0.1; Table 3).

Discussion

We found no difference in clutch size among larks, although adult biomass was differed across species. The calculation of clutch size, being based on nest contents at hatching, did not include any correction for partial egg loss or very early chick loss. However, a very few brood losses were observed in this study, and predation pressure was extremely low, so that it is unlikely that the estimates of clutch size were biased. Moreover, the mean clutch size of 3.72 eggs recorded in the present study was close to the average of 3.44 eggs reported in other studies of some larks (Mainjargal, 2005, 2007; Gantulga, 2006). Likewise, mean clutch sizes in our study were very similar to those reported in studies conducted in Europe and North America (Beason, 1995; Poulsen *et al*., 1998). Several factors influence on clutch size such as food abundance, nest predation, population

Table 3. Summary statistics on morphology and body mass of four lark species in Mongolia. Differences in morphological traits among lark species were testing using One-way ANOVA.

Species name	Wing span		Body mass		Bill		Tarsus		Tail	
	Mean + SD	N	Mean + SD	N	Mean + SD	N	Mean + SD	N	Mean + SD	N
L. short-toed lark	23.51 ± 13.83	27	10.72 ± 5.43	18	3.79 ± 0.95	27	2.47 ± 1.72	27	8.11 ± 5.69	24
Mongolian lark	23.11 ± 14.72	27	15.47 ± 8.62	18	5.52 ± 2.02	27	3.56 ± 2.45	27	7.62 ± 7.25	20
Eurasian lark	13.53 ± 5.50	33	12.03 ± 2.76	26	4.21 ± 1.45	33	2.28 ± 1.41	33	5.40 ± 3.75	25
Horned lark	20.21 ± 12.76	33	15.70 ± 7.43	23	4.37 ± 1.66	33	3.54 ± 2.79	33	5.11 ± 3.80	26

density, and female age (Perrins & McCleery, 1989; Decker *et al*., 2012). Unfortunately, we did not collect data for these variables to understand how the clutch size responds to environmental and intrinsic factors. Further, clutch size in larks has been associated with aridity, being smaller in the species inhabiting the most arid environments (Tieleman *et al*., 2004). In the present study, four larks species showed similar patterns in spatial distribution as the majority of their locations being occurred in steppe ecosystem.

Two ecological factors are thought to play key roles in growth rate variation (Arendt, 1997; Dmitriew, 2011). While greater food limitation can serve as a proximate cause of slower growth within species (Richner *et al*., 1989; Naef-Daenzer & Keller, 1999), higher risk of juvenile predation can favor evolution of faster growth to minimize exposure time to predators (e.g. Williams, 1966; Bosque & Bosque, 1995; Remeˇs & Martin, 2002). We found no relationship between nestling growth rates and clutch sizes among four species. Similarly, Shkedy & Safriel (1992) found that an experimental brood reduction did not accelerate the growth rate of the Crested Lark (*Galerida cristata*) and the Desert Lark (*Ammomanes deserti*) nestlings in the Negev desert of Israel. In contrast, growth rates of nestlings did differ in relation to nest diameters (e.g. greater exposure to detection by predations). In Eastern Mongolia, predation accounted for the highest proportion of cause-specific mortalities of larks (Gombobaatar & Gantulga, 2008). It is therefore, suggested that lark species we studied show strategies in response to predation risk whereby food resources are not the primary limit on growth rate differences among species (Martin *et al*., 2011). Food quality can also affect the growth and development of chicks, for example, grey partridge (*Perdix perdix*) chicks fed upon a high protein diet grew more quickly and developed better plumage compared to those reared on a lower protein diet (Southwood & Cross, 2002).

With respect to diet compositions, remains of insects (e.g. invertebrates) were the most frequent, followed by plants/seeds and other items such as stone and sand particles, and this pattern was observed very similar for four species in our study. The invertebrates most frequently recorded in diets may reflect their relative abundance in open landscapes, but no comprehensive measure of their relative abundance exists because of the difficulty in accurately sampling all groups simultaneously. On the other hand, sampling efforts were biased towards to spring and summer seasons, thus it may explain why proportion of the invertebrates was greater in the diet composition. Of the insects, the Coleoptera were important for the greatest number of bird species, along with the Orthoptera. Furthermore, in this study, the Coleoptera contained the greatest number of families that were classified as being important, especially the Carabidae, Scarabaeidae, and Curculionidae being the most commonly consumed. Similarly, invertebrates formed a large part of the skylark diet in summer, the Coleoptera made up 83% of invertebrate remains in the feces (Green, 1978; Holland *et al*., 2006).

Conservation implications

The population trends of four larks considered being stable, however, there are no population estimates available in Mongolia (Gombobaatar & Monks, 2011). Recently, the third campaign of land reclamation was launched in Mongolia, aiming to decrease food imports via re-intensification of agricultural land use (Bayar, 2008). As a result, since 2008 agricultural areas were increased and the size of natural grasslands converted to agricultural lands were expanded (Bulgamaa, 2008). Conversion of natural grasslands into simple and homogenous vegetation may create less suitable habitat for breeding larks in Mongolia, as observed elsewhere in Europe and North America (Shrubb, 1990; Kamp *et al*., 2012). The grassland vegetation heterogeneity is necessary for nesting, as it contributes to higher breeding success (Erdos *et al*., 2009). Secondly, the number of livestock in Mongolia increased steadily over 30 years and such trends cause ecosystem degradation and decreased capacity for the persistence of native species (Berger *et al*., 2013). The livestock grazing is detrimental to birds communities as changing their abundance and diversity (Martin & McIntyre, 2007), as well as it increases trampling and disturbance; hence decreased the suitability for nesting (Pavel, 2004). Consequently, we identify priorities for research, focusing mainly on relationships between bird populations and agricultural practices as well as livestock grazing, but we also recognize a need for a better understanding of the role of predation.

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References

Arendt, J. D. 1997. Adaptive intrinsic growth rates: an integration across taxa. *Quarterly Review of Biology*, 72: 149–177.

Bayar, S. 2008. The Prime Minister of Mongolia—Statement at the *GENERAL DEBATE* of the 63rd Session of the United Nations General Assembly, New York, USA, September 24, 2008.

Beason, R. C. 1995. Horned lark (*Eremophila alpestris*). In: Poole, A., Gill, F. (Eds.), *The Birds of North America*. No. 195. The Birds of North America, Inc., Philadelphia, PA.

Berger, J., Buuveibaatar, B. & Mishra, C. 2013. Globalization of the cashmere market and the decline of large mammals in Central Asia. *Conservation Biology,* 27: 679–689.

Bulgamaa, B. 2008. *Bumper Crops for Mongolia This Autumn*. UB Post, Thursday, July 31, 2008. http://ubpost.mongolnews.mn/index.php (accessed 01/2009).

BirdLife International. 2013. *IUCN Red List for birds*. Downloaded from http://www.birdlife.org on 22/11/2013.

Bosque, C. & Bosque, M. T. 1995. Nest predation as a selective factor in the evolution of developmental rates in altricial birds. *American Naturalist*, 145: 234–260.

Decker, K.L., Conway, C. J. & Fontaine, J. J. 2012. Nest predation, food, and female age explain seasonal declines in clutch size. *Evolutionary Ecology,* 26: 683–699.

Desante, D. F., Burton, K. M., Velez, P., Froehlich, D. & Kaschube, D. 2008. *MAPS manual 2008 protocol: instructions for the establishment and operation of constant-effort bird-banding stations as part of the monitoring avian productivity and survivorship (MAPS) program*, Institute for Bird Populations, Point Reyes Station, CA.

de Juana, E., Suarez, F. & Ryan, P. G. 2004. Family Alaudidae (Larks). In: *Handbook of the Birds of the World, Vol. 9, Cotingas to pipits and wagtails,* (eds) J. del Hoyo, A. Elliot & D.A. Christie, pp. 496–601. Lynx Edicions, Barcelona.

Dmitriew, C. M. 2011. The evolution of growth trajectories: what limits growth rate? *Biological Reviews*, 86: 97–116.

Erdos, S., Baldi, A. & Batary, P. 2009. Nest-site selection and breeding ecology of Sky Larks *Alauda arvensis* in Hungarian farmland. *Bird Study,* 56: 259–263.

Gantulga, B. 2006. *Breeding biology of larks (*Alaudidae*) in the steppe at Darkhan soum of Hentii province*. Bachelor thesis. National University of Mongolia, Ulaanbaatar, Mongolia.

Gombobaatar, S. & Gantulga, B. 2008. Breeding biology of some species of *Alaudidae* in the Mongolia steppe. *Proceedings of the Institute of Biology,* 27: 43–46.

Gombobaatar, S. & Monks, E. M. (compilers), Seidler, R., Sumiya, D., Tseveenmyadag, N., Bayarkhuu, S., Baillie, J. E. M., Boldbaatar, Sh. & Uuganbayar, Ch (editors). 2011. *Regional Red List Series* Vol. 7. Zoological Society of London, National University of Mongolia and Mongolian Ornithological Society.

Gombobaatar, S. 2013. *Saker falcon (*Falco cherrug*) in Mongolia*. Mongolian Ornithological Society, National University of Mongolia, Ulaanbaatar, Mongolia.

Green, R. 1978. Factors affecting the diet of farmland skylarks, *Alauda arvensis*. *Journal of Animal Ecology,* 47: 913–928.

Gunin, P., Vostokova, E., Dorofeyuk, N., Tarasov, P. & Black, C. 2000. *Assessing present day plant cover dynamics*. Vegetation Dynamics of Mongolia, Geobotany, 26. Kluwer Academic, Dordrecht, the Netherlands.

Holland, J. M., Hutchison, M. A. S., Smith, B. & Aebischer, N. J. 2006. A review of invertebrates and seed-bearing plants as food for farmland birds in Europe. *Annals of Applied Biology*, 148 49–71.

Kamp, J., Siderova, T. V., Salemgareev, A. R., Urazaliev, R. S., Donald, P. F. & Hölzel, N. 2012. Niche separation of larks (*Alaudidae*) and agricultural change on the drylands of the former Soviet Union. *Agriculture, Ecosystems* *and Environment,* 155: 41–49.

Mainjargal, G. 2005. Ecological peculiarities and reproductive of some species (*Melanocorypha mongolica* Pall, 1776, *Alauda arvensis* L, 1758) of the larks in Mongolia. *Proceedings of the Institute of Biology*, 25:199–204.

Mainjargal, G. 2007. Distribution, habitat and biometer data of Horned lark (*Eremophila alpestris* L., 1758). *Proceedings of the Institute of Biology*, 27: 164–168.

Martin, T. E., Lloyd, P., Bosque, C., Barton, D. C., Biancucci, A. L., Cheng, Y. R. & Ton, R. 2011. Growth rate variation among passerine species in tropical and temperate sites: an antagonistic interaction between parental food provisioning and nest predation risk. *Evolution*, 65: 1607–1622.

Martin, T. G. & McIntyre, S. 2007. Impacts of livestock grazing and tree clearing on birds of woodland and riparian habitats. *Conservation Biology,* 21: 504–514.

Naef-Daenzer, B. & Keller, L. F. 1999. The foraging performance of great and blue tits (*Parus major* and *P. caeruleus*) in relation to caterpillar development, and its consequences for nestling growth and fledging weight. *Journal of Animal Ecology*, 68: 708–718.

Pavel, V. 2004. The impact of grazing animals on nesting success of grassland passerines in farmland and natural habitats: a field experiment. *Folia Zoologica*, 53: 171–178.

Perrins, C. M. & McCleery, R. H. 1989. Laying dates and clutch size in the Great tit. *Wilson Bulletin*, 101: 236–253.

Poulsen, G. J., Sotherton, N. W. & Aebischer, N. J. 1998. Comparative nesting and feeding ecology of skylarks *Alauda arvensis* on arable farmland in southern England with special reference to set-aside. *Journal of Applied Ecology*, 35: 131–147.

Remeˇs, V. & Martin, T. E. 2002. Environmental influences on the evolution of growth and developmental rates in Passerines. *Evolution*, 56: 2505–2518.

Richner, H., Schneiter, P. & Stirnimann, H. 1989. Life-history consequences of growth rate depression: an experimental study on carrion crows (*Corvus corone corone* L.). *Functional Ecology*, 3: 617–624.

Schaller, G. B. 1998. *Mongolia's golden horde, a million migrating gazelles*. Wildlife Conservation, November/December, 36–41.

Shkedy, Y. & Safriel, U. N. 1992. Nest predation and nestling growth rate of two lark species in the Negev Desert, Israel. *Ibis,* 134: 268–272.

Shrubb, M. 1990. Effects of agricultural change on nesting lapwings *Vanellus vanellus* in England and Wales. *Bird Study*, 37: 115–127.

Sokal, R.R. & Rohlf, F. J. 2000. *Biometry the Principles and Practice of Statistics in Biological Research*. W.H. Freeman, New York.

Southwood, T. R. E. & Cross, D. J.2002. Food requirements of grey partridge *Perdix perdix* chicks. *Wildlife Biology*, 8: 175–183.

Tieleman, B. I., Williams, J. B. & Visser, G. H. 2004. Energy and water budgets of larks in a life history perspective: parental effort varies with aridity. *Ecology*, 85: 1399–1410.

Tong, C., Wu, J., Yong, S., Yang, J. & Yong, W. 2004. A landscape-scale assessment of steppe degradation in the Xilin River Basin, Inner Mongolia, China. *Journal of Arid Environments*, 59: 133–149.

Williams, G. C. 1966. *Adaptation and natural selection*. Princeton Univ. Press, NJ.

WWF Mongolia Programme Office. 2010. *Filling the gaps to protect the biodiversity of Mongolia*, Ulaanbaatar, Mongolia.

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