Great Horned Owl *Bubo virginianus* vocalizations and associated behaviours

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Visual observations of nocturnal species such as owls can be difficult. Knowledge of vocalizations associated with particular behaviours is therefore an extremely useful tool in studying owls in the field. For this purpose, I studied the vocalizations and behaviours of the Great Horned Owl *Bubo virginianus*, collecting observations on a female human-imprinted individual and wild pairs. Spectrographically, Great Horned Owl calls were divided into three main categories: hoots, chitters, and squawks. These categories were further subdivided into five types of hoots, four types of chitters, and five types of squawks based on inflection, number of syllables, duration, pitch, volume, and behavioural context. Two types of non-vocal communication were also distinguished: hisses and bill clacking. Although owl vocalizations are generally considered innate and variation between individuals should not differ in basic makeup and behavioural context, further verification on wild owls is encouraged.

Key words: Great Horned Owl, *Bubo virginianus*, vocalizations, behaviour

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INTRODUCTION

There is a substantial interest in understanding the vocal repertoire of owls, as their vocalizations are fundamentally important in surveying and monitoring the vast majority of species around the world. Moreover, in behavioural studies, an understanding of the context associated with each vocalization type can allow an observer to make inferences about behaviour based on vocalizations alone.

To date there has been no study of the vocal repertoire of the Great Horned Owl *Bubo virginianus*, despite its extensive range throughout much of the American continents. Houston *et al.* (1998) noted that Great Horned Owl vocalizations are varied and difficult to characterize, and Baumgartner (1938) stated the male can produce "an indescribable assemblage of hoots, chuckles, screeches, and squawks."

Owl vocalizations are generally accepted as inherited, not learned (König *et al.* 1999). Therefore even a human-imprinted owl should have normal vocalizations. I have possessed a permanently injured, human-imprinted, female Great Horned Owl 'Alice' for educational purposes for nine years. This allowed me to collect data on vocalizations in a wide array of behavioural contexts. Data on this individual were supplemented, and compared, with observations on wild owls. The goal of this study was to arrive at an extensive description of the Great Horned Owl's sound repertoire and associated behaviours.

METHODS

I recorded Alice and wild Great Horned Owls in rural Houston, Minnesota, USA (43°47'N, 91°38'W) beginning in October 2004. Recordings were also made in the spring of 2006 and 2007 at a nest located at the Rochester Golf and Country Club in Rochester (74 km northwest of Houston) Minnesota, USA, which were supplemented with behavioural observations using an ATN Nightshadow 2 night vision bi-ocular. Playback was not used to elicit vocalizations. Recordings before August 2006 were made using a Sony TCS-60DV tape

recorder; recordings after that date were made digitally with a Sony MZ-RH1 mini disc recorder using a Sennheiser MKH-110 shotgun microphone. Date, time, location, vocalization type and context were noted at the end of each recording. Tape recordings were uploaded to computer and digitized using Syrinx ver 2.5q (John Burt, Seattle, WA). Digital recordings were uploaded using Sonic Stage ver 3.4 (Sony Corporation). Recordings were filtered as needed with Audacity ver 1.2.4 (SourceForge.net) and analyzed spectrographically using Spectrogram 14 (Visualization Software LLC). These spectrograms served to classify the sounds recorded.

Individual wild owls were identified by their territorial hoots, which were consistent for each individual and sufficiently distinct from each other to serve to 'fingerprint' individuals. Rohner (1996) previously noted this was possible in male Great Horned Owls, as has been shown to be possible for several other owl species (Galeotti & Pavan 1991, Galeotti *et al.* 1993, Otter 1996, Delport *et al.* 2002). The owls in Rochester were identified visually. The owls referred to in this study were:

(1) 'Alice', a permanently injured, human-imprinted, captive female.
(2) 'Wheezy', the resident female in the Houston study site when the study began. She and her mate, Wendell, were pushed off their territory to the east in January 2005. She succumbed to West Nile Virus in August 2006 and was an old bird at that time judging by the thick layering on her bill.
(3) 'Wendell', mate of Wheezy. He moved out of the study area after Wheezy died.
(4) 'Victor', the current resident male in Houston. Mate of 'Virginia'.
(5) 'Foxy', the Rochester female, found dead under her nest 15 April 2007 from an infection.

For the purposes of this paper, 'spring' is loosely defined as the period from nesting to fledging (February to April in my study area), 'summer' is the period when the fledglings are still partially dependent on their parents (May to July), 'fall' is the period of juvenile independence and dispersal (August to October), and 'winter' is the onset of courtship leading up to nesting (November to January). 'Notes' are defined as the smallest sound unit in bird song (Marler & Slabbekoorn 2004).

Previous authors have attributed various names and descriptions to Great Horned Owl vocalizations. Without recordings or spectrograms it is difficult to classify these descriptions according to the naming system presented in this paper. But some authors give clear enough descriptions of vocalizations and context to allow a reasonable level of certainty in matching them to my categories.

RESULTS AND DISCUSSION

When analyzed spectrographically, three distinct vocalization types are apparent: hoots, chitters, and squawks. Each of these categories can be further subdivided into more specific types based on inflection, number of syllables, duration, pitch, volume and behavioural context. There are also two types of non-vocal communication used: hisses and bill clacking.

Hoots

Hoots (Fig. 1) are produced with the bill closed and gular sac expanded. If the mouth is open during sound production (such as while holding something in the bill), an "ah" sound is produced instead of the normal "oo" sound. There are five different types of hoots. For the purpose of this paper I will use the term "hoot" to describe a defined sequence of "hoo" notes, such as "Hooo, hoo-hoo-hoo, hooo, hooo".

Territorial Hoot. This type of hoot is always given in a forward leaning posture with the tail held in an upright position. Territorial Hoots are given repeatedly, with highly variable spacing between hoots based on level of excitement. The number of notes per hoot and their spacing is uniform for an individual, with males typically having 4–5 notes per hoot and females 6–9 notes. Territorial Hoots are given by adults of both sexes, and may be given by individual birds, as a 'duet' of a mated pair, or as a 'duel' with neighbour or stranger owls. Territorial Hoots can be given at any time of year, but are most common in fall and winter. Territorial Hoots may be given repeatedly without the last note by adult females in fall or winter. This seems to be an indicator of sexual arousal in Alice and perhaps could be considered a distinct type of hoot. Possible analogies: "Hoot" (Bent 1938; Austing & Holt 1966); "official hoot" (Heinrich 1993); "courtship calling" (Gottfred & Gottfred 1996); "song" (König *et al.* 1999); "full hoot" (Terman 1996); "territorial advertisement song" (Houston *et al.* 1998).

Bent (1938) described the territorial hoots of the male Great Horned Owl as being more elaborate than those of the female, and this description has been cited in the major references on the species (Austing & Holt 1966, Houston *et al.* 1998). However this description is inaccurate in that the typical male hoot has only 4–5 notes, while the typical female hoot has 6–9 notes.

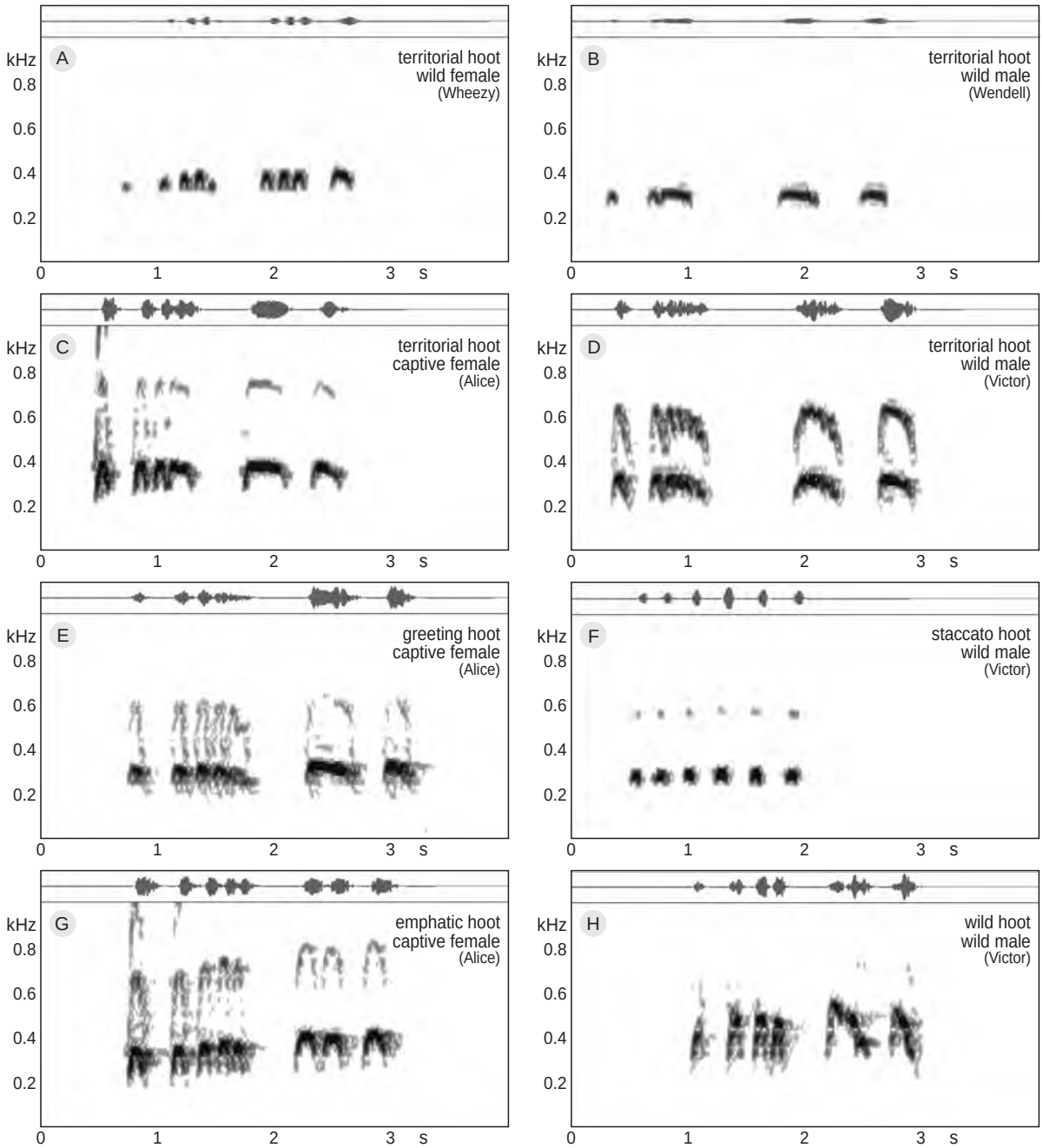

Figure 1. Spectrograms of the types of hoots from wild and captive Great Horned Owls; origin of owls from Minnesota and Wisconsin, USA.

Occasional males use vibrato on the second note of their hoot which might be interpreted as being more 'elaborate,' but these owls constitute a small portion of the population (pers. obs.). I intend to address details of the Territorial Hoot in a future paper that will explore sex and regional variation in that specific vocalization.

Females are the larger sex in Great Horned Owls but have a smaller syrinx which results in a higher-pitched hoot than the male (Miller 1934). But overall the Territorial Hoot of the Great Horned Owl is a very low-pitched (usually between 300–400 Hz) vocalization in the world of birds. Kroodsma & Miller (1982) noted

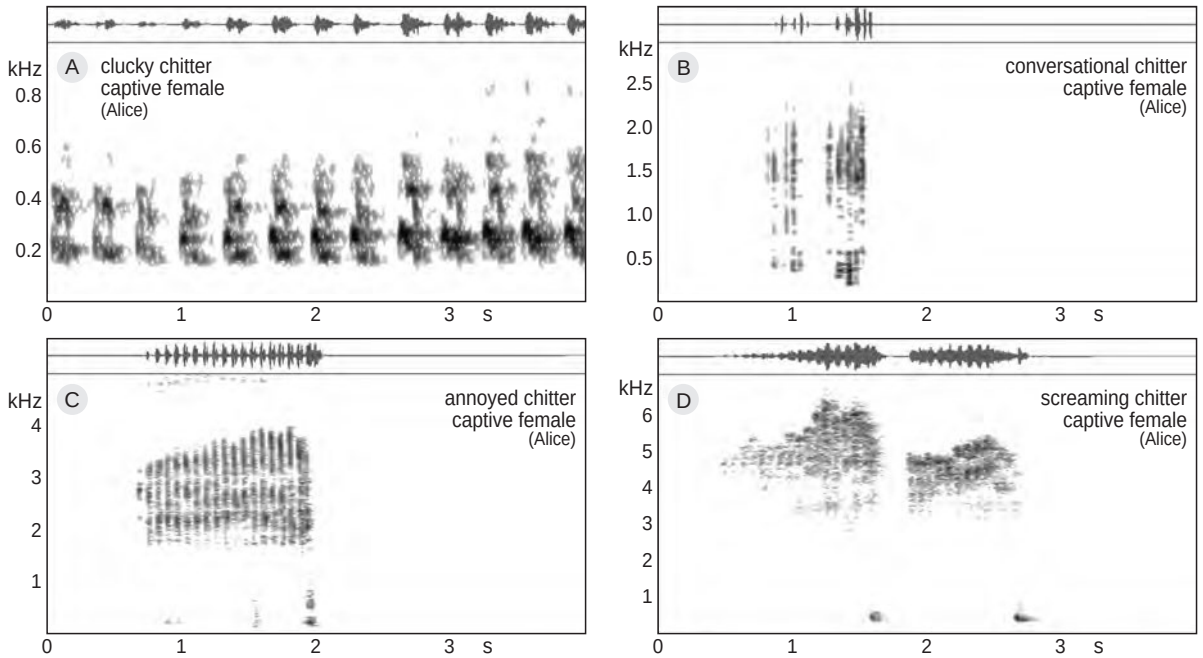

Figure 2. Spectrograms of the types of chitters from a captive, human-imprinted, female Great Horned Owl; origin of owl from Wisconsin, USA.

that low-frequency sounds allow for maximum reach with a minimum of attenuation in a variety of habitats, assuming the sound is not given too close to the ground.

Greeting Hoot. I know this hoot only from Alice. This type of hoot is used as a greeting after an absence or to announce landing on a new perch. Greeting Hoots are given singly or in a short series without the tail in the vertical position. They are quieter, lower in pitch, and may have fewer notes than an individual's Territorial Hoot, with as few as just two notes. They are given year round. Possible analogies: "Hello hoot" drops in pitch and volume from normal hoot and last notes are faint and sometimes dropped (Heinrich 1993); "contact calls" (Gottfred & Gottfred 1996).

Staccato Hoot. This hoot is given when excited, usually when birds of a mated pair are together, and may often precede copulation. It is a rapid series of brief and evenly spaced individual notes that often leads into a Territorial Hoot. It may consist of as few as three notes up to 15 or more notes. This vocalization is given by adults of both sexes, and is delivered in a forward leaning posture. As with Territorial Hoots, it is most often given in fall and winter. Possible analogies: Human-imprinted captive female prefaced hoots to her human mate with "grunts" (Heinrich 1993); "short, rapid hoots" (Gottfred & Gottfred 1996); "repeated hoots during copulation" (Vyn 2006).

Emphatic Hoot. I know this call only from Alice. It is not given in a territorial context, and may be given in association with various Squawks. Emphatic Hoots are very loud and include one or more extra, heavily accented and enunciated syllables at the end of the hoot. It may be given singly or repeatedly. Alice gives this vocalization most often in fall. Possible analogy: Human-imprinted captive female gave "Hooo-hoo-hoo-hoo hooo-hoo-*hooo*" with a strong emphasis on the last syllable when a stranger came (Heinrich 1993; note: Heinrich states that he does not know his owl's sex but thinks it a male, however the spectrogram in his book is definitely that of a female).

Wild Hoot. I have heard this call only from Victor. The Wild Hoot has a different rhythm, more notes, is louder, higher pitched, and more heavily accented and enunciated than the Territorial Hoot. It is given repeatedly, interspersed with Single Squawks. It may be given at any time of year, but is slightly more common in summer and fall. Wild Hoots may have a territorial function, but more observations are needed. Possible analogy: A male may "…hoot for the mere pleasure of hearing his own voice, and the notes produced are an indescribable assemblage of hoots, chuckles, screeches, and squawks given so rapidly and disconnectedly that the effect is both startling and amusing" (Baumgartner 1938).

Chitters

Chitters (Fig. 2) are produced with the bill closed at lower intensities and with the bill open in higher levels of agitation. They appear as a series of closely spaced vertical bars on a spectrogram. The types of chitters I define below are based primarily on behavioural observations and are somewhat arbitrary since chitters are a graded vocalization on a continuum from low frequency to high frequency that range from quiet and clucky to moderate and 'chattery' to screaming and very loud.

Clucky Chitter. I know this call only from Alice. Clucky Chitters are given with the bill closed at lower volume and with the bill open with increasing volume. They are a series of rapidly repeated, evenly spaced syllables that sound a bit like "hut, hut, hut" at lower intensities. They may increase in volume and lead into Territorial Hoots. They are given only in or near the nest or while standing on food. They may be given at any time of year, but are most common in winter. Possible analogies: "Hut, hut, hut" call by female to young when returning to nest to brood (Hoffmeister & Setzer 1947); female entices male to nest with monotone, guttural hoot "-oo-oo-oo-oo-oo-oo-oo" (Austing & Holt. 1966); semi-tame female 'clucking' around artificial nest, in squirrel's nest, on workbench, and on eggs (Terman 1996).

Conversational Chitter. I know this call only from Alice. These vocalizations are very quiet and are produced with the bill closed. Often they are so quiet that only a slight movement of the upper body or tail is noticeable. They are delivered in short bursts with spaces in between and can roughly be transcribed as "Hmm? Hmm? Hmm? Hmm?" Conversational Chitters can be given any time of year. They are directed to another individual at close range. Possible analogies: After mother left nest, "rasping peerahhh" calls between mother and owlet in nest (Bent 1938); human-imprinted captive owl gave "fast little nasal, reedy chuckles….with an inflection on the end: Hmm? Hmm?" that are quiet but make shoulders jiggle (Heinrich 1993); "chuckling" vocalizations by semi-tame female (Terman 1996).

Annoyed Chitter. This call is very similar to Conversational Chitters but is louder, higher pitched, and each burst is longer. The bill is slightly open during sound production, and there is a low frequency pulse at the end of each chitter burst. It is given by adults and juveniles of both sexes any time of year, and may sound like low level screaming. It is given when annoyed and is generally repeated until the annoyance is removed. It may be accompanied by biting. Annoyed Chitters are also given by the female while being treaded by the male during copulation. Possible analogies: "Krrroooooo" by adults during an attack (Bent 1938); "chuckles" grade into "cackles of a higher pitch" in human-imprinted captive owl when slightly irritated (Heinrich 1993); "high-pitched squeal" during copulation and "trailing variable length chatter" after some copulations (Gottfred & Gottfred 1996); when tried to pick up semi-tame owl she made "loud chattering" sounds (Terman 1996); "squealing chitter call" by the female at the end of copulation, and by injured bird indicating discomfort or agitation (Vyn 2006).

Screaming Chitter. This call is very loud and higher pitched than Annoyed Chitters. The bill is open during sound production and may be accompanied by Bill Clacking and/or biting. It is given by adults and juveniles of both sexes, and is given in times of extreme annoyance such as when being physically restrained. As its name implies, it sounds like a high-pitched scream. Possible analogy: "High-pitched, hawk-like, piercing scream" (Bent 1938).

Squawks

Squawks (Fig. 3) are the result of a syllable being produced while the bill is being opened. They are often loud and seem to have a contact and/or separation call function.

Begging Call. Begging calls are given repeatedly. They are given by juvenile owls of both sexes from spring through fall, and have a harsh, screeching quality. Begging calls appear to serve both to stimulate the adults to deliver food and to let the adults know the location of the fledglings once they have left the nest. Begging Calls are a broad spectrum vocalization with a sharp onset and termination, and are given repeatedly, all of which make them highly locatable in short range communication (Kroodsma & Miller 1982). Possible analogies: "Short, harsh penetrating cry which was not unlike the peep of *Chordeiles*" given repeatedly by a captive juvenile (Bent 1938); "Yank" call by juveniles (Wilson & Grigsby 1979); "screeek" call by juveniles (Harris 1983); "screeches incessantly in an irritating, rasping voice" for food and even when not hungry, but only on home territory (Heinrich 1993); young female "cheeped" often (Terman 1996); "young beg for food with hoarse discordant screams" (König *et al.* 1999); "fledgling begging call" (Vyn 2006).

Single Squawk. These calls have a lower pitch than Begging Calls. They vary substantially between individuals and even for the same individual, and are given by adults of both sexes. They may sound like a harsh "wah!" or almost like two syllables as a "ke-*wick*".

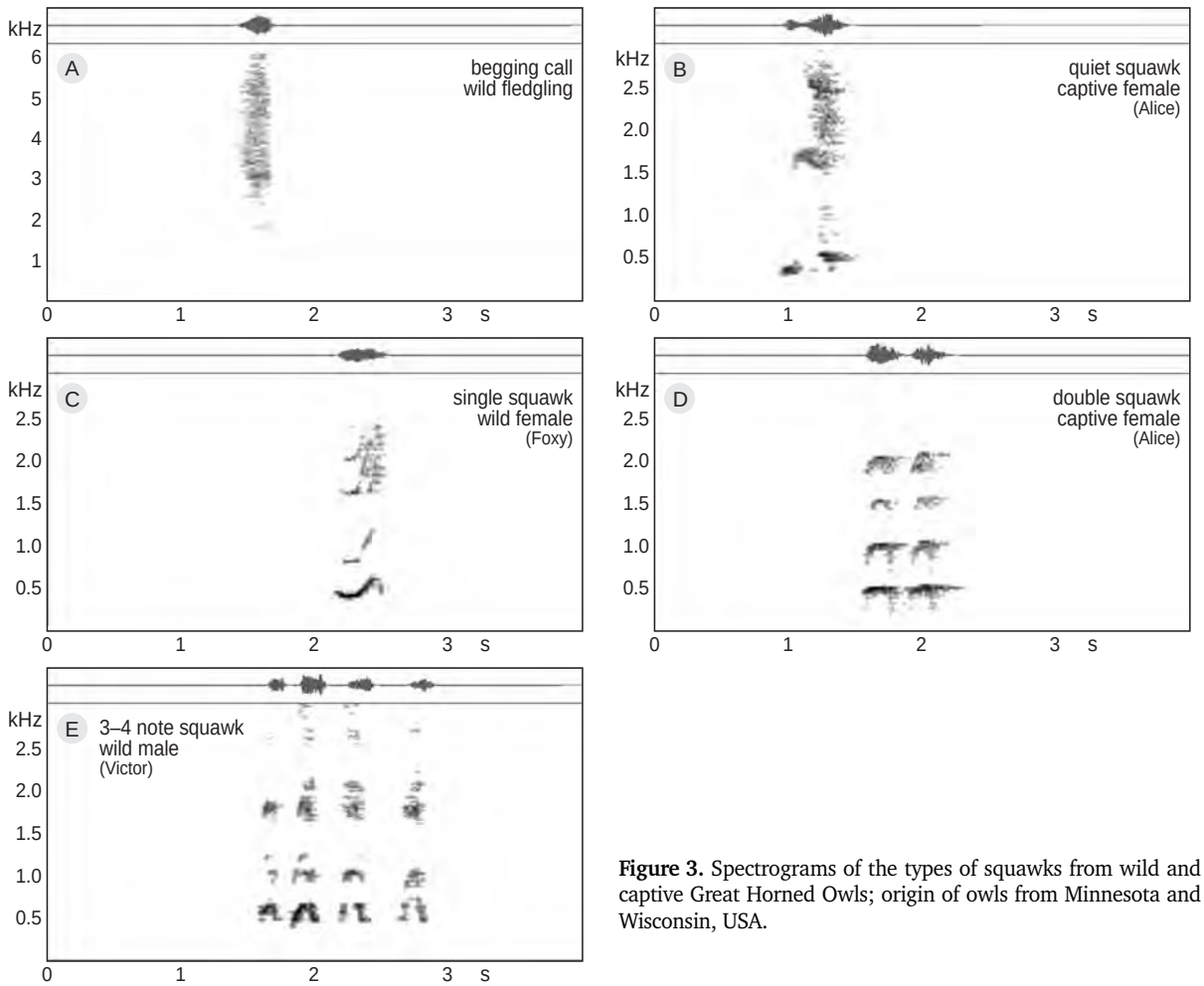

Figure 3. Spectrograms of the types of squawks from wild and captive Great Horned Owls; origin of owls from Minnesota and Wisconsin, USA.

Females give them apparently as a contact call when away from their young. After Foxy died, her mate began uttering very high pitched, almost whistling Single Squawks, apparently taking over the function of keeping in contact with his recent fledglings. Alice gives Single Squawks most commonly in the evening in a wide variety of contexts. Victor gives Single Squawks interspersed with Wild Hoots. When more is understood about the functions of Single Squawks it may become appropriate to divide Single Squawks into more than one kind of call. Possible analogies: "Meow" from nest (Bent 1938); "Yank" call by adults (Wilson & Grigsby 1979); male and female used "harsh squeals of a kind usually used by yearling horned owls to denote hunger" (Austing & Holt 1966); semi-tame adult female gave "cheeps" when she saw the person who raised her (Terman 1996); "squawk" used by female to solicit food and also used by male, and "bark-like call" (Vyn 2006).

Double Squawk. Double Squawks are given in bursts of two notes, are often given repeatedly, and are loud. They are accurately transcribed as "wac-wac." I know this call mostly from Alice, but have heard it from Victor on two separate occasions. Alice gives it in situations where she is not engaged by anything, apparently as a means to get attention. Since the Double Squawk is given both when wild females are disturbed in the nest and by my captive owl when she wants attention, I infer that this call may serve a mate summoning function. Possible analogies: "Wha, whaart" (Bent 1938); female disturbed at nest gave "wac-wac, whoooo-hoo-hoo" and female enticing young to fly gave "wac-wac-hoo-hoo" (Austing & Holt 1966); "wac-wac" by female defending nest (Heinrich 1993); "wac-wac" by female during nest defence (Vyn 2006).

3–4 Note Squawk. I have heard this call only twice, both times from Victor during the summer. This call is loud, given as 3–4 closely spaced notes, is repeated,

and sounds like "wac-wac-wac-wac." It was given in association with Single Squawks, Double Squawks, and Wild Hoots, likely indicating a high level of excitement. I did not find any references to a similar sound.

Quiet Squawk. I have heard this call given only by Alice. It is a quiet version of the Single Squawk, and can be given at any time of year. It often has a rising inflection like "wah?" It is sometimes given along with other types of squawks or hoots, and is notably given in the presence of other humans than me. James Duncan (pers. comm.) noted that Quiet Squawks are nearly identical to the food begging call of the adult female Great Gray Owl, and, interestingly, Martinez & Zuberogoitia (2002) noted that European Eagle Owl *Bubo bubo* females sometimes responded to the hoot of a stranger-male with a mate begging call, which I assume to be similar to this vocalization. Possible analogy: "Erk, erk" in feeble tones by female at nest (Bent 1938).

Non-vocal Communication

Although not produced by the syrinx, the following none-the-less serve as types of communication and are therefore addressed here (Fig. 4).

Hiss. Hisses are broad spectrum sounds, but are not loud. They are produced with the bill open while air is forcibly expelled through the mouth, and they are usually repeated. Hisses are given by birds of all ages and both sexes at any time of year. They are given in the context of fear. Hisses may be accompanied by Bill Clacking, Annoyed Chitters, and/or a defence display with wings fanned forward and head lowered. Possible analogies: Human-imprinted captive owl hisses "in defiance" (Heinrich 1993); semi-tame owl hissed when attempting to pick her up (Terman 1996).

Bill Clacking. Bill Clacking is done by both sexes of adults and juveniles at any time of year and may be accompanied by Hisses, Annoyed Chitters, Screaming Chitters, and/or a defence display. It is generally given in situations of higher fear or agitation than Hisses. It is also done by fledglings during food deliveries. Possible analogies: "Bill snapping" in courtship display (Austing & Holt 1966); "bill snapping" by female defending nest (Heinrich 1993); semi-tame owl "clacked" bill when attempting to pick her up (Terman 1996); "Bill-clapping" "when angry, disturbed, or stressed, or as warning or aggressive sound." (Houston *et al.* 1998); "bill-clap" by female during nest defence (Vyn 2006).

Final remark

This paper outlines a framework for the vocalizations of the Great Horned Owl, but is not an exhaustive list of all vocalizations uttered in every context. I plan to continue this research by acquiring a permanently injured pair of wild Great Horned Owls to breed on a long-term basis, using remote cameras and microphones in their cages to make observations and recordings, releasing the young in the spring after their Territorial Hoots have developed. This will also provide opportunities to look at development of vocalizations, identification of individuals by their Territorial Hoots, long-term stability of an individual's Territorial Hoot, and inheritance of Territorial Hoot characteristics. More research should be done on the behavioural context of the vocalizations of free-ranging wild Great Horned Owls.

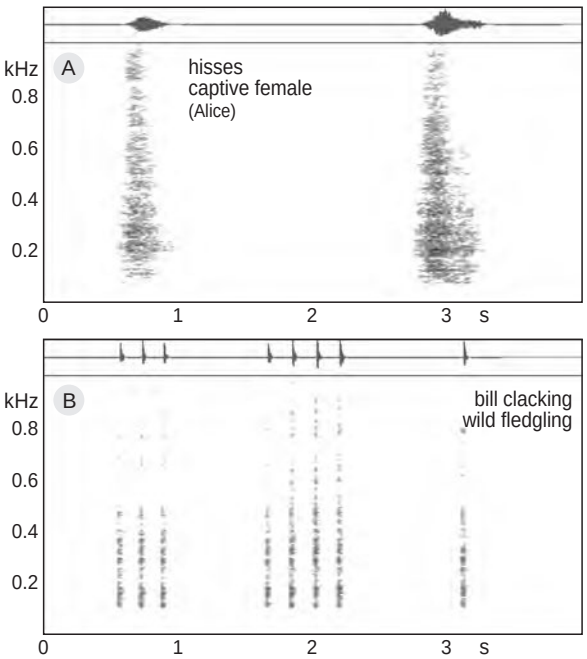

Figure 4. Spectrograms of non-vocal hiss and bill clacks from wild and captive Great Horned Owls; origin of owls from Minnesota and Wisconsin, USA.

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SAMENVATTING

Het is vaak moeilijk om directe waarnemingen aan nachtactieve dieren te doen. Het kan bij veldonderzoek aan nachtactieve uilen nuttig zijn om goed de geluiden te kennen die ze in verschillende situaties laten horen. Met dit doel onderzocht de auteur het geluid en gedrag van de Amerikaanse Oehoe *Bubo virginianus* door gegevens te verzamelen aan een vrouwtje dat op mensen was ingeprent en aan vogels in het wild. Een analyse van de geluiden die spectrografisch waren vastgelegd, liet zien dat er drie groepen geluiden waren te onderscheiden: "hoots", "chitters" en "squawks". Deze groepen werden, op basis van toonhoogte, aantal lettergrepen, duur, klank, volume en gedrag, onderverdeeld in vijf typen hoots, vier typen chitters en vijf typen squawks. Er werden daarnaast twee niet-vocale geluiden onderscheiden: sissen en klikken met de snavel. Meer waarnemingen aan wilde uilen zijn nu nodig om de classificatie te verifiëren.

ARDEA

TIJDSCHRIFT DER NEDERLANDSE ORNITHOLOGISCHE UNIE (NOU)

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