

NESTLING DEVELOPMENT AND AGING OF ARIZONA GRASSHOPPER SPARROW

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ABSTRACT: We studied breeding Arizona Grasshopper Sparrow (*Ammodramus savannarum ammoregus*) status and distribution, natural and life history, habitat use, and nest survival from 2004 through 2014 in southeastern Arizona. In this paper we present descriptions and photographs of known-age nestlings that will assist field biologists to identify Arizona Grasshopper Sparrow nestlings to species, more accurately age them for nest survival studies, and conduct more detailed nestling development studies. Our observations of developing characteristics included: eyes, ears, skin, down, major feather tracts, bill, rictal flange and gape colors and patterns, and behavior. More field data collection is required to supplement our information and to determine how broadly applicable this information is to other Grasshopper Sparrow subspecies.



Adult Arizona Grasshopper Sparrow carrying food.
2 August 2009. Photo by Janet Ruth

The Grasshopper Sparrow (*Ammodramus savannarum*), a widely distributed grassland bird, breeds throughout the grasslands of North America, Central America, and the Caribbean. Across its entire range, and in many biogeographic regions, this species has experienced long-term population declines (Sauer et al. 2014). It has been designated a Common Bird in Steep Decline (Berlanga et al. 2010, NABCI 2014, Rosenberg et al. 2016) and a focal species by the U.S. Fish and Wildlife Service (USFWS; Ruth 2015). Four subspecies are recognized in North America, with an additional four from southern Mexico to northern Ecuador and another four resident in the Caribbean (Vickery 1996).

The Arizona Grasshopper Sparrow subspecies (*A. s. ammoregus*) occurs in the desert and plains grasslands of southeastern Arizona, southwestern New Mexico, and northern Sonora, Mexico (Mills 1982, Strong 1988, Williams 1991, Ruth 2008). The largest numbers and densities of breeding *A. s. ammoregus* are found in the Sonoita and San Rafael valleys in Arizona, and the Animas Valley in New Mexico, with additional small or remnant populations in the Altar, San Pedro, San Bernardino, Santa Cruz, and Sulphur Springs valleys in Arizona, and in Sonora, Mexico (Mills 1982, Strong 1988, Ruth 2008). It seems likely that breeding *A. s. ammoregus* also occur in northwestern Chihuahua, Mexico (Manzano-Fischer et al. 1999, Ruth 2015). The winter range of *A. s. ammoregus* has been described as extending from southern Arizona south to Sinaloa and Morelos, Mexico, and Guatemala (Vickery 1996, Corman and Wise-Gervais 2005).

Despite being listed as a Bird of Conservation Concern for USFWS Region 2 (USFWS 2008) and as endangered in the state of New Mexico, prior to the last decade the *A. s. ammoregus* was arguably the least studied of North American Grasshopper Sparrow subspecies, with research limited to roadside surveys and associated basic habitat work (Meents 1979, Mills 1982, Strong 1988, Williams 1991).

In response to this lack of information, an extensive study of breeding Arizona Grasshopper Sparrow status and distribution (Ruth 2008), natural and life history (Ruth 2017), habitat use (Ruth and Skagen 2017), and nest survival (Ruth and Skagen 2018) was conducted from 2004 through 2014 in southeastern Arizona. This series of papers has

contributed substantially to our understanding of this subspecies. *A. s. ammoregus* in southeastern Arizona occupied territories (mean \pm SD) that were 0.72 ± 0.37 ha; male return rate was 39.2%; nest initiation occurred in early to mid-July after the monsoons had begun; domed nests were constructed on the ground with nest openings oriented north; mean \pm SD clutch size was 3.97 ± 0.68 ; and males generally weighed less than other subspecies (16.0 ± 0.8 g), but with intermediate exposed culmen length (11.6 ± 0.5 mm) and wing chord length (62.7 ± 1.5 mm) similar to the other 2 migratory subspecies (Ruth 2017). Male *A. s. ammoregus* selected territories with sparser vegetation structure, and, in areas with low shrub density, males selected more tall shrubs (>2 m tall) than in random plots; within male-established territories, females located nest sites in areas with lower small shrub (1–2 m tall) densities when possible and preferentially selected native grasses under which to construct nests (Ruth and Skagen 2017). The mean \pm SE daily survival rate (DSR) of *A. s. ammoregus* nests was 0.960 ± 0.006 , corresponding to an overall nest success of 46% (Ruth and Skagen 2018). Previous seasonal precipitation, large rain events, and nest concealment were the most important factors explaining DSR, although sometimes in unexpected directions.

While collecting data relevant to natural and life history, ecology, and nest survival in *A. s. ammoregus*, we collected additional data useful for aging nestlings. Information about nestling appearance, growth, and development is useful to field scientists interested in identifying the nestling species in multispecies studies, aging nestlings for nest survival studies, or for more detailed studies of development and growth. It can also have implications for management and conservation of the species. Jongsomjit et al. (2007) and Morales Fernaz et al. (2012) provide useful reviews of the literature regarding nestling development and aging in altricial passerines. It was beyond the scope of our study to collect the kind of detailed data, especially measurements and mass, that are presented by Jongsomjit et al. (2007) for seven other passerines, including one sparrow—Song Sparrow (*Melospiza melodia*)—and two grassland birds—Sprague's Pipit (*Anthus spragueii*) and Chestnut-collared Longspur (*Calcarius ornatus*)—and by Morales Fernaz et al. (2012) for Barn Swallow (*Hirundo rustica*). Nevertheless, we were able to take extensive notes and photographs of known-age Arizona Grasshopper Sparrow nestlings, which we present here.

METHODS

We studied Arizona Grasshopper Sparrow breeding ecology in the desert and plains grasslands of the Sonoita Valley in southeastern Arizona on two sites—Audubon Appleton-Whittell Research Ranch and BLM Las Cienegas National Conservation Area, Davis Pasture. Detailed descriptions of these study sites can be found in Ruth (2017), Ruth and Skagen (2017), and Ruth and Skagen (2018). We collected data for the entire study from 2004–2014; we conducted the nest finding/monitoring/habitat measurement/nest survival component (Ruth and Skagen 2017, Ruth and Skagen 2018) in the summers of 2011–2013. We used observations, notes, and photographs taken during the final 2013 field season for this document, although we incorporated knowledge we had gained over the previous two years. Nest search and monitoring methods are described in more detail in Ruth and Skagen (2017) and Ruth and Skagen (2018). Each time we monitored a nest for the survival study, we took notes regarding the development of the chicks as we could see them in the nest. In nests for which we knew the age of the chicks, based on incubation initiation dates and egg hatching dates, we removed one or two chicks to make additional observations and notes, and to take photographs, if we felt it was safe to do so. We minimized the amount of time that the nestling was outside the nest and moved away from the nest immediately following replacement of the chick. All capture and handling procedures were approved by the Institutional Animal Care and Use Committee of the USGS Fort Collins Science Center and we followed the recommendations in Jongsomjit et al. (2007) to the extent they applied to our more limited effort.

We took notes about the following characteristics or development components reported by Jongsomjit et al. (2007): eyes, ears, skin color, color and amount of down, major feather tracts, behavior, and miscellaneous observations. We refer to feather tracts using the terminology in Jongsomjit et al. (2007) [see Figure 1 in Jongsomjit et al. 2007] – capital tract (head), dorsal tract (back), caudal tract (tail), and crural tract (legs). Frequently, in addition to referring to alar tract (wings), we provide specific information about primary, secondary, and/or covert tracts, and in addition to ventral tract, we provide specific information about throat and breast/flank tracts. We did this because, at times, these tracts developed at different rates. In light of recent literature regarding the importance of colors and patterns of rictal

flange and gape in either increasing the detectability of nestlings or signaling condition to affect parental feeding (Kilner and Davies 1998, Dugas 2010, Dugas and Dillow 2013) we also took notes about bill, rictal flange, and gape colors and patterns. We summarized notes associated with multiple nests and iteratively reevaluated and revised our descriptions as we collected additional notes during the nest season.

RESULTS

We monitored 128 nests over three years; 61 of these nests were monitored on the two sites in 2013. Of these nests in 2013, 22 were found while still in the egg phase and also successfully fledged at least one nestling, with dates and data sufficient to confidently age the nestling(s) at fledging. Useful information was sometimes extracted from additional nests that were found during the nest phase but experienced predation prior to fledging. We present summary descriptions and photographs best representing observations across numerous individuals. Day-by-day descriptions (bullets providing Key Visual Indicators, and longer General Descriptions) and photographs (figures) are presented below. We present day number for each day, with hatch day as Day One.

Day1: Hatch Day

Day 1 Key Visual Indicators

- Young are small (egg-sized)
- Down may still be moist
- Skin pink; no feather tracts visible
- Cannot or has trouble lifting its head



Figures 1A and 1B. Arizona Grasshopper Sparrow chicks – Day 1 (25 July 2013). Photos by Janet M. Ruth

General Description

Young are small (egg-sized) and spend much of their time curled up as if still in egg. Eyes and ears closed; openings into ear canal and eye slits not yet visible. Down may still be moist; pale gray or whitish-gray fuzz if dry. Although Vickery (1996) describes Grasshopper Sparrow hatchling down as grayish-brown, in this subspecies, pale gray or whitish-gray is more accurate. Skin pink. No feather tracts/pins are visible below skin. Some individuals retain the egg tooth, which appears as a lighter-colored (whitish) “bump” at tip of mandible. Bill color, especially on mandible, is combination of pink and some yellow, especially close to the rictal flange. Rictal flange yellow. Gape is primarily reddish-pink with yellow on the rictal flange and some color pattern developing in the gape. Inside the upper mandible, there are pale fringes on either side of the darker choanal slit, and two dark gray spots on either side of the slit; inside the lower mandible the papillae at the base of the tongue can appear yellow or pale against the pink background. No gaping, or has difficulty gaping. Cannot (or has trouble) lifting its head. If head is lifted, cannot be kept up for more than a couple seconds.

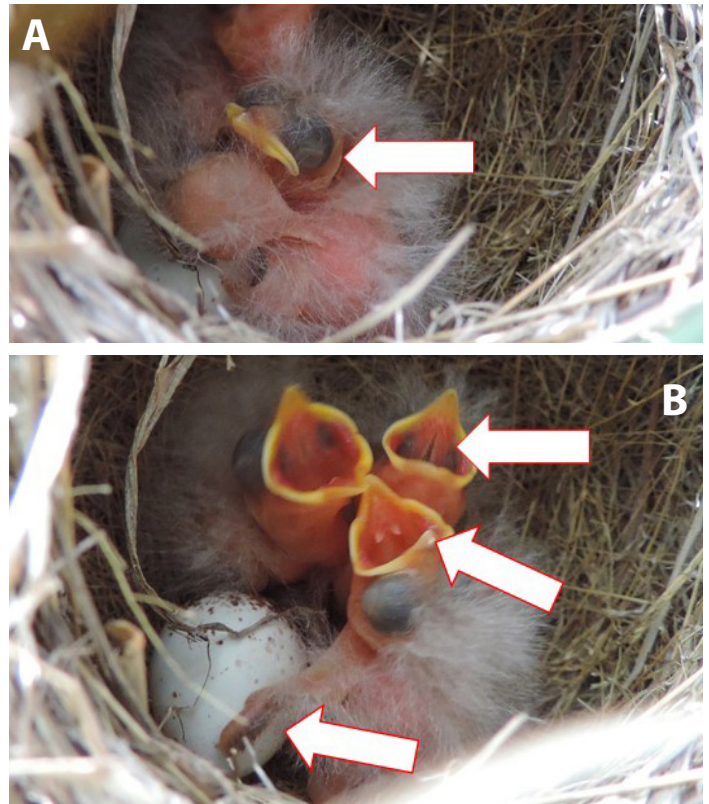
Day 2

Day 2 Key Visual Indicators

- Eyes closed, but eye slit may be visible
- Alar tract (primary) feathers visible subcutaneously
- Able to gape and lift head

General Description

Eyes closed although eye slit may be visible. Ears closed. Fuzzy; fuzz whitish-gray or pale gray. Skin pink. Alar (primary) tracts on wings visible subcutaneously; no other feather tracts are visible. Some individuals still retain pale egg tooth, but it is usually gone after second day. Bill is still mostly pink on the outside. Yellow rictal flange extends from the rictal commissure (posterior point where the mandible and maxilla meet) all the way around the edge of the bill. Interior of mouth is primarily reddish-pink and the color patterns described for Day 1 have become more distinct. Able to gape and lift its head; has better control over head movements and can keep head up while gaping for several seconds without difficulty. Responds to sounds like adult chip notes/feeding cue call (camera beep!).

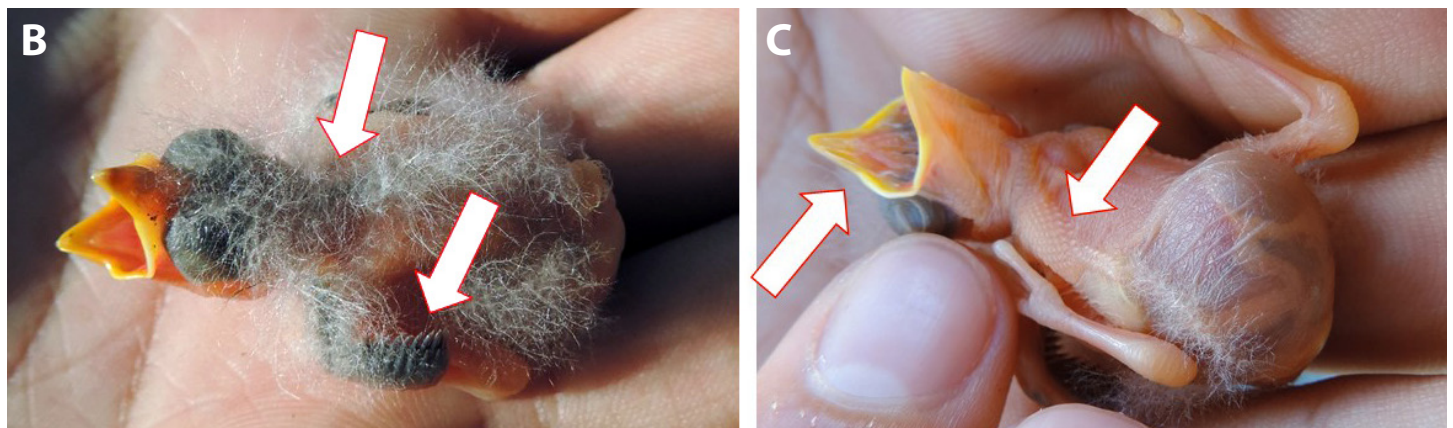


Figures 2A and 2B. Arizona Grasshopper Sparrow chicks – Day 2 (29 July 2013). Photos by Janet M. Ruth

Day 3

Day 3 Key Visual Indicators

- Eye slits visible
- Ears starting to form/open
- Dorsal tract and ventral tract (breast/flanks) visible subcutaneously
- Alar tract (primary, secondary, and covert pin feathers) beginning to emerge
- Gapes in response to any movement or sound



Figures 3A – 3C. Arizona Grasshopper Sparrow chick – Day 3 (3A – 3 August 2013; 3B and 3C from a different nest on 6 August 2013). Photos by Janet M. Ruth

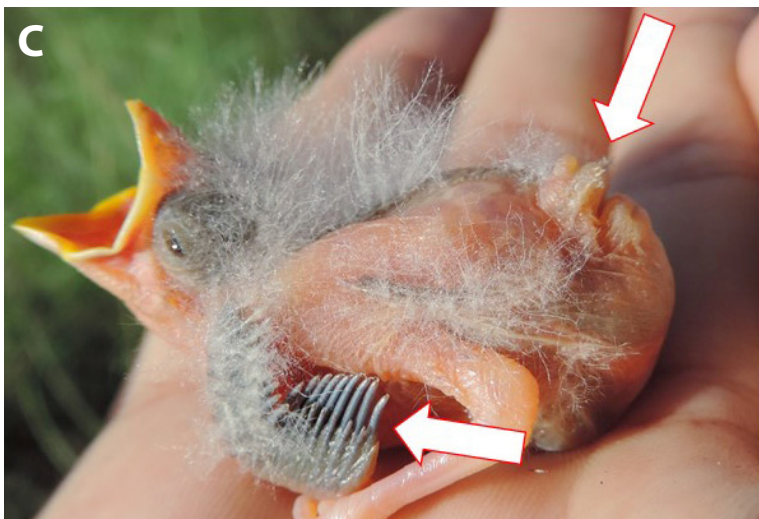
General Description

Eyes closed; eye slits visible and skin at slit may begin to separate, but can't see eye yet. Ears starting to form/open—skin beginning to descend into ear. Still fuzzy, with whitish-gray or pale gray down on capital, dorsal, alar and crural tracts. As feather tracts develop, skin begins to look darker. Dorsal tract and ventral tracts (along breast/flanks) visible subcutaneously. Ventral tract feathers often lighter in color than other feather tracks so may be difficult to see under skin, but a “bumpy” appearance develops as feathers emerge through skin. Alar tracts (primary, secondary, and covert pin feathers) beginning to emerge through skin. Tip of bill beginning to develop horn color on mandible in some individuals, but maxilla pinkish or yellow. Rictal flange remains bright yellow all around the edge of the bill. Gapes in response to any movement or sound.

Day 4

Day 4 Key Visual Indicators

- Eye slits partially open
- Skin continues to descend into ear canals, but not complete
- Capital and caudal tracts visible subcutaneously
- Pin feathers beginning to emerge on dorsal, ventral (breast/flanks), and crural tracts
- Alar tract (primary, secondary, and covert) pin feathers have extended about 1 cm



Figures 4A – 4D. Arizona Grasshopper Sparrow chick – Day 4 (4A – 4B 2 August 2013; 4C – 4D from a different nest on 6 August 2013). Photos by Janet M. Ruth

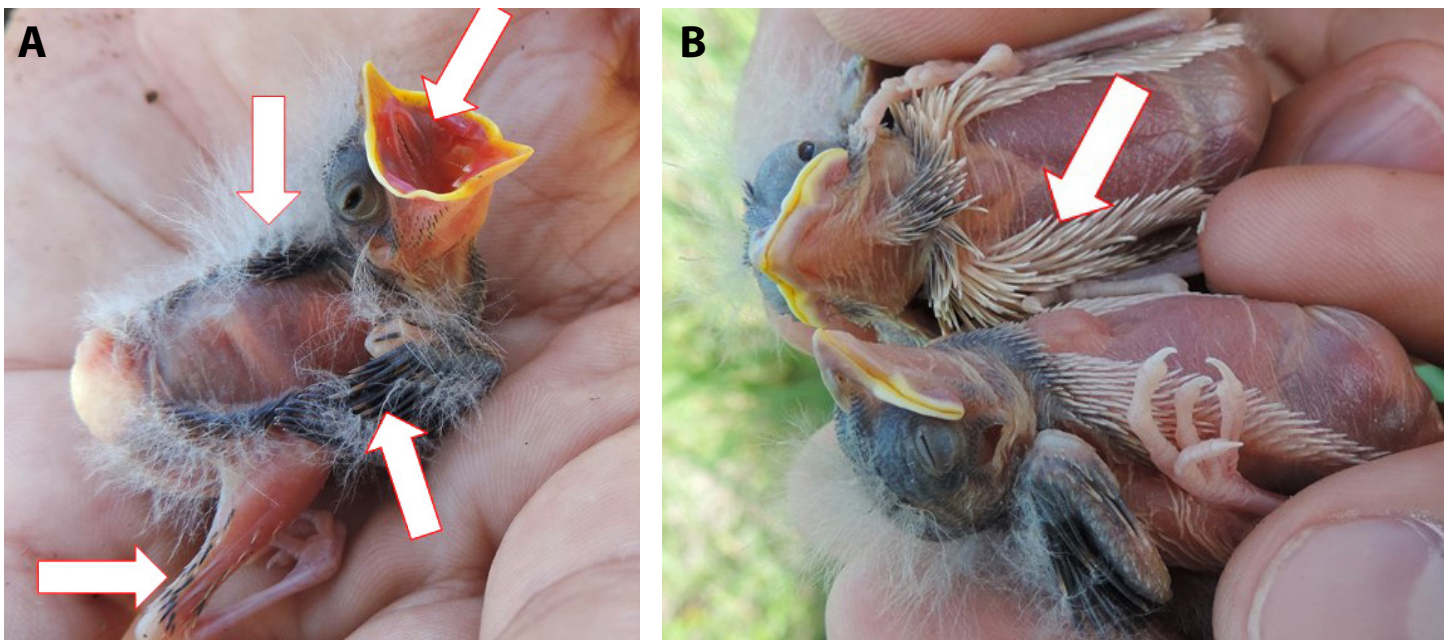
General Description

Eye slits partially open; may be able to see part of eyeball through the slit. Ears continue to open; skin continues to descend more deeply into ear but not yet forming complete ear canal. Still sparse whitish-gray or pale gray fuzz along capital, dorsal, alar, crural and caudal tracts. Skin continues to darken, at least partially due to subcutaneous feather tracts. Capital and caudal tracts visible subcutaneously – looks like dots beneath skin on head. Pin feathers begin to emerge through skin on dorsal, ventral (breast/flank) and crural tracts. Alar tract (primary, secondary, and covert) pin feathers in sheath have extended about 1 cm. Mandible continues to show some horn color, and yellow rictal flange still extends from the rictal commissure all around the edge of the bill. Gape continues mostly reddish-pink with some darker gray spots on inside of mandible and yellow on tongue papillae. Gapes in response to any movement or sound. Has better control over body movements and now sits upright in nest rather than appearing to flop around.

Day 5

Day 5 Key Visual Indicators

- Eyes partially open; ears completely open
- Fuzzy down beginning to disappear
- Pin feathers on dorsal, ventral, and crural tracts beginning to extend, still in sheath
- Alar tract (primary, secondary, and covert) pin feathers extended 2-3 cm but still in sheath
- “Wires” extend from caudal tract where pin feathers will emerge



Figures 5A and 5B. Arizona Grasshopper Sparrow chicks – Day 5 (5A – 29 July 2013; 5B – chicks from a different nest on 3 August 2013). Photos by Janet M. Ruth

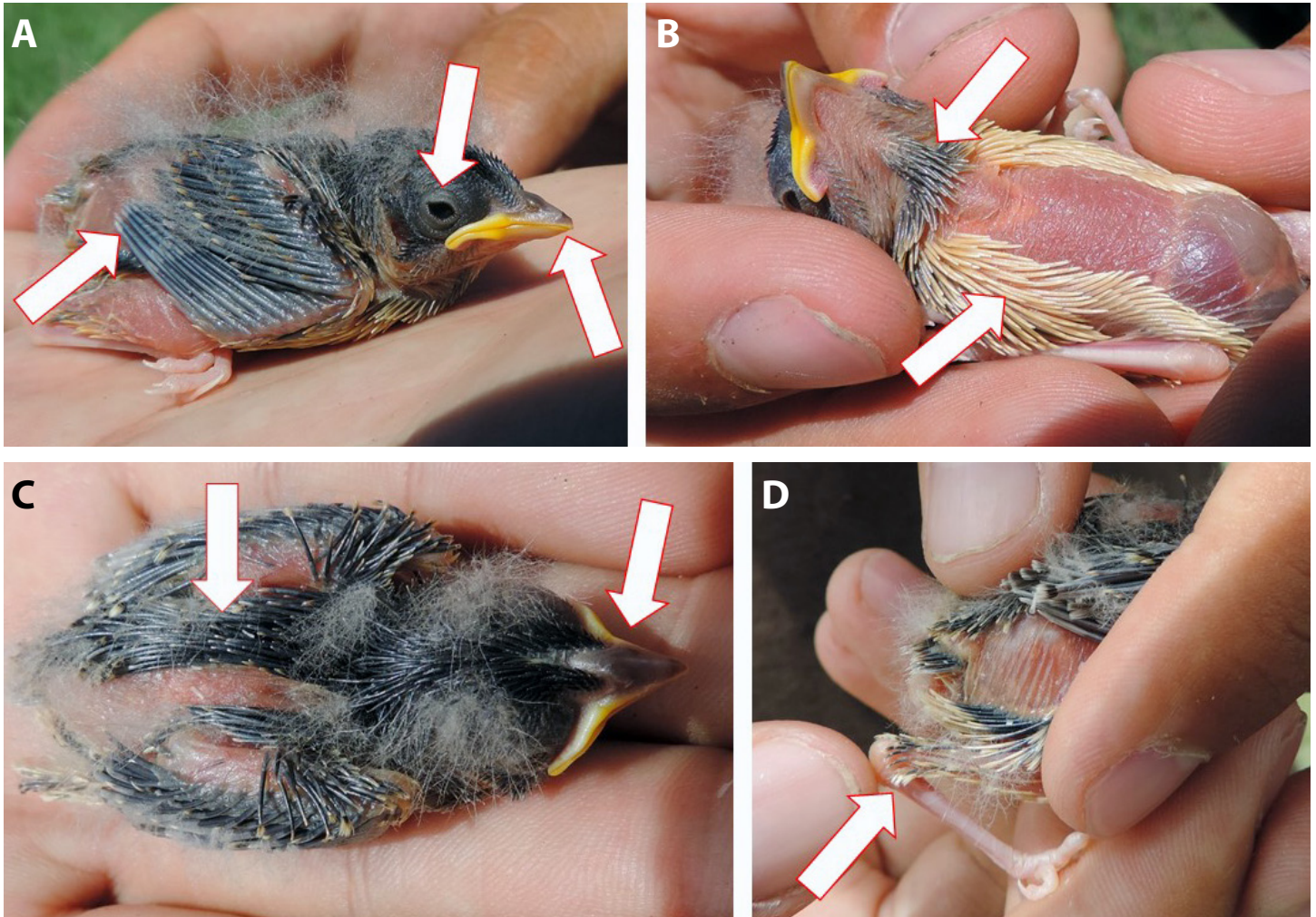
General Description

Eyes still only partially open; eyelids are becoming recognizable. Ears completely open. Fuzzy down along capital, alar, crural, and caudal tracts becoming less obvious as the pin feathers extend. Skin continues to appear darker. Capital tract on head still subcutaneous but appears like a “patch.” In caudal tract, thin “wires” extend where the pin feathers will soon emerge. Pin feathers on dorsal, ventral (breast/flanks), and crural tracts beginning to extend, still in sheath. Alar tract (primary, secondary, and covert) pin feathers extended 2-3 cm (not fully extended and still in sheath). In at least some individuals, the mandible is becoming more gray or horn-colored; the rictal flange is becoming paler yellow and beginning to be distinctly bright yellow only at the rictal commissure. Color patterning is fading in the gape, in and around choanal slit; gape primarily reddish-pink. Gapes in response to movement but stops when realizes it’s not a parent; clearly able to see even if eyes not fully open. Gapes towards entrance of nest and not just up. More able to move around within the nest and will attempt to move farther back in the nest away from a perceived threat.

Day 6

Day 6 Key Visual Indicators

- Eyes completely open
- Pin feathers on capital tract, face and ventral (throat) tract, as well as caudal tract, emerged and may be extending
- Pin feathers on dorsal, ventral (breast/flanks), crural, and alar (primary, secondary, and covert) tracts fully extended; some tips may begin to unsheathe
- Bill becoming more horn-colored and larger/longer



Figures 6A – 6D. Arizona Grasshopper Sparrow chick – Day 6 (6A and 6B – 3 August 2013; C and D – chick from a different nest on 5 August 2013). Photos by Janet M. Ruth

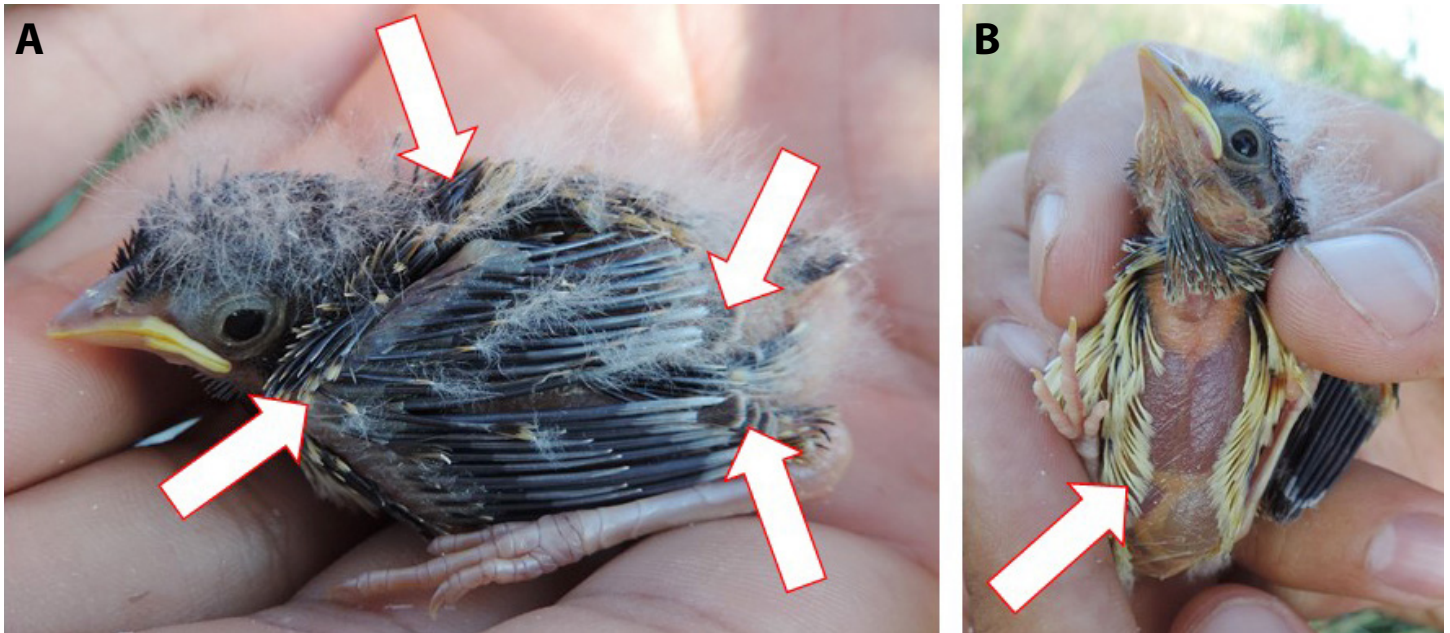
General Description

Eyes completely open. Fuzzy whitish-gray or pale gray down is sparser along the major feather tracts. Pin feathers on face, capital, ventral (throat), and caudal tracts emerged through skin and beginning to extend. Alar tract (primary, secondary, and covert) pin feathers fully extended, and some tips are beginning to unsheathe (appear pale or white); pin feathers on dorsal, ventral (breast/flanks), and crural tracts are fully extended and some tips are also beginning to unsheathe. Bill, especially mandible, primarily horn-colored and getting longer. Bright to paler yellow gape flange restricted to rictal commissure. Continues to gape in response to movement but stops when realizes it's not a parent. Note: since nestlings rarely gape for observers at this age, no longer able to describe gape color or patterns. Debris from feather sheaths may become visible at the bottom of the nest at this point looking like small shiny flakes, straws, or dust.

Day 7

Day 7 Key Visual Indicators

- Losing remaining down on head and body
- Caudal and capital tract pin feathers extending, still in sheath
- Dorsal tract pin feathers still sheathed
- Ventral (breast/flanks) and crural tract pin feathers beginning to unsheathe
- End of alar tract (primary, secondary and covert) pin feathers unsheathed
- No longer gaping; flinch response



Figures 7A and 7B. Arizona Grasshopper Sparrow chick – Day 7 (2 August 2013). Photos by Janet M. Ruth

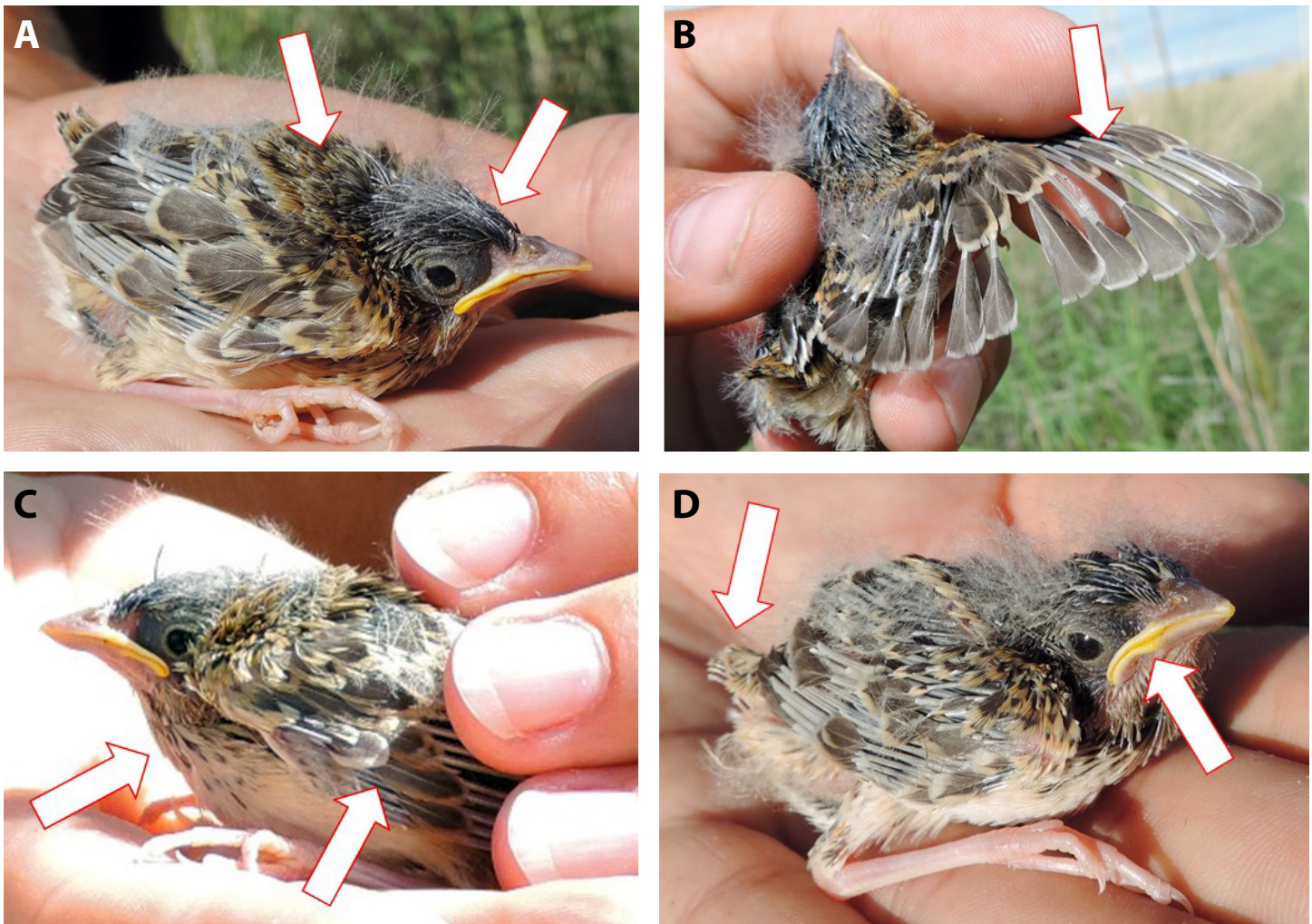
General Description

Tufts of down sparser but protruding between feather pins on capital, alar, crural and caudal tracts. Capital tract pin feathers beginning to extend, still in sheath, but caudal tract pin feathers still short; dorsal tract pin feathers still sheathed. Ventral (breast/flanks) and crural tract pin feathers partially unsheathed. The ends of alar tract (primary, secondary and covert) pin feathers are unsheathed (dark brownish color with pale tips). Bill mostly horn-colored and continues to grow longer; gape flange at rictal commissure is turning paler yellow. No longer gapes in response to observer, and in fact, begins to exhibit a “flinch response” when observer approaches the nest. Feather sheath debris increasing at bottom of nest.

Day 8

Day 8 Key Visual Indicators

- Caudal tract pin feathers barely extended and most still in sheath
- Most capital tract pin feathers still in sheath; a few starting to unsheathe
- Alar (primaries and secondaries), dorsal and ventral (breast/flank) pin feathers unsheathed as much as halfway
- Spots becoming visible on feathers below chin
- Nestling looks back at observer



Figures 8A – 8D. Arizona Grasshopper Sparrow chick – Day 8 (8A – 8C 5 August 2013; 8D – chick from another nest on 3 August 2013). Photos by Janet M. Ruth

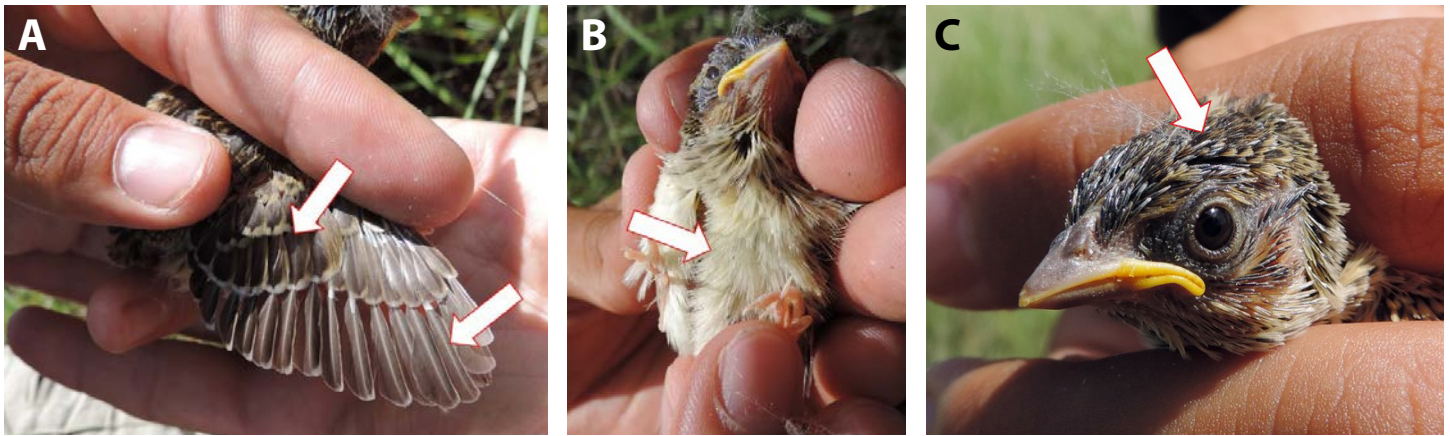
General Description

A few bits of down remain on head and back. Caudal tract pin feathers short; barely extended and only a few pale unsheathed tips. Most capital tract pin feathers still sheathed; a few may be starting to unsheathe. Dorsal and ventral (breast/flank) pin feathers unsheathed halfway or more. Streaking on throat feathers becoming apparent. Alar tract (primary and secondary) pin feathers unsheathed from 1 cm to halfway; alar tract (covert) and crural tract pin feathers unsheathed as much as three quarters. Bill continues to grow; both mandible and maxilla are primarily horn-colored. Rictal flange continues to recede, turning paler yellow with the exception of the base of the rictal commissure. Is alert - looks back at observer (follows movements with eyes/head), no longer gapes in response to observer, and flinches when observer approaches the nest. NOTE: By this day (Day 8) there is a notably increased chance of forced early fledging due to nest or nestling disturbance; the majority of nestlings fledged over the next two days. Conduct monitoring and nestling handling with care.

Day 9

Day 9 Key Visual Indicators

- Capital tract (crown) pin feathers $\frac{1}{2}$ unsheathed; central crown stripe may be visible
- Dorsal tract pin feathers $\frac{1}{2}$ to completely unsheathed
- Alar tract (primary and secondary) pin feathers $\frac{1}{2}$ to $\frac{3}{4}$ unsheathed
- Alar (covert), ventral (breast) and crural tract feathers fully unsheathed
- Body appears fully feathered



Figures 9A – 9C. Arizona Grasshopper Sparrow chick – Day 9 (5 August 2013). Photos by Janet M. Ruth

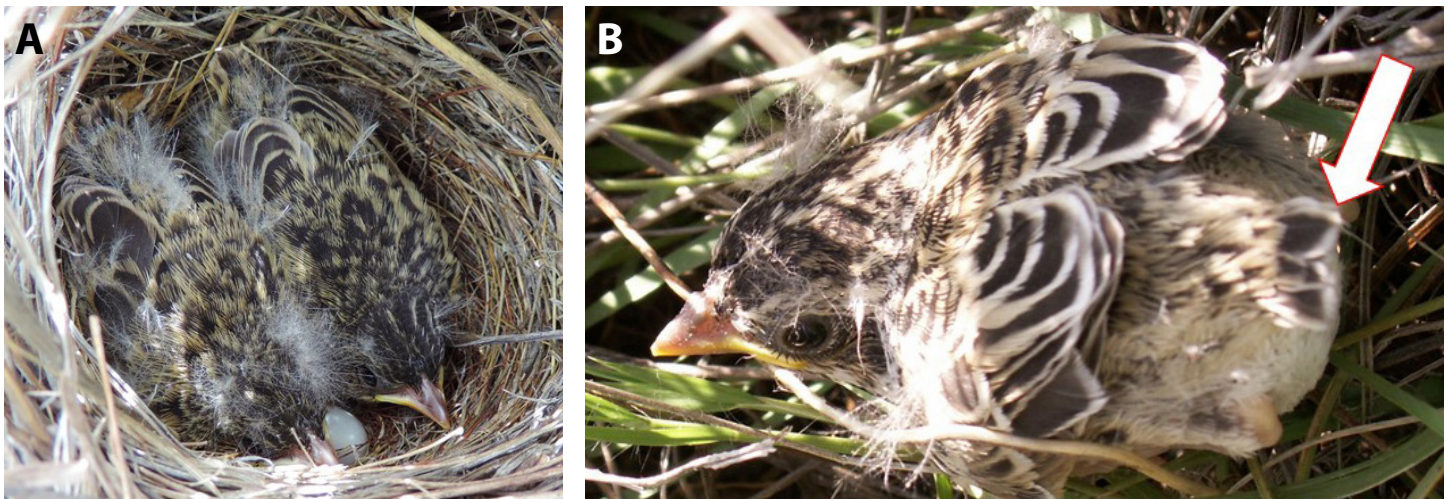
General Description

Only a few tiny tufts of down remain on the head of some individuals. Face and capital (crown, and head) pin feathers half unsheathed and central crown stripe may start to be visible. Dorsal tract pin feathers half to completely unsheathed. Caudal tract feathers still short but partially unsheathed. Alar tract (primary and secondary) pin feathers halfway to three quarters unsheathed; alar tract (covert) feathers completely unsheathed. Ventral (breast/flank) and crural tract feathers completely unsheathed; breast feathers on some individuals appear beige while others have a distinct yellowish color. Bill is primarily horn-colored and continues to grow; rictal flange continues to recede and become paler yellow. Is alert—looks back at observer, no longer gapes in response to observer, and flinches when observer approaches the nest. Is now capable of walking and perching; may attempt to hold on to something with feet rather than feet remaining limp when handled. Notable amounts of feather sheath debris have accumulated at bottom of nest, although, due to parental removal, the nest is still free of fecal sacs. Based on approximately 40 of the 128 nests monitored over 3 years for which we had sufficient data, the vast majority of Arizona Grasshopper Sparrow nestlings fledged 8–9 days after hatching day (Ruth 2017), making that Day 9–10. Therefore, many nestlings fledged on this day (Day 9) or the subsequent day.

Day 10

Day 10 Key Visual Indicators

- Tail short but visible part is unsheathed
- Chick appears fully feathered
- Wing and body feathers completely unsheathed
- Central crown stripe may be obvious on some individuals



Figures 10A and 10B. Arizona Grasshopper Sparrow chicks – Day 10 (10A 5 August 2013; 10B – a chick just fledged from a different nest on 31 July 2012). Photos by Janet M. Ruth

General Description

Almost all down is gone, with remaining bits along the capital and lower dorsal tracts of some individuals. All alar tract and body feathers completely unsheathed; wing feathers take on a cleaner look without any pin feather sheathes remaining. Body appears fully feathered. Central crown stripe may be obvious on some individuals. Tips of caudal tract feathers unsheathed but short with bases still sheathed but not visible. Yellow rictal flange at rictal commissure is still visible but continues to recede. Has well-developed wings, feet and legs and is capable of fluttering and hopping away from an observer. Is alert—looks back at observer, no longer gapes in response to observer, and flinches when observer approaches the nest. Frequently hunkers down and freezes. Most nestlings fledge on this day (Day 10), or before, and we don't have information or photographs about any older known-aged chicks. As mentioned for previous days, from Day 6 onward, feather debris may accumulate in the bottom of the nest, which is easiest to see after the chicks have fledged (Figure 11).



Figure 11. Feather debris (white flakes and straws in center) that begins collecting in the bottom of a nest after Day 8; here in a nest in which chicks have just recently fledged; arrows point to fecal sacs left by fledging chicks on rim of nest (9 August 2012). Photo by Janet M. Ruth

DISCUSSION

We hope that the information we provide will allow other biologists to identify and achieve better nestling age estimates for Arizona Grasshopper Sparrows. One observation of note is related to the color of hatchling/nestling down and applications beyond this region and subspecies. The color of down on newly hatched altricial young birds varies among species from white through gray and brown to black (Kilner 2006). A quick perusal of *Birds of North America* accounts (BNA 2018) for similar-sized grassland bird species that overlap with Grasshopper Sparrows in the western part of its range identifies down colors including slate gray, pale smoky gray, light gray, pale or medium neutral gray, buffy, buffy gray, cream-buff, and grayish-brown. One of the authors was able to use our observations of nestling down color along with nest structure to identify the first Grasshopper Sparrow nest (*A. s. perpallidus*) from among other grassland bird nests on an eastern Alberta, Canada study site (J. Kitting, pers. comm.).

As others have recommended (Jongsomjit et al. 2007, Morales Fernaz et al. 2012), we emphasize that a combination of characteristics should be used to reliably age a nestling, due to individual variation in any particular characteristic. We acknowledge the limitations of the observations we made and encourage other field biologists to take additional measurements, especially mass, total body length, and length of wing chord, tarsus, primary and retrix pins, and culmen (Jongsomjit et al. 2007), to supplement the basic information we provide for the *ammolegus* subspecies. In addition, the same information should be collected for nestling development in other Grasshopper Sparrow subspecies to determine whether this information for *ammolegus* is applicable across the entire species or whether there are important subspecific differences.

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