

ELECTRONIC APPENDIX

This is the Electronic Appendix to the article
Economy of mate attraction in the Cassin's finch

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Appendix

In Cassin's finches (*Carpodacus cassinii*) (figure 1), male song can occur year-round, although it is concentrated during the breeding season. Cassin's finches produce two general types of songs. The vast majority of songs are of a type that is loud, stereotyped, rapid-cadence,



Figure 1. Male Cassin's finch (*Carpodacus cassinii*). Photograph by Monte M. Taylor.

and given while perched or, in the early breeding season, during gliding flight (figure 2). The syntax of these songs appears to be the same whether the birds are perched or flying (Samson 1976).

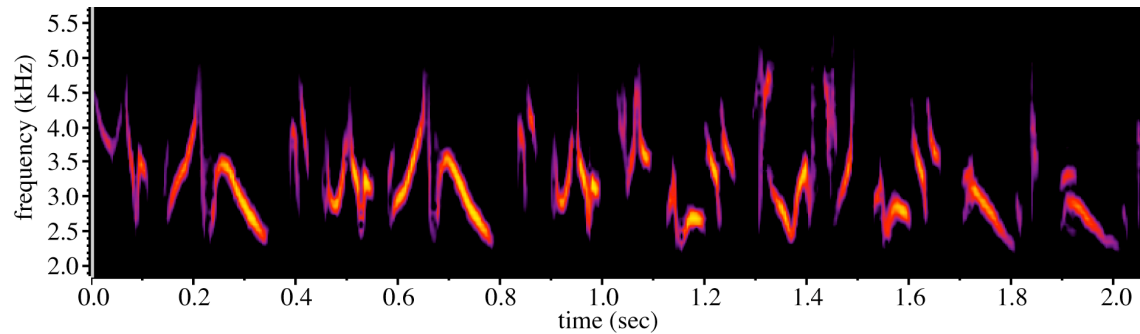


Figure 2. Spectrogram of stereotyped, rapid-cadence Cassin's finch (*Carpodacus cassinii*) song composed primarily of species-specific syllables. Color warmth reflects amplitude. In Adobe Acrobat, **click on the spectrogram to hear the song.**

The second general type of song is given only when perched (Hahn 1996). It differs syntactically from the stereotyped, rapid-cadence songs in being relatively slow cadence (i.e., longer pauses between song elements), very long (over 1 min in duration is not unusual), and in consisting almost entirely of heterospecific imitations occasionally interspersed with very high frequency (about 10 kHz) pure tones (figure 3). Whereas the stereotyped, rapid-cadence songs are loud and appear to occur during a variety of social contexts, including times when there are no other Cassin's finches in immediate proximity to the singer, the slow-cadence songs are often produced at very low amplitude and apparently only when another bird is very near. Slow-cadence songs may be particularly frequent immediately prior to copulations, but males have been observed seemingly directing them at other males. The vast majority (over 95%) of songs recorded in this study were of the stereotyped, rapid-cadence type (figure 2).

Mated males tend to cease singing entirely around the time their mates begin nest building, whereas unmated males continue singing for several weeks past the time most females begin nest building (Samson 1976). This, combined with the fact that males do not sing when aggressively defending their mates from other males (Samson 1976), suggests that song serves primarily a mate attraction function (Hahn 1996). However, it is possible that the two different song types, rapid- and slow-cadence, play different roles; the loud, rapid-cadence songs likely

function primarily in longer-distance, general advertisement for a mate, whereas the soft slow-cadence songs may function primarily in highly specific inter-individual interactions when a

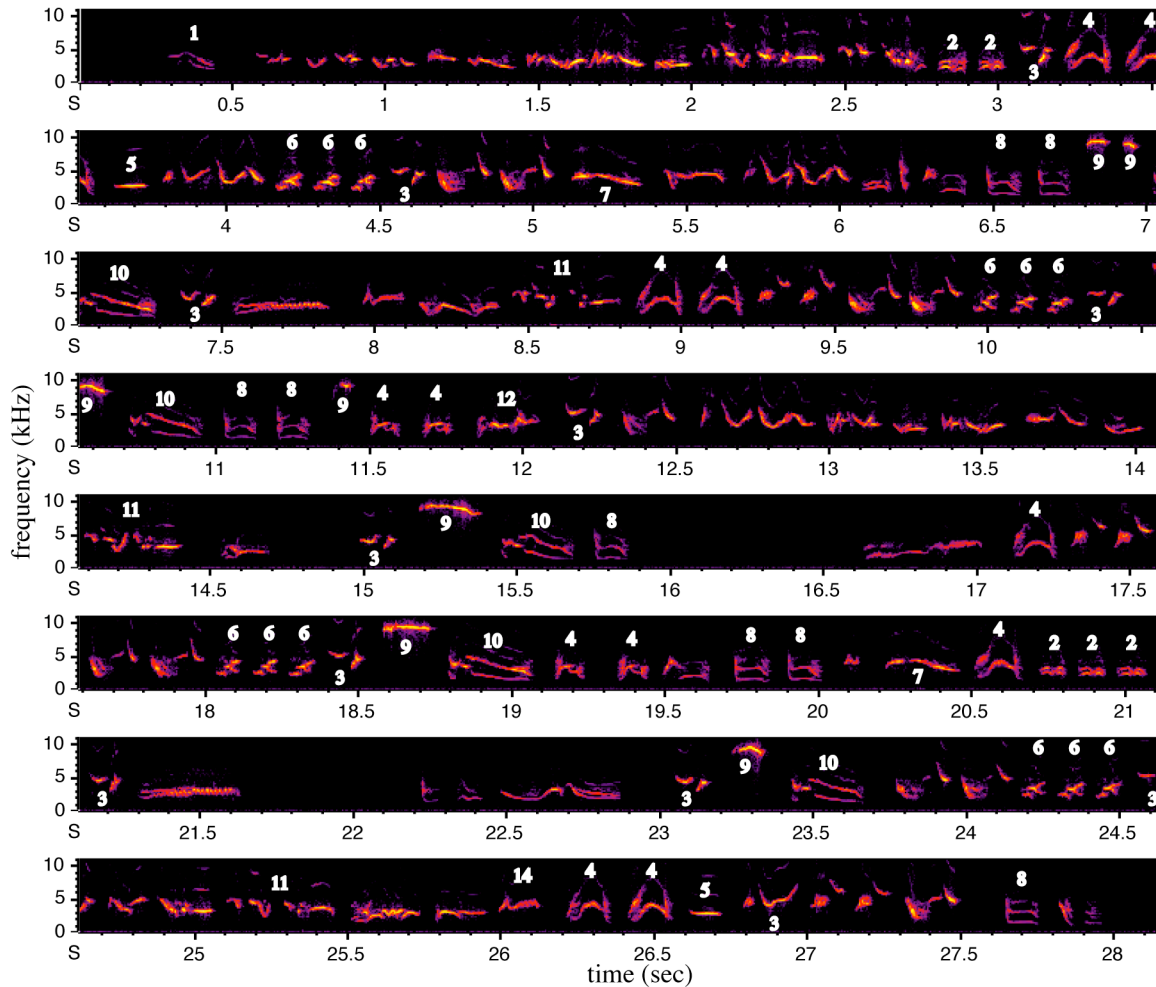


Figure 3. Spectrogram of slow-cadence Cassin's finch (*Carpodacus cassinii*) song composed of mostly heterospecific syllables. Color warmth reflects amplitude. In Adobe Acrobat, **click on the spectrogram to hear the song**. Numbered notes and note complexes were identified by ear as: 1, Cassin's finch "teew" call; 2, white-breasted nuthatch (*Sitta carolinensis*); 3, dusky flycatcher (*Empidonax oberholseri*); 4, American robin (*Turdus migratorius*); 5, Townsend's solitaire (*Myadestes townsendi*); 6, Steller's jay (*Cyanocitta stelleri*); 7, type II evening grosbeak (*Coccothraustes vespertinus*); 8, dark-eyed junco (*Junco hyemalis*); 9, Cassin's finch high "whistle"; 10, northern flicker (*Colaptes auratus*); 11, mountain chickadee (*Poecile gambeli*) "gargle"; 12, western tanager (*Piranga ludoviciana*); 13, pine grosbeak (*Pinicola enucleator*); 14 western wood-pewee (*Contopus sordidulus*).

mate or potential mate is in close proximity. An intriguing possibility is that rapid- and slow-cadence Cassin's finch songs are analogous to the "undirected" and "directed" songs, respectively, described for zebra finches (*Taeniopygia guttata*) (Zann 1996).

Cassin's finch breeding occurs in loose colonies in coniferous forests of the western United States. Dense breeding populations occur as low as about 1000 m in dry ponderosa pine (*Pinus ponderosa*) forests in the eastern Cascades of Washington State, up to around 3000 m elevation in lodgepole pine (*Pinus contorta*) forests of the Sierra Nevada in California (figure 4).



Figure 4. Representative Cassin's finch (*Carpodacus cassinii*) habitat in late spring at approximately 3000 m elevation in the Sierra Nevada, California, USA. Habitat is composed primarily of lodgepole pine (*Pinus contorta*) stands interspersed with wet clearings. Photograph by Keith W. Sockman.

Individuals appear to be socially monogamous (Samson 1976); there is no information regarding rate of extra-pair fertilizations. Males feed their mates during incubation, and females recognize individual-specific "feeding calls" produced by their mates. When incubating females hear their mate's feeding call, they fly to a perch near the nest to be fed, but they do not respond in this way to the feeding calls of other males (Samson 1978). Rather than defending fixed, all-purpose territories, males exclude other males from the area immediately surrounding their mate,

wherever she may be. The size of the defended area peaks at the time of clutch initiation. As noted above, song is not used as part of mate defence at this time.

Male Cassin's finches display delayed plumage maturation; yearling males achieve breeding condition while still in a drab, brown female-like plumage (Samson 1974). Their testes are fully competent, though averaging slightly smaller than those of older males. The sex ratio can be substantially male biased, and in some studies the brown, yearling males are less likely than the red, older males to acquire mates (Mewaldt & King 1985). It is unknown whether this mating bias is related to the immature plumage or to the somewhat less complex songs sung by yearling males (cf. Samson 1978).

Cassin's finch breeding schedules are highly seasonal and likely controlled strongly by photoperiod, although detailed studies remain to be performed. Breeding occurs only during the long days of late spring and early summer (Hahn 1996), and individuals become absolutely refractory to the stimulatory effects of long days (Hahn and MacDougall-Shackleton, unpublished data), like their close relative, the house finch (*Carpodacus mexicanus*) (Hamner 1968). Inter-annual variation in environmental conditions can lead to variation in timing of onset and termination of reproductive activity, on the order of a few weeks (Hahn 1996), and, for this reason, seasonal timing of singing activity varies somewhat among years (Samson 1976, 1978; Mewaldt & King 1985). Like most photoperiodic bird species, variation in timing of reproductive activity can also be attributed to inter-individual differences in reproductive schedule, as described in the present study.

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