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HORNED LARK (EREMOPHILA ALPESTRIS L.) PREDATION ON ALKALI BEES, NOMIA MELANDERI COCKERELL

Richard W. Rust

ABSTRACT.—Horned Larks (Eremophila alpestris L.), sampled during the first 2 weeks of alkali bee (Nomia melanderi Cockerell) emergence at bee nesting sites in 2 alfalfa seed-growing regions in central Nevada, ate significantly more male than female alkali bees. Exploitation rates suggest that individual Horned Larks consume 10 to 200 alkali bees per day and feed an additional 300 to 1000 bees per day to nestlings.

Key words: predation, Great Basin Desert, alfalfa, insects, birds.

Horned Larks (Eremophila alpestris L.) are common, year-round residents of the Great Basin Desert sand scale community and adjacent agricultural lands (Behle and Perry 1975, Ryser 1985, Medin 1986, 1990). They are ground-nesters and forage as ground-gleaning omnivores (DeGraaf et al. 1985), feeding on seeds in winter months and arthropods and seeds during the remainder of the year (Beason 1995). Nestlings are fed predominantly arthropods, especially Lepidoptera larvae and Orthoptera (Maher 1979). Horned Larks are known predators of adult alkali bees (Nomia melanderi Cockerell; Frick 1962). Alkali bees, a western North American species, nest gregariously in soils associated with alkali flats (Bohart and Cross 1955, Ribble 1965) and are effective and efficient pollinators of alfalfa (Medicago sativa L.; Bohart 1957, 1972, Bohart and Koerber 1972), for which they have been utilized and developed (Torchio 1987, Wichelns et al. 1992).

Here I examine the foraging impact of Horned Larks on adult alkali bees as determined by digestive tract content analysis and foraging bird densities measured during 2 periods of adult bee emergence and from 2 locations in central Nevada.

METHODS AND MATERIALS

Horned Larks were collected from 4 alkali bee nesting sites in the alfalfa-growing regions of both Lovelock (LL) and Dixie Valley (DV), Pershing County, Nevada, during the 1st and 2nd weeks of adult alkali bee emergence in summer 2001. The 4 Lovelock sites are natural and range in size from 1.5 to 3.0 ha; the 4 Dixie Valley sites are man-made (Bohart and Knowlton 1960, Stephen 1960), adjacent to alfalfa fields, and range in size from 0.16 to 0.5 ha. In both locations nonagricultural lands are Great Basin sand scale desert (Vankat 1979) dominated by species of Atriplex and Sarcobatus (Chenopodiaceae).

I made bird counts at each site upon each arrival and scanned the bee-nesting site with binoculars. Nesting sites are free of vegetation, allowing an easy count of birds. Birds were shot between sunrise and 1200 hours (PST) and individually bagged and placed on ice for transport to the laboratory.

The digestive tract from oesophagus to cloaca was removed. I opened the crop and proventriculus (McLelland 1979) and preserved the contents in 70% ethanol. Crop and proventriculus contents were sorted and items were identified to sex of alkali bees, with other insects and arthropods identified to order, family, and genus where possible. Seeds were sorted by morphological types. Alkali bee males were identified by the presence of their enlarged hind tibiae and females by the pseudopygidium on the sixth abdominal tergum (Ribble 1965, Stephen et al. 1969). These 2 parts remained diagnostic despite the grinding action of the proventriculus. In addition to the above parts, male genitalia, anterior portions of male abdominal sterna 4 and 5, and female antennal scape were found in most stomach contents containing alkali bees.

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Descriptive statistics and 2-factor analysis of variance were employed to test the relationship between mean birds present and mean captures for the 2 locations and sampling periods (Zar 1996). Means ± standard deviations are presented. Analyses were performed in Minitab® release 12 (Minitab 1998).

Horned Larks were removed with permits from the state of Nevada (Scientific Collection Permit S20567) and Federal Fish and Wildlife (Permit MB042219-0). All birds are deposited in the ornithological collection at the University of Nevada, Reno.

RESULTS

Thirty-nine Horned Larks were obtained. From Lovelock nesting sites, I acquired 2 before alkali bee emergence (31 May 2001), 9 the 1st week of emergence (12 June 2001), and 9 the 2nd week (19 June 2001). From Dixie Valley sites, I acquired 10 during the 1st week of bee emergence (1 June 2001) and 9 the 2nd week (7 June 2001). I obtained an almost equal number of males and females (LL 10 males and 10 females, DV 10 males and 9 females). All birds had enlarged ovaries or testes and 1 female contained developing eggs.

Counts of Horned Larks at the nesting sites averaged significantly more during the 1st week of bee emergence ($F_{date} = 12.55$, df = 1,42, $P = 0.001$; LL 1st week mean 8.2 ± 6.7, range 0–20, 2nd week mean 0.7 ± 0.5, range 0–1; DV 1st week mean 4.8 ± 2.1, range 2–9, 2nd week mean 2.5 ± 1.6, range 0–5). The location and date-location interactions were not significantly different ($P = 0.55$ and $P = 0.06$).

All birds taken during the 1st and 2nd weeks of alkali bee emergence contained 1 or more arthropods, including spiders (reported as birds with 1 or more prey items; LL 5 of 18, DV 3 of 19) and solpugids (LL 1 of 18). Insects were represented by Lepidoptera larvae (LL 6 of 18, DV 12 of 19), Coleoptera families Cicindellidae (Cicindella sp.) larvae (LL 2 of 18, DV 2 of 19) and Curculionidae adults (DV 1 of 19), Hemiptera family Lygaeidae adults (LL 1 of 18, DV 6 of 19), Diptera family Bombylidae (Heterostylum robustum) adults (LL 2 of 18), and Hymenoptera, other than alkali bees, family Formicidae adults (LL 2 of 18, DV 1 of 19). Only Lepidoptera larvae were in sufficient numbers for analysis. There was a significant difference in the number of larvae taken between the 2 locations ($F = 4.33$, df = 1,29, $P = 0.049$; LL mean 0.57 ± 0.75, range 0–2; DV mean 2.31 ± 3.36, range 0–12). There was no significant difference in the mean number taken between the 1st and 2nd weeks or the interaction of location and date ($P = 0.09$ and $P = 0.102$, respectively).

Ninety-five percent (18 of 19; LL 9 of 9, DV 9 of 10) of birds from the 1st week of bee emergence contained 1 or more alkali bees, whereas only 28% (5 of 18; LL 1 of 9, DV 4 of 9) of birds from the 2nd week contained alkali bees (Table 1). The distribution of alkali bees taken by Horned Larks by location, date, and sex showed that male bees were taken significantly more often than females at both times (total bees $F = 7.28$, df = 1,29, $P = 0.011$; male bees $F = 6.98$, df = 1,29, $P = 0.013$; Table 1). There were no significant differences in female bees taken between location and date or the location-date interaction ($P = 0.136$; LL mean 0.57, $P = 0.566$, and $P = 0.565$, respectively; Table 1). There were no significant differences in total bees, male bees taken by date, or the location-date interaction (total bees location $P = 0.493$, interaction $P = 0.537$, male bees location $P = 0.697$, interaction $P = 0.617$).

Two Horned Larks taken prior to alkali bee emergence at Lovelock contained only Chenopodiaceae seeds with cotyledons (probably Atriplex) in their digestive tracts. Fifteen (83%) Lovelock birds and 16 (64%) Dixie Valley birds contained 1 or more seeds. Fifty-eight percent of the seeds from Lovelock and 70% from Dixie Valley birds were chenopod (probably Atriplex). The other identifiable seed was alfalfa (Medicago sativa). Most chenopod seeds had germinated with cotyledons present. There was a statistical difference in mean number of seeds taken at both locations ($F = 8.93$, df = 1,29, $P = 1.29$, $P = 0.006$) and between the 1st and 2nd weeks ($F = 7.54$, df = 1,29, $P = 0.01$) and the location-date interaction ($F = 0.025$, df = 1,29, $P = 0.025$). Mean seeds taken at LL was 19.6 ± 21.8, range 0–60, and DV 8.2 ± 9.4, range 0–37; 1st week mean was 8.7 ± 10.4, range 0–37, and 2nd week 18.9 ± 21.6, range 0–60.

DISCUSSION

Horned Larks collected from alkali bee nesting sites during the first 2 weeks of bee
Table 1. Time and location predation by Horned Larks, *Eremophila alpestris*, on adult alkali bees, *Nomia melanderi*, recorded from 2 locations in Nevada. Dates represent the 1st and 2nd weeks of alkali bee emergence in a location. Data are means and standard deviations with ranges given in parentheses.

<table>
<thead>
<tr>
<th>Date</th>
<th>Males</th>
<th>Females</th>
<th>Sex undetermined</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 June</td>
<td>19 June</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lovelock, NV</td>
<td>3.0 ± 2.8</td>
<td>0.0</td>
<td>0.3 ± 0.5</td>
<td>3.3 ± 2.6</td>
</tr>
<tr>
<td>12 June</td>
<td>(0-9)</td>
<td>(0)</td>
<td>(0-1)</td>
<td>(0-9)</td>
</tr>
<tr>
<td>19 June</td>
<td>0.2 ± 0.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2 ± 0.4</td>
</tr>
<tr>
<td></td>
<td>(0-1)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0-1)</td>
</tr>
<tr>
<td>Dixie Valley, NV</td>
<td>2.9 ± 2.4</td>
<td>0.1 ± 0.3</td>
<td>0.4 ± 0.7</td>
<td>3.4 ± 2.5</td>
</tr>
<tr>
<td>1 June</td>
<td>(0-9)</td>
<td>(0-1)</td>
<td>(0-8)</td>
<td>(0-9)</td>
</tr>
<tr>
<td>7 June</td>
<td>1.0 ± 2.6</td>
<td>0.2 ± 0.4</td>
<td>0.2 ± 0.4</td>
<td>1.4 ± 3.2</td>
</tr>
<tr>
<td></td>
<td>(0-8)</td>
<td>(0-1)</td>
<td>(0-1)</td>
<td>(0-10)</td>
</tr>
</tbody>
</table>

Emergence (early to mid-June) showed characteristic ground-gleaning omnivorous foraging (DeGraaf et al. 1985, Beason 1995). Unlike other studies where Hymenoptera represent minor portions of Horned Lark diets (Rotenberry 1980) and food for nestlings (Maher 1979), Lovelock and Dixie Valley birds were exploiting the rich supply of alkali bees, especially males, during the initial week of bee emergence. This high rate of capture decreased significantly when female bees started to appear during the 2nd week of emergence. The non-significant difference between the 1st and 2nd weeks at Dixie Valley resulted from 1 second-week bird that had taken 10 bees (Table 1).

Alkali bees are protandrous (Bohart and Cross 1955) with males appearing approximately 5 to 7 days before females; both sexes have a 25- to 30-day period of emergence (Stephen 1965, Mayer and Miliczky 1998). Horned Larks were apparently "learning" to recognize alkali bees and even to discriminate between the sexually dimorphic individuals (Ribble 1965), avoiding females and their defensive sting in preference of male bees, which do not possess a sting apparatus (Michener 2000). Horned Larks ate fewer females and fewer total bees in the 2nd week of emergence. Male bees search for females at the nesting site as females emerge (Bohart and Cross 1955, Mayer and Miliczky 1998). Males fly over the nesting site usually within 10 cm of the surface and approach emerging females from upwind. Mayer and Miliczky (1998) report numerous male approaches and contacts to newly emerging females during the first few minutes they are on the surface of the site. Males will leave the nesting site for alfalfa fields where they feed on nectar and may sleep attached to alfalfa plants at night (Bohart and Cross 1955, Stephen et al. 1969). Male mating behavior probably increases their susceptibility to Horned Lark or other ground-gleaning bird predation.

Conservative exploitation rates based on the assumption that the observed gut contents represent 1 day's hunting and consumption for the individual and not food for nestlings (McAtee 1905, Pickwell 1931, Maher 1979) suggest that Horned Larks may consume 13 to 22 alkali bees per day from a nesting site (mean bees eaten × mean birds per site) to perhaps a maximum of 200 bees per day (maximum bees x maximum birds per site). Since nothing is known concerning nutritional requirements (Beason 1995) or daily consumption rates necessary to maintain energy reserves that reach lowest levels during incubation and overnight fasting (Swain 1991, 1992), these alkali bee exploitation rates may represent minimum values. The removal of 200 bees per day to 1400 per week, mostly males, probably has a minor impact on populations of bees in large natural nesting sites or well-managed artificial sites, where 50 to 200 bees per m² have been estimated (unpublished data). In smaller or less productive nesting sites, this estimated removal could have a major impact on bee populations. However, if predator-prey functional response concepts (Holling 1959) are considered, fewer bees will be removed by birds in low-density sites.

If Horned Larks forage on alkali bees for nestling food, then they may have a large impact on male bee populations. Maher (1979) in a 3-year study found Horned Larks to take between 6.3 and 10.0 prey items per hour.
with a median range of 5–9 prey per sample. The highest percentage of prey changed from Lepidoptera larvae in May (48%) to Orthoptera, mainly grasshoppers, in July (71%) and August (88%; Maher 1979). Hymenoptera were less than 5% in any month. During the first week of alkali bee emergence with mostly males emerging, this might equal 2300 to 7000 bees as nestling food per nesting pair (items per hour x prey per sample x 15 hours of foraging time x 7 days x 75% average high prey capture rate). However, only 1 Horned Lark taken in the present study had prey in its beak—a lepidopteran larva.

Presence of the bombylid fly (Heterostylum robustum), a parasite of alkali bee (Bohart et al. 1960), and larvae of the tiger beetle (Cicindella sp.), a predator of alkali bees (Frick 1962), in 4 Lovelock and 2 Dixie Valley birds shows the generalist feeding behavior of larks on the nesting sites. For H. robustum, Frick (1962) recorded similar observations with a higher percentage of flies present in the birds sampled, but numbers captured by bird species were not given.

In addition to the bird predators listed by Frick (1962)—blackbirds (species not reported), American Robin (Turdus migratorius), English Sparrow (Passer domesticus), Horned Lark, and Black-billed Magpie (Pica pica)—that consume alkali bees, I observed the Sage Sparrow (Amphispiza belli) and Western Kingbird (Tyrannus verticalis) to hunt, capture, and eat alkali bees. Sage Sparrows were present in both Lovelock and Dixie Valley nest sites, and Western Kingbirds were observed on 1 artificial site in the Lovelock area. A pair of Western Kingbirds nesting in a farm storage building were observed to take many alkali bees, presumably males, over a 2-week period during alkali bee emergence. Both Horned Larks and Sage Sparrows have been observed feeding on alkali bees in other natural and artificial nesting sites in Nevada alfalfa seed-growing areas near Orovada, Humboldt County, and Baker, White Pine County, Nevada.

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LITERATURE CITED


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