Part 2: Syntax

Birding by Ear, Visually

It's dawn and the birds are singing. Here's the American Robin with four or five cheery warbles, there's the Eastern Towhee with *drink your tea*. Off in the swamp the Barred Owl still goes *who cooks for you?* Also from the swamp comes a hurried-sounding series of hiccups leading to a recognizable Acadian Flycatcher song. And there is more, much more, including Chuck-will's-widow, Brown Thrasher, Northern Mockingbird, Great Crested Flycatcher, Eastern Bluebird, Northern Parula, and Prothonotary Warbler, here at Lumber River State Park in eastern North Carolina, at 5:00 a.m. in late April. Not a bird is to be seen, but the dawn chorus proves they are all in.

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What a wondrous cacophony! I might pause to ask why they're all singing at once (see Staicer et al. 1996). No, no time for that. I'm already beginning to focus my attention on one singer at a time, conjuring now a golden yellow head, now a white belly flanked by rufous, now intricate swirls of brown and gray. Matching a sound with a visual image so you can name it—Is that a skill you would like to improve?

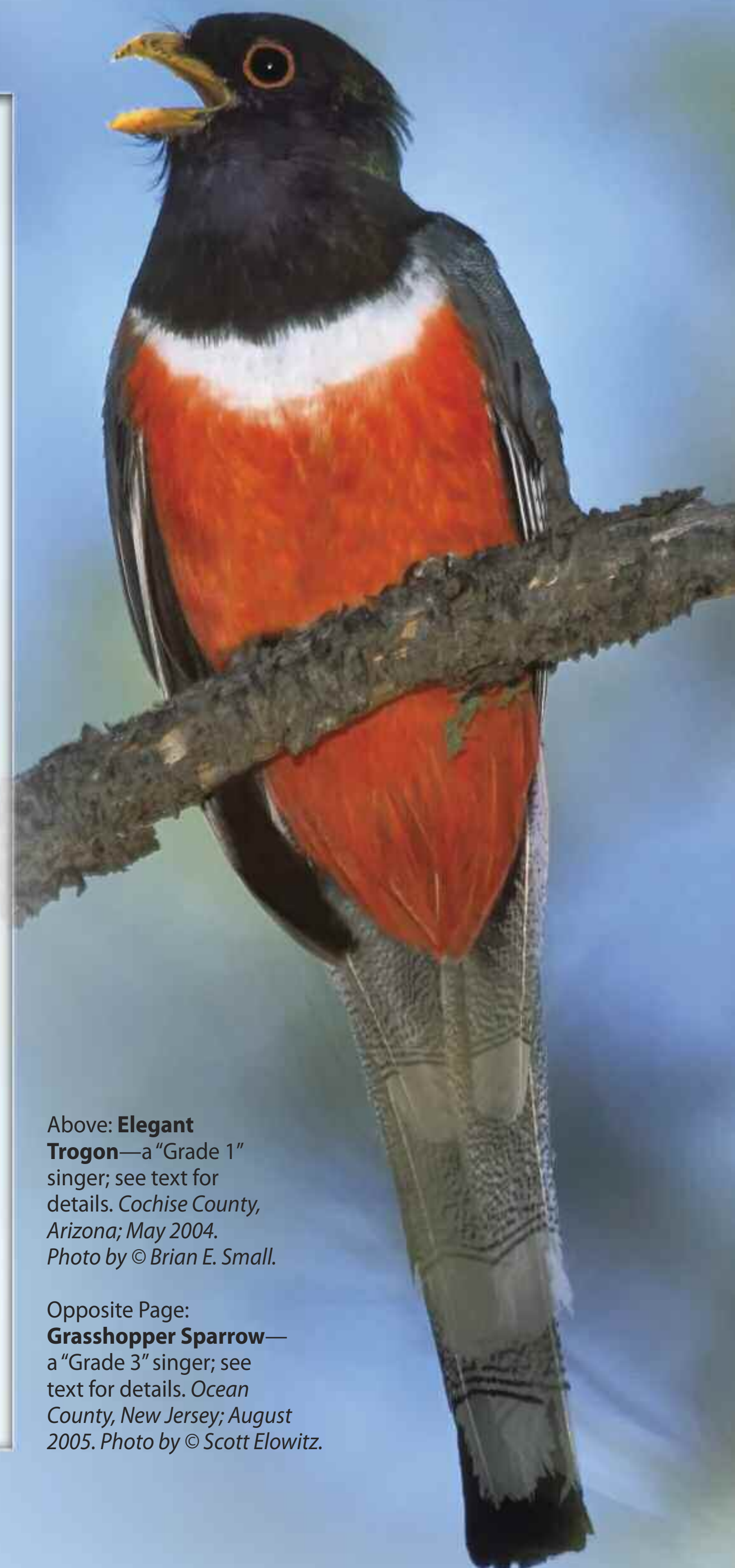
Human language and music confirm that we are made for listening, but many birders struggle with birdsong. Why is that? And what can be done about it? The "why" is simple, in my opinion. Birds are much smaller than we are, and everything about small animals works faster—not only the sound-production machinery, but also the sound-perception machinery. We simply can't keep up with the temporal detail in their ultrafast (for us) vocal productions. On top of that, our brains merge the details of complex sounds, presenting them to consciousness as chords (Hartmann 1998), which birds can tease apart better than we can (Dooling 2004).

The solutions are (1) to retrieve the details lost between the ear and the brain and (2) to slow the doggone things down. The way to do that is to use our eyes. Pictures of sound, called sound spectrograms or "sonograms," give us a way to reconstitute the harmonics that were merged in our brains, and to slow down the breakneck speed of the birds' tiny voice boxes (McCallum 2010). That's birding by ear, *visually*.

Communication

Acoustics Only

Most species of birds have large repertoires of vocal signals. Many of these sounds are short *calls*. Calls give simple messages, typically saying something about the internal state of the sender, such as "I am (still) here" or "I am hungry!" or "Get out!" or "Sex now, puh-leeez!" A few types of calls refer to a thing, such as food or a predator, that is external to the calling bird (Marler 2004b). Some calls, especially those



Above: **Elegant Trogon**—a "Grade 1" singer; see text for details. *Cochise County, Arizona; May 2004. Photo by © Brian E. Small.*

Opposite Page: **Grasshopper Sparrow**—a "Grade 3" singer; see text for details. *Ocean County, New Jersey; August 2005. Photo by © Scott Elowitz.*

We're all aware that birds sing. But what *is* birdsong? What are the components of birdsong? In this article, we learn that birdsong has parallels with human language. Individual notes and phrases are strung together according to certain rules of *syntax*, and the result is birdsong. How can we make sense of it all? A great way is to learn some of the basics of avian syntax, paying special attention to three major "grades" of singing in North American land birds. This article teaches us how.

which refer to predators, are often designed for open communication with other species, and so are not necessarily identifiable to species.

The information in calls is encoded in acoustic variation, so identifying calls requires a good ear and good memory for sound. Looking at sonograms while listening to these calls may help you commit them to aural memory. Slowing these sounds down may help you hear more of their detail at full speed. I discussed the acoustics of bird sounds in a recent article in *Birding* (McCallum 2010), which I refer to in this article as *Part 1*. Check the Web-Extra <tinyurl.com/2bj8qlj> for *Part 1* to pair slowed-down sounds with sonograms.

Acoustics Plus Syntax

The dawn chorus displays a different class of bird sounds, namely, *songs*. On average, the *notes* and *phrases* (Fig. 1) that make up songs are more intricate acoustically than calls. That gives them more capacity for carrying information. Moreover, these notes and phrases are combined in distinctive ways to make the songs. More information! Finally, singing birds arrange songs in formal sequences, which can be called *serenades* (Hailman et al. 1994). Yet more information!

Why do songs and singing (Smith 1991) have so much information-encoding capacity? Perhaps it's because singing, unlike calling, is related to long-term investments. Singers are communicating their willingness to defend their spaces and/or their desirability as mates (Kroodsma and Byers 1991, Collins 2004). The latter objective especially calls for full disclosure; the choosy sex—usually but not always the female—needs as much information as possible to select a healthy and supportive mate. And, of course, a bird wants to be sure of the species of its suitor, lest it waste a nesting attempt on a mate with incompatible genes. The fitness and species of the singer are encoded in the details of its songs and singing. Those details include combination rules, or *syntax*.

We're Naturals At Syntax

In August of 2010, I heard a song in the boreal conifers of coastal Maine that I did not recognize. Neat song. I was hoping it was one of those spruce-woods warblers that I seldom encounter. After about three renditions of the song, it came to me: *trees, trees, pretty little trees*. Brown Creeper. I'm quite sure I had never heard that exact song before. I was able to identify it because I recognized the syntax of the song, the way notes of different duration, pitch, and quality were assembled into a whole. Good mnemonics, such as *trees, trees...*, help by capturing some of the diagnostic syntax of the song in a catchy phrase we can remember.

The mnemonics work because we humans have a natural facility, born of our language instinct (Pinker 1994), for those "combination rules," or syntax. We use syntax to construct and interpret understandable sentences. Syntax is the reason we can understand sentences we've never heard before.

Birds use their combination rules to construct and evaluate songs and serenades that are "acceptable" to members of their species. Singing is more of an audition, or an oration, than a conversation. But, even though human syntax and bird syntax have different uses, they are structurally similar. In both cases, small parts—for example, notes and phrases in birdsong, consonants and vowels in human language—are strung together into longer parts (songs, words), which, in turn, are strung together into longer parts (serenades, sentences). We use our own syntactical gifts to recognize the "species code" in the combinations birds construct. It's a lot easier than identifying a mammal by its odor. No wonder we like birds so much; we are amazingly like them, with our two-legged gait, love of color, and ear for syntax.

The Visual Approach

There are, of course, so many kinds of birds, each with a different code! That brings us back to sonograms, which freeze time and display the details of the songs, revealing and reminding us of the code in an instant. Does that sound familiar? Isn't that the approach Roger Tory Peterson taught us? His arrows showed us the salient features of complex visual patterns. Let's adapt Peterson's format, with sonograms substituted for paintings of the birds, and arrows pointing to the salient features that help you identify the song in the field. *Pitch*, *pitch trend*, *tempo*, and *syntax* are among these salient features that are visible on a sonogram (Fig. 1). Many songs can be identified by these features alone. And a collection of pictures is much easier to search than a collection of sounds.

Although each species has a different code, many species can share the same combination rules. In this article I want to show you the syntactical "lay of the land"—the kinds of combination rules you can expect from the birds you listen to. It turns out that one can distinguish at least three *grades* of singing in North American land birds—for the purposes of this article, those breeding in the continental U.S. and Canada. The three grades are largely confined to different taxonomic groups; they are correlated with the anatomical characteristics of those groups; and they are characterized by various acoustic "field marks," field marks just as diagnostic as the structure of the foot or the shape of the bill. Here we will use them as a framework (see table, p. 38) for organizing our knowledge of birdsong, and for assessing the challenges of birding by ear.

Grade 1: Monotony Rules

Grade 1 includes many nonpasserines, among them doves and pigeons, gallinaceous birds, cuckoos, trogons, woodpeckers, hawks, falcons, owls, and nightjars, as well as several passerine groups that do not occur in North America. They are the monotonous ones, the birds who sing the same thing on and on. Some have separate repertoires for repelling rivals and attracting mates, but, in such instances, they do not intermingle these repertoires in a given serenade. Their singing performances don't vary geographically except in concert with genetic differentiation of the sort represented by described subspecies. This level of geographic variation implies that they do not learn their songs, although I don't know that the matter has been investigated experimentally in Grade 1.

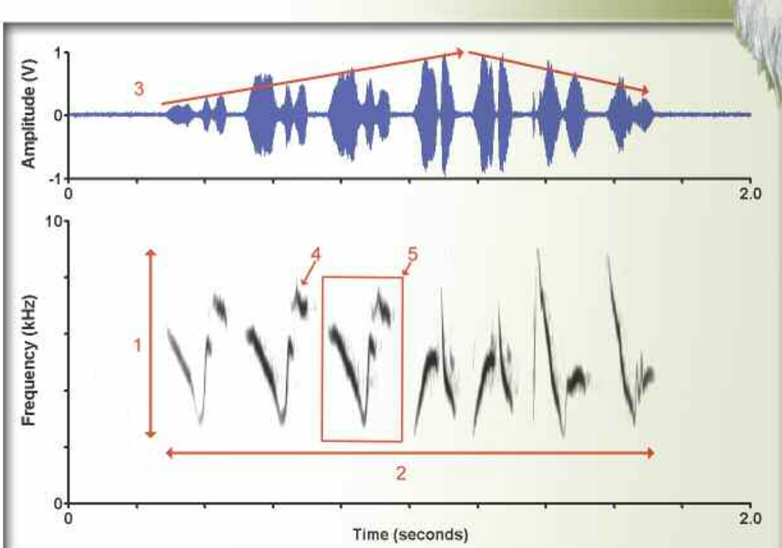
Songs in Grade 1 are either *series* of similar sounds—for example, the song of the Elegant Trogon—or short simple tunes—for example, the Mourning Dove's *coo* song. It may be the case that members of these taxonomic groups are anatomically incapable of producing the rapid pitch changes and buzzes of the songbirds.

The simple-tune singers of Grade 1 are among the easi-

Fig. 1. Shown here is a *song* of a **Lazuli Bunting,** presented as a sound spectrogram or "sonogram" (below) and as an oscillogram or waveform (above). A sonogram is a plot of frequency (vertical axis), measured in kiloHerz (KHz), against time (horizontal axis), and reveals at a glance (1) the frequency range and (2) the duration of a song. The oscillogram is a plot of variation in amplitude (perceived as loudness), measured in volts (V). The gradual increase and then decrease in loudness of this song is shown by both the vertical range of the blue blobs (3) and the darkness of the black traces on the sonogram.

Both graphs also show the timing of the song, which is even, rather than accelerating or decelerating. Each continuous trace is a *note* (4). Notes are often combined into *phrases* (5), which are easily recognized as such if they are repeated as a unit. Both notes and phrases function as "grammatical" units that may be repeated. The *syntax* of a Lazuli Bunting's song involves the repetition of three different *phrase types.* Although such graphs can't let you hear the sound, they describe it much more precisely and economically than words can.

Sound recording made at Hart Mountain National Antelope Refuge, Lake County, Oregon; 11 June 2002. Recording and sonogram by © Arch McCallum.



Lazuli Bunting. *Okanagan Valley, British Columbia; May 2010. Photo by © Glenn Bartley.*

est of birds to identify by voice. Every dove or pigeon in North America has a distinctive ditty, most of which can be remembered with mnemonics, such as *who cooks for you?* for the White-winged Dove. As this mnemonic reminds us, doves and owls (think of the Barred Owl's *who cooks for you?*) can sound remarkably similar. That's the gist of Grade 1: not much information.

In many series, the silent intervals between notes of Grade 1 songsters are about the same duration as the notes themselves. Most are even tempo, although some accelerate like a bouncing ball, and a few slow down. Most stay at the same pitch, but some rise or fall. Even with pitch change and acceleration, it's still a very simple, economical, even elegant way to make a song. It probably doesn't take much brain space.

The simplicity of the series, plus the widespread occurrence of this pattern in the nonpasserines, suggests that this may have been the first kind of song-syntax to evolve in birds. In this regard, it's worth noting that a similar pattern is found in many frogs, not to mention crickets. It's so basic, it has probably been independently "invented" (by evolutionary convergence) in many unrelated kinds of animals. That idea is supported by the reappearance of this simple pattern among the vocally complex oscines of Grade 3 (discussed below), quite a few of which also use series.

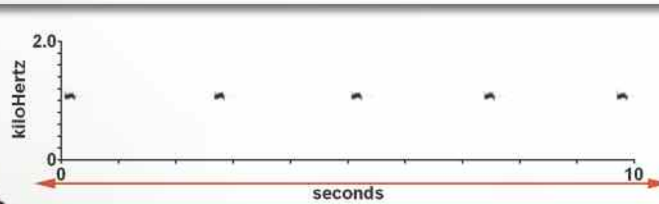
The distinctions that exist within Grade 1 are mostly quantitative, involving pitch and the time interval between notes. You can judge how well pictures capture these distinctions by looking at Fig. 2, which is in "field guide format." You can hear these sounds on a *Birding* WebExtra for this article <aba.org/birding/v43n5p45w1.html>, as well as on my website <tinyurl.com/66mdcnn>, where you can download three prototype field-guide pages with clickable sonograms for your handheld smartphone or android device.

Grade 2: Tyrant-Flycatchers, The Goldilocks Group

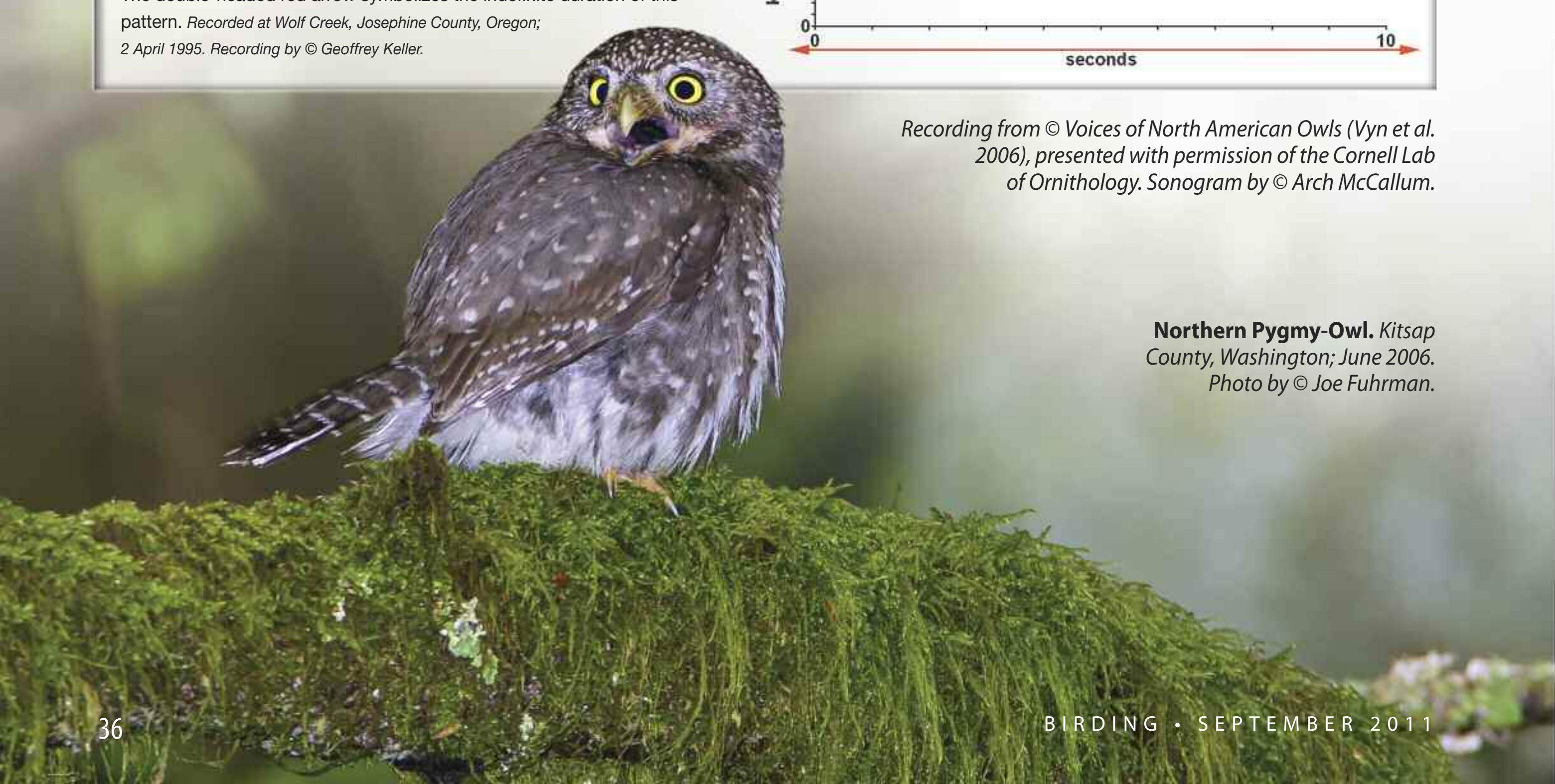
The passerines, which include more than half the bird species on earth, are subdivided into two groups: the *suboscines*, most of which live in South and Middle America,

Fig. 2. Shown here is a single entry—for the Pacific population of the **Northern Pygmy-Owl**—from a forthcoming field guide to bird sounds. Just as in the traditional format for the genre, this field guide to bird sounds will feature text on the left-facing pages matched with "pictures" (sonograms in the case of this field guide) on the right-facing pages. To see an entire two-page spread, showing seven species of owls, please consult the WebExtra <aba.org/birding/v43n5p45w1.html> that accompanies this article.

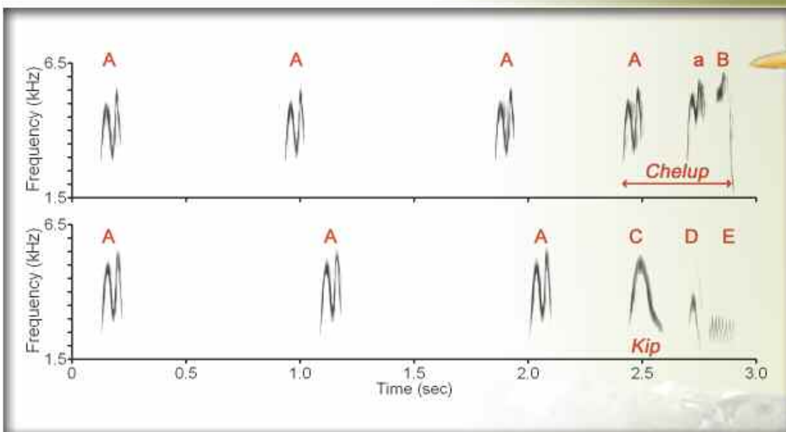
Northern Pygmy-Owl—Pacific and northern Rocky Mountain populations (*Glaucidium gnoma*, in part). Very slow tempo (one note every 2.5 sec) of toots distinguishes these populations from other species and subspecies. The double-headed red arrow symbolizes the indefinite duration of this pattern. *Recorded at Wolf Creek, Josephine County, Oregon; 2 April 1995. Recording by © Geoffrey Keller.*



Recording from © Voices of North American Owls (Vyn et al. 2006), presented with permission of the Cornell Lab of Ornithology. Sonogram by © Arch McCallum.



Northern Pygmy-Owl. *Kitsap County, Washington; June 2006. Photo by © Joe Fuhrman.*



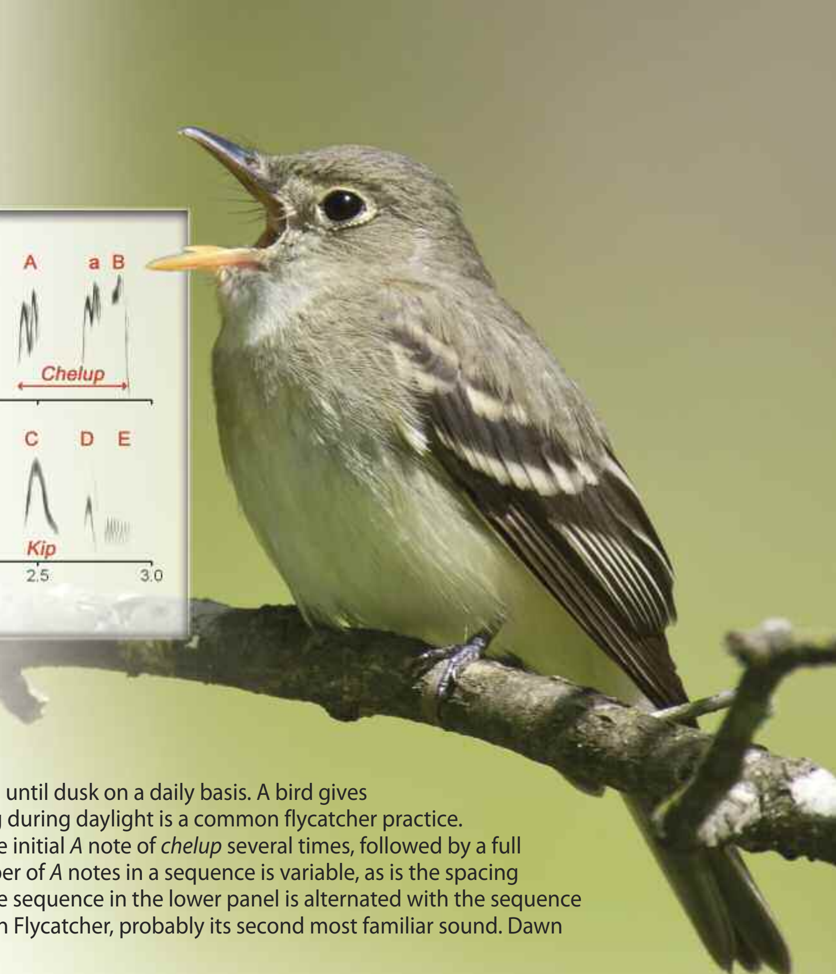


Fig. 3. The relationships among parts of a flycatcher serenade follow strict rules, as illustrated by the **Acadian Flycatcher.** *AaB* designates the familiar *chelup* song of this species, which can be heard in an occupied territory from dawn until dusk on a daily basis. A bird gives only one or two *chelup* songs per minute, as sporadic vocalizing during daylight is a common flycatcher practice.

To produce the dawn song (upper panel), the bird repeats the initial *A* note of *chelup* several times, followed by a full *chelup*, and then repeats this sequence continuously. The number of *A* notes in a sequence is variable, as is the spacing between *A* notes. Evening song is dawn song with a twist, as the sequence in the lower panel is alternated with the sequence in the upper panel. Note that *C* is the *kip* call note of the Acadian Flycatcher, probably its second most familiar sound. Dawn song and evening song are not given daily.

Recorded at Lumber River State Park, Robeson County, North Carolina; 30 April 2009. Recording and sonogram by © Arch McCallum.

Acadian Flycatcher. *Scioto County, Ohio; May 2004. Photo by © Robert Royse.*

and the *oscines*, which dominate songbird faunas in the rest of the world. Oscines *learn* their songs (Hultsch and Todt 2004), whereas most suboscines don't. Enter North America's main suboscine representatives, the tyrant-flycatchers in the family Tyrannidae. Their singing is unique. While all the other suboscines are in Grade 1, the tyrant-flycatchers and a few close relatives have Grade 2 singing all to themselves.

Three features distinguish flycatcher singing from the singing of all other birds (Lanyon 1982, Fitzpatrick 2004): (1) the simple acoustics and lack of variation in their songs, which are not learned, (2) the practice of singing at dawn with song types that go unused during the rest of the day, and (3) the order, or syntax, of song types in these dawn serenades.

Like Grade 1 singers, tyrant-flycatchers don't learn their vocalizations, so song types are uniform and identifiable within any particular species. Field guides that describe flycatcher song types as variable—for example, the *fitz-bew* of the Willow Flycatcher—are mistaken. The Willow Flycatcher actually has three distinct, invariant song types: *fitz-bew*, *fizz-bew*, and *creet* (Stein 1963, Sedgwick 2000, Kroodsma 2005). These song types are paragons of stereotypy.

Lack of learning-based variation is where the similarity between Grades 1 and 2 ends. Flycatcher sounds are mostly (1) chips, (2) plaintive whistles with small pitch changes (see *Part 1*, Fig. 5), and (3) slow buzzes (see *Part 1*, Fig. 6)—and combinations thereof. These sounds may owe their simplicity to the relative simplicity of the syrinx (the avian "voice box") of flycatchers (Amador et al. 2008).

Flycatcher songs may be simple, but they are often produced at a frenetic pace, especially before dawn. The syntax of these serenades is species-specific. Several species—for example, Eastern Phoebe, Western Wood-Pewee, and "Western" Flycatcher—cycle through their repertoires in order. But others—for example, Willow, Hammond's, and Dusky flycatchers—seldom repeat a song type but otherwise follow no particular order. In contrast to these non-repeaters, Say's Phoebe and Gray, Buff-breasted, and Acadian flycatchers (Fig. 3) repeat a favored song type several times before inserting a single example of another. Most kingbirds have only one, and they repeat it *ad nauseam*.

Although nearly every sound a singing flycatcher makes is distinctive enough to be readily identifiable on a sonogram, you don't have to learn all those sounds if you learn the birds' serenade syntax. For example, the patterns of singing of North America's *Empidonax* flycatchers are sufficiently different that you can identify them from syntax alone. Fig. 4 shows the diagnostic serenade syntax and sounds of the Hammond's Flycatcher. Go online <aba.org/birding/v43n5p45w1.html> to hear and "see" the vocalizations of other western *Empidonax* flycatchers.

With diverse but stereotyped songs and distinctive syntax, the flycatchers are the ear-birder's delight: Not too little information as in the monotonous nonpasserines of Grade 1, not too much as in the oscine virtuosos of Grade 3, but just right. I think of them as the Goldilocks Group.

Grade 3: The Oscine Virtuosos

The most brilliant singers are the oscines (Kroodsma 2005). The extra set of syringeal muscles that makes their vocal virtuosity possible (Suthers 2004) is controlled by song circuits in the brain (Jarvis 2004), which are only partly programmed at birth. To finish the job of programming these circuits, these birds must hear others of their kind singing, and then they must practice what they learn. If an oscine has no "tutor," it will sing, but the song will not be what we, or its intended listeners, expect (Baptista and Petrinovich 1984, Hultsch and Todt 2004, Kroodsma 2004).

This system of programmed learning of notes and phrases yields huge amounts of variation. Some of this variation is manifested geographically, as dialects, for example, as in the case of the White-crowned Sparrow

	Grade 1	Grade 2	Grade 3
Taxonomic Groups	non-passerines and most suboscines	flycatchers and allies	oscines
Variation	none[1]	none[1]	geographic and individual[2]
Learning	none[3]	none	basic elements of songs
Different Song Types	have different functions	have different roles in syntax	display variety and/or individual signature
Acoustics	simple slurs; mostly "overslurs"	drawn-out slurs and buzzes	just about anything
Song Syntax	series; simple tunes	songs brief and simple	series, combinations, other
Serenade Syntax	monotonous repeats	complex but rules-bound sequence of 1–3 song types	none, eventual, or immediate variety of functionally equivalent song types

[1] *Geographic variation reflects genetic variation, for example, among different subspecies.*

[2] *Mostly based on learning of song elements.*

[3] *Some cotingas are known to learn songs; see Kroodsma (2004).*

(Chilton et al. 1995). The songs from different dialect areas are recognizably different from each other, but they remain recognizably representative of the species. The different song types in an individual bird's repertoire—for example, the Black-crested Titmouse—are also variations on a common theme (Fig. 5). If we hear two in sequence, we will ordinarily be able to say, easily, "That's different," after the second one. There is abundant evidence that the birds themselves can also tell one song type from another.

The differences among song types reside mostly in the fine structure of the sounds. Both song syntax and the acoustic quality of the component sounds are part of the species code. These features don't vary geographically or even from song type to song type in the repertoire of a single individual (Fig. 5). It has to be so. There must be "species universals" (Marler 2004a) or the species would differentiate into reproductively isolated song communities. As in Grades 1 and 2, some species do divide the flirting and fighting (Collins 2004) functions of singing into two separate "song systems," as in the Type I and II songs in warblers (see Spector 1992). In general, though, these systems are mostly very similar acoustically and syntactically.

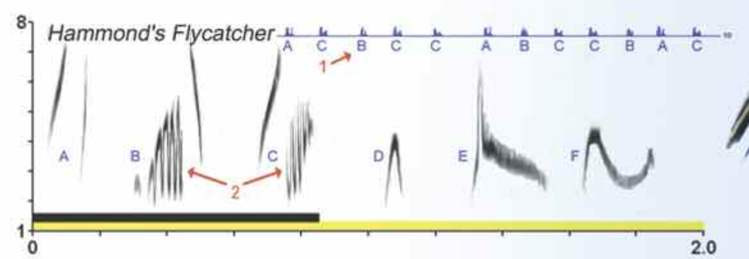
Acoustic Quality

Our task as ear birders is to infer certain "universals" amid all the variation and to listen for these diagnostic features when identifying a sound. To begin with, the songs of a given species are typically restricted to a rather narrow part of the frequency spectrum. Then, although an immense variety of sounds is possible with the five simple ways a bird can manipulate its basic tune (see *Part 1*), each oscine species exercises only some of its options. The ear birder must address these acoustic features species by species. Sonograms instantly tell us whether a sound is high or low and long or short, and with practice they reveal much more about acoustic quality. See *Part 1* and Pieplow (2007) for hints.

Hammond's Flycatcher. *Victoria, British Columbia; May 2010. Photo by © Tim Zurowski.*

Fig. 4. Shown here is a single entry—for **Hammond's Flycatcher**—from a forthcoming field guide to bird sounds. See Fig. 2 for additional perspective. To see an entire two-page spread, showing five species of flycatchers, please consult the WebExtra <aba.org/birding/v43n5p45w1.html> that accompanies this article.

Recording data available online <tinyurl.com/66mdcnn>. Recording and sonogram by © Arch McCallum.



Hammond's Flycatcher (*Empidonax hammondii*) Dawn song: Three song types (*A*, *B*, *C*) presented in unpredictable order (1), but with *A* most frequent on some occasions. Before dawn, presentation is rapid, more than one per second. Pace slows after dawn, and *C* is sometimes given alone in daytime, especially in mid-summer. Two of three song types have a burry note (2), vs. one burry note for Dusky. *B* and *C* are similar-sounding, but distinguishable. *Pip* contact note (*D*) shared only with Alder Flycatcher. *K-lear whee-zee* (*E*, *F*) call system resembles *du-hic* of Dusky (*E*, *F*). *C* sounds similar to Least Flycatcher *che-bec* and Gray Flycatcher *A*.
Recording data available online. <tinyurl.com/66mdcnn>.Recording by © Arch McCallum.

Song Syntax

The combination rules by which oscines construct their songs are amazingly varied. Closely related species often have very different rules (Tietze et al. 2008). Still, we can recognize several basic rules that are shared by many species, some not very closely related. Let's look at a couple of these in some detail.

Series

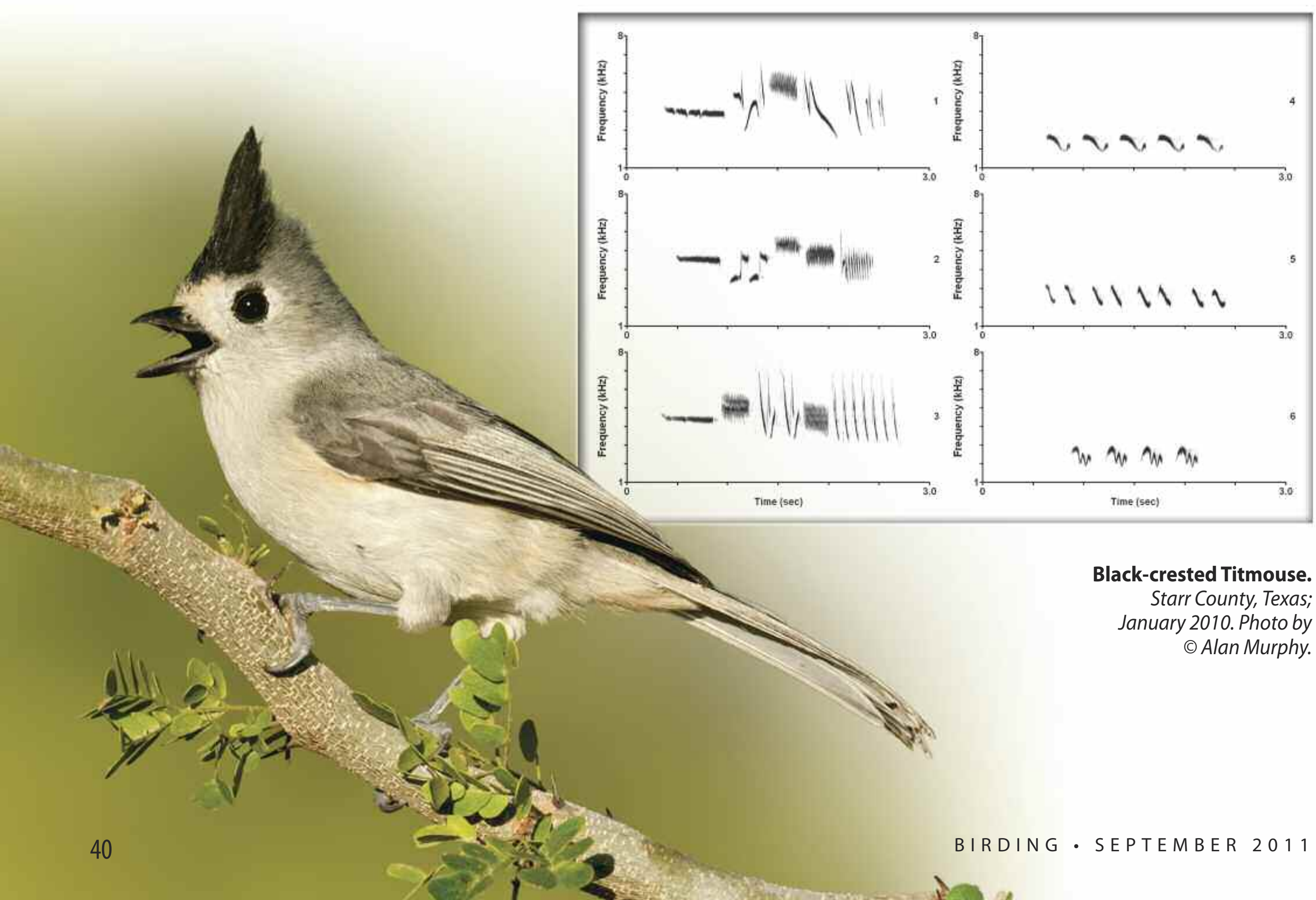
The simplest kind of song syntax is the series. It is nothing more than a repeating sequence of a single note type or phrase type. We have already seen simple series in Grade 1. Most series in Grade 1 stay on the same pitch and unfold at an even tempo (Fig. 2). This is true for many species in Grade 3, as well (Fig. 6). But the pitch, duration, and quality of the repeated element can change through the course of the song. A good example is the descending series at the beginning of a Canyon Wren's song.

Some 38% of the breeding oscine species in North America produce primary songs that are simple series. Differences in complexity or duration of the repeated element (Worm-eating Warbler vs. Carolina Wren), pitch (Tufted Titmouse vs. Cape May Warbler), pitch trend (Orange-crowned vs. Prairie Warbler), and amplitude trend and acceleration (Wrentit vs. Canyon Wren) help subdivide them into smaller subgroups of series singers. Try making a list of the series singers in your neighborhood, and then look for ways to subdivide them.

Fig. 5. The *song types* of a Grade 3 species are variations on a common theme, whether they represent geographic variation (as in the White-crowned Sparrow, left panel) or individual variation (as in the Black-crested Titmouse, right panel).

Left: Three White-crowned Sparrow dialects. Individual males in some populations typically have only one song type, which is shared with neighbors. These song neighborhoods, or dialects, can comprise hundreds or thousands of individuals, all singing the same song type. These samples are all from the migratory *pugetensis* subspecies. Note that all are of similar duration, occupy similar frequency range, start with a whistle, and include buzzes, slow trills, and/or a few complex syllables. *Top: Newport, Lincoln County, Oregon; 21 April 2001. Middle: Deschutes County, Oregon; 14 May 2009. Bottom: Lummi Island, Whatcom County, Washington; 10 April 2004. Recordings and sonograms by © Arch McCallum.*

Right: Three songs of a single Black-crested Titmouse also show similarity in frequency, duration, and syntax. *Recorded in Jeff Davis County, Texas; 31 May 2010. Recordings and sonograms by © Arch McCallum.*



Black-crested Titmouse. *Starr County, Texas; January 2010. Photo by © Alan Murphy.*

Swamp Sparrow (*Melospiza georgiana***)**. Song is a simple flat trill (1), like Dark-eyed Junco's and Chipping Sparrow's, but slower. Repeated phrase (2) is actually a combination of brief notes (3) drawn from a repertoire of six types, shared by the entire species. Specific combinations are learned, and different subspecies use different combinations as the basic phrase type. Each individual has several such phrase types and therefore song types, which are static. "Variety" is "eventual." *Recorded at Cotton, St. Louis County, Minnesota; 7 July 2007. Recording by © Arch McCallum.*

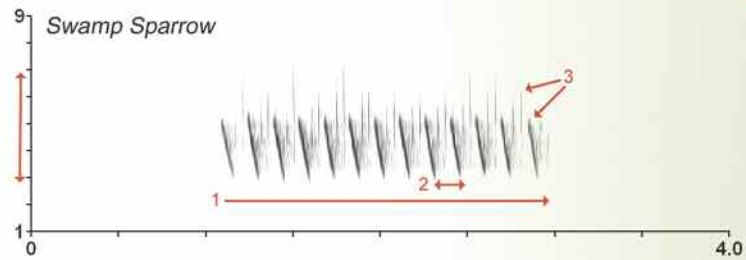


Fig. 6. Shown here is a single entry—for **Swamp Sparrow**—from a forthcoming field guide to bird sounds. See Fig. 2 for additional perspective. To see an entire two-page spread, showing five species of sparrows, please consult the WebExtra <aba.org/birding/v43n5p45w1.html> that accompanies this article.

Recording data available online <tinyurl.com/66mdcnn>. Recording and sonogram by © Arch McCallum.

Swamp Sparrow. *Cold Lake, Alberta; June 2010. Photo by © Tim Zurowski.*

Combinations of Series

As the list of contrasts above suggests, series are not limited taxonomically. Perhaps the original oscine was a series singer, and that syntax has been retained by many of its descendants, being replaced by something more complex in others. In this scenario, perhaps the next step was simply to baste two series together, as with the Yellow-rumped Warbler, or three, as with the Northern Waterthrush. Or even more, as with the Yellow Warbler and a slew of sparrow species (see Fig. 6). A combination of short series produces a song that can contrast strongly with a simple series, but the two are not that far apart syntactically. Perhaps that is why one often sees both kinds of rules in the same genus (see Fig. 6).

Ordered Combinations, or "Towhee Syntax"

Several species give vocalizations that start with some brief notes and end with a long, broadband note, or a trill occupying a similarly large patch of the sonogram. This pattern, or "rule," unites *chick-a-dee* calls (*Part 1*, Fig. 8; see Hailman et al. 1985) with towhee *drink-your-tea* songs (*Part 1*, Fig. 1). It must work well because it seems to have been discovered several times in the course of oscine evolution. These are examples of *ordered combinations*, in which each of several parts in the sequence of sounds is filled from a different repertoire. For example, a Wood Thrush song has three parts, always in the same order, each filled from a different repertoire, uninfluenced by the repertoire choice for the other two (Fig. 7); see Roth et al. (1996).

You get the idea. Oscine songs are clearly assembled according to rules. These rules may be similar across species because they were inherited from a common ancestor, as with *Catharus* thrush syntax. In other instances, they have been "discovered" independently, as with chickadees and *Pipilo* towhees. Regardless, there is something about the structure of every song that helps identify it, even if it is as simple as duration: Compare the short-duration song of the Henslow's Sparrow with the very long songs of desert thrashers.

Repertoire Size

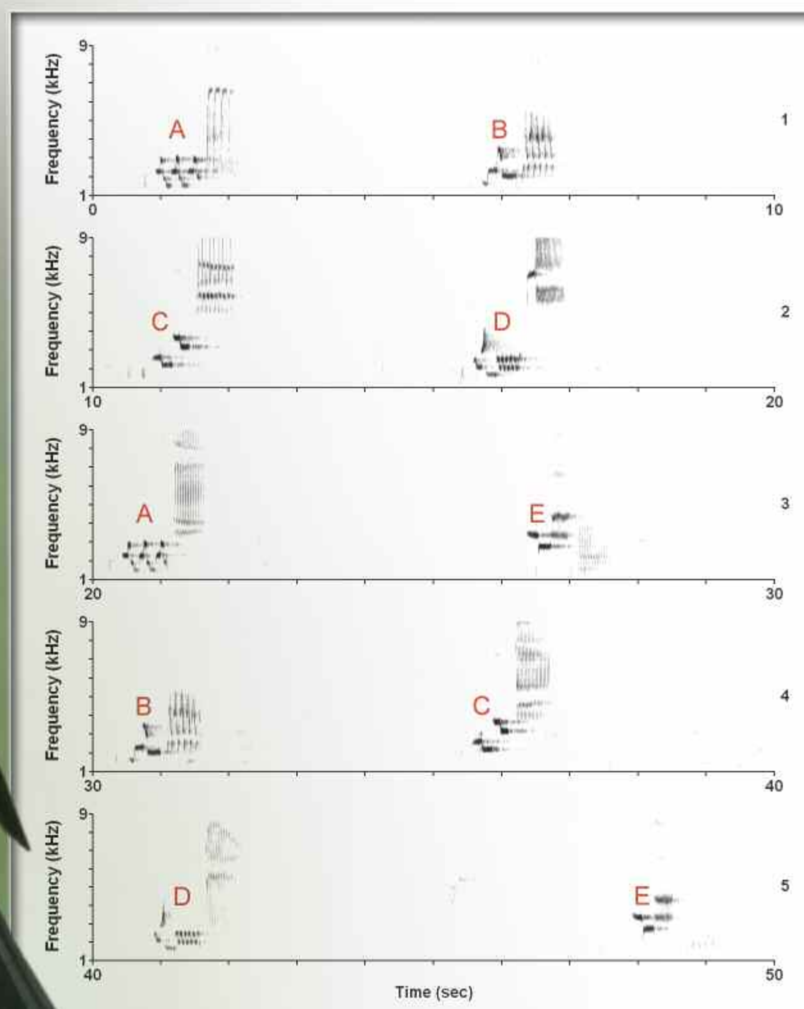
As previously mentioned, all the song types of an individual, across any particular species, are constructed according certain rules. The resulting variety exists to distinguish individuals in some cases, to link individuals in others, and simply to demonstrate virtuosity or learning ability in others. *Passerina* bunting songs are combinations of several phrase types (Fig. 1) from a species-wide repertoire. Oneyear-old male Indigo and Lazuli buntings settle on a single sequence after hearing the songs of older males in their breeding neighborhoods (Payne 1993, Greene et al. 1996). Song Sparrows (see Fig. 6) also listen to their neighbors and then crystallize their songs, but in their case they will have several distinct song types (Kroodsma 2005). These song types are static; they remain in the bird's repertoire through the season and beyond.

The Lark Sparrow (see Fig. 6) also creates a song by stringing a sequence of note types together, repeating each note type before going to the next. Unlike the Indigo Bunting and Song Sparrow, the Lark Sparrow changes the sequence with each song, creating a dynamic repertoire of semi–song types on the fly. A male Wood Thrush (Fig. 7) also has a dynamic repertoire, even though he generates songs by drawing elements from three different repertoires

Wood Thrush. *Tomkins County, New York; May 1996. Photo by © Lang Elliott.*

Fig. 7. Shown here is a portion of a serenade of a Wood Thrush. A single song is a combination of three components, always in the same order: (1) a series of faint *bup* notes, barely visible in the sonogram, but audible in the recording; (2) a variable whistle (indicated by letters); and (3) an optional terminal trill. Colored letters highlight the pattern of repetition of the variable whistle types. In most cases, the trill type is not predictable from the whistle type. Some individuals sing with much less variety than this one.

Recorded at Montreat, Buncombe County, North Carolina; 8 May 1993. Recordings and sonograms by © Arch McCallum.



in a fixed order rather than rearranging elements from a single repertoire. Whatever the gambit a species uses to create variety, the commonalities among songs are easily seen on sonograms of a serenade (Fig. 7). These commonalities, part of the universal code of the species, are field marks we may listen for.

Serenade Variety

Why all this variety? Charles Hartshorne, a noted philosopher who also studied birdsong, proposed (Hartshorne 1956) that serenade syntax was designed to prevent monotony for the intended receiver by varying the presentation of song types. Some species, nonetheless, have only one song type per individual, and thus cannot sing with variety. Chipping Sparrow and Indigo Bunting are examples. “Eventual variety” starts out sounding like “no variety,” but the bird reveals that he does have a repertoire size greater than one when he switches; the Green-tailed Towhees does it this way. Because he sings with eventual variety, it could take days for you to hear all the song types in a Carolina Wren’s repertoire (Borror 1956).

In “immediate variety,” every song differs from the one before it. That does not mean the entire repertoire is recited in a fixed sequence. Large repertoires can take a long time to unwind, especially when used for *song matching*, as with the western Marsh Wren. Immediate variety can be practiced with fixed repertoires, as with the Marsh Wren’s, but a string of songs from a dynamic library, like that of the Lark Sparrow, will also produce immediate variety, albeit not as dramatically.

“Immediate” and “eventual” are Hartshorne’s categories. Pieplow (2007) splits out “alternating variety” as a special case of immediate variety with only two song types, and his “variable variety” is immediate variety with some repeats. Variety itself can be a field mark. You can use it, for example, to distinguish Painted from Indigo buntings. They have songs of similar duration and acoustic quality, but Painted Buntings eventually change song types, whereas Indigos do not.

When you combine the amazing variety of sounds birds make (*Part 1*) with the myriad ways they can combine them into songs, and songs into serenades (this article), the possibilities mount up. But then, you need a lot of information to distinguish the hundreds of species of birds singing in North America. And did you consider the possibility that all this vocal variation is the reason we have so many species? It’s likely that syntactical innovation is an engine of speciation in the oscines.

The Lay of the Land

Here is the acoustic lay of the land, if you will. Birds use five simple mechanisms to modulate the basic sounds produced by the vibrating membranes deep in their breasts. The result: to my ear at least, the most varied, complex, and beautiful sounds in the entire living world. They use simple rules to combine unit sounds into songs, and other rules to combine songs into serenades. Oscines pull out all the stops. The result: a dawn chorus somewhere near you. You can parse it and identify the components: the species and the individuals, the songs and phrases, the buzzes and slurs. Or you can simply let it wash over you in a surge of wonder. Maybe you can do both at once.

Ear birding can be a challenge, but it also can be an adventure. If no one has ever invited you to this adventure before, let me. If you want to get into sonograms seriously, read Kroodsma (2005). His book is full of engaging stories, but the real meal is served up with sonograms, which are explained in a friendly manner. *Nature’s Music* (Marler and Slabberkoorn 2004) is the best single introduction to research on every aspect of bird sound, and it too relies heavily on sonograms. For the visual approach to identifying birds by ear, pay regular visits to Nathan Pieplow’s blog <tinyurl.com/yesm6zd> and check in with me from time to time online <tinyurl.com/66mdcnn>. When you’re ready to generate your own sonograms, you can download a free sonogram program. You might want to try spectrogram.exe <tinyurl.com/6jhnv63>. You can listen to the entire sound library at America’s two biggest sound archives, Ohio State’s Borror Laboratory of Bioacoustics and Cornell’s Macaulay Library, but you can also see sonograms of them at Cornell. Have fun, and good ear birding, visually!

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