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THE CALLS OF *Poecile atricapillus* (Black-capped Chickadee) ARE CHANGING

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ABSTRACT

This paper is intended to supplement present knowledge of the vocal array of *Poecile atricapillus* (Black-capped Chickadee) with three calls presently known only from *Poecile carolinensis* (Carolina Chickadee) and evidence that morphing is occurring. Originally conceived as a simple list of all calls that adult Black-capped Chickadees make during the winter months in northern Michigan, the inclusion of calls already described for *P. carolinensis* and the surprising paucity of the complete Chick-a-dee call suggested consideration of anthropogenic factors affecting their communication. In addition, calls made by wild birds before, during, and after copulation are described for the first time, as well as a novel element that is sometimes associated with a Gargle call. Some possible language systems have been considered for the chickadees since before 2000, with their complicated combinatorial Chick-a-dee and Gargle calls. In 2016 lexical syntax in another parid was demonstrated. The repetitive *dee* alarm given by *P. atricapillus* in response to a high-risk predator suggests phonological components in their semantics. Here is presented spectrographic evidence for one call type integrating into another and frequent use of polyphonic sounds, providing a new window for viewing communication in these very social birds. Understanding the meaning of *P. atricapillus'* vocalizations is incomplete, but progress is being made, chiefly on the basis of spectrograms revealing far more detail than the average human ear can discern.

KEYWORDS: anthropogenic effects, Black-capped Chickadee, Carolina Chickadee, *Poecile atricapillus*, *Poecile carolinensis*, semantics, spectrogram, vocalizations

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LAY SUMMARY

- The calls of the Black-capped Chickadee are changing.
- These new vocalizations may not be obvious to the unaided ear, because they are often at pitches outside the normal hearing range, but they can be seen as spectrographic images by recording the birds' voices and analyzing them on a computer audio program.
- You may have noticed that there are fewer chickadees at your home feeder. Indeed, studies have shown that the numbers of these and many other familiar birds have declined.
- There may be a connection between the new calls and the declining numbers of chickadees.
- Studies have shown evidence of communication in the chickadee calls. If the calls are changing, it seems likely that communication has become more difficult for them.
- It is likely that Black-capped Chickadee numbers will continue to decline unless human- generated noise and native habitat destruction decrease.

INTRODUCTION

Poecile atricapillus (Black-capped Chickadee) is among the bird generalists whose numbers have fallen by as much as 50% since 1970 (Rosenberg et al. 2019; Johnston et al. 2025). Many people may not have noticed, which is probably why birds need protection. One way to direct more attention to their plight was demonstrated by the phenomenal surge in the general public's interest in whales and dolphins by the discovery that they make sounds suggesting possible communication. This sparked popularization of "whale songs," and led to legislative protection. Similarly, *P. atricapillus,* which is a well-known bird that is threatened by habitat loss, mortality from roaming cats, collisions, and climate change, and whose numbers are declining especially in the areas where it was most abundant (Johnston et al. 2025), probably would benefit from discoveries about how it communicates. Recognizing *P. atricapillus* vocalizations not only furthers understanding of possible lexical syntax, permitting anticipation of a bird's future behavior, but may elicit more interest in *P. atricapillus* and desire by the general public to make environmental changes to increase survival of these and other birds.

Much work has already been done on *P. atricapillus* vocalizations. The early studies of Millicent Ficken (Ficken et al. 1978; Hailman and Ficken 1986; Ficken et al. 1994) firmly established that there were four notes, arbitrarily named A, B, C & D in the Chick-a-dee call, but they weren't all always present.
She and coworkers realized there was a combinatorial syntax with an unlimited call repertoire in the Chick-a-dee calls of both P. atricapillus and (then) Parus sclateri, now Poecile sclateri) (Mexican Chickadees), and this invited investigation into possible communication in more parids including P. carolinensis (Bloomfield et al. 2005; Templeton 2005). *P. carolinensis*, a congeneric of the *P.*

atricapillus, is resident in the Southeast and there is little overlap of the two birds' distributions.

In the authoritative Cornell *Birds of the World* (Foote, 2020), the Chick-a-dee call of *P. atricapillus* is said to be comprised of four possible note types, named A, B, C, and D. More recently several investigations have described additional elements in the Chick-a-dee calls of other parids (Bloomfield et al. 2005, Freeberg et al. 2008) and showed that *P. atricapillus* and *Parus minor* (Japanese Great Tit) can detect the order of syllables – at least that D should come after, and not before, ABC (Campbell et al. 2023; Suzuki et al. 2016). Those syllables in that order (compositional syntax) mean generally, as stated in the BOW account, "come here." It is not clear, however, how much more information is conveyed by a Chick-a-dee call.. A variety of configurations of the call sound very much alike to the human ear. Do *P. atricapillus* garner different meanings from sound-alikes that have diverse spectrographic images? It seems possible that they do from the work done on ***Taeniopygia guttata*** (Zebra Finch, not a parid) which showed them to be exquisitely sensitive to small acoustical changes in vocalizations (Fishbein et al. 2019).

Many past studies have been conducted in artificial settings, however, and the results may have been affected by human influence, such as training birds to peck on a particular cue (Fishbein et al. 2019); use of playback (Ficken et al. 1994; Templeton 2005; Suzuki et al. 2016; Freeberg et al. 2012); housing captured birds in cages and handling of the birds and drawing blood samples from them (Campbell et al 2023); using wooden hawks and plastic owls to simulate predators (Ficken et al 1994; Freeberg et al 2012); exposing chickadees to live predators (Templeton 2005); and banding the bird subjects and placing an observer or microphone outside their nest holes (Ficken et al 1978). At least one investigator found that *P. atricapillus* showed a preference for silence over any playback (Campbell et al, 2023).

Do *P. atricapillus* really communicate, and if so, is their message delivered only to conspecifics, or is it understood by congenerics, too, or even sympatrics and allopatrics? Suzuki et al. (2017) found that when certain syllables are in the correct order, *Parus minor* individuals respond to *Poecile montanus* alert and recruitment calls, but not when the syllables are reversed. *Sitta canadensis* (Red-breasted Nuthatches) paid attention and responded to *P. atricapillus* vocalizations by becoming suddenly silent when a *P. atricapillus* called (XC975499 at 1:26 minutes into the recording); was this just a coincidence, was only the amplitude of the call important, or was a message transmitted by the call? Nuthatches can decode information about predation risk from *P. carolinensis* calls (Freeberg et al. 2012).

Now it is clear that there are more than four possible note types in the *P. atricapillus* Chick-a-dee call. Additions include the E element and the High-tee-chick call, both previously known from *P. carolinensis*; as well as an element that appears on the spectrogram to be a mirror image of the High-tee-chick call; and variations of the D element including the D_{hybrid} known from *P. carolinensis*. Not part of the Chick-a-dee call but newly ascribed to their repertoire are another D that is given at, or immediately after, copulation; the Copulatory Twitter (different from the Twitter described in BOW); and a mu-shaped element associated with a Gargle call given in pairs or triplets. *P. atricapillus* can also produce sounds that seem to merge two elements.

It is common for one or more of the ABCD elements to be omitted from the Chick-a-dee call (and most humans' ears and brain are unable to detect the difference), but in this study of thousands of calls, it was actually difficult to find a single example of a complete ABCD call. It is perplexing why a call that was apparently ubiquitous fifty years ago is not now. Additionally, contrary to established knowledge, the elemental order of ABCD is not inviolate.

The purposes of this paper include the following: 1. Recognize more vocalizations that *P. atricapillus* can make. 2. Look for patterns in *P. atricapillus* calls that may be keys to understanding their communication, especially when behavior can be correlated with their calls. 3. Demonstrate that field work still has a place in ornithological science. It is likely that no matter how well designed controlled experiments are, human influence confounds the results, if only by intimidating the subjects of the study. When three *P. atricapillus* saw a parked car on a dirt track in the forest with no human activity nearby and foraged on plants next to the car, they were recorded making over 100 soft calls during a period of almost three minutes, but no Chick-a-dee calls, before they flew away (11/22/24, XC980257). One interpretation of this behavior – since vegetation is sparse in November in Michigan and the birds were probably in full view of each other during the recording – is that these were not just contact calls and that the Chick-a-dee call may be made or altered in response to the presence of humans. Passive acoustic monitoring techniques are being adapted to handle large data samples of bird vocalizations and are showing effects of anthropogenic noise (Symes et al. 2022).

The novel aspects of this research include discovery of new calls not previously known to be made by this species, and recognition that morphing and polyphony are significant features of their vocalizations and deserve more attention, especially with regard to possible use in communicating.

Finally, why is this research significant? Evidence that *P. atricapillus* makes some of the same vocalizations known to be made by *P. carolinensis*, a species with which it shares 96% mitochondrial DNA similarity and with which it hybridizes occasionally (Curry 2005), is not surprising, but increases the opportunity to understand these vocalizations; if the meaning of them is discovered for either species, it may apply to the other species or to other congenerics. The morphing of one element into another on spectrograms may indicate alteration of a message or relate to a physiological state, but in any case, invites investigation. The English language expresses meaning using both phonology and lexical semantics. If *P. atricapillus* is able to do the same, we should be able to make reliable predictions of future behavior from their vocalizations, but we are not able to do that yet. The

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D element may be unique when it is an alarm note. Then it is instantly recognizable as a loud warning signal, transmitted urgently and unambiguously, so that it can be acted upon. The D element is the first of the Chick-a-dee syllables that juvenile *P. atricapillus* can make. When delivered at high amplitude and in series, D seems to be a phonological element. The other vocalizations, as well as a softer, calmer D in other settings, may be conversational and depend more on syntax than phonology to transmit information. Finally, this study suggests that wild birds are listening, and the use of playback with phone apps may be confusing and possibly threatening to them, disturbing essential routine behaviors such as feeding, mating and care of juveniles.

It is hoped that these findings might be sufficiently interesting to evoke more concern for *P. atricapillus* or perhaps interest others to continue this line of research. If *P. atricapillus* benefits, many other birds likely will, too.

METHODS

Recordings that are cited in this paper were made when only adult birds would be vocalizing (in late fall through winter), except as noted. One exception is the Copulatory Twitter which was recorded in early April (when it is possible, though not likely, that juvenile birds might have been in the vicinity). All recordings made by this author were without use of playback or pishing or enticements of any kind, and are of wild birds in areas where *P. carolinensis* does not occur, mostly in Delta County in the Upper Peninsula of Michigan. This is an observational study that lasted from October 2020 to April 2025 of hundreds of wild birds in their native habitat, with the recordist attempting to be as unobtrusive as possible. Vocalizations were recorded on a Sound Devices MIXPRE-3 recording unit with a Sennheiser microphone, a handheld 22 inch parabola or shotgun wand fitted with a Softie Windshield, and then analyzed on OcenAudio 3.9.7.0. It is possible to filter sounds and adjust sampling speed and amplitude on OcenAudio, but my recordings are unmodified, unless otherwise stated. Recordings made by this author and by others published on Xeno-canto and in eBird’s Macaulay Library were also examined.

Abbreviations of online sites: XC: Xeno-canto (To retrieve XC files, search for nr: plus the number cited); ML: Macaulay Library (Cornell); BOW: Birds of the World (Cornell).

DEFINITIONS

The simplest note, e.g., A, B, C or D, is an **element**. These may be combined to form **syllables**. Syllables may constitute a **call** or a **song**. A song is a stereotypical series of elements or syllables, often sung loudly by a male to attract a female or to repel a rival, but occasionally may be sung for other reasons. Songs may sound beautiful to human ears, but that is not a criterion for them, nor is a call necessarily unmusical. The songs of *P. atricapillus* are named Fee-bee, Faint Fee-bee, and Gargle (also considered a call because its function is primarily one of aggression rather than to solicit sex). The simplest calls (*tseet* or *Psip* and *tsleet*) are probably

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to maintain contact within the flock; they are elements. Although an alarm note may consist of a single element, it may not be beneficial if the fleeing bird makes an inappropriate choice of direction, so variations and patterns of sound are necessary for all but the simplest communications. A call is used for many other purposes but not often as a sexual attractant. Songs may be sung by females, and calls are given by both sexes. The present study focuses on the calls made by adult *P. atricapillus*, chiefly those associated with the Chick-a-dee call.

Semantics deals with the study of a fixed relationship between a signal and a meaning. The Chick-a-dee calls of *P. atricapillus* were designated the first truly combinatorial system of vocal communication found in animals (Hailman et al, 1987), and those of *P. sclateri*, the second such system (Ficken et al, 1994). In human language **phonology** gives meaning to a part of a word and **lexical syntax** gives meaning to the whole word (Collier et al. 2014), **combinatorial syntax** deals with combining words in a certain order without regard to meaning (Hailman and Ficken 1986), **compositional syntax** correlates with behavior if the words are in the correct order (Suzuki 2016), and **syntax** gives several words meaning when they form a sentence. **Lexical syntax** gives meaning to sounds in most animal communication (Collier et al. 2014). **Phonology** has been shown for the D element, but not yet for the other elements that comprise the Chick-a-dee call (Ficken et al. 1994). **Compositional syntax** was demonstrated in another parid, formerly *Parus minor*, now *Parus cinereus* (Japanese Great Tits), by Suzuki et al. (2016). Tits combined the distinct behavior they produce when they hear ABC calls followed by D calls, but the ABC–D calls must be produced in that order to be a meaningful unit (i.e., possess compositional syntax) and will not be recognized if the order is reversed. Suzuki et al. (2017) extended that investigation and demonstrated the ability of *Parus cinereus* to recognize and respond to a similar alarm call by the *Poecile montanus* (Willow Tit) if the order was preserved, but not if it wasn't. Further, during the autumn/winter season, when birds are in small flocks instead of breeding pairs, syntax matters more than it does in spring/summer among *P. carolinensis* (Clucas et al. 2004). The present paper also deals with morphing of various elements, anomalous signals that seem to lack phonological significance, but perhaps produce meaning when they are in combination with other elements.

Polyphonic sounds are two sounds, one from each lung, produced simultaneously, of different frequencies. These sounds result from voluntarily contracting muscles that control the labia that extend from the double-sided syrinx into the two bronchi. The partials may rise and fall simultaneously or may cross; they are complex and they sound noisy. Polyphony is clearly demonstrated on spectrograms as an additional line or lines at a higher frequency than the dominant sound; it can be differentiated from a harmonic because harmonics occur only at multiples of the fundamental, and polyphonic sounds are not at multiples of the fundamental. Examples of familiar polyphonic songs are those of *Spinus pinus* (Pine Siskins) and *Polioptila caerula* (Blue-gray Gnatcatchers) (Pieplow, 2017, p. 4 and 23). *P. atricapillus* can make many polyphonic sounds including C and D elements. Polyphony increases the number of frequencies of a sound and makes it, even when emitted softly, more likely to be heard in a noisy world.

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Spectrograph: A sound analyzer with graphical output showing the amplitude and frequency content of a sound and its variation in time. The output is called a **spectrogram** or sonagram. Spectrographic analysis of bird songs and calls provides useful information because many vocalizations that are seen on a spectrogram (especially polyphonic ones) are emitted at frequencies above the range of normal human hearing and/or last too briefly for understanding. The spectrograph has been used to analyze bird vocalizations for about 75 years.

Conspecific: birds of the same species
Congenerics: birds of the same genus
Parid: members of the family that includes *Poecile* and *Parus* genera and contains *P. atricapillus*, *P. carolinensis*, *P. sclateri*, and *Poecile gambeli* (Mountain Chickadee).

Birds of the World, BOW, is the most comprehensive source for the present study, but the latest text update of the *P. atricapillus* vocalizations section was in 2010. That section is summarized here for convenience (modified with e-mailed permission from BOW). The references it cites have been omitted for brevity. Hiss, Snarl and Squawk were not encountered in the present study and their descriptions, as well as those of juveniles, are omitted below.

Development

The D element is the first of the four Chick-a-dee syllables to appear in young birds. By day 40 juvenile *P. atricapillus* are able to sing/call most of the adult vocalizations including Gargles.

Vocal Array

Adults have at least 13 different kinds of vocalizations of which 10 are calls likely to be encountered outside the breeding season. (The well-known ***Fee-bee*** is a song to advertise territories and attract mates.) The adult calls are Chick-a-dee; Gargle; Broken dee; Variable see; Hiss; Snarl; Twitter; High zee; Contact notes which include a Flight or Restless note; and the Squawk. All are given by both sexes except as noted.

Chick-a-dee, the eponymous call, is comprised of "four possible note types." It has been the subject of numerous studies because of the complexity of its recombinant elements and its use in many situations that suggest meaningful language. It is given throughout the year, although especially in fall and winter. The Chick-a-dee call serves diverse functions, but one unifying aspect of these functions is a "come here" message.

Gargle. A complex variable vocalization given primarily by males who often have a repertoire of Gargle calls. It should be noted that Gargles are sometimes considered songs because of their use in a sexual context, when they may be associated with Variable Sees and copulation, but Gargles usually indicate aggression.

Broken Dee* and *Faint Fee-bee. Both are breeding season calls associated with courtship, the Broken Dee only by hungry females.

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Variable See. Only during breeding, most often before and during copulation and often in combination with Gargle calls. Usually accompanied by wing quivering that intensifies as birds approach their copulation partner.

Twitter. A rare call associated with unexpected confrontations with other chickadees. May inhibit attack and may also be used when a male approaches a brooding female, and while giving her food.

High Zee. The high intensity alarm note, given particularly when a fast-approaching predator is detected.

Contact call (*tseet* or *Psip*). A soft call given by undisturbed chickadees at all times of year that indicates the chickadee's position to others nearby. ***Flight or restless note*** (*tsleet*): A louder contact call made when a chickadee pair or flock is about to move.

RESULTS

THE CHICK-A-DEE CALL

The term **Chick-a-dee** call refers to the sound most humans hear, and includes any or several of the seven spectrographic elements described in this paper. Implying a desire to locate or contact others, a lone *P. atricapillus* was observed flying from tree to tree calling Chick-a-dee each time it landed – and after repeating this behavior 10 times without getting any response, it finally flew off (author's observation on 3-19-21). This behavior is consistent with BOW's deduction that the call means, "Come here," although it does not exclude other possible meanings. In *P. carolinensis*, Bloomfield et al. (2005) and Freeberg et al. (2012) ascribed the following functions to the individual elements: **A** with the presence or approach of a predator; **B** function unknown; **C** with flight; **D** with the presence of a perched rather than a flying predator. However, the focus of the Chick-a-dee call in *P. atricapillus* is not just on predators. The object of it might be any other *P. atricapillus* in the vicinity, or the bird's mate before copulation, or to indicate a new food source to others in its troop, or to gather a flock. Occasionally the Chick-a-dee call is initiated upon my arrival with recording equipment; they may call "Chick-a-dee" as they inspect me from several angles or fly within inches of the fur-sheathed shotgun microphone or inside the plastic parabola until their curiosity is satisfied and they go. The spectrograms show incomplete Chick-a-dee calls. "Come here" is a start, but the meaning of the Chick-a-dee call at this time has not been fully explicated.

In the present study of *P. atricapillus* the **A** element occurs so frequently it is difficult to assign any particular function to it. **B** seems to be a transition signal, when one behavior is about to be stopped and another begun, e.g., from foraging to flying, possibly relating to a restless migrant flock of small birds that associate with *P. atricapillus*. **B** is found more often on fall recordings. The functions of the other elements are discussed below.

A spectrogram showing the entire assemblage of elements is surprisingly rare in the nonbreeding season. Bloomfield et al. (2005) and Templeton (2005) in papers about *P. carolinensis* included a spectrogram of a complete ABCD Chick-a-dee call from a *P. atricapillus*, and these may be two of the latest published images of that

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complete call. Freeberg et al.(2012) stated that when all elements are present in a *P. carolinensis* call, they follow an AEBCD$_{hybrid}$D ordering rule, but did not include a spectrogram showing this. Now, in winter in Michigan, only two or three of the various elements are usually present. These may include any of the three elements that were previously described for *P. carolinensis:* **E, High-tee-chick,** and **D$_{hybrid}$** (FIGURES 2 and 6).

A is the element most frequently seen prior to **D**. **A** is often in pairs or series. The typical **A** is simple (illustrated by Ficken et al. 1978 and Pieplow 2017), but it may be polyphonic (Templeton 2005), and both types of **A** can be present on the same recording (FIGURE 9). **A** is the element that most frequently merges with **D** to become a **D$_{hybrid}$**. It is **A**'s descending arm that contributes to **D$_{hybrid}$.**

B may be simple or polyphonic. Bloomfield et al. (2005) split the **B** element of *P. carolinensis* into three subtypes on the basis of their spectrographic appearance. **B$_1$** is simple, **B$_2$** is polyphonic, and **B$_3$** resembles an inverted U with or without polyphony. Freeberg stated he was unable to distinguish Bloomfield's **B$_1$** and **B$_2$** of *P. carolinensis* under his working conditions, and therefore lumped **B$_1$** and **B$_2$** into a new letter which he called **E** (Freeberg, 2008, p.898). I have retained his usage, because of occasional similar problems discerning polyphony in some B's. As a result the term **B** is reserved only for the inverted U shape with arms of approximately equal length, which is Bloomfield's **B$_3$**, with or without polyphony. Both **B** and **E** elements were found in the present study. The **A** and **E** elements resemble each other in usually having a slender projection across several frequencies (an arm). **A** has a long descending arm and **E** has a long ascending arm (FIGURE 1).

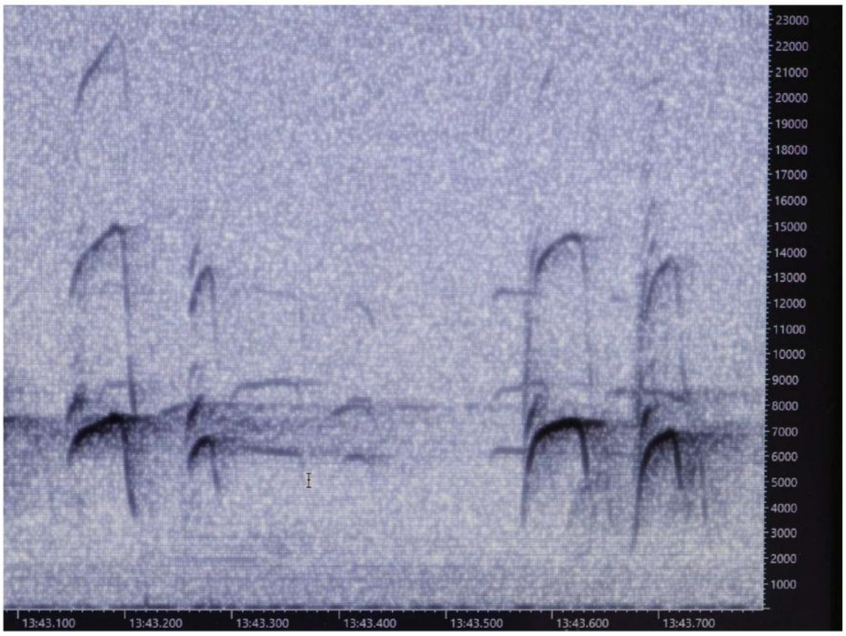

FIGURE 1 -0872, 1/5/25. **E** element on the right (with a long ascending arm), and a simple **A** element on the left (with a long descending arm). Gladstone.

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The **C** element is always polyphonic and has a burriness or noisy sound. It often occurs in series, but may occur alone. Ficken et al. (1994) noted that the number of C elements tended to increase when the birds were disturbed, which agrees with this author's findings. **C** is used as an alert call and in aggression, and seems to demand attention. **C** is often, but not always, accompanied by flight. Given by a *P. atricapillus*, three **C**'s in series among polyphonic **High Zees** had the effect of abruptly silencing five Sitta canadensis when a Buteo lineatus (Red-shouldered Hawk) was in the vicinity (XC975499), but none of the birds flew.

Starting with early research on P. atricapillus, **D** has been associated with the presence of a predator. It is the eponymous *dee* sound of the Chick-a-dee call. A noisy element with dominant frequencies between 2-5 kHz, D is usually well-heard by humans with normal hearing, a feature which undoubtedly contributed to its being the subject of numerous investigations. Templeton (2005) showed that the number of **D** elements quantitatively describes the relative risk of a predator to *P. atricapillus*; more and louder D's indicate greater danger. The small hawks and owls elicit a longer series of **D**'s than the large slow-moving raptors, because parids can evade the large slow-moving ones more easily than they can the fast small maneuverable ones. The evolution of Chick-a-dee calls from one *P. atricapillus* to, finally, a barrage of D's by many chickadees occurred in XC973952. This recording begins with the instigation of an attack on a sleeping *Aegolius acadicus* (Northern Saw-Whet Owl) under natural conditions. At the beginning of the recording, the Chick-a-dee calls asked other birds to come, to which a dozen chickadees and birds of at least five other species responded, coming to mob the owl. Then the Chick-a-dee calls stopped and loud **D**'s became almost continuous. These D's rallied a group effort to oust a dangerous predator. Yet there are many instances when a low amplitude D is part of a Chick-a-dee call given by calm birds when no predator is present.

CALLS NEWLY ATTRIBUTED TO *P. atricapillus*

E was initially associated with the signaler being located high off the ground in *P. carolinensis* and the usual ordered pattern was said to be AEBCD when all these elements were present (Freeberg et al. 2012). With *P. atricapillus* there were situations when E seemed to denote something else. The E element is on the following *P. atricapillus* recordings available on eBird: ML49751 @ 5:24 (recorded by Kevin Colver in Utah in July 1990); and ML217850561 at 1:11 (recorded by Jay McGowan in New York in March 2020) where it is part of a series of five elements (AEEEE) in the midst of Fee-Bee songs. The E element is also on eight recordings of *P. atricapillus* made in Michigan by the present author. Winter is the time of year when *P. atricapillus* form flocks of about seven birds, but within the flocks they often move in pairs. Polyphonic E's are present in what seemed to be a conversation between two birds that were inspecting snags, possibly looking for a suitable place to make a cavity, with one pulling on soft loose bark or perhaps foraging for seeds previously cached there (FIGURE 2).

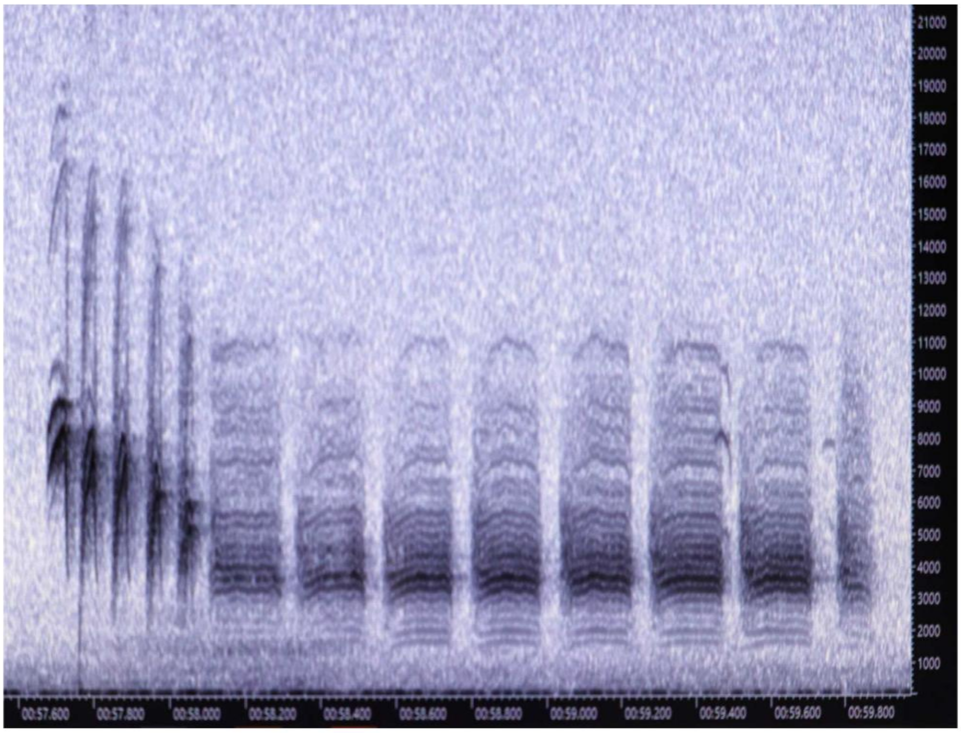

FIGURE 2 – 0243, 1/13/21. **High-tee-chick** in the first position followed by polyphonic **E** elements. Two calm birds were inspecting snags at Portage Point. This image is analogous to the classic ABCD Chick-a-dee call. High-tee-chick substitutes for A and the polyphonic E's substitute for B prior to C and D – the only such instance found in the entire study.

Cavities in trees are often used for shelter on winter nights, and those that are higher off the ground are preferred for nesting and probably also for safety during the winter. The breeding season for *P. atricapillus* depends on local conditions and food sources, but would not be expected to begin before the end of March in the Upper Peninsula of Michigan. E's in series are also associated with copulation (XC716042). E element calls recorded from birds foraging near the ground in November show novel shapes, each one different, but all with a dominant ascending arm; it suggests that E may communicate something other than the signaler being high off the ground (XC980257). Possibly the E element is reserved for communicating with a bird that is a mate or otherwise related.

The **High-tee-chick** is a polyphonic call made rarely by *P. carolinensis* (Bloomfield et al 2005). Its function is unknown. The polyphony occurs at variable frequencies and lasts only about 30-50 ms; it has a long ascending arm and a short descending arm. A single High-tee-chick call was made by a *P. atricapillus* during mobbing of *A. acadicus* (XC973952 at 1:22, lasting 30 ms; also shown in FIGURE 3).

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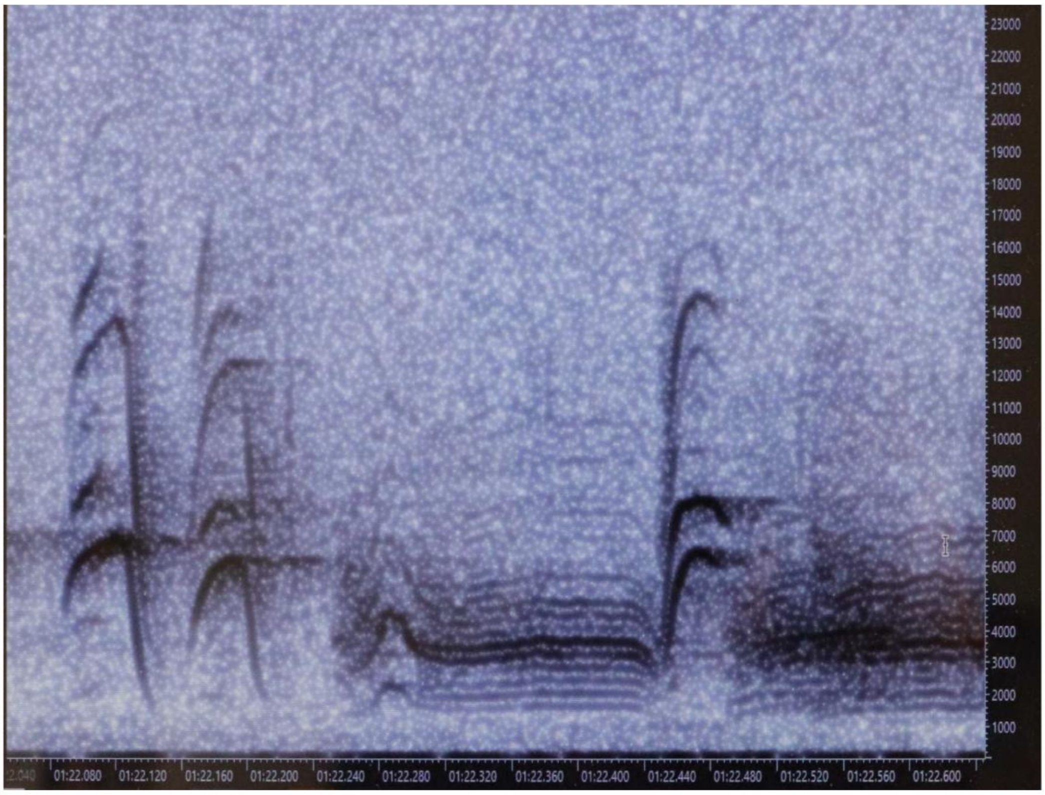

FIGURE 3 - 0267, 1/30/25. **High-tee-chick** in Bloomfield's original orientation and **Dhybrid**. These birds were mobbing a sleeping Northern Saw-whet Owl, a predator. Flat Rock.

It is the only instance found of the High-tee-chick call with the same orientation as Bloomfield's original description. Mirror images of the High-tee-chick call are much less rare; this author has recorded at least seven of them. They have a slightly longer duration, lack the ascending arm but usually have a descending arm, and may occur in series (FIGURES 4 and 5).

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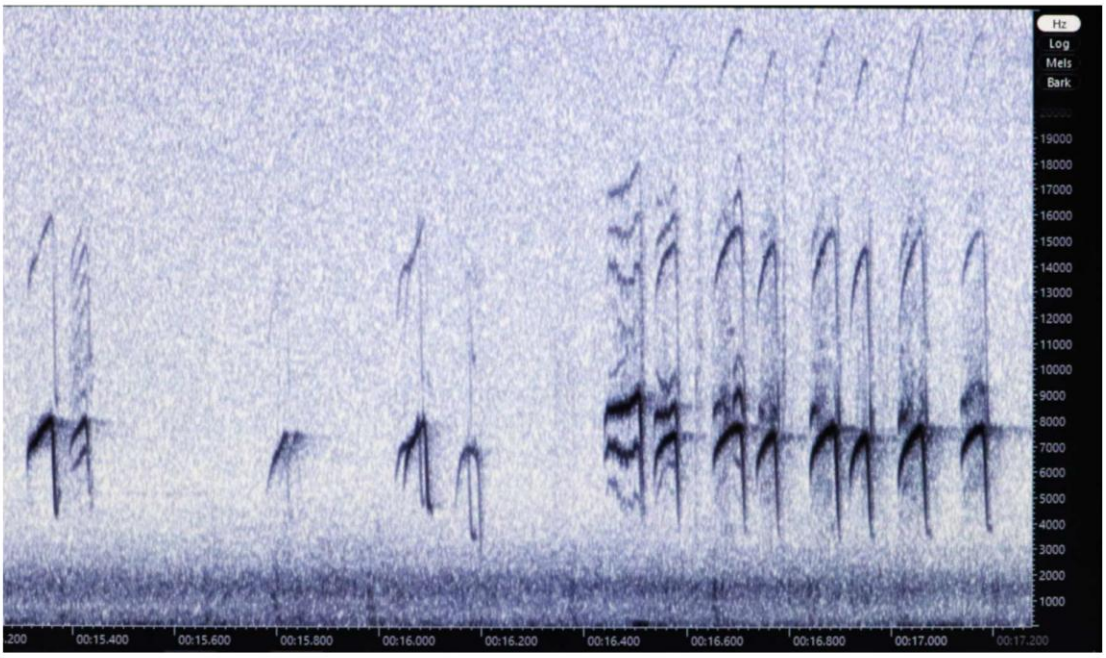

FIGURE 4 – 0266, 10/24/20. **High-tee-chick** mirror images and morphing made by members of a flock of about 12 birds at the boardwalk in Manistique.

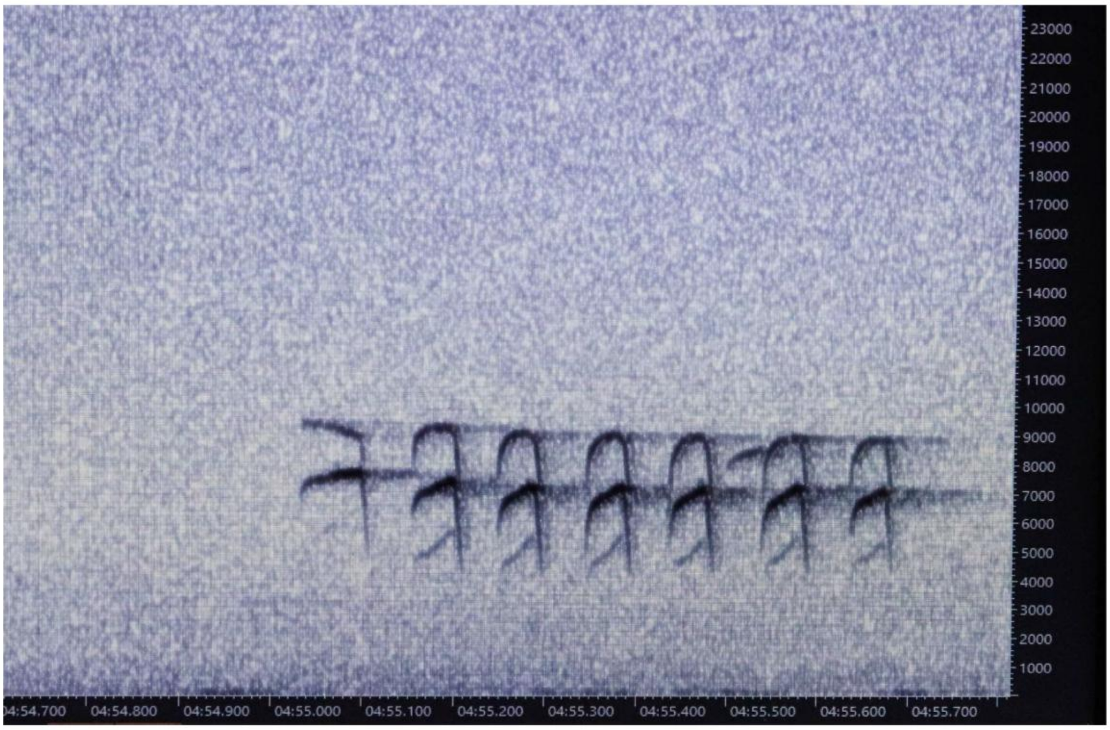

FIGURE 5 - 0860, 4/19/24. Unique **High-tee-chick** mirror image series made during a territorial dispute at Portage Point, see text.

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Figure 5 is associated with what seemed to be a territorial dispute among five *P. atricapillus*; the conflict ranged over about 10 meters with an alder tree near the center which both the pair and the three others seemed to claim. High-tee-chick mirror image calls in *P. atricapillus* seem to be closely related to the A element. The number of partials distinguishes between the mirror image of High-tee-chick and polyphonic A, the former with multiple partials, the latter usually with only two, the fundamental and one other (FIGURES 2 and 9).

D elements are variable in polyphony and range of frequency as well as the number of D's in a series (Templeton 2005). The **D** element has a longer duration than the other elements and usually a wide frequency range, from lower than 2 kHz to over 11 kHz. It usually follows one or more of the AEBC elements, but may occur without any preceding element (XC973952). D may have limited polyphony when it follows a Gargle call and is emitted during a territorial dispute, or immediately after copulation (XC716042), implying that a D of limited frequency may be a marker for high excitement, whether or not a predator is present. The final D on that recording appears to be morphing into the more usual D shape. Variability in the D element shape, the range of amplitudes at which the sound is emitted, and the circumstances in which it is given imply that D's may have various functions.

P. atricapillus A's, B's and C's can morph into D's forming the $\mathbf{D_{hybrid}}$ described by Bloomfield et al. (2005) for *P. carolinensis*, and the "A/D structure" described by Ficken et al. (1994) for *P. sclateri*. $\mathbf{D_{hybrids}}$ appear multiple times on a spectrogram made of *P. atricapillus* in Labrador on a recording made by Doug Hynes on 3/9/2011 (XC935615); this recording sounds like a conversation with a near bird calling, then pausing while a distant bird seems to reply. $\mathbf{D_{hybrids}}$ are also present on XC757914 of *P. atricapillus* recorded by Sue Riffe in Colorado. Michigan recordings of $D_{hybrids}$ are not rare (FIGURES 3 and 6).

The merging of two elements to form one is analogous to a contraction of two words if they have a phonological meaning and retain it. However, the morphing is so brief that no behavior or meaning has been assigned to it.

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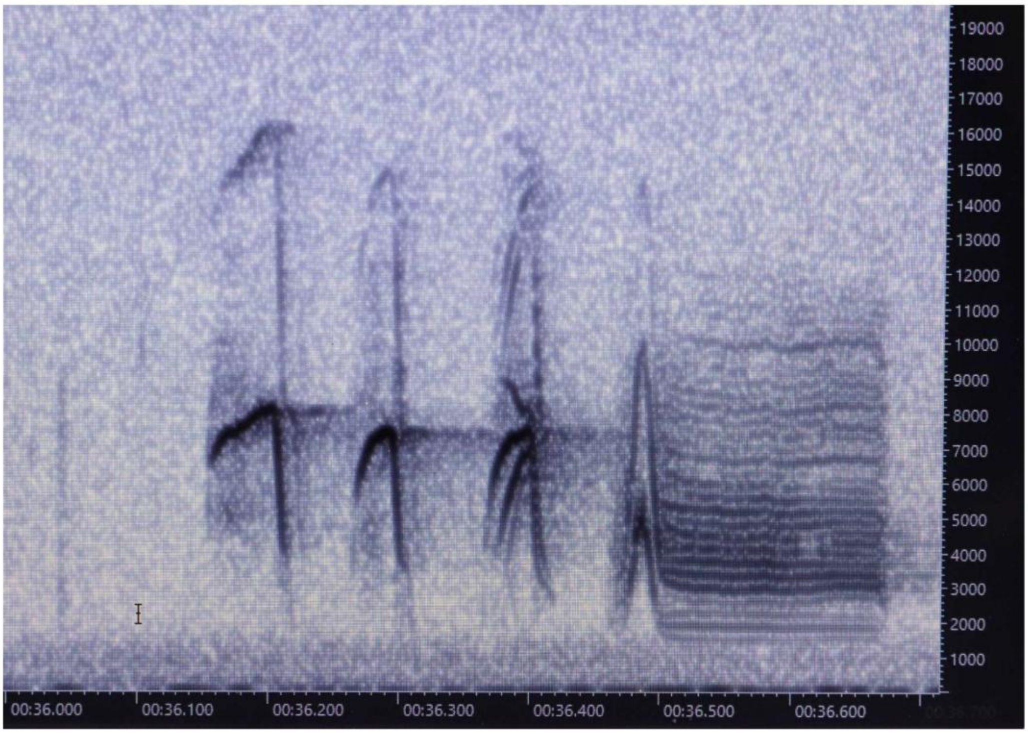

FIGURE 6 – 0873, 1-7-21. **Dhybrid** and **High-tee-chick** mirror image. Portage Point.

The **mu-Chick** call on spectrograms resembles the Greek letter lowercase mu. Most humans with normal hearing will have no difficulty discerning the sounds that form the dark twin peaks at 3-4.5 kHz. It is possibly just one variant of a *P. atricapillus* Gargle repertoire. I have recorded it from seven birds. Often fine lines precede the mu-Chick on the spectrogram and these are probably part of the Gargle and usually inaudible. The ascending and descending arms of mu-Chick vary in length. Four calls in two pairs occurred among Gargles on 11-10-2023 when *P. atricapillus* were seen in the company of *Regulus satrapa* (Golden-crowned Kinglet) and *Dryobates pubescens* (Downy Woodpecker). Pairs of mu-Chick sound like “Chickit.” On 3-10-25, XC988636, a *P. atricapillus* called mu-Chick eight times in one minute, mostly in triplets, as it moved around in tall shrubs (FIGURE 7); it was joined by a second *P. atricapillus* that was calling Chick-a-dee. The phone app, Merlin, did not recognize the triplet mu-Chick. The function of the mu-Chick call is unknown.

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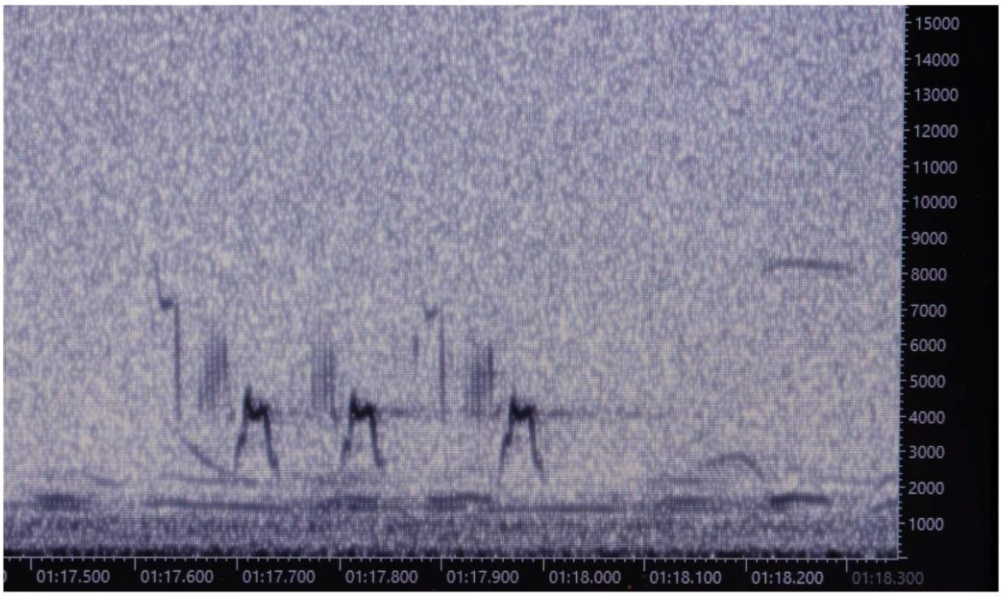

FIGURE 7 – 0911, 3/10/25. triple **mu-Chick** call, Rapid River Boat Launch. From XC988636.

The **Copulatory Twitter** was recorded during observation of two *P. atricapillus* mating in Stephenson, Menominee County, MI on 4-14-22. The entire recording, over a minute long, is on XC716042, which can be downloaded so the spectrogram can be examined. This twitter is different from that described in BOW. Ficken et al. (1978) stated that they were unable to hear differences in Snarls, Hisses and Twitters, all of which were "noisy structures" with a frequency range of 1.5-6.7 kHz, and all were made when escape was thwarted. The Copulatory Twitter is better described as an insectlike ticking sound with a frequency range of 5-9 kHz. Copulatory vocalizations began when the female, with quivering wings, had worked her way gradually up through the branches to the male, who was about 2 meters off the ground in the same shrub. The **D** element was given once, immediately after each of the two copulations. A single **Gargle** call preceded the first **Variable See** by 14 seconds, then the Copulatory Twitter occurred 23 seconds later. The Copulatory Twitter preceded copulation by less than 5 seconds and resumed after the first copulation for approximately another second, by which time another copulation had occurred. Vocalizations by *P. atricapillus* during copulation on 5/4/2003 in New Jersey are on ML135759, a six-second recording made by Randolph Little, and it also shows the high frequency brief notes and the ticking notes.

MORPHING

Unlike the stereotyped Fee-bee song, which is repeated unchanged for extended periods of time in the breeding season, the fall/winter calls are more diverse, possibly due to gregariousness of chickadees in colder seasons. Unusual shapes on spectrograms were examined, because birds can register units of sound that last as little as 1 millisecond, while humans can manage 3-4 milliseconds at best

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(Henderson 2023, p.138). Fishbein (2019) showed that fine detail seen on spectrograms of *T. guttata* is significant. Some *P. atricapillus* spectrograms show indeterminate elements that seem to integrate with each other. Morphing in *P. carolinensis* vocalizations has been documented (Mostrom et al. 2020), and also in *P. sclateri* by Ficken et al. (1994, Fig 1.d), where an "A-like introductory note followed by an A/D-like structure of long A component and short D component" was likely an early report of a **D_{hybrid}**. Such calls may be more likely to be found in recordings made of wild birds in their natural settings. They are not rare and it was not difficult to find more than twenty examples of morphing on recordings made in Michigan. They often take the form of ambiguous elements when chickadees are interacting with other species as in migratory flocks. FIGURE 4 shows High-tee-chick mirror image calls with morphing structures between them. $D_{hybrids}$ are often formed by ambiguous elements. Nascent B elements may represent another instance of morphing (FIGURE 8).

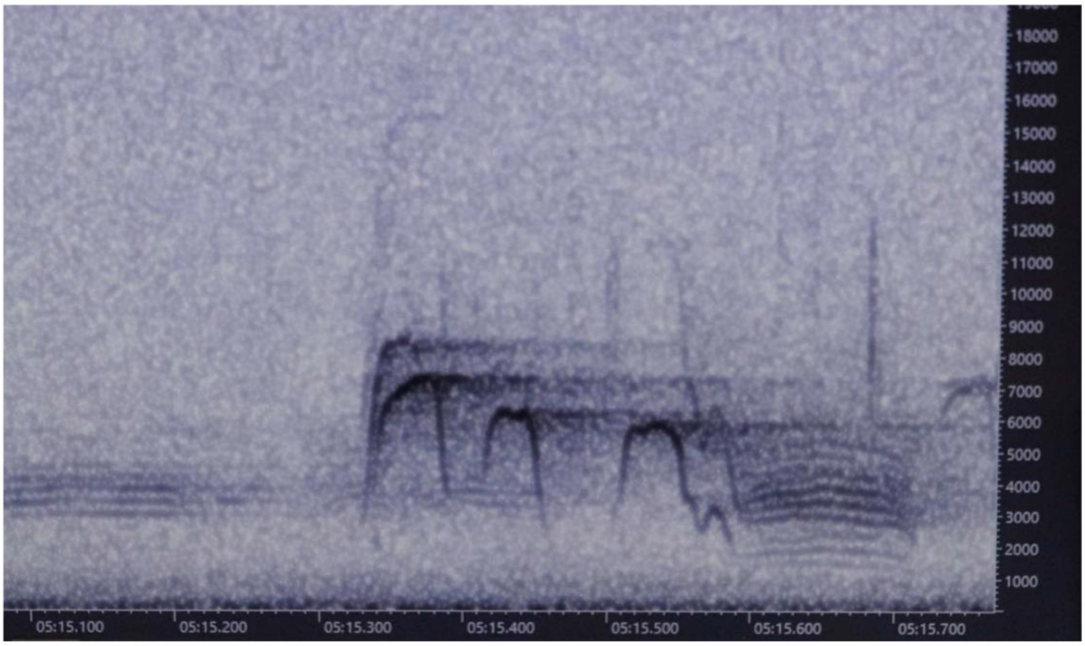

FIGURE 8 - 0859, 10/21/24. Morphing with a nascent **B**. Three species interacting: *P. atricapillus, Sitta canadensis, and Regulus satrapa.* Hunter's Point.

Although syringeal muscle fatigue might be imputed as a cause for morphing, there is abundant evidence that vocalizations can last many seconds without morphing of the elements. Nonpolyphonic elements can morph into polyphonic ones in the same series (FIGURE 9). Morphing of various elements demonstrates transient signals that likely have little phonological significance, but produce meaning in combination with other elements.

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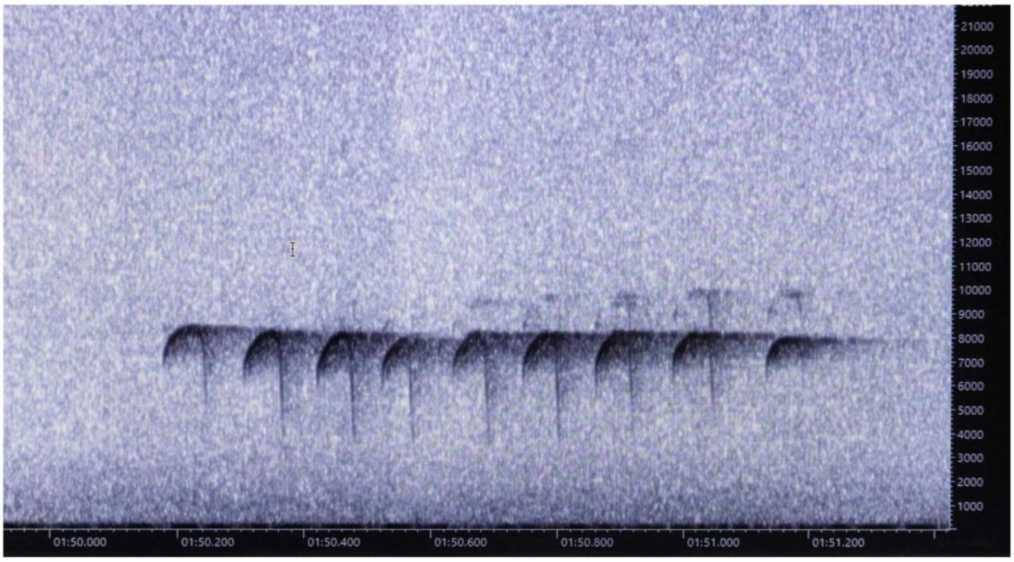

FIGURE 9 – 3128, 1/16/21. Four simple **A**s becoming increasingly polyphonic, Portage Pt.

Finally, contrary to BOW and other authors, it is possible to find spectrograms that provide examples of elements out of order. They are rare, but a few examples were found. FIGURE 10 is one example. Whether such sequences are nonsensical to the chickadees is unknown, but in Campbell's study (2023) they were not preferred.

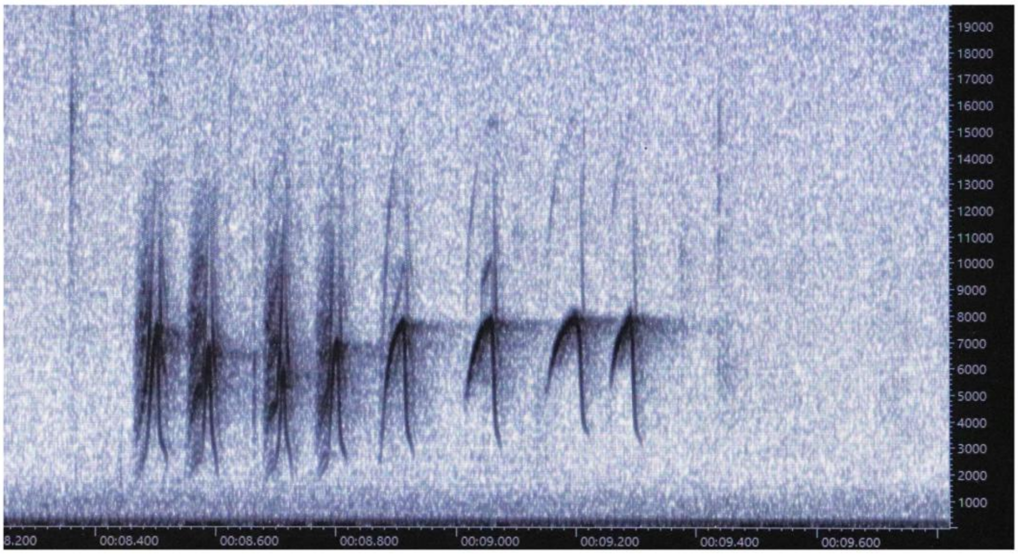

FIGURE 10 – 0399, 10/26/20. Reverse order of elements: 4**C**, 1**E**, 3**A** in that order. Rapid River.

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DISCUSSION

Evidence has been presented here for seven elements that are made by *P. atricapillus* in its Chick-a-dee call, three of which had been previously known only from *P. carolinensis*. These are the E element, High-tee-chick, and D_{hybrid}. In addition, vocalizations made by a copulating pair of *P. atricapillus* are novel sounds, as is another call (mu-Chick) that seems to be associated with a Gargle call. Evidence was also presented for polyphony and morphing of elements, and an example was provided of elements out of order. Finally, a paucity of the previously well-known, well-accepted, complete ABCD Chick-a-dee unit has been discovered. All of these changes were recognized by examining spectrograms. They may relate to evolution of the Chick-a-dee call and the threat that vocalization changes might be to communication signals that maintain bird societies in an increasingly noisy and warming world (Podos and Webster 2022; Symes et al. 2022).

CONCLUSION

The results in this paper are supported by other research in the field. Habitat loss, noise, and other stresses have resulted in dwindling population numbers of even such commonly known birds as chickadees in areas of past abundance, as reported by Johnston et.al., in their very recent publication. Symes et al., as well as other researchers, have found that anthropogenic noise, especially from traffic, is affecting bird vocalizations. It is obvious that birds are really listening and are sentient creatures, as discussed by Podos and Webster. The present study suggests that traffic noise is not the exclusive anthropogenic effector of change in *P. atricapillus* vocalizations. By implementing passive acoustic techniques, more factors that are associated with changes in bird vocalizations are likely to be recognized and hopefully mitigated. The implications of this study suggest curtailing some human behaviors, including excessive use of phone apps in the field, surveys that require interference with breeding birds, and unnecessary handling of wild birds – measures that may be unpopular, unfortunately, with some birding enthusiasts. Supporting organizations that acquire land to be protected as bird habitat may also help stabilize the *P. atricapillus* population. To incentivize people to make these changes, we look to human curiosity about communication in non-human animals. The D element, for example, the subject of many studies, is an example of a sound that has both an intrinsic meaning when it is loud and in a long series, and other meanings when given at normal amplitude and in a shorter series. The function of the D element in warning of a predator is so important that D’s may deserve unique and instant recognition, whereas A, B, C and E elements, as well as D’s not in a high amplitude series, may communicate detailed information of a less urgent nature. This research shows a duality of patterning remarkably akin to human speech, and implies that *P. atricapillus* is using both phonology and semantics to express thoughts. We are only a few steps away from understanding them.

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LITERATURE CITED

Bloomfield, L.L., L.S. Phillmore, R. G. Weisman, and C. B. Sturdy (2005). Note types and coding in parid vocalizations. III. The chick-a-dee call of the Carolina Chickadee (*Poecile carolinensis*). *Can. J. of Zoology* 83:820-833.

Campbell, K.A, M. Hoeschele, D. Mann, J.V. Congdon, E.N. Scully, S. K. Mischler, C. Montenegro, W.D. Service, and C. B. Sturdy (2023). Black-capped chickadees (*Poecile atricapillus*) discriminate between naturally-ordered and scrambled-ordered chick-a-dee calls and individual preference is related to rate of learning. *Behavioural Processes* 206:104842.

Clucas, B.A., T. M. Freeberg, and J. R. Lucas (2004). Chick-a-dee call syntax, social context and season affect vocal responses of Carolina chickadees (*Poecile carolinensis*). *Behavioral Ecology and Sociobiology* 57:187-196,

Collier, K., B. Bickel, C. P. van Schaik, M. B. Manser, and Simon Townsend (2014). Language evolution: syntax before phonology? *Proceedings of the Royal Society of London B.* 281:20140263. https://doi.org/10.1098/rspb.2014.0263

Curry, R. L. (2005). Hybridization in chickadees: much to learn from familiar birds. *The Auk* 122:747-758.

Ficken, M. S., R. W. Ricken, and S. R. Witkin (1978). Vocal Repertoire of the Black-capped Chickadee. *Ornithology* 95:31-48. https://doi.org/10.2307/4085493

Ficken, M. S., E. D. Hailman, and J. P. Hailman (1994). The Chick-a-dee Call System of the Mexican Chickadee. *The Condor* 96:70-82.

Fishbein, A. R., W. J. Idsardi, G. F. Ball, and R. J. Dooling (2019). Sound sequences in birdsong: how much do birds really care? *Philosophical Transactions of the Royal Society* B 375:20190044. https://dx.doi.org/10.1098/rstb.2019.0044

Foote, J. R., D. J. Mennill, L. M. Ratcliffe, and S. M. Smith (2020). Black-capped Chickadee (*Poecile atricapillus*), version 1.0. In *Birds of the World* (A. F. Poole, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.bkcchi.01

Freeberg, T. M. (2008). Complexity in the Chick-A-Dee Call of Carolina Chickadees (*Poecile carolinensis*): Associations of Context and Signaler Behavior to Call Structure. *The Auk* 125:896-907.

Freeberg, T. M., J. Lucas, and I. Krams (2012). The Complex Call of the Carolina Chickadee (Can the Chick-a-dee call provide lessons about language?) *American Scientist* 100:398-407.

Hailman, J. P. and M. S. Ficken (1986). Combinatorial animal communication with computable syntax: chick-a-dee calling qualifies as 'language' by structural linguistics. *Animal Behavior* 34:1899-1901.

Hailman, J.P., M.S. Ficken, R.W. Ficken (1987). Constraints on the structure of combinatorial "chick-a-dee" calls. *Ethology* 75:62-80.

Henderson, C.(2023). *A Book of Noises: Notes on the Auraculous.* University of Chicago Press.

Johnston, A., A. D. Rodewald, M. Strimas-Mackey, T. Auer, W. M. Hochachka, A. N. Stillman, C. L. Davis, V. Ruiz-Gutierrez, A. M. Dokter, E. T. Miller, O. Robinson, S. Ligocki, L. O. Jaromczyk, C. Crowley, C. L. Wood, D. Fink (2025). North American Bird Declines Are Greatest Where Species Are Most Abundant. *Science (American Association for the Advancement of Science)* 388:532-537, no. 6746. https://doi.org/10.1126/science.adn4381

Mostrom, A. M., R. L. Curry, and B. Lohr (2020). Carolina Chickadee (*Poecile carolinensis*), version 1.0. In *Birds of the World* (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.carchi.01

Pieplow, N. (2017). *Peterson Field Guide to Bird Sounds of Eastern North America*. Houghton Mifflin Harcourt. Boston, NY.

Podos, J. and M. S. Webster (2022). Ecology and evolution of bird sounds. *Current Biology* 32: R1100-R1104. doi.org/10.1016/j.cub.2022.07.073

Rosenberg, K.V., A. M. Dokter, P. J. Blancher, J. R. Sauer, A. C. Smith, P. A. Smith, J. C. Stanton, A. Panjabi, L. Helft, M. Parr, P. P. Marra (2019). Decline of the North American avifauna, *Science* 9. doi: 10.1126/science.aaw1313

Soard, C. M. and G. Ritchison (2009). "Chick-a-dee calls of Carolina Chickadee convey information about degree of threat posed by avian predators. *Animal Behavior* 78:1447-1453.

ISSN: 0028-0712

Suzuki, T. N., D. Wheatcroft, and M. Griesser (2016). Experimental evidence for compositional syntax in bird calls. *Nature Communications* 7: Article Number 10986.

Suzuki, T. N., D. Wheatcroft, and M. Griesser (2017). Wild birds use an ordering rule to decode novel call sequences. *Current Biology* 27:2331-2336, Issue 15. http://dx.doi.org/10.1016/j.cub.2017.06.031

Symes, L. B., K. D. Kittelberger, S. M. Stone, R. T. Holmes, J. S. Jones, I. P. Castaneda Ruvalcaba, M. S. Webster, M. Ayres (2022). Analytical approaches for evaluating passive acoustic monitoring data: a case study of avian vocalizations. *Ecology and Evolution* 12: Article number e8797.
doi: 10.1002/ece 3.8797

Templeton, C. N., E. Greene, and K. Davis (2005). Allometry of Alarm Calls; Black-capped Chickadees Encode Information about Predator Size. *Science* 308:1934-1937.