Classification of Williamson's Sapsucker Calls

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Abstract: Williamson's Sapsucker (*Sphyrapicus thyroideus)* calls have been described anecdotally but without published spectrograms, and there has been confusion in application of the naming scheme. I revised the classification of Williamson's Sapsucker calls and provided spectrograms for all common calls. The basic territorial call is the Chyaah (formerly known as the Churr) which may contain either broadband noise, tonal structure, or both in one call. The Scold (which sounds like a soft *churrr* with a rolled r) is the call most commonly given to intruders near nests. Other calls are the Chatter, Rattle, Ca-haw (an intense introduction to the Chatter), Soft Chatter (low intensity calls between mates), Pa-chik-a-wik (for which a recording was not available and which is not illustrated here), Scream, and several nestling calls.

Key Words: Williamson's Sapsucker, *Sphyrapicus thyroideus,* call names, spectrograms

Introduction

Williamson's Sapsucker (*Sphyrapicus thyroideus)* uses both drums and calls to communicate, and may also use tapping on wood (Crockett 1975). The drum has considerable variability (Hadow 1977) but its rhythmic pattern distinguishes it from all other North American woodpeckers. The typical drum consists of a number of rolls where the beats within each roll decay in volume. Adults also give a number of calls which Crockett (1975) was the first to classify as the Churr, Chatter, Ca-haw, Rattle, Scold (also known as Alarm), and Scream. Hadow (1977) quantified and provided spectrograms of the most commonly heard territorial call, the Churr call, but only Crockett's (1975) descriptions are available for the other calls.

Unfortunately, based on my own field experience, there is difficulty identifying calls based only on the verbal descriptions in Crockett (1975) or on paraphrases of those descriptions in Dobbs et al. (1997). For example, "Churr" or "churring" has been applied by various authors to almost every call Williamson's Sapsucker makes. Furthermore, some available commercial recordings make no attempt to classify the calls (e.g., Neville 1996, Stewart 2008) while others give different names to calls, or seem to have interpreted Crockett's classification in different ways (e.g. Cornell Laboratory of Ornithology 1992, Keller and Vyn 2008). Only Short (1982) attempted to classify all the Williamson's Sapsucker sounds he heard according to Crockett's classification but was not entirely successful. Here I re-examine the classification of Williamson's Sapsucker calls, provide spectrograms of each call, and propose some revised names.

Methods

I listened to every Williamson's Sapsucker recording available (132 minutes) on the Macaulay Library of Natural Sounds website (http://macaulaylibrary.org/index.do) to ensure that the classification of sounds would be as comprehensive as possible. All these recordings were from Oregon or California. I also relied on my own experience watching and listening to Williamson's Sapsucker in all areas of their range in British Columbia (see Gyug et al. 2007) from 1997-2009, and in Montana, Oregon and Washington in 2009. To my ear, there did not seem to be regional differences in calls.

All waveforms and spectrograms were produced in Raven Lite 1.0 software (Charif et al. 2006). Wherever possible, I used sounds from the Macaulay Library of Natural Sounds to illustrate the spectrograms of calls (Table 1). The individual recordings cited in Table 1 include the Macaulay Library catalogue number and the position (time) on the recording so that any reader with broadband internet access can listen to the exact sounds illustrated here by streaming audio from the Macaulay Library website. Where calls were not available on Macaulay Library recordings, or were not of sufficient audio quality, I used other sources, including my own recordings, but have also indicated the Macaulay Library catalogue number and position on the recording where similar sounds could be heard. My own sound recordings were made in 2009 in British Columbia on a Marantz PMD 620 solid-state recorder with an Azden SGM-X shotgun microphone.

I reviewed previous Williamson's Sapsucker call classi-

Table 1. Sources of Williamson's Sapsucker sounds used in Figs. 1-5. For the Rattle and Nestling calls which are very infrequently represented in the Macaulay Library of Natural Sounds collection, locations of all examples are given.

Call Name	Figure	Macaulay Library Catalogue No. and position (Min:Sec)	Date, Recordist, Location
Chyaah			
basic	Fig. 1A	47581 (0:06)	14 June 1990, David S. Herr, at Lincoln Meadows, Sierraville, Calif.
noisy	Fig. 1B	111169 (3:00)	23 May 1991, Thomas G. Sander, at Bear Valley, Grant, Oreg.
clear	Fig. 1C	56809 (6:08)	15 June 1990, Diane Richardson at Loyalton, Calif.
Scold	Fig. 2C, F	45299 (0:17)	2 July 1989, David S. Herr at Union County, Oreg.
Chatter	Fig. 2A, D	56927 (4:58)	9 June 1991, Geoffrey A. Keller at Sierraville, Calif.
Rattle	Fig. 2B, E	47584 (2:57)	15 June 1990, David S. Herr at Loyalton, Calif.
	Not shown	49020 (22:52)	
	Not shown	80339 (3:33)	
Ca-haw	Fig. 3A, B	105704 (1:53)	15 June 1995, Geoffrey A. Keller near LaGrande, Oreg.
	Fig. 3C first three notes	105704 (1:53)	15 June 1995, Geoffrey A. Keller near LaGrande, Oreg.
	Fig. 3C final three notes	56927 (3:53)	9 June 1991, Geoffrey A. Keller near Sierraville, Calif.
Soft Chatter	Not shown	80339 (0:30)	5 June 1991, Randolph S. Little at Yuba Pass, Calif.
Pa-chik-a-wik	Not shown	N/A	
Scream	Fig. 4	80340 (0:22)	5 June 1991, Randolph S. Little, at Yuba Pass, Calif.
Nestling calls	Not shown	45299 (4:10)	
	Not shown	87914 (0:03)	
	Fig. 5A	N/A	23 June 2009, Les W. Gyug, near Princeton, B.C.
	Fig. 5B	N/A	23 June 2009, Les W. Gyug, near Princeton, B.C.

fications, and considered alternate names and descriptions applied to each call by previous researchers. For each call, I provided a spectrogram, quantified the rate and beat length for the repetitive calls that depend on rhythm for identification, and provided any new or additional information for the context of each call.

Proposed Classification of Calls

I propose nine basic call names for Williamson's Sapsucker (Table 2) which overlap somewhat with Crockett (1975). Examples of each of these (except the Pa-chik-a-wik) can be found in the Macaulay Library recordings (see Table 1 for locations). Descriptions of the calls available on four widely available commercial audio products but using the revised naming scheme are given to assist readers (Table 3).

Chyaah (formerly Churr)

Crockett (1975) and Hadow (1977) named the basic territorial call the Churr because of similarities in context and form to other Melanerpine woodpeckers that "churr" but I have renamed it to avoid confusion with the Scold (see below). While similar in context to the Squeal of the Rednaped Sapsucker (*Sphyrapicus nuchalis*) (Walters et al. 2002), Squeal was not an appropriate name for this call as it very often lacks any tonal structure and sounds very harsh. Crockett (1975) provided the phonetic transcription *churr*, although for Williamson's Sapsucker, the call may be either tonal (squeal-like), harsh (noisy), or both combined (Hadow 1977). This basic territorial call has variously been described as *queeah* (Sibley 2000), "explosive noisy, pulsating, single calls" (Winkler et al. 1995), "abrupt, explosive outcry" (Coues 1874), "shrill and like that of a red-tailed hawk" (Michael 1935), a "nasal *cheerrr*" (Peterson 2008), a "weak, wheezy *whang*" (Grinnell and Storer 1924), "*cheeur*" (Dobbs et al. 1997), and "*cheer-cheeur-cheeur*" or "*churr*" (Short 1982).

The Chyaah includes three basic variants with different harmonic structures (Fig. 1), but with similar timing and volume, and given in the same contexts. The most often heard form mixes broadband noise with harmonic structure. Less frequently heard is the noisy Chyaah, which is harsh in sound and consists entirely of broadband noise. Even less frequently heard is the clear Chyaah which is similar to the Northern Flicker's (*Colaptes aureus*) piercing *klee-yer* (Lawrence 1966) or Peah (Wiebe and Moore 2008), or the Red-

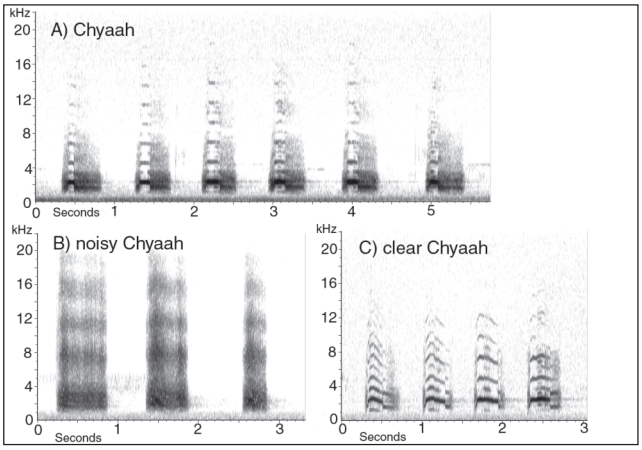

Figure 1. Spectrograms of the basic territorial Williamson's Sapsucker Chyaah call showing the three main variants.

Table 2. Summary of revised Williamson's Sapsucker call names including description and context.

Revised Call Name	Call Name of Crockett (1975)	Description and Context
Chyaah	Churr	Most commonly given territorial call; The name is derived from the three parts to the basic call: *Ch* as the initial broadband noise, *y* as the clearly defined tonal section with harmonics, and *aah* as the final section of broadband noise.
basic		Short section of tonal structure beginning and ending with broadband noise
noisy		Noisy call dominated by broadband noise with no clear tones
clear		Clear call dominated by tonal structure sounding similar to Northern Flicker's Peah or Red-naped Sapsucker 's Squeal
Scold	Scold (Alarm)	Repeated soft *churrr* directed at intruders near a nest or defended sap trees; repeated rolled *r* notes given at the rate of 32-37/sec; rolled *r* notes are separated by broadband noise, not by silence; given by adults and by young shortly before and after fledging
Chatter	Chatter	Repeated *chee* or *ch*- notes at the rate of 7-8/sec; used in within pair communication or in aggressive territorial encounters with conspecifics; *chee* notes have distinctive pattern beginning with broadband noise (*ch*) and ending with descending tones (*ee*)
Rattle	Rattle	Repeated *ch* notes at the rate of 15-17/sec; flat tonal structure different from Chatter *chee* notes; given only at end of encounters during moth flight (very quick fluttering of wings) while flying away; volume of sound tails off very quickly during the call
Ca-haw	Ca-haw	*Chk-haww* usually repeated several times as introduction to the Chatter in very aggressive territorial situations; name derived from explosive loud introductory note (*Ca*) followed by very brief silence (-), followed by broadband noise (*haw*)
Soft Chatter	Considered a type of Chatter	Halting and irregular soft *chee* or *ch* notes; typically used in within-pair communication; *chee* notes have same tonal structure as notes in Chatter call
Pa-chik-a-wik	Not named	Recording not available and context not definitive; may have similar context to Soft Chatter in use between members of a pair but using sounds other than the *chee* note, and may be given in other contexts
Scream	Scream	Calls given by birds during handling or when caught in mist nets; not usually heard in natural situations
Nestling calls	Not named by Crockett; Twittering name applied by Short (1982)	Variety of begging and other softer calls similar to other woodpecker nestlings with at least four distinctive forms: 1. constant soft twittering calls given by undisturbed nestlings typically at the rate of 4-6/sec 2. sharper (begging) calls when feeding by parents is imminent, and rising in pitch and intensity when being fed 3. soft warbling calls of 0.5-0.8 sec duration with modulations at the rate of 20-25/sec within the call 4. soft cooing calls similar to the warbling but without the modulations

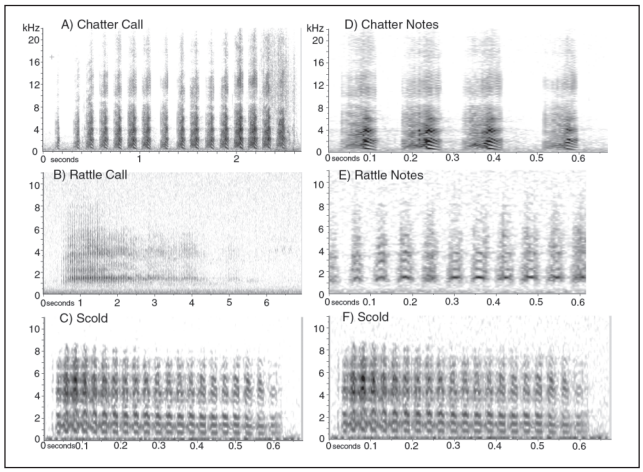

Figure 2. Spectrograms of the Chatter, Rattle and Scold calls of Williamson's Sapsucker showing entire calls on the left (A-C) using time scales (x-axis) necessary to fit in entire calls, and showing notes of the same calls on the right (D-F) but using the same time scale in each spectrogram to illustrate the differences in note duration and rhythm.

naped Sapsucker's Squeal (Walters et al. 2002). It consists almost entirely of sounds with tonal structure, sometimes with minor and almost inaudible amounts of harsh noise at the beginning and end. There is typically a sharp drop in the harmonic structure in the latter half of the call.

Hadow (1977) found that in response to call playbacks, the atonal version (noisy Chyaah) and the Chyaah with tonal structure were given almost interchangeably, and each about 50% of the time. He did not distinguish between calls that had partial tonal structure and those almost entirely made up of clear tones and harmonics.

Scold

Described as a "hoarse guttural roll" (Crockett 1975) or as containing "a number of rolling *r's*, beginning with a guttural *k—k'–r–r–r—*" (Coues 1874), the Scold sounds more like *churrrr* (with a rolled r at the end) than does the Chyaah (which Crockett termed the Churr call). Short (1982) used Crockett's (1975) naming convention for the basic territorial call, the Churr, but apparently mistook Crockett's Scold as a form of Churr as well. He described one of the types of Churr sounds as "*purr–purrr–prrr*" that was given

Table 3. Williamson's Sapsucker sounds available on four commercial audio products showing the track, location on each track, and the sound named using the revised names proposed in this paper. No endorsement of any of these products is implied.

Source	Cut on CD	Location on Track (Min:Sec)	Williamson's Sapsucker Sound using Revised Names	CD Liner Notes	Comments
Cornell Laboratory of Ornithology. 1992. (Peterson Field Guides: Western bird songs, 2nd ed.)	CD 1; 51. Woodpeckers	1:13-1:21	2 drums	Track 52 in the liner notes actually refers to Track 51 on the CD.	
		1:21-1:29	Chatter	Referred to as *churring*	
		1:29-1:32	4 clear Chyaahs	Referred to as "cheeer" calls	
Neville 1996	57. Williamson's Sapsucker	0:19-0:30	8 Chyaahs	None	
		0:31-0:44	3 drums		
		0:45-0:47	2 Chyaahs		
		0:48-0:54	3 Scolds interspersed with tapping		
Stewart 2008	28. Williamson's Sapsucker	0:04-0:06	2 Chyaahs	None	
		0:09-0:15	Chatter		24 chee notes in call
		0:16-0:19	Chatter		16 chee notes in call
		0:21-0:23	2 Chyaahs		
		0:27-0:28	Scold		
		0:31-0:35	1 drum		
		0:36-0:38	1 drum		
Keller and Vyn 2008	CD 3; 1. Williamson's Sapsucker	0:04-0:08	4 Chyaahs	"squeal call" "harsh, descending *chee-ur* notes"	Calls have tonal structure in the middle, but begin and end with noise.
		0:11-0:14	3 noisy Chyaahs	Incorrectly referred to as "Ca-haw call"	Dominated by harsh broadband noise although very slight tonal structure present
		0:18-0:26	4 Scolds interspersed with tapping	Referred to as "call of female"	The Scold may vary slightly in pitch even when given by a single bird, and is given by both sexes.
		0:29-0:35	Chatter	Chatter	36 chee notes in call, rising and falling in volume
		0:37-0:45	Chatter	Chatter	39 chee notes in call, rising and falling in volume
		0:48-0:53	1 drum	"Drum begins with a fast steady roll followed by single, irregularly spaced taps."	The drum consists of 10 rolls, with multiple decaying beats within each roll. Even though the 9 terminal rolls were referred to as "single taps", they have multiple beats.
		1:05-1:09	1 drum	(Same as above)	The drum consists of 8 rolls, with multiple decaying beats within each roll.
		1:13-1:19	1 drum	Second example of drum	An atypical drum: beats in rolls 1 and 7 do not decay in volume.
		1:19-1:24	1 drum		An atypical drum where the beats in rolls 1 and 2 do not decay in volume after the first beat.

"toward humans walking toward a nest", which perfectly describes the Scold in sound and context. Thus, to avoid confusion, I suggest maintaining Crockett's (1975) name of Scold which describes the intent or context of the call, rather than giving this call a name based on the description of the sound.

A single Scold call lasts 0.25–0.60 sec, and consists of a rapid modulation between broadband noise and notes with tonal structure (Fig. 2). There are 10-16 tonal notes inserted into a single call at a rate of 32–37 notes/sec. Each note within a single scold call contains clear tonal structure up to at least 8 kHz above the first harmonic at 0.5–1.0 kHz.

Crockett (1975) described the Scold call as "given by the adults for up to 15 minutes almost continuously in response to human-intruders, ground-based predators and other birds." I have found this to be the case, and to be the

single most useful call to determine when territorial birds are disturbed by human presence. The call is usually given when an observer approaches within about 50 m of the nest tree or a set of sap trees. I have only ever once heard scolding given by an adult male in another situation. This male had been insect gleaning on a dead Douglas-fir (*Pseudotsuga menziesii*) stub about 150 m from the active nest. When it returned from delivering the food to the nest, it found me inspecting the stub and began to scold me.

A softer version of this call is also used by the young, both in the nest shortly before fledging, and outside the nest shortly after fledging (Crockett 1975, pers. obs.). A few days before fledging, the young in the nest will respond to parent's scolds of intruders with this call. Soft scolding from a number of unseen sources near a known nest tree is a typical sign that the young have fledged but remain near the nest tree. In some cases, where some young remained inside the nest and had yet to fledge, the soft scolds could be heard from young both inside and outside the nest.

Chatter

Described as *chee-chee-chee* (Crockett 1975) or *ch–ch–ch–ch–ch* (Short 1982) a Chatter call consists of a series of notes at a rate of 7-8 notes per second, which may, in total, last up to 8 seconds (Fig. 2A). A spectrogram of the Chatter call was mistakenly labeled "Churr" (Fig. 2 of Dobbs et al. 1997), and the call was labeled "churring" in the Peterson Field Guide CD "Western Bird Songs" (Cornell Laboratory of Ornithology 1992). Each *chee* note begins with broadband noise and ends with downslurred harmonics (Fig. 2D), which was found in every Chatter Call in the Macaulay Library collection. While the duration of each *chee* note was typically 0.05 seconds, Stewart (2008) provided a recording where the Chatter notes (at the 16–19 second mark on track 28) were each slightly longer, lasting 0.08–0.10 seconds each.

This call can be used by breeding pairs communicating with each other, or as an aggressive call between territorial males. Adults may give slower variants of the chatter as they begin or end the call, or if they start the call but do not proceed to a full version of the call. They may only give single notes of the call, or a very halting version, which would be considered Soft Chatter if it is in the context of mated pair interactions.

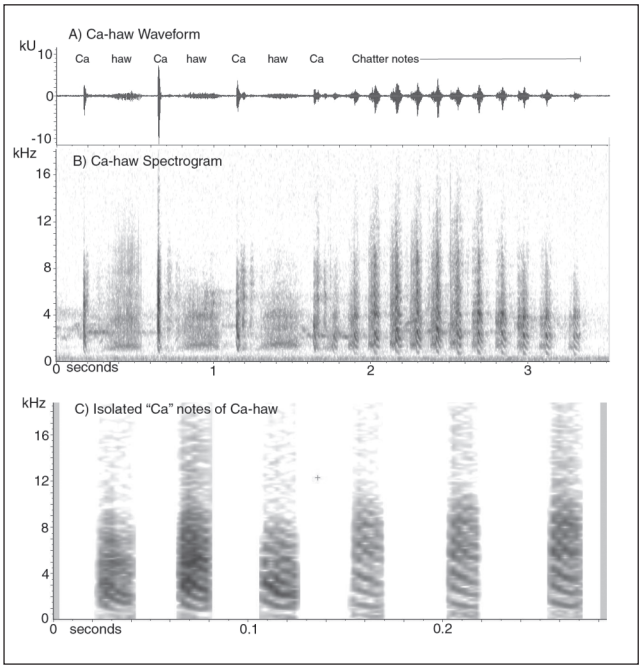

Figure 3. Waveform (A) and spectrogram (B) of a Williamson's Sapsucker Ca-haw call showing individual ca-haw notes followed by Chatter notes, and (C) spectrogram of isolated "ca" notes showing the descending tones.

Rattle

Crockett (1975) described this as a "rapid guttural trill similar to the dry rattle of a House Sparrow or a Belted Kingfisher". Short (1982) thought the "Rattle Call" of Crockett (1975) was inappropriately named because it was not like the rattle of *Picoides* woodpeckers, and that it should be lumped as a fast form of Chatter. However, the Rattle has a rate and tonal structure that are different from the Chatter (Fig. 2), and is used in a different context (Table 2). The notes within the Rattle are twice as fast as the Chatter, the tonal structure is different, and the volume of the Rattle consistently trails off quickly. Based on analysis of four rattle calls (three from the Macaulay Library, and one I recorded) notes were repeated at rates between 15.7 and 16.7 notes/sec with mean note duration of 32.9 ms (range 32.0–34.5 ms), and mean between-note interval duration of 28.3 ms (range 24.0–32.5 ms).

The Rattle call of Williamson's Sapsuckers is given rarely: there were only 3 rattles among the 131 minutes of recordings in the Macaulay Library (Table 1), and in 15 days of Williamson's Sapsucker surveys in 2009, I only heard the Rattle three times. The Rattle has a context quite separate from the many contexts in which Chatters may be used, i.e., it occurs "at the termination rather than the initiation of an encounter" (Crockett 1975) and is "usually associated with the moth flight instead of the bouncing flight display." I have heard Rattle calls given by 1) a male flying away from an intense male-male territorial interaction where the interaction had been initiated in response to call playbacks, 2) a male flying away from a drumming post after being displaced by a Pileated Woodpecker (*Dryocopus pileatus*), and 3) a male agitated after responding to call playbacks flying away with the moth flight after a female (not apparently his mate) had just landed on the same tree.

Ca-haw

This call has been a source of confusion as Short (1982) suggested the Ca-haw call of Crockett (1975) was just a

form of Churr call, and Keller and Vyn (2008) incorrectly identified a variant of the basic territorial call (Chyaah or formerly Churr) as a Ca-haw. However, Short (1982) did describe a "*ch–a–ch–a*", which I believe was the Ca-haw, but which he considered a type of variable Chatter. Since the Ca-haw is usually followed by chatter notes (Crockett 1975, pers. obs.) it was perhaps not surprising that Short thought of this sound as a form of Chatter.

The Ca-haw is separated into two syllables (*chk–haw,* or *C'–haw*) (Fig. 3) the first of which is characterized by a very explosive, short introductory note that lasts 0.015–0.017 sec and has distinguishable downslurring tonal structure with a number of harmonics above the dominant at about 1–2 kHz. The introductory note is followed by a silence of 0.14–0.15 sec; then by a longer broadband noise of 0.25–0.30 seconds that is much lower in volume than the introductory note. This call is normally followed by the Chatter call, although sometimes the following Chatter may be cut short or not given during intense interactions.

Soft Chatter

Short (1982) described other calls rendered as "*t–ch t–ch t–ch*", and "*ch–ch–ch*" between members of a mated pair that he assumed were all types of Chatter call not described by Crockett (1975) although the latter recognized softer and lower intensity chatter calls between members of a mated pair. These calls sound like modified or incomplete versions of the Chatter, with the birds sometimes speeding up and sometimes slowing down, and a very halting or irregular rhythm. The individual notes of this call have the same harmonic structure and approximately the same duration (0.05-0.07 sec) as the notes of the Chatter, and are not illustrated separately. This call would be similar to the "intimate notes" (Kilham 1962) or "mutual notes" (Lawrence 1966) of Yellow-bellied Sapsuckers (*Sphyrapicus varius*) or the Interaction-Call Complex of Red-naped Sapsuckers (Walters et al. 2002).

Pa-chik-a-wik

Transcribed as "*pa–chik–chik–wik–wik–wik–a–wik–a–wik*" between members of a courting pair (Short 1982), Crockett (1975) did not refer to this call but probably grouped it with the low intensity chatter calls (i.e., Soft Chatter). I was unable to obtain recordings of this call, but based on personal observation, it sounds more like the Wicka (*wik–a–wik–a*) call of the Northern Flicker which is also highly variable and used in courtship between members of a pair or in territorial interactions (Wiebe and Moore 2008). I believe this is different from Soft Chatter because the individual notes are probably quite different in tonal structure than the Chatter note and I have heard it in contexts other than between members of a courting pair. The *wik* portion of the Northern Flicker's Wicka call, which sounds very much like this call, consists of rising tones that are not found in the Chatter notes of Williamson's Sapsucker. The classification of this call should be reexamined when recordings and spectrograms are available, and when more instances of the context of the call have been noted.

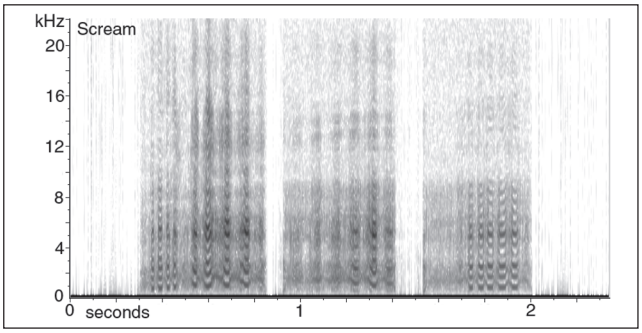

Figure 4. Spectrogram of Williamson's Sapsucker male scream while caught in a mist net.

Scream

A Williamson's Sapsucker Scream from a bird in a mist nest sounded like typical non-specific bird distress calls (Fig. 4). The call contained broadband noise punctuated by harmonic structure that appeared to continue above the limit of the recording equipment or the limitations of the Raven Lite Software at 22 kHz. I have never heard this call produced by free-ranging Williamson's Sapsuckers.

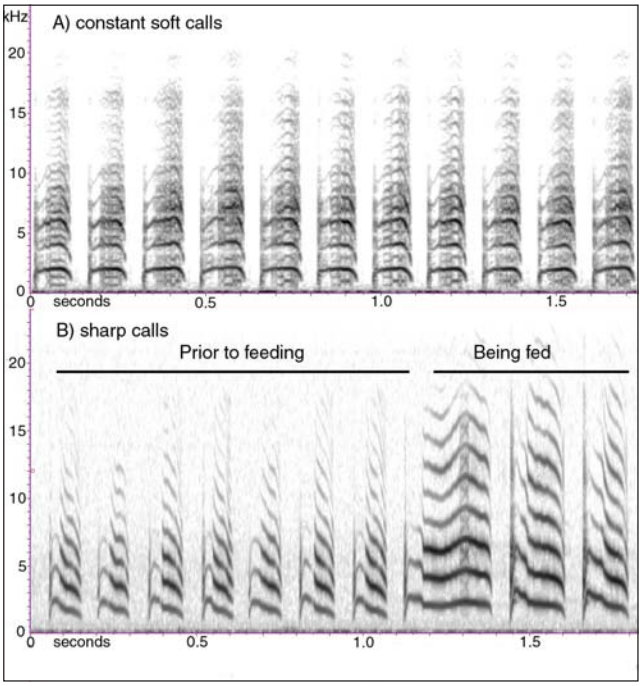

Figure 5. Spectrogram of Williamson's Sapsucker nestling calls including (A) constant soft twittering calls when undisturbed, and (B) immediately prior to, and when being fed by adults.

Nestling Calls

Crockett (1975) did not name these calls, but referred to them as "constant twittering. . . . interrupted only while they were being fed, when their calls became louder, higher pitched, and more emphatic." Short (1982) applied the name Twittering to Williamson's Sapsucker nestling calls, and described them as similar to the Chirp and Loud Chirp group of calls of Picoides woodpeckers. Lawrence (1966) cautioned against calling them begging calls because the young make noises even in the absence of parents, and the noises are not always associated with begging. Walters et al. (2002) did not specify each possible nestling call for Red-naped Sapsuckers as there were many variations of calls as nestlings moved or interacted with one another. For Williamson's Sapsucker, I recognized at least four different nestling calls including the constant twittering calls of undisturbed nestlings, warbling, cooing, and the sharp calls immediately prior to being fed, or when they are being fed that would be considered begging calls.

The constant twittering calls are very similar in sound and cadence to the calls of other nestling woodpeckers but are generally softer and less strident than Red-naped Sapsuckers or other Picoides woodpeckers (pers. obs.). The calls of nestling Picoides woodpeckers (Winkler and Short 1978) are typically sharper and more peaked in tonal structure than the relatively flat tonal structure of Williamson's Sapsucker (Fig. 5) or of Red-naped Saspsuckers (Walters et al. 2002). The constant Williamson's Sapsucker nestling calls are generally soft but increase in intensity and volume, and decrease in the pitch of the fundamental harmonic, as the young get older. Based on my own recordings (not illustrated), the fundamental harmonic is at 2-3 kHz for young that are 1-2 weeks old, and 1.5-2 kHz for young that are about 3 weeks old. Recently-fledged young may continue relatively sharp and insistent (begging) calls to solicit food when in sight of the parents for a few days after leaving the nest.

In addition to the constant twittering, Williamson's Sapsucker nestlings, and other woodpecker and sapsucker nestlings as well, make warbling or cooing noises. Based on my own recordings of young that were estimated to be about two weeks old, the warbling was lower in pitch (fundamental harmonic 1–2 kHz) than the constant calls (2–3 kHz), longer (0.5–0.8 sec) than the constant calls (~0.15 sec) and had very fast modulations (20–25/sec) within the call. I did not record any instances of cooing, but it sounded similar to the warbling but without the very fast modulations.

Acknowledgements

This project would not have been possible without the extensive collection of recordings available in the Macaulay Library of Natural Sounds. The sounds illustrated as spectrograms in this paper (other than those based on my own recordings) were used under licence to the author from The Macaulay Library at the Cornell Lab of Ornithology, Ithaca, New York. This paper benefited from reviews by Mary Taitt and Karen Wiebe.

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