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ABUNDANCE AND DIVERSITY OF ARTHROPODS IN NESTS OF LARK SPARROWS (*CHONDESTES GRAMMACUS*)

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Abstract—We examined abundance and diversity of arthropods in nests of lark sparrows (*Chondestes grammacus*). No true ectoparasite occurred in the nests sampled ($n = 69$) and no ectoparasite was found on nestlings. However, 67% of nests contained non-parasitic arthropods from $\geq$16 families. There was no significant difference in number of arthropods per gram of nesting material or diversity (at familial to higher taxonomic order) with height of nest (ground or arboreal), date of nesting, duration of activity per nesting attempt, mean or maximum temperature of nest, and frequency of prescribed burning of the habitat, or in relation to nest-building by two species of birds (lark sparrows and northern mockingbirds *Mimus polyglottos*).

Resumen—Examinamos la abundancia y diversidad de artrópodos en nidos de *Chondestes grammacus.* Ningún ectoparásito verdadero fue encontrado en la muestra de nidos ($n = 69$ nidos), tampoco se identificaron ectoparásitos en crías de *C. grammacus.* Sin embargo, 67% de los nidos tenían artrópodos no-parasitarios de $\geq$16 familias. No encontramos diferencias significativas en el número de artrópodos por gramo de material del nido ni diversidad taxonómica (al nivel de familia o más alto) en relación con la altura del nido (terrestre o arbóreo), fecha de anidación, duración de la actividad por intento de anidación, promedio o máxima temperatura del nido, y frecuencia de quema prescrita del hábitat, o en relación a la construcción de nidos de dos especies de aves (*C. grammacus* y *Mimus polyglottos*).

Arthropods are associated with birds and their nesting materials. Non-parasitic arthropods (nest-arthropods hereafter) frequently inhabit nesting materials of birds and feed on decaying plant matter or feces within nests (Triplehorn and Johnson, 2005). Other arthropods associated with birds and their nesting materials are more parasitic and feed on tissues of avian hosts during at least one stage of their life cycle.

Two main categories of avian ectoparasites associated with direct parasitic behavior include obligate avian ectoparasites and free-living ectoparasites. Obligate avian ectoparasites live exclusively on hosts (e.g., chewing lice *Dennyus hirundinis*; Lee and Clayton, 1995), while other free-living ectoparasites live in close association with hosts (e.g., swallow bugs *Oeciacus vicarius*; Oesterle et al., 2010). Such free-living ectoparasites may only exploit tissues of avian hosts during various stages of their reproductive cycle, but may also use avian nesting materials during the non-breeding season, awaiting the opportunity to exploit their next host during the subsequent breeding season (Marshall, 1981). While nest-arthropods often have little impact on avian hosts (Triplehorn and Johnson, 2005), ectoparasites have some negative effect (Lehman, 1993; Proctor and Owens, 2000). For avian hosts, infestation by ectoparasites may limit mating opportunities (Møller, 1990), reduce size of clutches (O'Brien and Dawson, 2005), induce desertion of nests (Oppliger et al., 1994), and reduce growth of nestlings (Fitze et al., 2004).

Factors influencing infestations by ectoparasites have been the subject of much research. Infestations of nests by ectoparasites may be correlated positively with re-use of nests by birds (Shields and Crook, 1987; Merino and Potti, 1995; Tomás et al., 2007), mass of nests (Heeb et al., 1996), height of nests (Matsuoka et al., 1997), and structure of habitat at nesting sites (e.g., greater in dense woody vegetation; Matsuoka et al., 1997). Prevalence of ectoparasites within nesting materials may decrease with decreasing ambient temperatures (Merino and Potti, 1996) and when microclimates in nests deviate from optimal temperatures (Maurer and Baumgärtner, 1992; Dawson et al., 2005). Abundance of ectoparasites also may increase in nests as the avian nesting season progresses (Shields and Crook, 1987).

Little is known about ectoparasites and arthropods associated with lark sparrows (*Chondestes grammacus*) and their nests. Carriker (1902, 1903; Price et al., 2003) documented parasitic lice on lark sparrows in Nebraska (*Brueelia angustifrons*) and Costa Rica (*Machaerilaemus laticorpus*), and McClure (1984, 1987, 1989) reported hippoboscid flies (*Ornithoica vicina*) and mites (*Neo-*

shoengastia americana, *Proctophyllodes*) on lark sparrows in California. Our objective was to investigate occurrence of ectoparasites in nests of lark sparrows in relation to behavior associated with re-use of nests. While we did not measure conspecific re-use of nests by lark sparrows, the species exhibits both conspecific and heterospecific re-use of nests (i.e., lark sparrows re-use nests of northern mockingbirds *Mimus polyglottos*; Mcnair, 1984; Martin and Parrish, 2000); thus, we expected to find ectoparasites in nests of lark sparrows. Examples of ectoparasites associated with northern mockingbirds include mites (Knemidokoptidae, Macronyssidae, Proctophyllodidae, and Trombiculidae; Ventura, 1968; Phillis and Cromroy, 1972; McClure, 1987, 1989; Latta and O'Connor, 2001), ticks (Ixodidae; Wilson and Durden, 2003), lice (Menoponidae and Philopteridae; Burmeister, 1838; Cicchino and Emerson, 1983; Wilson and Durden, 2003), and haematophagous flies (Muscidae; Ventura, 1968), some of which potentially could be observed in nests of lark sparrows as a result of behavior associated with re-use of nests. While much research has focused on the ecology of avian infestation by ectoparasites, few studies have investigated the ecology of nest-arthropods in nesting materials of birds. From the research that has been conducted, abundance of nest-arthropods might increase with mass of nests (Tryjanowski et al., 2001) and vary with height of nests (Coulson et al., 2009; Krištofík et al., 2009). Additionally, occurrence of nest-arthropods may vary with microclimate of nests (e.g., temperature; Sinclair and Chown, 2006) or date of nesting season (Riley, 2000). Prescribed burning, used as a management technique to reduce woody vegetation, may have direct and indirect effects on populations of nest-arthropods (Warren et al., 1987) and avian ectoparasites (Jacobson and Hurst, 1979; McClure, 1981). We examined abundance and diversity of arthropods in nests of lark sparrows in relation to heterospecific re-use of nests, height of nests (ground or arboreal), date of nesting season, duration of nesting activities, temperature of nests, and frequency that nesting habitats were burned.

We conducted our research during 8 June–15 July 2009 on the Cross Bar Cooperative Management Area, ca. 20 km NW Amarillo, Potter County, Texas (35°N, 101°W). This 4,811-ha former ranch is co-managed by the United States Bureau of Land Management and West Texas A&M University. Historically, the Cross Bar Cooperative Management Area was dominated by shortgrass prairie. As a result of suppression of fires and overgrazing, it now is dominated by woody plants such as honey mesquites (*Prosopis glandulosa*) and chollas (*Cylindropuntia*), forbs such as prickly pears (*Opuntia phaeacantha*), common broomweeds (*Xanthocephalum dracunculoides*), and small soapweed yuccas (*Yucca glauca*), but also includes grasses such as blue grama (*Bouteloua gracilis*), sideoats grama (*B. curtipendula*), and buffalograss (*Buchloe dactyloides*). In 2002, the United States Bureau of Land Management and West Texas A&M University established nine 120–220-ha experimental plots on the area. These plots were burned with varying frequencies of fires (burning every 2, 4, or 10 years with three replicates of each treatment), with the goal of examining how frequency of burning influences vegetation and wildlife in southern shortgrass prairie.

Nests were found using systematic searches and observation of parental behavior following Martin and Geupel (1993). We determined use of old nests of northern mockingbirds by lark sparrows based on architecture, position (ground or arboreal, which was elevated above the ground $\leq$2.4 m and typically in chollas), dimensions (height, width, and depth), and mass of nests. Re-use of nests by lark sparrows was only determined for nests of northern mockingbirds because we were unable to definitely identify conspecific re-use of nests. We assumed that nests of northern mockingbirds were active for some period, but history of activity of northern mockingbirds at those nests is incomplete.

Dates of initial construction of nests were estimated from direct observation of construction or by backdating from known dates of laying or hatching as described by Martin and Parrish (2000). For nests depredated during incubation, we estimated date of initiation as the midpoint between minimum and maximum possible dates of initiation. Age of nestlings, estimated from morphological characters provided by Baicich and Harrison (1997), was used to determine date of initiation for nests found after hatching. We recorded mean and maximum temperatures of nests, which might vary with microhabitats, by inserting data loggers (Thermochron iButton Temperature Sensors, Maxim Integrated Products, Sunnyvale, California) placed directly beneath the lining of nesting materials of 30 nests (including four nests of northern mockingbirds used by lark sparrows). These devices recorded temperature (C°) every 10 min.

After completion of nesting (fledging or failure, e.g., predation of clutch), nests were collected, sealed in plastic bags, and kept within a plastic container that was shaded from ambient outdoor conditions for $\leq$3 days. Nests were then placed in Berlese-Tullgren funnels (3–4 days) to extract arthropods following Marshall (1981) and Clayton and Walther (1997). We also visually inspected nestlings of lark sparrows for ectoparasites, including apteria, feathers (if present), and facial, neck, and wing regions as described by Clayton and Walther (1997). Arthropods were identified as precisely as possible.

Density of arthropods was calculated as number of specimens per gram of nesting material. Diversity of families of arthropods per nest was calculated using the Shannon-Wiener diversity index (H'), which was adjusted for mass of nests by dividing H' by grams of nesting material. Some arthropods were identified to order only, and thus, at least one family. We believe our calculations of taxonomic diversity to familial or ordinal level provides a reasonable representation of at least minimal diversity per nest. We used linear regression and analysis of variance to compare response variables (i.e., density and diversity) to height of nest (ground or arboreal), date of nesting season (i.e., date of extraction of nest from the field), duration of nesting activity, mean and maximum temperatures of nest, and frequency of burning the habitat (2, 4, or 10 years). We set α at 0.05 for statistical procedures. As sizes of samples were asymmetrical between nests of lark sparrows and northern mockingbirds (61 and 7, respectively), a non-parametric Wilcoxon rank-sum test was used to compare mean scores for density and diversity of arthropods between nests of these two species (SAS Institute, Inc., version 9.2, Cary, North Carolina).

Of the 69 nests sampled, 46 (67%) contained arthropods, 7 (10%) of which were nests of northern mockingbirds used by lark sparrows. Nests of lark sparrows consisted of grasses and forbs, whereas nests of northern mockingbirds consisted primarily of larger twigs. Mean ($\pm SD$) dimensions of nests of lark sparrows ($n = 58$; height $= 6.33 \pm 1.94$ cm, width $= 11.64 \pm 2.13$ cm, depth $= 3.51 \pm 0.95$ cm, and mass $= 18.23 \pm 8.43$ g) were smaller than mean ($\pm SD$) dimensions of nests of northern mockingbirds used by lark sparrows ($n = 6$; height $= 11.17 \pm 5.87$ cm, width $= 15.75 \pm 5.10$ cm, depth $= 3.92 \pm 1.69$ cm, and mass $= 43.78 \pm 17.06$ g). Temperatures of nests on the ground ($n = 3$; mean = 29.90°C, 95% CI = 28.58–31.22; maximum = 58.00°C, 95% CI = 52.67–63.33) and arboreal nests ($n = 20$; mean = 31.10°C, 95% CI = 29.7–32.5; maximum = 51.35°C, 95% CI = 45.14, 57.56) were similar (data loggers disappeared from seven nests). Overall, 542 arthropods from 9 orders were observed (Table 1), including 230 individuals from unknown families. No avian ectoparasite was detected (Table 1). Mean number of arthropods sampled per nest was 7.9 (95% CI = 2.6–13.2) and mean diversity per nest was 0.4 (95% CI = 0.3–0.5). Mean density and diversity of arthropods per gram of nesting material was 0.662 (95% CI = −0.070–1.394) and 0.022 (95% CI = 0.015–0.030), respectively. These means included $H' = 0$ for nests with only one, or no, taxon of arthropods. There was no statistically significant difference (all $P > 0.15$) in density or diversity of arthropods between nests of lark sparrows and nests of northern mockingbird used by lark sparrows, or with height of nest, date of nesting season, duration of nesting activity, mean or maximum temperatures of nest, or frequency of burning.

Other studies have documented ectoparasites on adult lark sparrows (Carriker, 1902, 1903; McClure, 1984, 1987, 1989). Incidental activity of ectoparasites within nests of parasitized birds is possible (Clayton and Tompkins, 1995; Clayton and Walther, 1997). However, we detected no avian ectoparasite in nesting materials sampled and we did not observe ectoparasites on nestling lark sparrows. Climate of our study site, particularly the consistently low relative humidity, might be a contributing factor to the lack of ectoparasites in nesting materials. Moyer et al. (2002) indicated that abundance of ectoparasites on birds may be less in arid versus humid regions as a result of unfavorable microclimate (i.e., low relative humidity) within the plumage that may limit survival of ectoparasites. Perhaps, the taxa of nest-arthropods we observed were more resilient to arid conditions of our study area than were ectoparasitic taxa.

Table 1—Arthropods in nests of lark sparrows (*Chondestes grammacus*) on Cross Bar Cooperative Management Area, Potter County, Texas, 8 June–15 July 2009.

Taxa	Abundance[a]	Relative abundance[b]
Arachnida		
Araneae	8	0.01
Acariformes (Acari)	201	0.37
Pseudoscorpionida	1	<0.01
Insecta		
Thysanoptera		
Phlaeothripidae	1	<0.01
Psocoptera		
Liposcelididae	214	0.39
Unidentified	1	<0.01
Coleoptera		
Staphylinidae	2	<0.01
Dermestidae	2	<0.01
Anthicidae	1	<0.01
Unidentified	8	0.01
Hymenoptera		
Formicidae	58	0.11
Unidentified	3	0.01
Chalcidoidea	2	<0.01
Lepidoptera	1	<0.01
Diptera		
Phoridae	11	0.02
Unidentified	5	0.01
Unidentified larvae	17	0.03
Unidentified arthropods	6	0.01

[a] Number of individuals.
[b] Number of individuals per total number of arthropods.

Although we did not find ectoparasites in nests of lark sparrows, we did observe arthropods in nesting materials. The two most dominant arthropods were bark lice (Liposcelididae) and non-parasitic mites from an unidentified family of Acariformes. Few studies have examined nest-arthropods in other birds in North America, but these limited studies reported similar results. For example, Hicks (1953) observed arthropods in 47 nests of 15 species of birds in Iowa. Bark lice (*Liposcelis*) were in nests of 11 species, including yellow-billed cuckoos (*Coccyzus americanus*), eastern phoebes (*Sayornis phoebe*), blue jays (*Cyanocitta cristata*), house wrens (*Troglodytes aedon*), marsh wrens (*Telmatodytes palustris*), American robins (*Turdus migratorius*), gray catbirds (*Dumetella carolinensis*), brown thrashers (*Toxostoma rufum*), rose-breasted grosbeaks (*Pheucticus ludovicianus*), common grackles (*Quisca-*

lus quiscula), and house sparrows (*Passer domesticus*). Nolan (1955) documented >143 individuals from 19 species of arthropods and 1 gastropod (*Gastrocopta armifera*) in nine nests of prairie warblers (*Setophaga discolor*) in woodlands of Indiana. Among associates in nests were seven individuals of bark lice and five individuals of non-parasitic mites from three families of Acariformes (Ceratozetidae, Oribatulidae, and Tetranychidae). In Quebec, Riley (2000) documented 90,729 arthropods in 15 nests of house sparrows and seven nests of tree swallows (*Tachycineta bicolor*). He also observed 82 species of arthropods from 58 families, including 18 individuals of non-parasitic mites (Acariformes: Oribatulidae) from nests of house sparrows and 38 individuals of bark lice from nests of tree swallows.

Abundance and diversity of nest-arthropods were not related to our covariates. Nests of incubating birds may provide some non-parasitic arthropods with suitable habitats (e.g., temperature microclimates; Sinclair and Chown, 2006). However, variation in temperature among nests did not appear to affect occurrence of non-parasitic arthropods in our study. Riley (2000) suggested that competition within nests during a single season may change composition of the community of arthropods. However, the relatively short duration of our study (8 June–15 July) may have limited detection of such changes in communities of arthropods. Tryjanowski et al. (2001) noted that abundance and species richness of gamasid mites in nests of the red-backed shrike (*Lanius collurio*) were correlated positively with mass of nest. In our study, mass of nests was not an important factor in explaining density or diversity of arthropods.

Fire, which changes structure and composition of vegetation, variably affects species of arthropods (Van Amburg et al., 1981; Warren et al., 1987). The lack of substantial variation in density or diversity of nest-arthropods among the three burning treatments may be due to time since the most recent prescribed burn, which occurred in spring 2008. This may have provided sufficient time for communities of arthropods to rebound, even on the most recently burned plots. Cully (1999) reported that abundance of ticks (Acari) was impacted negatively only in the year of a burn of tallgrass prairie. Woody vegetation may affect abundance of ectoparasites (Matsuoka et al., 1997) and other arthropods (Semtner et al., 1971). However, Long et al. (2012) revealed limited differences in densities of shrubs across plots at Cross Bar Cooperative Management Area. Moreover, nest-arthropods may randomly occur in nests of birds as a result of transport of nesting materials during construction of nests (Neubig and Smallwood, 1999; Tryjanowski et al., 2001). Density and diversity of arthropods were not explained by the environmental variables we measured, and this might be explained appropriately as incidental occurrences of arthropods in nests of lark sparrows.

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