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Context of rattle-call use by adult Belted Kingfishers (*Megaceryle alcyon*) near their nests

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ABSTRACT—We documented use of rattle calls when adult Belted Kingfishers (*Megaceryle alcyon*) approached or departed active nest burrows, and contrasted rattle-call use during incubation and nestling phases of nesting. Adults rattled on 92.7% of 109 nest approaches and 56.2% of 105 nest departures ($P = 0.021$) combining both phases of nesting. During the incubation phase rattling occurred on 81% of 36 approaches and 28% of 32 departures ($P < 0.001$), and during the nestling phase rattling occurred on 99% of 73 approaches and 69% of 73 departures ($P < 0.001$). Overall, a significantly lower amount of rattling occurred during the incubation phase, both when approaching and departing the nest. Males and females exhibited similar patterns of rattle-call use at nest burrows during both phases of nesting. We suggest that use of rattle calls is more prevalent when approaching the nest burrow, despite drawing attention to the nest location, to advertise a mate's or parent's presence prior to entering the burrow and to avoid injury from the tending adult or nestlings defending themselves against an unknown intruder. We also suggest that adults are more secretive near the nest burrow during the incubation phase, especially when departing, because of a reduced need to communicate with their mate while tending the eggs during lengthy bouts of nest attendance. Nevertheless, it remains unclear why adults use rattle calls as much as they do when departing from the nest, which appears to unnecessarily advertise the nest location. *Received 28 August 2019. Accepted 5 October 2021.*

Key words: communication, Montana, nesting behavior, sex differences, vocalization.

Contexto del llamado de matraca de los adultos del martín pescador *Megaceryle alcyon* cerca de sus nidos

RESUMEN (Spanish)—Documentamos el uso de llamados de matraca cuando los adultos del martín pescador *Megaceryle alcyon* se acercaban o alejaban de sus cavidades-nido y contrastamos el uso de estos llamados durante las fases de incubación y crianza de su anidación. Los adultos hicieron llamados de matracas en 92.7% de 109 llegadas al nido y 56% de 105 partidas del nido ($P = 0.021$) combinando ambas fases de la anidación. Durante la fase de incubación, el llamado de matraca ocurrió en el 81% de 36 llegadas y 28% de las partidas ($P < 0.001$) y durante la fase de cría de polluelos el llamado de matraca ocurrió en el 99% de 73 llegadas y 69% de 73 partidas ($P < 0.001$). En general, una cantidad significativamente menor de llamados de matraca ocurrió en las llegadas y partidas durante la etapa de incubación. Machos y hembras exhiben patrones similares de uso de llamados de matraca en cavidades-nido durante ambas fases de la anidación. Sugerimos que, pese que atraen la atención sobre la localización del nido, el uso de llamados de matraca es más prevaleciente cuando llegan a la cavidad-nido para anunciar la llegada de su pareja o de alguno de los padres antes de entrar a la cavidad. Con ello podrían evitar heridas por parte del adulto que se encuentra en el nido o de los polluelos que se defendiesen de un intruso desconocido. También sugerimos que los adultos son más discretos cerca de la cavidad-nido durante la fase de incubación, especialmente al partir, porque existe una menor necesidad de comunicarse con su pareja mientras está cuidando los huevos durante los prolongados periodos de permanencia en el nido. Sin embargo, no está claro por qué los adultos usan los llamados de matraca cuando parten del nido, lo cual parece anunciar la localización del nido innecesariamente.

Palabras clave: comportamiento de anidación, comunicación, diferencias de sexo, Montana, vocalización.

Belted Kingfishers (*Megaceryle alcyon*) are common North American birds associated with waterways and other aquatic habitats, where they hunt for fish and nest in burrows typically excavated in vertical earthen banks. Both sexes participate in burrow construction, incubation, and tending the young (Kelly et al. 2009). Throughout the year, Belted Kingfishers often make their presence known with a familiar and loud rattle call, a series of harsh wooden or mechanical-sounding rattling notes (Kelly et al. 2009). Rattle calls are the most common vocalization uttered by Belted Kingfishers, whether perched or in flight, and are used in a variety of behavioral contexts (Hamas 1975, Davis 1988, Albano 2000, Woodall 2001, Kelly et al. 2009).

We found surprisingly few studies providing details of rattle-call use during the breeding season. Bent (1940), White (1953), and Woodall (2001) make no mention of rattle calls around active nests. Mousley (1938) noted that a pair of kingfishers uttered a series of rattle calls when their nest burrow was threatened by cattle and continued to rattle until the cattle left, a nest-defense scenario also reported by Wheelock (1912) in reference to human intrusion. Mousley (1938) also noted, apparently during the nestling

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phase, that members of the nesting pair routinely rattled as they approached the nest area before first perching nearby and then entering the nest burrow. Hamas (1975) mentioned rattling as one of the calls used during courtship and territorial chases, and as a contact call between adults and their recent fledglings. Kelly and Van Horne (1997) stated that adult kingfishers became noisy (presumably emitting rattle calls) at nests once eggs hatched, which they used as a behavioral cue to determine the onset of the nestling phase; this appears to be the pattern previously reported by Mousley (1938). Albano (2000) noted that rattles and other calls were part of the mating and nest building phases of nesting, but did not discuss rattle calls during the incubation and nestling phases. Davis (1988) quantified acoustic properties of rattle calls and related them to 10 behavioral contexts, such as threats during territorial disputes, being startled or disturbed, soliciting copulation, greeting a mate, perching undisturbed, and "flight," which he defined as flying by, to, or from the nest site, and noted there were no signs of disturbance to or prior interaction with the bird making those calls. Elsewhere, Davis (1986) identified rattle calls of 0.5–1.0 s duration uttered by either sex as they approached or left nests and termed them "approach calls," which were frequently given >30 m from the nest. He showed that use of these calls allowed an adult in the burrow to recognize its mate from a stranger.

Our interest in rattle-call use near nest burrows was piqued by it appearing to advertise the nest location. We quantified the context of rattle-call use by adult Belted Kingfishers near their nest burrow while they tended eggs (incubation phase) and dependent young (nestling phase). Here, we document the frequency of nest approaches and departures that were accompanied by a rattle call, whether the frequency of rattling near the nest differed between incubation and nestling phases, and whether rattle calls were used equally by each sex when near the nest. Finally, we speculate on why rattle calls are used near active nests as much as they are.

Methods

We have followed nesting activities of Belted Kingfishers along Rattlesnake Creek, Missoula County, Montana (46°55′N, 113°58′W; 1,082 m elevation) most years since 2009 (Hendricks et al. 2013). The stream bank used for nesting is about 100 m in length and occupied annually by a single pair of kingfishers. Our observations of kingfisher activities were made from a blind about 25–30 m across the creek and opposite the nest burrow. We used 10× binoculars to aid with identifying the sex of attending adults on each nest visit.

We compiled data on use of rattle calls at the nest burrow during 6 years (2014–2020; no observations in 2017), representing 140.7 h in the blind (74.5 h during the incubation phase, with observation dates 5 May–14 Jun among years; 66.2 h during the nestling phase, with observation dates 11 Jun–9 Jul among years) on 58 d (31 d during the incubation phase, 27 d during the nestling phase). We made nest observations when free from other obligations, not daily. The majority (65%) of observation time occurred during 2 years: 2014 (22.0 h on 10 d during the incubation phase, 15.3 h on 7 d during the nestling phase) and 2019 (20.0 h on 7 d during the incubation phase, 33.9 h on 11 d during the nestling phase). Phase of nesting was determined indirectly (except when large nestlings could be heard or seen at the burrow entrance) based on behavior of the adult kingfishers, such as occupying the burrow for >30 min or carrying fish to the burrow, and assuming a 24 d incubation period and 30 d nestling period (Woodall 2001, Kelly et al. 2009). Once activity at the burrow appeared to cease, we also searched for fledglings at a nearby reservoir where they were often led by the adults after leaving the burrow, then back-dated from the estimated date of nest departure if onset of incubation and hatch day were not known with certainty.

For each nest entry and departure, we recorded if an adult gave a rattle call or was silent while airborne within an estimated 1 s of approaching or departing the burrow (<5 m distant). Adults often uttered one or more rattle calls from perches >30 m from the burrow before flying to it and entering. We did not include these calls in our analyses of rattles emitted upon approaching the nest. For all but 4 trips (2 approaches and 2 departures during incubation) we were able to assign sex to the approaching or departing adult by noting the presence (female) or absence (male) of a rufous band below a bluish gray band on the breast (Kelly et al. 2009).

Little has been determined about lifespan or site fidelity of adult Belted Kingfishers. What data there are suggests relatively high rates of adult mortality or significant dispersal from breeding locations. Other data indicate that the few returning adults (especially males) may remain within a few kilometers of prior nesting territories, and some females are known to return to breeding streams for up to 4 years (Kelly et al. 2009). We saw disputes between 2 females prior to onset of nesting at our study site during 4 years (we never observed more than a single male each year), indicating a potential turnover of breeding birds during the 7 years of our study. Because birds were not banded or color-marked, however, we have no way of knowing if the mated pairs we observed involved the same individuals. Thus, we pooled samples from all nests when analyzing rattle-call use in general and by males or females. Statistical analyses (Fisher's exact tests, one-sample proportions tests) comparing the number of nest visits when adults uttered rattle calls or were silent were conducted using Statistix 8 (Analytical Software, Tallahassee, Florida, USA).

Table 1. Rattle-call use by adult Belted Kingfishers near the nest burrow at 6 nests in Montana. "Rattle" indicates adult emitted a rattle call while in the air within 1 s of approaching or departing the burrow. Samples were collected during 140.7 h of observation in 6 years. Disparities in sample totals and sample sizes for males and females during the incubation phase are due to approaches and departures where sex was not determined. One-sample proportions tests were used to compare proportions of total trips accompanied and unaccompanied by rattle calls. Fisher's exact tests were used to compare differences by males and females in rattle-call use near the nest.

Phase	Total	*P*	Male	Female	*P*
Incubation (approach)					
Rattle	29	<0.001	19	8	0.66
Silent	7		4	3	
Incubation (depart)					
Rattle	9	0.013	6	2	0.42
Silent	23		12	10	
Nestling (approach)					
Rattle	72	<0.001	36	36	1.00
Silent	1		1	0	
Nestling (depart)					
Rattle	50	0.002	26	24	0.80
Silent	23		11	12	

Results

Context of rattle-call use near nests

We observed 109 nest approaches and 105 departures, combining incubation and nestling phases at 6 nests in as many years (Table 1). Adult kingfishers (regardless of nesting phase and sex) rattled on 93% of all approaches (one-sample proportions test: $Z = 8.91$, $P < 0.001$) and 56% of all departures (one-sample proportions test: $Z = 1.27$, $P = 0.20$), a significant difference in the context of rattle-call use (Fisher's exact test, $P < 0.001$). Overall, rattling was significantly more prevalent when approaching the nest burrow than when departing from it.

During the incubation phase, rattling occurred on 81% of 36 approaches and 28% of 32 departures, both of which were significant (Table 1). During the nestling phase, rattling occurred on 99% of 73 approaches and 69% of 73 departures, both of which were also significant (Table 1). When contrasting the 2 phases of nesting, rattling occurred on a smaller proportion of trips near the nest burrow during incubation (Fisher's exact tests: $P < 0.002$ comparing approaches, $P < 0.001$ comparing departures). However, 4 of 7 silent approaches during incubation (Table 1) appeared related to atypical circumstances. In one case the adult female saw the male depart shortly before she entered the burrow, in a second case the female exited the burrow after she was disturbed by several Northern Rough-winged Swallows (*Stelgidopteryx serripennis*) at the burrow entrance, then <30 s later she reentered the burrow. The other 2 cases occurred when a male tended the nest alone in the morning for at least 150 min during which time he departed twice for short absences of 12 and 18 min, apparently to feed. If these 4 cases are subtracted from the silent entry category, then frequency of rattle-call use on approach to the nest burrow is similar (Fisher's exact test, $P = 0.084$) between incubation (91%) and the nestling phase (99%).

Sex differences in context of rattle-call use near nests

Males and females showed similar patterns in use of rattle calls near nest burrows (Table 1). Overall (nesting phases combined), males rattled on 92% of 60 approaches and 58% of 55 departures (Fisher's exact test: $P < 0.001$). Females rattled on 94% of 47 approaches and

54% of 48 departures (Fisher's exact test: $P < 0.001$). We found no significant differences between males and females in the overall frequency of rattling (Fisher's exact tests: $P = 0.73$ for approaches, $P = 0.70$ for departures). Both sexes showed a tendency to rattle significantly more frequently during both phases of nesting when approaching than departing nest burrows (Fisher's exact tests: $P = 0.003$ for males during both nesting phases; $P = 0.012$ for females during incubation, $P < 0.001$ during the nestling phase). None of the comparisons between males and females were significantly different in frequency of rattle-call use during either phase of nesting (Table 1).

Discussion

Generality of patterns in rattle-call use by Belted Kingfishers near the nesting burrow remains a question for additional research on multiple known pairs. All of our observations were made at a single nesting bank by an unknown number of unique individuals, even though our observations spanned 7 years and at least some turnover in pair membership was likely during that time (Kelly et al. 2009). Despite uncertainty in how many individual kingfishers were involved in our study, and even assuming our observations were made on only a single pair, the patterns we observed in rattle-call frequency between nesting stages (incubation vs. nestling) and the comparisons between males and females provide new insight into a behavior that merits additional study.

A parent bird uttering loud calls as it approaches its nest seems counterproductive behavior that is likely to reveal the nest location, perhaps draw attention of potential predators, and possibly lead to loss of the nest (Kilham 1974). Yet several kingfisher species regularly vocalize near their nests. Besides Belted Kingfisher (Table 1), adults of the Giant Kingfisher (*M. maxima*), Ringed Kingfisher (*M. torquata*), and Amazon Kingfisher (*Chloroceryle amazona*), all of which are members of the subfamily Cerylinae, sometimes vocalize when approaching their nests (Skutch 1957, 1972; Arkell 1979, Jones 1983), and at least one member of the Alcedininae, the Half-collared Kingfisher (*Alcedo semitorquata*), behaves similarly (Moreau 1944). Vocalizing under these circumstances seems to communicate some important information that selection has favored over the silent approach to nest burrows. Further, all 6 Belted Kingfisher nests we monitored during 2014–2020 produced at least one fledgling, indicating that rattling near the nest may not be particularly detrimental insofar as nest success is concerned.

Kingfisher burrows are assumed to be relatively secure from weather and predators (Kelly et al. 2009) but are very dark environments in which to tend eggs or nestlings, and where sensory mechanisms other than vision may be needed for this purpose (Maziarz and Wesołowski 2014). A nest burrow we excavated at our study site in 2009 measured 132 cm horizontally into the nest bank, with a chamber at the back where it had been occupied by eggs and nestlings; burrows can extend 250 cm or more from the entrance, with tunnel dimensions of 7.6–12.6 cm (Hamas 1975, Kelly et al. 2009). Acoustic recognition may be the only mechanism by which an individual kingfisher within a dark nest burrow can identify a bird outside near the entrance. Incubating Belted Kingfishers can discriminate the rattle calls of their mates from those of strangers (Davis 1986) and may depart from the nest when hearing a stranger's rattle call; presumably the nestlings, too, learn to recognize the rattle calls of their parents.

We suggest that rattling occurs frequently when approaching the nest burrow (Table 1) so that an adult kingfisher is recognized as a parent or mate by the burrow occupants when it enters the burrow, and is not severely or fatally injured by them biting or striking with their formidable bills in the dark at an unknown intruder. Bills of Belted Kingfishers have evolved to withstand impacts with water and shallow-water substrates during plunge dives for fish (White 1953, Crandell et al. 2019) as well as for digging and bill-first collisions with banks during burrow construction (Hendricks et al. 2013). Using the bill to bite and strike at human hands and other foreign objects in burrows is a behavior known to be employed by adults and nestlings of some kingfisher species, including Belted Kingfishers (Mousley 1938; Skutch 1957, 1972). Similar defensive behavior with the bill has also been reported for cavity-nesting birds, such as the Pileated Woodpecker (*Dryocopus pileatus*), when striking at humans or predators threatening the nest (Hoyt 1957, Nolan 1959).

We also suggest that adults are generally more secretive near the nest burrow during the incubation phase (Table 1), especially when departing from a nest, because a temporal division of labor, with either sex spending greater blocks of time at the nest during incubation, requires less communication with the mate than when nestlings are present and being brooded or fed by both parents (Albano 2000). Duration of nest attendance bouts can exceed 2–3 h during the incubation phase for each sex (Hamas 1975, Albano 2000; PH 2019, pers. obs.). Thus, the need to communicate approaches and departures to the mate is reduced when taking short breaks during extended bouts of incubation, and there is also less need to communicate an approach to the nest during incubation when the departure of an adult is seen by its mate. We observed both circumstances on 4 of 7 silent approaches during incubation (Table 1). Our results are consistent with the comment of Kelly and Van Horne (1997) that adult kingfishers become noisier at the nest once eggs hatch, but an increased level of vocalization when nestlings are present is a function of 2 variables: (1) more frequent nest visits by adults to feed the young, and (2) a greater proportion of adult rattle-call use during the nestling phase when approaching and departing the nest.

What remains puzzling in our interpretation of use of rattle calls near nest burrows is why rattle calls were uttered as often as they were when departing the nest, particularly during the nestling phase. Rattling when departing the nest burrow appears to unnecessarily draw attention to the nest location and increases the possibility that the nest will be depredated. Several species of mammalian predators have been found near nest burrows or attempting to dig into them (Bent 1940, White 1953, Woodall 2001, Kelly et al. 2009), including red squirrels (*Tamiasciurus hudsonicus*), a known predator of bird eggs and nestlings (Steele 1998). We saw a red squirrel on one occasion in 2019 descend the vertical bank <0.5 m from the nest burrow when the nestlings were unattended, but it showed no interest in the burrow. Snakes appear to be the predators most likely to gain access to nest burrows (Kelly et al. 2009), but rattle calls outside of the burrow would probably not draw their attention because snakes have no tympanic membranes and detect vibrations chiefly through the ground (Walker 1987).

Rattle calls vary in structural properties, such as pulse rate, leading Davis (1988) to suggest that the calls were structurally graded and related to the sender's internal (emotional) state; the calls could convey a variety of messages depending on their structure, duration, and context. Davis (1988) also determined that males and females uttered structurally similar rattle calls when performing similar behaviors, and the similarity in frequency of rattle-call use by males and females during nesting (Table 1) is consistent with this. Rattling upon nest departure seems to be directed to a mate outside of the burrow rather than to the burrow occupants. Perhaps using rattle calls when departing the nest during the nestling phase communicates information to the mate that the burrow is not currently tended and helps coordinate food deliveries. The possibility that rattle calls differ in structure and duration in some significant way when approaching and departing the nest should be investigated.

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