VOCALIZATIONS OF THE LONG-BILLED CURLEW

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Although the vocalizations of many species of birds have been studied with the aid of sound spectrographic techniques in recent years, the Scolopacidae have been neglected. However, vocabularies of several species have been described verbally (Vogt 1937; Nethersole-Thompson 1951; Haverschmidt 1963). The limited nature of the vocal repertoire of shorebirds and the structural simplicity of their calls make them ideal subjects for such studies.

This study presents a spectrographic analysis of the vocalizations of the Long-billed Curlew, *Numenius americanus*, and attempts to elucidate the function of these vocalizations in the curlew's biology. Few of the curlew's calls have been described. Bent (1929:104–105) mentioned six calls: a trilled, liquid *curleeeuuu*; a clear *pil-will*; a loud *quee-hee*; a melodious *coy*; a rapid *wheety*; and a *curlew*.

RÉSUMÉ OF THE ANNUAL CYCLE

Many of the curlew's vocalizations were found to be connected with specific stages in the breeding cycle. Therefore, a preliminary discussion of the annual cycle for northern Utah is necessary.

Curlews arrived in small flocks of up to 12 birds during late March and early April. At this time, they frequented freshly plowed fields and flooded pastures. The birds seemed to be paired on arrival, as was noted in Montana by Silloway (1900). Much agonistic behavior was observed among flock members during the latter part of April. During this time flock break-up occurred and the pairs scattered to the pastures, salt flats, and foothills to breed. In Cache Valley the breeding pairs were widely scattered, whereas at the Bear River Bird Refuge they were found closer together. No nest, however, was found nearer than 500 yards to another.

The nests apparently were constructed solely by the females (one observation), and the three or four eggs were laid at two-day intervals (observations on one nest) during early May. Evidence suggests that renesting attempts were not made. The duration of incubation is unknown, but Bent (1929:101) suggested that it might be 30 days. Both sexes incubated and protected the young, which hatched in late May or early June. The young acquired their juvenal plumage by early June. By mid-July the adults and juveniles had left the area. Breeding cycle data are summarized in figure 1.

The curlews were not synchronized in their breeding. Even in pairs that bred relatively close together, there was often a lag of three weeks between the least and most advanced pairs. The lack of synchrony was especially evident during nest building, incubation, and fledging. No biological significance in the asynchrony was apparent to me. Similar variations in the reproductive stages of other shore birds, including the Pectoral Sandpiper, *Erolia melanotos* (Pitelka 1959), and the Dunlin, *Erolia alpina* (Holmes 1966), have been reported.

MATERIAL AND METHODS

Recordings of vocalizations were made with a Nagra III tape recorder at a tape speed of 15 in/sec, using an Altec 633A microphone mounted on a 24-inch diameter parabolic reflector. All tapes were voice-edited in the field with time, location, and behavioral context of the calls. In the laboratory, tapes were played back on a Roberts Model 192 FT tape recorder at a tape speed of 15 in/sec. Analysis was made on a Kay Electric Company Sound Spectograph using the wide band filter and FL 1 setting. The acoustical terminology of Mulligan (1963:276) is followed.

Four pipped eggs were taken from a nest in Box Elder County. One egg was preserved immediately for further study. The remaining eggs hatched and the birds were hand-reared. The birds survived to an age of 5, 9, and 17 days, respectively. A chick approximately 47 days old was captured 3.3 mi. W of Logan Post Office, Cache County. It was color-marked, banded, and released.

Recordings and observations were made March–July 1965, 1966, and 1967. The irrigated pasture land west of Logan, Cache County, Utah, and the salt flats in and around the Bear River Bird Refuge, Box Elder County, Utah, were used in 1965 and 1966. In 1967 the salt flats adjacent to the Salt Creek Waterfowl Management Area and the Public Shooting Area, Box Elder County, Utah, were used as study areas. Additional recordings were made 20–28 December 1965 in Texas at Aransas National Wildlife Refuge, Aransas County, and at Kingsville and Padre Island National Seashore Monument, Kleberg County.

Recognition of individual curlews for extensive periods of time proved impossible because no birds could be color marked. For individual field trips,

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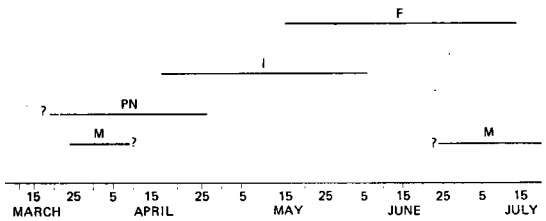

FIGURE 1. Breeding schedule of the Long-billed Curlew in Cache and Box Elder Counties, Utah (M = migration; PN = prenesting; I = incubation; F = fledgling care).

however, some birds could be followed. Individual variation in calls was studied by making recordings at widely scattered points within the general study area. Recognition of the sexes proved fairly reliable because females are noticeably larger than males (unpublished data), with distinguishably longer bills. The tentative determination of sex of two individuals collected during the study proved to be correct upon dissection.

ADULT VOCALIZATIONS

Arc Display Call. This call consisted of two types of notes: a long harsh note, 0.5–1.0 sec in duration, and a shorter note that started harshly and ended with an undulating quality (fig. 2A). Phonetically these notes were rendered as *guaaah* and *kieee*, respectively.

In the *Arc Display*, the bird, flying 5–6 ft off the ground, flew straight at the intruder. When only 2–3 ft away, the bird flew straight upward to a height of 20–30 ft. The bird uttered *guaaah* one to three times when approaching. It gave the *kieee* note when it reached the top of its upward flight. This display was seen only toward the end of incubation and after the chicks had hatched.

Less intense versions of this display were observed on many occasions 26 April–16 July. These displays differed from the intense form described above in that they were initiated farther from the intruder and from a greater height, and the upward flights were shallower. The calls associated with the display were different too. The harsh introductory note was absent, and the *Ki-keck* call (see below) often replaced the *kieee* note. The less intense *Arc Display* was also found in breeding birds of

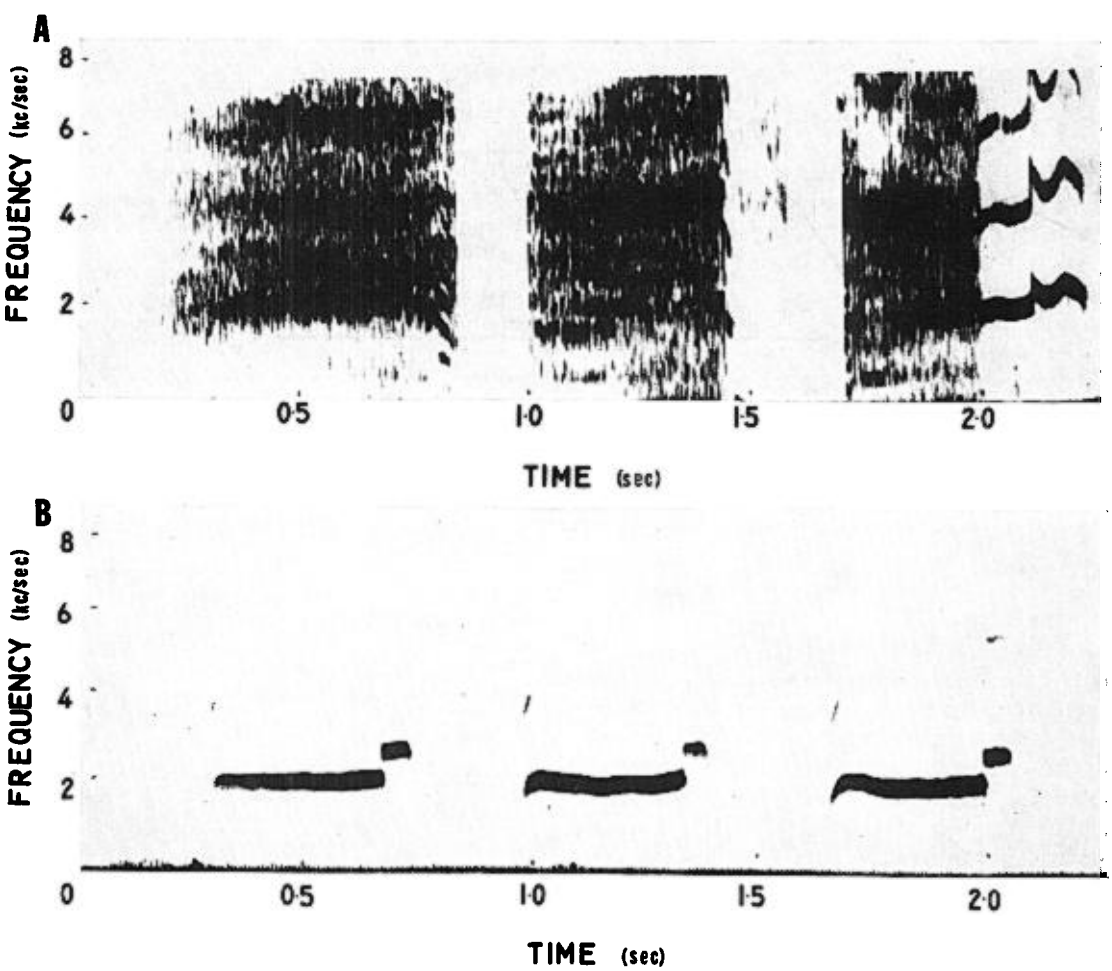

FIGURE 2. Sound spectrograms of some calls of adult Long-billed Curlews. A. *Arc Display* call. Note that two types of notes are present. B. *Curluoo* call.

the subspecies *N. a. parvus* in Washington State by LaFave (1954).

The harsh nature of the call suggests that it functions as a defense against predators of the nest and young. Grinnell et al. (1918) mentioned that the bird giving this display flew out to meet the intruder. It is my impression that only parents whose nest or young were being threatened gave the intense version. The intense version was given on one occasion when the eggs were pipped, a period when parental care "tendency" would be near its peak. These facts indicate the defensive nature of the *Arc Display* call. The less intense version and associated calls probably reflect either a lessening of threats to the eggs or young, because of a greater distance from the nest, or underdevelopment or waning of the parental tendency.

Curluoo Call. This call, from which the Long-billed Curlew received its name, was the most frequently recorded call. It was heard during all observation periods, even on the wintering grounds in Texas. The *Curluoo* call was a whistle consisting of two notes (fig. 2B). The first note had a frequency of 2 kc/sec and was longer ($\bar{x} = 0.224$ sec, SD = 0.09, $n = 47$) than the second note ($\bar{x} = 0.08$ sec, SD = 0.09, $n = 47$). The second note was higher pitched (3 kc/sec).

This call was given by individuals of both sexes with equal frequency, and was uttered in a variety of circumstances. I recorded the *Curluoo* call from migrating and wintering flocks. It was given by single birds when flushed or surprised on the ground and was the call interchanged between birds on the ground and curlews flying overhead. Nesting pairs on the ground gave this call when an intruder was near the nest.

The *Curluoo* call appears to serve two functions: as a contact note between flock members and between individuals of a pair, and as an anxiety note when the nests are disturbed or birds are flushed from the ground. In these respects, the functions appear to be similar to those of the *Tyew* call of the Greenshank, *Tringa nebularia* (Nethersole-Thompson 1951:92). The literature available on the vocalizations of other members of the genus *Numenius* indicates that only the Whimbrel, *N. phaeopus* (Bent 1929:119), and the Eurasian Curlew, *N. arquata* (North 1959), have a similar *Curluoo* call; however, in these species neither function nor causation has been suggested.

Gur Call. This call was heard on one occasion and no recording was made. On 17 June 1966, 3.3 mi. W of Logan Post Office, a male flew to within 10 ft of me from the western part of the field. As he approached, he gave a soft, low frequency *gur* note three times. Each time, the bird opened its bill wide. The male turned and flew west into another field and landed. No data were obtained as to the cause or the function of this call.

Ki-keck Call. This call was found to be a trill with five basic variations. The syllables were grouped in either twos, threes, fours, or fives, or were evenly spaced at 0.1 sec intervals (fig. 3). The two- and three-syllable versions constituted the majority of the phrases analyzed (63 per cent, $n = 70$), with the remainder evenly distributed among the other forms. The five variations were often mixed in the same calling bout.

The *Ki-keck call* was a seasonal call, first heard at incubation and later during fledgling stage. Both sexes gave the call, although it was more frequently given by the male (72 per cent, $n = 62$). The fact that females were incubating during most observation periods probably accounted for the low incidence of this call by females. In 98 per cent of the cases, the call was given during flight.

This call functioned as a general predator alarm call. It was directed against humans, Ring-billed Gulls (*Larus delawarensis*), and California Gulls (*L. californicus*). This is probably the call given by nesting birds that attacked Marsh Hawks (*Circus cyaneus*) and Swainson's Hawks (*Buteo swainsoni*), as reported by Cameron (1907). It was elicited by humans as far as 750 yards from the nest, and was the call with which a parent answered the *Squeee* call of a 47-day-old chick on 11 July 1966. It often served as a mobbing call, bringing males from the general area to the vicinity of the mobbed object. In this context, the notes of the *Ki-keck* call resemble the physical structure of the mobbing calls of some passerines (Marler 1955).

Long Call. This call consisted of a single whistled note averaging 0.9 sec in length (SD = 0.4, $n = 13$). The entire note had a frequency of about 2 kc/sec (fig. 4A). The call was not loud, being audible to a range of only 50 yards. The phonetic rendition of this call was a loud drawn out *ur-e-e-e-e.* Both sexes gave the call, and it was heard throughout the study, except during the winter in Texas.

The *Long* call frequently preceded the *Long Curluoo* call (see below). The bird, sailing on set wings, would give the *Long* call one to three times, then land, raising its wings over its back, and give the *Long Curluoo* call. On several occasions the *Long* call was given without the *Long Curluoo* call. On 6 April

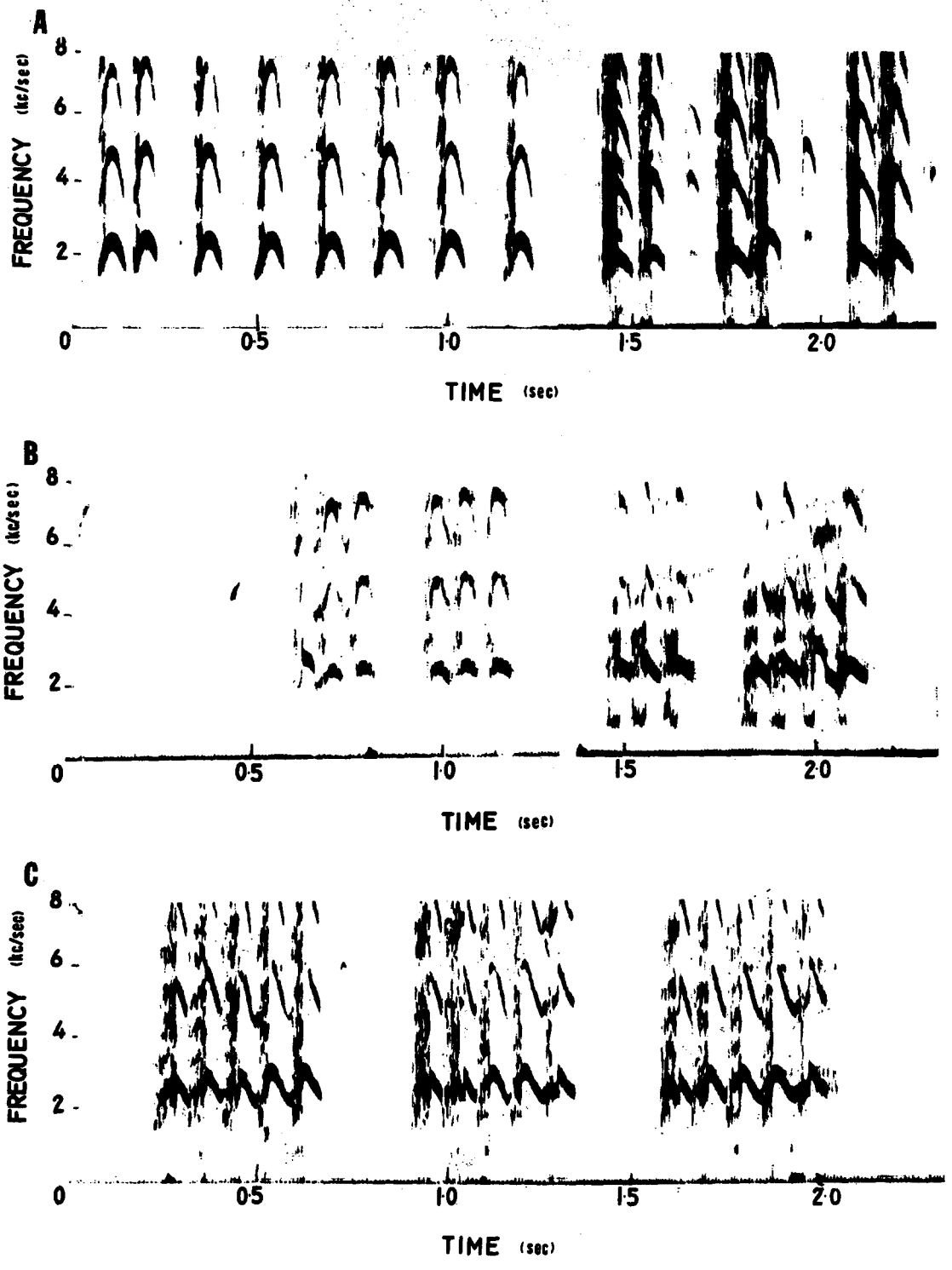

FIGURE 3. Sound spectrograms of the *Ki-keck* call and its variations. A. (left) One-note variant; (right) two-note variant. B. (left) Three-note variant; (right) Four-note variant. C. Five-note variant.

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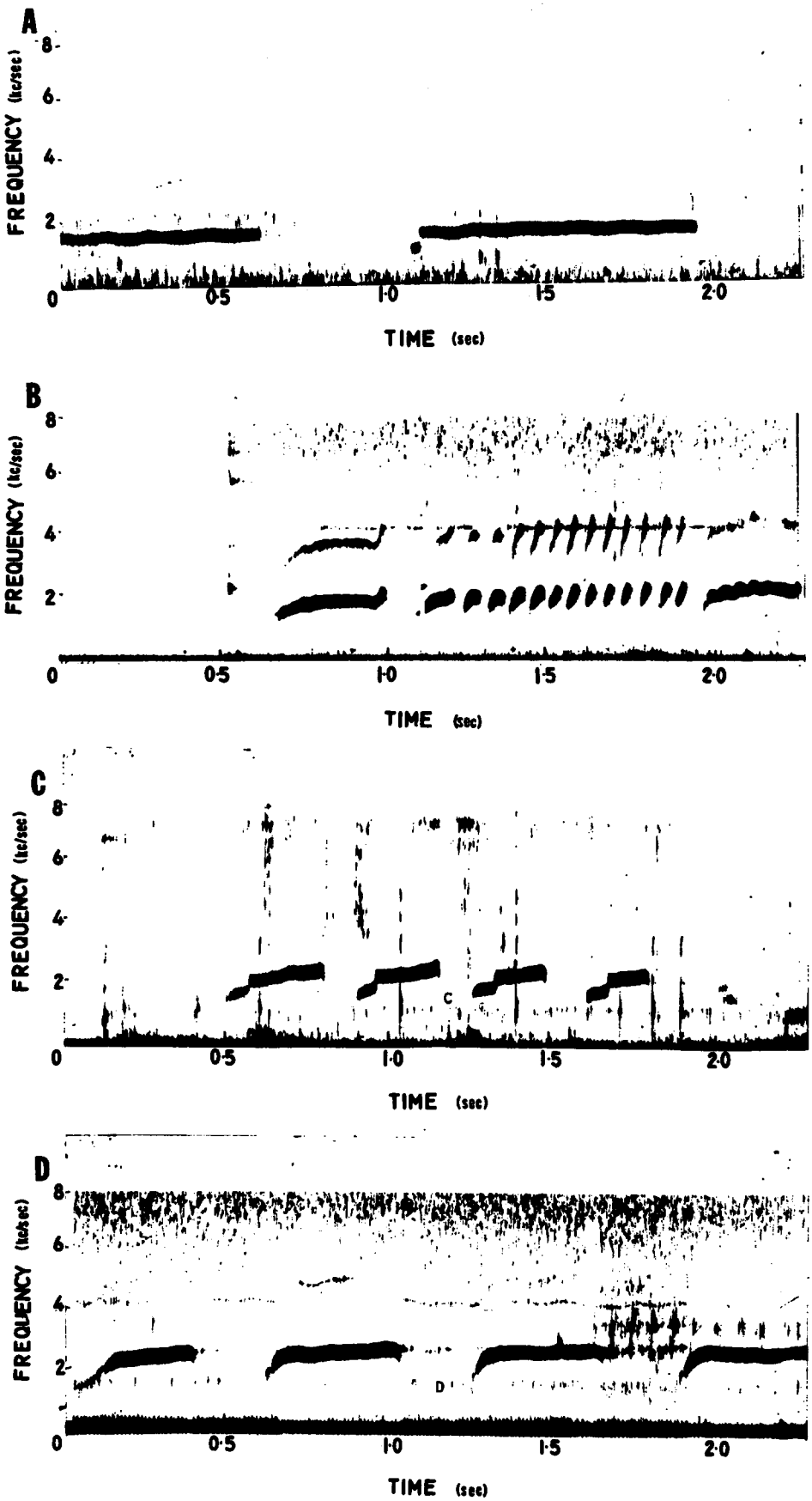
FIGURE 4. Sound spectrograms of certain calls of adult Long-billed Curlew. A. *Long* call. B. *Long Curluoo* call. C. Two-note variant of *Wheet* call. D. One-note variant of the *Wheet* call.


A
FREQUENCY (kc/sec)
8
6
4
2
0
0·5
1·0
1·5
2·0
TIME (sec)
B
FREQUENCY (kc/sec)
8
6
4
2
0
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1·0
1·5
2·0
TIME (sec)
C
FREQUENCY (kc/sec)
8
6
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TIME (sec)
D
FREQUENCY (kc/sec)
8
6
4
2
D
0
0·5
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TIME (sec)

1965 near College Ward, Cache County, Utah, a Sharp-shinned Hawk, *Accipiter striatus*, flew over but did not swoop down on a feeding flock of 12 birds. They gave the *Long* call several times and flew into another field. On another occasion when only the *Long* call was given (18 May 1966, at a nest 3.3 mi. W of Logan Post Office), the female was incubating and the male was absent from the vicinity when I arrived. As I approached the nest from the southwest, the male flew in from the north. He gave the *Long* call three times just before landing 15 yards southeast of the nest. He later gave the *Wheet* and *Ki-keck* calls.

The functions of this call are an enigma. In the situation involving the Sharp-shinned Hawk, it seemed to serve as an avian predator alarm call. Yet this call must have other functions because of the variety of behavioral situations in which the *Long* call occurred.

Long Curluoo Call. Taverner (1934) has well described the *Long Curluoo* call as, "a long-drawn '*curl-e-e-e-e-u-u-u*', sparkling clear and rising in the middle about five notes, and then dying gradually away, lowering in scale and volume." Sonograms revealed that Taverner's description was quite accurate, except that an average of 11.5 notes (SD = 5.8, $n = 6$) instead of five occurred in the middle of the call (fig. 4B). To me the call sounded more like *purt-bur-bur-bur-e-e* than *curl-e-e-e-e-u-u*. This call had an effective carrying quality. I often heard it when given over a quarter mile away.

The call was most frequently heard during the prenesting or flocking period, but its use continued throughout the breeding season. Taverner (1934) described the normal situation in which the call was given (cf. *Long* call): "As these birds alight they run along the ground a few yards, with their ample wings still raised straight over their backs, uttering their long whistle."

The *Long Curluoo* call was normally given from the ground. In over 93 per cent of the cases ($n = 47$), it was given as the birds landed, usually near other birds. On two occasions during the prenesting period, 2.5 mi. SW of Logan Post Office, a female gave the call from the ground after a male, flying by, gave the *Curluoo* call. On several occasions the call was given by a male chasing and bill sparring with a second male. Bill sparring was the most common agonistic behavior observed in curlews. The birds chased each other along the ground, their wings held over their backs in inverted *v*'s, and their bills parallel to the ground.

Several facts suggest that this call is used in territorial defense. It was often associated with agonistic behavior, especially bill sparring and chases, between two males. Its audibility over long distances makes the *Long Curluoo* call well adapted for territorial defense. The frequency of occurrence of this call decreased as the nesting season progressed. The *Long Curluoo* call also may help maintain the pair bond, as it was also given between the members of a pair.

Sou Call. This call was heard only once, and tape recordings were not possible. On 6 May 1965, 3.3 mi. W of Logan Post Office, I observed a male and female walking 10 yards from me, the female in a normal attitude with head and neck erect, and the male just behind and slightly to her left with his tail and bill parallel to the ground. He made U-shaped movements with his bill and continuously uttered a soft *sou sou sou* call which was barely audible 10 yards away. This sequence lasted for a minute; then both birds began feeding. Five minutes later both flew away.

A remarkably similar display has been described for the Eurasian Curlew, *N. arquata*, by Witherby et al. (1940), although no associated vocalization was reported. Copulation (six observations) was most frequent in *N. americanus* 27 April–10 May 1965 and 1966, the period in which the *Sou* call was heard. Although the call was not heard during any of these copulation attempts because of the distance from the observer, it is probable that the *Sou* call and associated display serve an epigamic function.

Wheet Call. This call was a whistle with two variations: a one-note call with a mean duration of 0.34 sec (SD = 0.55, $n = 53$), and a two-note variant with mean times of 0.09 sec (SD = 0.138, $n = 41$) and 0.230 sec (SD = 0.415, $n = 41$), respectively (fig. 4C,D). Both variations started at a frequency slightly under 2 kc/sec and ended slightly under 3 kc/sec. The sum of the means of the two-note variant (0.32 sec) approximated the mean of the one-note call (0.34 sec), suggesting that the motor basis of the calls was similar.

This call was heard throughout the year. It was most frequently heard during the nesting stage (70 per cent of observations, $n = 33$). As with many other calls of this species, males gave the call more often than females (17 of 19 observations). It was most often uttered by birds on the ground (13 of 17 observations). During the wintering and prenesting periods, the *Wheet* call was given when a bird was flushed from the ground. Also, when I approached a pair too closely, the birds became "nervous." Finally, one would fly up

TABLE 1. Synopsis of calls of the adult Long-billed Curlew.

	Call							
	Arc Display	*Curluoo*	*Gur*[a]	*Ki-keck*	*Long*	*Long Curluoo*	*Sou*[a]	*Wheet*
Sex of birds	Both	Both	Male	Both	Both	Both	Male	Both
Occurrence during annual cycle[b]	Late I, early F	All year	F	I, F	BS	BS	PN and/or early I	All year
Etiology	Potential ground predator proximal	Presence of other curlews; disturbance of nest or individual	Presence of human in vicinity of young?	Potential predator proximal to nest or young	Presence of hawk[a]	Presence of other curlews	Presence of female	Potential danger proximal to adults, nest, or young
Simultaneous behavior	Arc display	Flying or on ground	Flying	Flying; mobbing	Alighting; setting wings	Alighting	Epigamic display	Most often given on ground
Function	Defense against predator	Contact; anxiety	?	General predator alarm	Avian predator alarm?	Announcement	Epigamic	Anxiety
Distance decreaser	yes	yes	?	yes	?	probably	yes	no
Associated calls	*Ki-keck, Wheet*	*Long Curluoo, Long*	?	*Arc Display, Wheet, Curluoo*	*Long Curluoo, Curluoo*	*Long, Curluoo*	?	*Ki-keck*
Elicited by conspecifics	no	yes	probably not	no	?	probably	probably	no
Answered by conspecifics	yes	yes	?	yes	sometimes	yes	no	yes
Calls given by conspecifics	*Arc Display, Curluoo Wheet*		?	*Ki-keck, Arc Display, Wheet, Curluoo*[c]	*Curluoo, Long, Long Curluoo*	*Curluoo*	?	*Ki-keck, Arc Display, Curluoo*[c]

[a] One observation.
[b] I = incubation period; F = fledgling care; BS = breeding season; PN = prenesting period.
[c] All indicating alarm, disturbance, anxiety.

and land 20–30 yards farther from me. Then it would give the *Wheet* call, and the other member of the pair would fly to join its mate. During the nesting period a bird gave the *Wheet* call when an intruder was within 50 yards of the nest. The birds were visibly "nervous" when giving this call. They watched closely the activities of the observer at the nest. Often they would fly up and give the *Ki-keck* call (see above). This is also the situation in which the *Wheet* call was given when the young were hatched and I was in the vicinity.

The *Wheet* call functioned as an anxiety call. In all situations it clearly indicated a degree of danger or anxiety, either proximal to the adults themselves or to the young or nest. Although Bent (1929:104) mentioned this call, he gave no information on its cause or function.

The data on the adult calls are summarized in table 1.

VOCALIZATIONS OF THE CHICKS

Deee Call. This call had a duration of 1–1.2 sec (fig. 5A), and was slightly higher in pitch than the *Long* call of the adults (see above). It may prove to be a precursor of the latter call.

The *Deee* call appeared first in the 24 hr after hatching and was recorded up to six days later, after which the call was not heard again. Whether this was due to the absence of the appropriate stimulus or to the disappearance of the call from the chick's repertoire is not known. Chicks giving the *Deee* call exhibited a degree of "nervousness" and excitement. They usually gave the call while clustered together on the floor of the box or while walking about. Often more than one bird at a time gave this call. I suspect that this call communicates a certain amount of fear or uneasiness among the chicks. It might be termed an anxiety call; however the fear was not

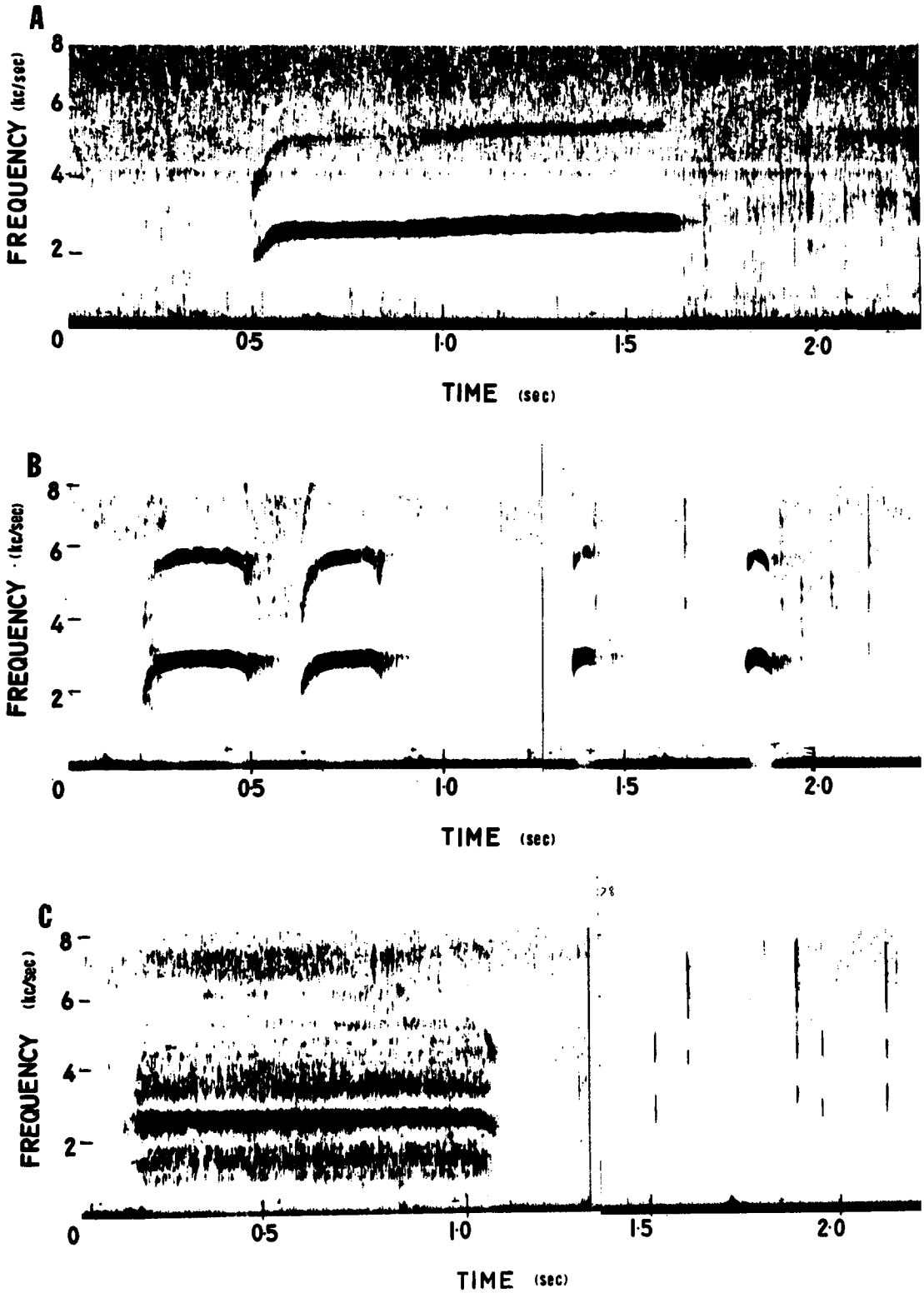

FIGURE 5. Sound spectrograms of the vocalizations of Long-billed Curlew chicks. A. *Deee* call. B. (left) *Peep-beep* call; (right) *Pert* call. C. *Squeee* call.

intense enough to elicite the *Squeee* call (see beyond) from the chicks. The fact that intermediates between the two calls exist indicates that they represent the extremes of responses to a continuum of stimulus intensity.

Peep-beep Call. The most typical form of this call consisted of two similar notes 0.2–0.4 sec in length at a frequency of 2 kc/sec. The two notes were convex in shape (fig. 5B). The *Peep-beep* call had many variations. Notes were uttered in groups of from one to three. The shape of the notes was sometimes straight instead of being arched. The duration of the call varied from 0.1 to 0.5 sec.

The *Peep-beep* call was the most common call of the curlew neonate. It was heard from the day of hatching. This call was replaced in frequency of occurrence by the *Squeee* call only when the chicks became ill prior to their death. The call was characteristically given after feeding or when the chicks were grouped together. It was normally given in the absence of loud noises or sudden movements. If one bird was placed in a separate box, out of sight of the others, it would give the *Peep-beep* call. It was answered with the same call by the other chicks.

The situations in which this call occurred suggest that the *Peep-beep* call served either as a contact note, or a pleasure note, or both. This call was a pleasure note in the sense that it was given in the absence of fearful stimuli such as human presence, sudden movements, or loud noises. Collias and Joos (1953:176–177 and fig. 1) recorded a pleasure note in the domestic fowl. It was physically unlike the *Peep-beep* call of the curlew neonate in that it was higher pitched and, after starting, rose to a frequency of 5 kc/sec. Simms (1954) recorded a *Cheep-cheep* call prior to hatching in the Stonecurlew, *Burhinus oedicnemus.*

Pert Call. This short call was most frequently heard in the 24 hr before hatching. The notes of the *Pert* call were 0.1–0.2 sec in duration. The fundamental tone was 3 kc/sec with a harmonic at 6 kc/sec (fig. 5B). Usually only a single *Pert* was given, but as many as three notes in sequence were recorded. After the chicks hatched, the *Pert* call became nearly identical, physically, with the one-syllable variation of the *Ki-keck* call (cf. fig. 3A). It is probable that, by an increase in the number of *Pert* notes and a decrease in the time between notes, the *Pert* call develops into the *Ki-keck* note when the chick fledges or shortly thereafter. The question remains as to whether the signal function of the *Pert* call also changes if it develops into the *Ki-keck* call.

There is some uncertainty as to the function of this call; but, unlike the *Ki-keck* call, it did not occur in situations indicating distress or anxiety. One possibility is that this call helps synchronize the hatching of eggs, or more likely that it serves as a contact call among the chicks. The *Pert* call was most often given when the eggs or chicks were close together in the bottom of the box, and in the absence of disturbing stimuli. When the call was given by one chick, others would answer with the same call. Prehatching call notes functioning as contact notes have been reported for other shorebirds, notably the Stonecurlew (Simms op. cit.), and the Eurasian Curlew (von Frisch 1956).

Squeee Call. This call consisted of one long note averaging 1.0 sec in duration (fig. 5C). The loudest part of the call was centered around the 2 kc/sec level. There was a rapid frequency change, similar to the first note of the *Arc Display* call. This change gave the *Squeee* call a harsh, grating quality.

This call indicated distress. It was first heard 10 hr prior to hatching when the egg was picked up and shaken vigorously. After hatching the *Squeee* call was given when sudden movements were made or a chick was picked up suddenly. The call was most frequently heard when the bird was ill and finally died. This was the only call given by the 47-day old captive curlew. When the call was uttered by a chick, it and the others crouched on their tarsometatarsi, retracted their heads, and became silent. Adults reacted to this call by giving the *Ki-keck* call and flying toward either the intruder or the chick.

A chick distress call was also found in the domestic fowl, but its physical structure differed markedly from that of the curlew (Collias and Joos 1953:fig. 1). The distress note of the chicken was shorter in length (0.2 sec), descended in frequency, and was more "musical." It lacked the harsh quality of the call given by the curlew. In *N. arquata*, the only other curlew that has been systematically studied, von Frisch (1956) did not find a chick distress call.

A summary of the vocalizations of the Long-billed Curlew chicks is presented in table 2.

DISCUSSION

Students of bioacoustics divide the vocalizations of birds into two categories: song (uttered principally by males; functioning in self-advertisement), and call-notes. With the exception of the *Long-Curluoo* call, none of the vocalizations of the Long-billed Curlew in this study fits Thorpe's definition of song (1961:15). Physically none was as complex

TABLE 2. Synopsis of juvenile Long-billed Curlew calls.

Call	Age at first occurrence	Age when last heard	Simultaneous behavior	Connotation
Deee	one day after hatching	6 days old	nervousness	anxiety
Peep-beep	one day after hatching	?	walking, feeding	contact, pleasure
Pert	24 hours prior to hatching	?	contact with other chicks	contact ?
Squeee	10 hours prior to hatching	47 days old	crouching	distress

as the song of most passerines. But functionally the *Long Curluoo* call meets the definition of song. It is not known to be given by females. When the *Long Curluoo* was given, it was often answered by other birds. Its physical structure indicates a good carrying quality necessary for the function of self-advertisement, and the call was most often associated with agonistic displays among males. These facts do not exclude the possibility that the *Long Curluoo* call can be classed as an aggressive call used in dominance relations or territorial defense rather than as a song in the passerine sense of the word (Thorpe 1961:35).

The rest of the vocalizations of *N. americanus* fit the category of call-notes as defined by Thorpe (1961:15). These utterances were of short duration, lasting less than 3 sec. Several, especially the *Ki-keck* call, were given in volleys of 15 sec or more, but they still fulfill Thorpe's definition.

I have described 12 breeding-season calls of *N. americanus*, four of which are used only by chicks. Six adult calls have been verbally described in the literature. Although it is impossible to equate with any certainty these verbally described calls with those found in this study, it is probable that the *Curleeeuuu* call of Taverner (1934) is equivalent to what I term the *Long Curluoo* call. The *Wheety* call of Bent (1929) is equivalent to the *Wheet* call of this study, and the *Curlew* call of Bent (1929) is the same as the *Curluoo* call. I did not find a call corresponding to the *Pil-will*, *Coy*, and *Quee-hee* calls of Bent (1929). Also, the identity of the series of guttural notes described in Bent (1929:104) is unknown.

In table 3 the richness of the vocabulary of the curlew is compared with that of certain other species of brids. With the exception of the Greenshank and the Domestic Fowl, the vocabularies of the passerines are richer than those of the non-passerines. With a total of 12 calls, the vocabulary of the curlew compares favorably with those of other non-passerines. Among those species in which the chick's vocalizations have been studied, the curlew and the domestic fowl have the most calls.

TABLE 3. Comparison of the vocabularies of selected species of birds.

Species	No. of vocal signals	Authority
Passerines		
Black-capped Chickadee (*Parus atricapillus*)	17	Odum 1942
Chaffinch (*Fringilla coelebs*)	20	Marler 1956
Song Sparrow (*Melospiza melodia*)	24	Nice 1937
Non-passerines		
Domestic Chicken (*Gallus gallus*)		
adult	20	Schjelderup-Ebbe
young	5	*fide* Bremond 1963; Collias and Joos 1953
Gambel's Quail (*Lophortyx gambelii*)	10	Ellis and Stokes 1966
Chukar Partridge (*Alectoris graeca*)	14	Stokes 1961, 1963
European Oystercatcher (*Haematopus ostralegus*)	5	Makkink 1942
Long-billed Curlew (*Numenius americanus*)		
adult	8	This study
young	4	
Willet (*Catoptrophorus semipalmatus*)	13	Vogt 1937; Tomkins 1965
Greenshank (*Tringa nebularia*)		
adult	25	Nethersole-Thompson 1951
young	2	
European Avocet (*Recurvirostra avosetta*)	10	Makkink 1936

Collias (1960) discussed the physical characteristics of avian sounds in relation to their function and showed that calls with the same function in different species have similar physical characteristics. Alarm calls, such as the *Squeee* call, were loud and of long duration. These physical characteristics make it difficult for predators to locate the sound source (Marler 1955:6–7).

Alarm calls were the major functional category in curlews. Calls of this type were: *Arc Display*, *Curluoo*, *Ki-keck*, *Wheet*, *Deee*, and *Squeee*. The *Long* call might also be included here. No indication of alarm calls given by parent curlews to the young was found in this study, although they are known to exist in the

Eurasian Curlew and other Scolopacidae (von Frisch 1958).

Only the *Curluoo, Peep-beep,* and possibly the *Pert* calls had a contact or locational function. The *Curluoo* call may serve to maintain contact between parents and young. Both the *Curluoo* and *Peep-beep* calls had physical structures similar to parental contact calls found in other species (Collias 1960:382–383). They were low-pitched and brief, and they often changed in pitch. According to Marler (1955:6), these characteristics help to locate the source of the sound. The *Sou* call is an epigamic call. It also has some of the characteristics of parental contact calls mentioned above. Collias (1960:383) found a similarity in physical attributes between sexual attraction calls and parental contact calls in many species of birds.

At least one call, the *Curluoo,* served more than one function. It served to locate the caller, to maintain contact between flock members and between members of the pair, and to communicate alarm to conspecifics. In its multi-functional nature, this call is similar to the Rally call of the Chukar Partridge, *Alectoris graeca* (Stokes 1961:115). They both serve to locate individuals and to maintain flock cohesion. The individual to whom each of these calls is addressed varies seasonally. During the breeding season it is the bird's mate, while during the non-breeding season it is the flock member.

Many of the functional categories of calls found in other non-passerines were absent in the curlew (cf. Thorpe 1961, table 1). Most striking was the lack of a flight-song. Flight-songs usually accompany elaborate flight patterns and are characteristic of many open-country nesting birds, including most Scolopacidae. These flight-songs serve as self-advertisement, either for mate attraction or territorial defense (Welty 1963:388; Armstrong 1963:135–148). A flight display has been observed in *N. arquata* (Witherby et al. 1940). Silloway (1900) described a flight display in the Long-billed Curlew. I never heard or saw a similar display, but the majority of vocalizations of the curlew is given in flight. The *Long Curluoo* call served the function of self-advertisement, but it was usually uttered when the bird was landing. On two occasions in 1967 I heard a male give the *Long Curluoo* call in flight when pursuing a second male. The curlew did not call from a calling post, as is characteristic of many open-country nesting species including the Willet, *Catoptrophorus semipalmatus,* and the Common Snipe, *Capella gallinago* (pers. observation). Both species breed in the same habitat as the curlew.

Sound spectrographic analyses showed considerable individual and intraspecific variation in the calls of *N. americanus,* especially in the duration of the calling bout. For example, the *Ki-keck* call was given in bouts lasting 1–30 sec. Other calls were equally variable in length. Another form of variation was the mixing of several types of notes in the same calling volley. Studies of passerines' songs showed considerable interspecific differences in the amount of variability (Marler 1952; Borror 1959; Marler and Isaac 1961). The presence of the same type of variation in the calls of curlews as in the songs of passerines suggests that they may be found universally among birds, although there is considerable interspecific difference in the amount and types of variations to be found.

Individual notes of the calls of the curlew varied in length and in spacing, but not in frequency. This is well shown by the variants of the *Ki-keck* call (fig. 3) and the *Wheet* call (figs. 4C,D). Variants of these two calls were formed by fusion or separation of individual notes. All the calls were of quite constant frequency, ranging from 1 to 4 kc, which is comparable to the range of *N. arquata* (Armstrong 1963:table 4).

As mentioned above, with the exception of alarm calls, the vocabulary of the curlew apparently lacks many functional categories, although at present it is impossible to be certain. Probably one reason for the lack of certain vocal signals is the greater importance of visual signals in this open-ground inhabiting species. Most agonistic behavior in *N. americanus* consists of bill sparring and flashing of the bright cinnamon wing linings, rather than of vocalizations. The total number and functional categories of vocalizations of a species reflect several of its attributes. The more complex the social organization of a species, the more types of vocalization it is likely to possess. A species that experiences a high degree of predation usually has a proliferation of predator defense calls. In dense habitat where vision is limited, sound communication is normally more elaborate than in habitats where visual clues are available.

SUMMARY

Free-living Long-billed Curlews, *Numenius americanus,* were studied during the breeding seasons of 1965, 1966, and 1967 in Cache and Box Elder Counties, Utah, and wintering flocks were observed in December 1965 in Aransas and Kleberg Counties, Texas. The ontogeny

of sound signalling was studied. Sounds made both prior and subsequent to hatching in three curlews were tape recorded. Vocalizations were then analyzed on a Kay Electric Company Sonagraph.

I was able to distinguish eight adult calls and four chick vocalizations. For each call, I attempted to give a physical description and to assess the function, causation, and amount of physical variation. The majority of calls served as alarm or threat calls against potential predators. A song-flight display was absent in this species. The *Curluoo* call was the only multi-functional call found. The number of calls in the vocabulary of the adults was similar to that of other non-passerines studied except the Domestic Fowl. Each call was quite variable, due to differences in the length and spacing of individual notes.

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