THE VOCALIZATIONS AND SYRINGEAL ANATOMY OF THE COMMON CROW, *Corvus brachyrhynchos*

by

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INTRODUCTION

Bio-acoustics has developed rapidly in the past decade as a tool available to the ethologist for the study of communicative mechanisms in wild animals. Bird vocalizations have long attracted researchers. The common crow (Corvus brachyrhynchos) is an ideal experimental subject for this type of research. Indeed, the casual observer of crow behavior soon recognizes the communicative and behavioral complexity of crow vocalizations. Intensive documentation of the sounds produced by the common crow, related to the appropriate behavioral context in which each call occurs in the wild, is the primary objective of this research.

Captive and wild common crows were tested with recordings of crows vocalizations to determine the nature of the vocalizations and signals of the common crow.

The anatomical structures and mechanisms by which sounds are produced are among the least understood aspects of avian biology.

Poor vocalizers like falcons (Falconidae) may have only two or three pairs of syringeal muscles, but true song birds typically have seven pairs, and as many as nine pairs have been reported (Welty, 1963: 118-119).

There is a widely accepted belief that the common crow is not capable of vocal versatility, i.e., significant variation in pitch and variety of notes produced. The present investigation of the functional anatomy of the syrinx in the crow contradicts this view for five pairs of intrinsic and one pair of extrinsic syringeal

muscles were identified.

The objectives of the syringeal research were to 1) determine the way in which sound is produced in the common crow, and 2) work out the anatomy and probable function of the syringeal components in this species.

Clearly, the need exists for research of all aspects of avian acoustics.

LITERATURE REVIEW

Frings and Frings (1964) gives three reasons for studying animal communication: an understanding of communication systems of animals can be used to manage useful species and control pest species; studies of animal communication will disclose the biological origins of human communication and suggest methods of communication other than those we now have; and, an understanding of animal communication is central to an understanding of animal behavior. The study of communication in animals has made significant strides in recent years, but a serious lack of basic organization still exists, especially the absence of any uniform system for describing and classifying animal sounds.

Lanyon (1960) states that earlier investigations of the development of bird vocalizations were largely observations by aviculturists who witnessed the responses of hand-reared birds. The earlier literature in this field has been adequately reviewed (Sanborn, 1932; Nice, 1943; Poulsen, 1951; and Thorpe, 1951). Konishi (1964) studied the variation in syllable shape of song in the Oregon junco (Junco oreganus). Marshall (1964) demonstrated vocalizations in brown towhees (Pipilo) sp. are communicative to members of the same species. Armstrong (1963) describes bird utterances as a language.

Bent (1946) devotes two pages to the characteristic vocalizations of the eastern common crow, citing observations by Forbush, Hoffman, Townsend, Allen, Wright, and Knight. Allen (1919) also relates crow notes to time rhythms, triplets, and other rhythmic combinations.

Good (1952) discusses the meanings of the following crow vocalizations: the "warning call" with which individual crows react to immediate and latent danger; "rattling" or "gurgling notes" emitted by the male crow during the mating display; female "caws" like that of young crows, during the spring courtship period; a "threat call," low in amplitude and like a "rattle," but lower pitched, is apparently used in the presence of an enemy not greatly feared; and "scolding calls" are given by adult crows during the mating season when the young are threatened. Good also mentions a "rally call," emitted after sighting or hearing an enemy; and a "distress call," or "squalling cry," uttered by a crow captured by a hawk or man. In addition, dove-like "cooing notes" were noted by Townsend (1927).

The "alarm," "rally" or "assembly," "ordinary cawing," and "begging cries" of the young have been tested with American and French crows, both in France and in eastern United States. Positive and negative phonotaxic responses to these calls were noted by Frings et al. (1958). The broadcasting of "distress calls" of the European jackdaw (Corvus monedula) at night near crow roosts in France, caused the birds of several species to desert the roosts entirely (Frings, et al., 1958).

Recordings of crow calls were made in France, Pennsylvania, and Maine. Responses to these calls were analyzed after testing in France and the United States. French crows responded positively to all recordings. The Maine crows responded only to the calls of their own species. Pennsylvania crows responded to the "distress calls" of the

French crows in the summer, but not in the winter (Frings, et al., 1958). The author suggests this differential response results from the isolation of the Maine population from southern crows. Maine crows migrate in winter only as far south as Pennsylvania. The Pennsylvania spring and summer populations, however, migrate to the southern states in winter. They learn there to respond to a wide variety of calls because of their association with fish crows (Corvus ossifragus), whose calls closely resemble those of the European jackdaw and crows from other regions (Busnel, et al., 1957).

Frings and Frings (1957) found both crows and herring gulls (Larus argentatus) feeding together in the Schoodic Peninsula in Maine. Interestingly, these two unrelated species learned to respond to each other's "assembly" and "warning calls."

French investigators have studied the habits, nesting, nutrition, mortality, movements, and economic importance of seven species of crows. They have attempted to control crows by the destruction of young, the use of frightening devices, and repellents, but techniques based upon biosonics have been the most effective (Chappelier, et al., 1959).

Busnel and Giban (1959) used "crow" "distress calls" to break up large colonies of nesting "crows," causing them to desert the eggs at night and allowing the eggs to cool and die. Sound was thus used for population control. Giban (1962) emphasized that "crows," in order to react to calls broadcasted, must notice the sound emissions. If the emission is not of sufficient intensity, the response is not produced.

This has been noted in "crow" roosts, and in the use of broadcasts to protect crops. Every factor that diminishes the acoustical strength of the emissions, such as absorption by the wind or sound screen, limits the extent of the crop area effectively protected. Andrieu (1963) emphasized that results obtained through the utilization of acoustical bird scaring methods, especially the broadcasting of "distress calls," are dependent on the quality of the recordings and broadcasting equipment. Gramet (1963) studied bio-acoustics in relation to dispersing Corvidae from airfields. Giban (1962) noted the behavior of coinhabiting pest species to the emissions of crow "distress calls" in French croplands. Studies of acoustical methods for controlling depredating birds also have been made by several American workers (Frings and Frings, 1962; Frings and Jumber, 1954). Recorded calls of the eastern common crow were used to attract and repel crows (Frings and Frings, 1957).

Audio-spectrographic analysis of typical calls of various species of North American and Mexican crows have been made and the results reported (Davis, 1958). Davis concluded that the Sinaloa crow (Corvus sinaloae) had the highest pitched voice of all the species studied, whereas the Tamaulipas crow (Corvus imparatus) had the lowest. The similarity between the voice of the Tamaulipas crow and that of the American raven was pointed out. The Sinaloae crow was described as a new species, Corvus sinaloae, from Escunopa, Sinaloa, Mexico (Davis, 1958).

Johnston (1961) states that even the most casual observer can detect pitch variation in crows, depending upon the orientation of the calling bird's head to the observer, and the speed at which the calls are given. In addition to these variations, there are possible differences attributable to sex or age. Such variations have yet to be clarified. Johnston summarized much of the work completed on communication in American crows, and stressed the need for additional research in crow communication.

Shufeldt (1890) treats the muscles of the air passages in the raven (Corvus corax sinuatus). In a preliminary study of sound production in the common crow, Miskimen (1951) reported seven pairs of syringeal muscles. In a further study of the functional anatomy of the common crow syrinx, Chamberlain et. al. (1967) found only six pairs of syringeal muscles. The functional anatomy of the chicken (Gallus domesticus) syrinx has been described by Myers (1917) and Gross (1964). Ruppell (1933) investigated the vocal structures of the herring gull (Larus argentatus). His apparatus for holding the syrinx made it possible to observe the vibration of the vocal membranes. Ruppell's review of the literature and experimental work emphasized the importance of pressure in the intraclavicular air sac during sound production. Miller (1934) was able to produce sound with the syrinx of the great horned owl (Bubo virginianus) and turkey (Meleagris gallopavo) by blowing compressed air through the bronchi without added pressure around the syrinx.

Stresemann (1934) asserts that in passerine birds the vibrations caused by air passing over the tympaniform membranes produces the sounds heard in song, and that in song birds the intrinsic syringeal muscles regulate the tensions of these membranes.

TECHNIQUES AND PROCEDURES

The methods used in this research includes: selection of field test areas, selection of electronic equipment, conduction of field tests, and the anatomical study of the crow syrinx.

Field Testing Areas

Recording and testing areas were located in western and southwestern Virginia, western and northern New York and the vicinities of Frederick, Maryland, Kennebunkport, Maine and Myaaka River State Park, Florida.

Electronic Equipment Specifications

Three tape recorders were used in the field to record common crow vocalizations: A "Wollensak" model 1700T with a built-in converter. It has a ten watt push-pull amplifier. The frequency response is 40-15,000 cycles per second (cps). The cps is at 3 3/4 and $7\frac{1}{2}$ inches per second (ips). Signal to Noise (S/N) is better than 48 decibel (db). A dynamic microphone was used with this tape recorder.

A battery operated "Kudelski Nagra III" recorder with 15 ips - 30 cps to 18,000 cps $\pm$ 1 db (30 cps to 16,000 cps $\pm$ 1.5 db) and at $7\frac{1}{2}$ ips - 40 cps to 15,000 cps $\pm$ 1 db (50 cps to 12,000 cps $\pm$ 1.5 db). The play back circuit gives at $7\frac{1}{2}$ ips and 15 ips at least 70 db of S/N.

A "Hitachi" transistor portable tape recorder model TRQ-370 was used for short range recording. Speeds are 3 3/4 ips and 1 7/8 ips. It utilizes a 6-transistor amplifier and 1-transistor high frequency oscillator. The TRQ-370 has frequency characteristics of 150 - 6,

5000 cps at 3 3/4 ips and 150 - 3000 cps at 1 7/8 ips. A dynamic microphone was used with the recorder.

A 39 inch parabolic reflector was used to record distant crow vocalizations. The parabola had a "Wollensak" or "Turner" microphone mounted at its focal point. A 26 inch "Snow Coaster" disc with a "Hitachi" microphone and recorder was employed to tape nearby crow vocalizations.

Missilgrams were used to illustrate call differences in fundamental, harmonic, intensity, frequency, and duration components. Missilgrams were made on a missilyzer manufactured by the Kay Electric Company between approximately 50 - 5000 cps at 2.24 secs. at a response of $\pm$ 2 db. The recording medium was a magnetic drum.

Field Testing Procedures

Selected calls of wild and tame crows were recorded, and the environmental context and behavior accompanying the calls were noted. Decoys, such as mounted crows and great horned owls, were used to support certain calls in an appropriate context. Tests of selected crow calls were transcribed onto continuous loop tapes from the original field tape. Loop tape tests were made from an automobile using the "Wollensak" recorder and an U. S. Army surplus cone speaker powered by a 12 volt car battery. The speaker was mounted on a ski rack on top of the automobile during field tests. Test tapes were broadcasted to crows from roads after the birds were observed in the field (Fig. 1). Every attempt was made to conceal the automobile and testing equipment from direct observation by

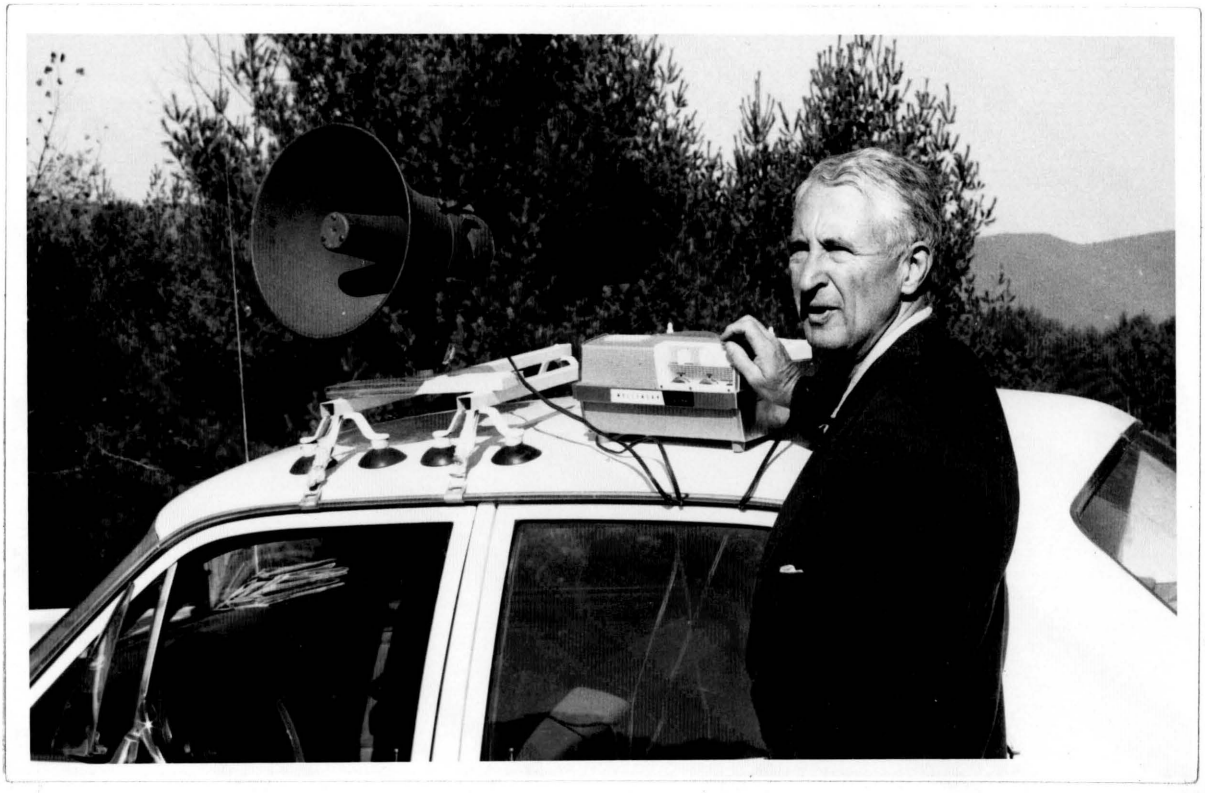

Fig. 1. Mr. Lee Wilkins operating field testing equipment.

crows in the field. Crow responses to tests were classified by the following phonotaxic system, derived from that of Frings, et al. (1958):

Class I: Specific predicted response of crows within the estimated hearing range.

Class II: Only "part" (the "part" was quantified as much as possible by field observation) of the crows within the estimated hearing range responded as predicted, while the remainder did not respond at all.

Class III: Only "part" of the crows within the estimated hearing range responded as predicted, while the remainder reacted in other than the predicted manner.

Class IV: No response among crows within the estimated hearing range.

Class V: Non-predicted response by crows within the estimated hearing range.

This ranking scheme was used for field classification of behavioral response to the broadcast of recorded vocalizations. I predicted the expected response prior to broadcast. Actual responses were compared to the predictions as a further confirmation of the context in which the calls were recorded and tested. Aside from the ranking system, the following data were recorded during field call testing: loop test number, loop test time, response time, comments on response behavior,

test observers, test call data, volume and tone of tape output, test date, test time, test location, test habitat description, estimated distance from sound source to crows tested, and weather conditions. Calls that failed to elicit a response were tested repeatedly in an attempt to establish the specific conditions under which they were given. For example, certain calls were given in a specific situation that did not evoke a flock response. Calls that apparently did not elicit a response were broadcasted to crows giving such calls to be certain that the calls did not elicit a visual or acoustic response.

Crow vocalizations are designated "primary" or "other." Sounds which cause responses among crows were classified as "primary," and non-response sounds were designated as "other."

Fifteen to 30 broadcasts were made of each important call, the actual number depending on the variability of response. With most calls, the responses tended to cluster within two or three of the five possible classes of response.

The reactions to field broadcasts were classified as positive (+) or negative (-) phonotaxis, and other responses to calls field tested. Positive phonotaxis was recorded when crows responded by flying directly to the broadcast source. Negative phonotaxis was recorded when the response was a direct flight away from the broadcast source.

Study of Syringeal Anatomy

Fifty-five common crows were collected and their syringes examined during this investigation. Collections were made during the winter of

1964 and fall of 1966. The birds were taken within 25 miles of Blacksburg, Virginia. Crows were decoyed to a mounted great horned owl with a crow call and collected with a shotgun.

The syringes used for microscopic examination were preserved in a ten percent formalin and normal saline solution during transport from the field to the laboratory. Others were examined in situ. prior to dissection.

Syringeal tissue was subjected to 11 histological solutions prior to cutting sections for staining and slide mounting in an effort to stop membrane swelling. None of the solutions were successful. The mounted tissue was stained with hematoxylin-eosin. Verhoelf-Van Gieson solution, a selective stain for elastic tissue, was used. This staining technique indicated that no elastic tissue was present in the syrinx.

The syringes were dissected and examined under a 15 power binocular microscope. Syringeal muscles from six crows were dissected and weighed.

Proposed functions of the six muscles were based on a careful determination of origin and insertion, and by manipulating the muscle while attempting to produce sound. Sound can be produced in birds by inserting a tube into the trachea. The connection between the tube and windpipe must be tight. Sucking on the tube causes the external tympaniform membranes to vibrate, thereby producing sound. The vibrating membranes are clearly observable.

Drawings and/or photographs were made of the following syringeal components: lateral view of the syrinx; lateral bones and cartilages; lateral muscles; ventral view of the syrinx; ventral bones and cartilages; ventral muscles; transverse view of the semilunar membrane with bronchial bones and muscles; and the frontal view of the syrinx.

RESULTS AND DISCUSSION

Vocalizations of the Common Crow

Primary Vocalizations

"Assembly Call"

The "assembly" or "rally call" is an intense and protracted "mobbing call" (Figs. 2-5), and is given when crows see or hear crow predators, e.g., the great horned owl (Bubo virginianus), red-tailed hawk (Buteo jamaicensis), and red fox (Vulpes fulva), etc. Assembly calls are emitted by crows when near a predator. I have collected crows using a crow call and mounted great horned owl in hundreds of locations in New York and Virginia. I have noted crows emitting "assembly calls" when near the owl decoys in almost all cases. The "assembly call" has the apparent function of calling together a group of crows so that the group might drive predators away from locations frequented by crows, such as roosting or feeding areas.

The common crow assembly call rapidly aggregates to the sound source common and fish crows within hearing range (Tables 1-3). For this reason, this call is frequently employed by crow hunters to lure crows within gun range.

Six night observations in Virginia crow roosts revealed that common crows emit "assembly calls" at night. These night observations are the basis for all subsequent references to night vocalizations.

"Assembly calls" are given throughout the year. Field tests and/or observations were made in all months of the year. These are the basis

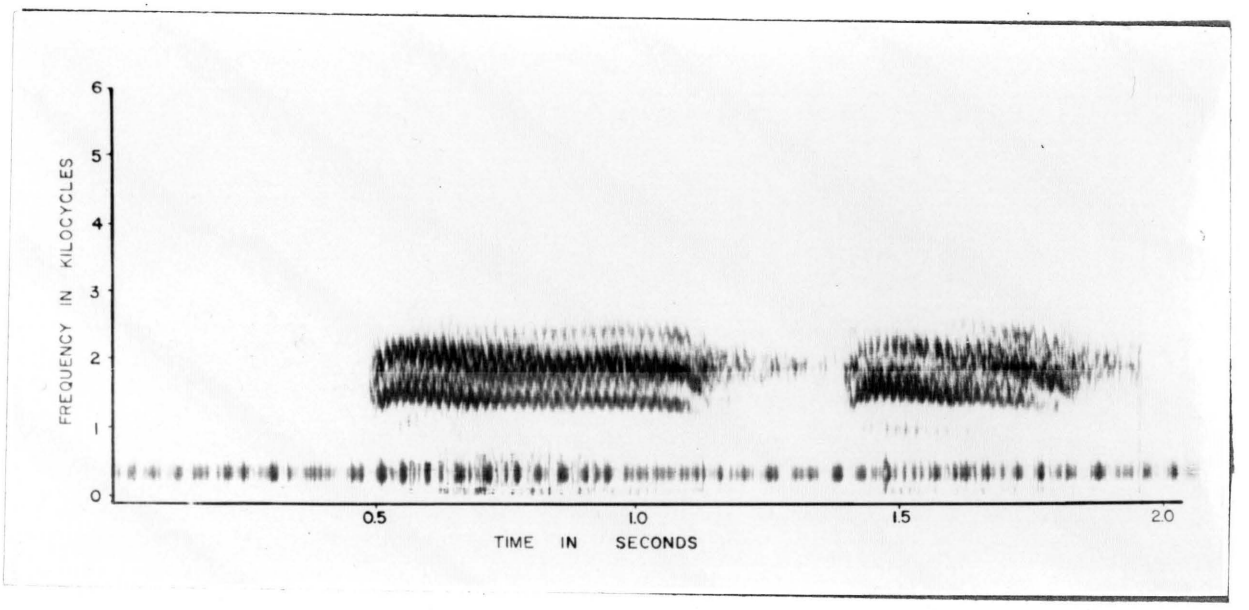

Fig. 2. "Assembly call." One crow, sex and age unknown, May 1, 1965, Prices Fork, Virginia. "Mobbing" a mounted great horned owl.

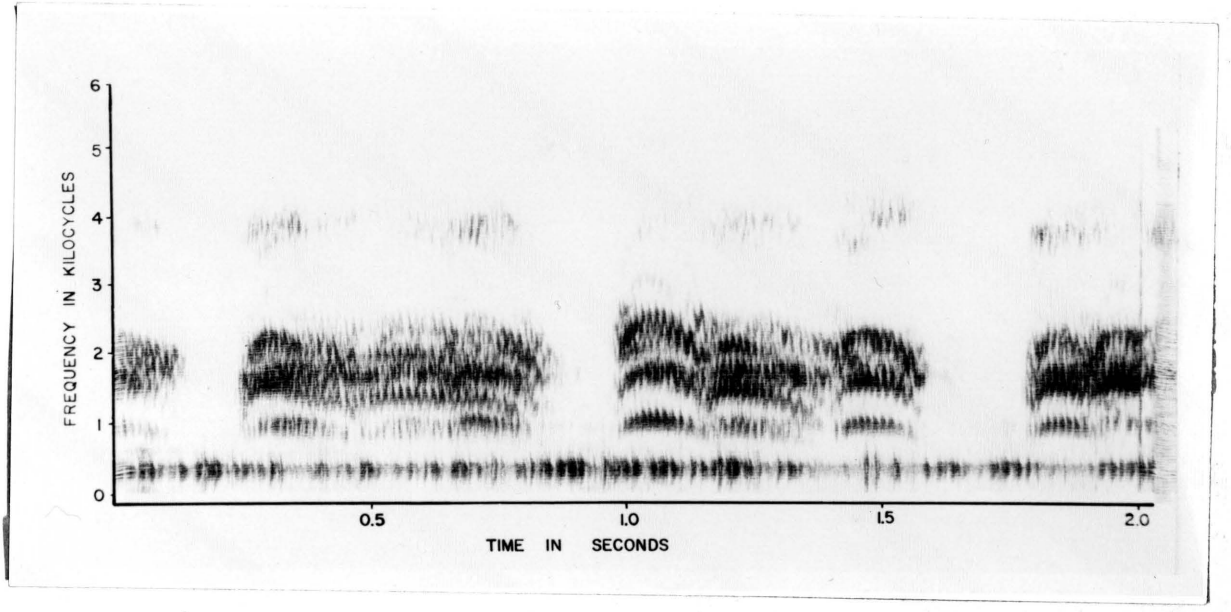

Fig. 3. "Assembly call." Two crows, sex and age unknown, June 22, 1965, Kennebunkport, Maine. "Mobbing" a mounted great horned owl.

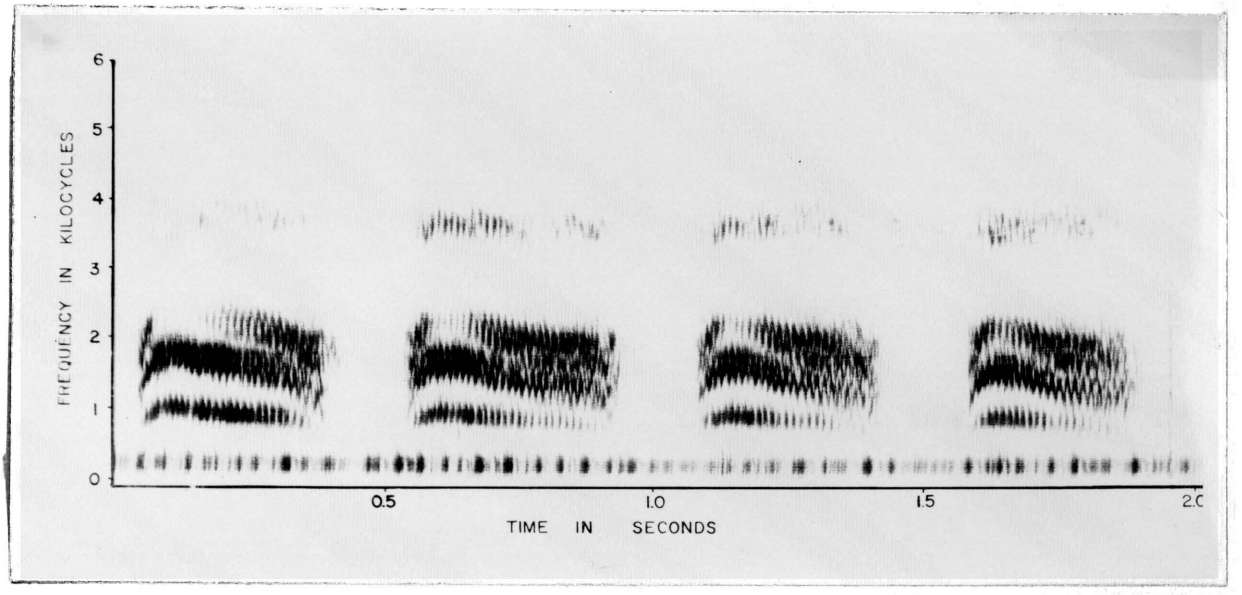

Fig. 4. "Assembly call." One crow, sex and age unknown, April 20, 1966, Myaaka River State Park, Florida. Given at my approach to a family group.

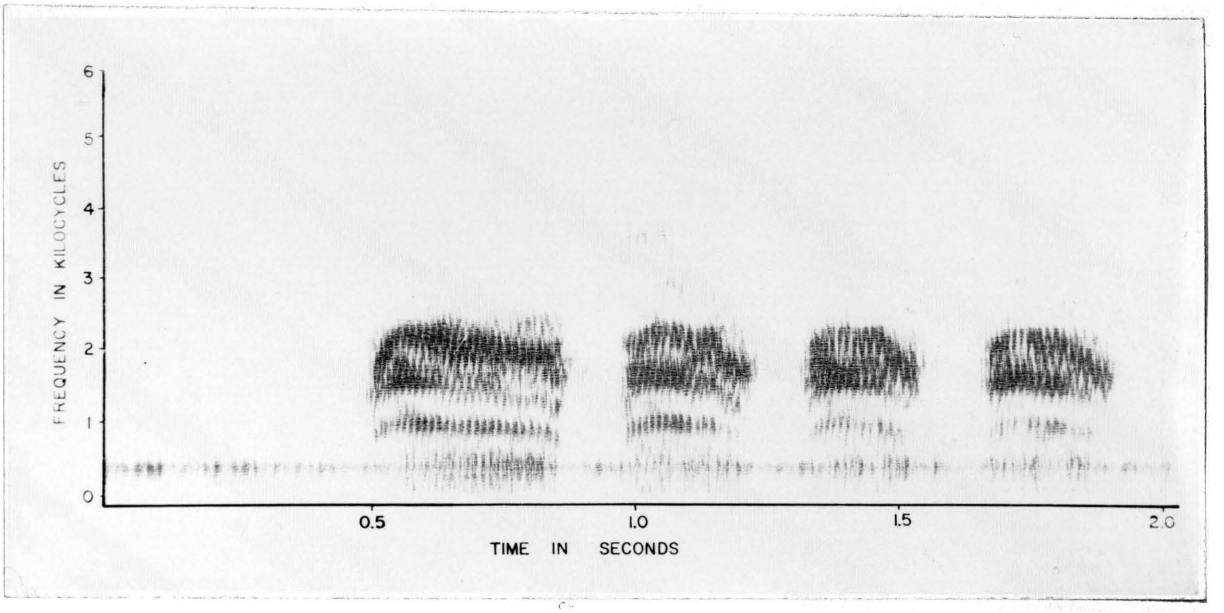

Fig. 5. "Assembly call." One crow, sex and age unknown, July 10, 1965, Fairhaven, New York. "Mobbing" a mounted great horned owl.

Table 1. Adult "assembly call", May 1, 1965, Prices Fork, Virginia

Number	Duration	Broadcast Date	Location	Time
1	15	12/11/65	Blacksburg, Va.	3:00 p.m.
2	30	12/11/65	Blacksburg, Va.	3:27 p.m.
3	120	12/11/65	Blacksburg, Va.	4:00 p.m.
4	45	12/15/65	Blacksburg, Va.	4:14 p.m.
5	30	12/12/65	Blacksburg, Va.	8:25 a.m.
6	30	12/12/65	McCoy, Va.	9:01 a.m.
7	30	12/12/65	McCoy, Va.	10:26 a.m.
8	60	1/8/66	Simmonsville, Va.	2:17 p.m.
9	60	1/8/66	Simmonsville, Va.	2:30 p.m.
10	60	12/31/65	Rochester, N. Y.	11:50 a.m.
11	60	12/31/65	Mendon, N. Y.	12:14 p.m.
12	60	12/31/65	Mendon, N. Y.	12:19 p.m.
13	60	1/2/66	Conesus Lake, N. Y.	9:00 a.m.
14	60	1/3/66	Carlisle, Va.	9:00 a.m.
15	30	12/12/65	McCoy, Va.	4:30 p.m.
16	30	12/12/65	McCoy, Va.	10:54 a.m.
17	30	12/12/65	McCoy, Va.	11:31 a.m.
18	30	12/12/65	Newport, Va.	11:59 a.m.
19	30	12/12/65	Newport, Va.	12:22 p.m.
20	30	12/12/65	Newport, Va.	3:36 p.m.
21	30	12/12/65	Eggleston, Va.	4:02 p.m.
22	30	12/12/65	Eggleston, Va.	4:22 p.m.
23	60	12/20/65	Deerfield, Va.	11:30 p.m.
24	60	12/20/65	Deerfield, Va.	11:40 p.m.
25	60	12/20/65	Deerfield, Va.	12:02 p.m.
26	60	12/20/65	Deerfield, Va.	12:25 p.m.
27	60	12/20/65	Deerfield, Va.	1:05 p.m.
28	60	12/20/65	Simmonsville, Va.	2:05 p.m.
29	60	12/15/65	Newport, Va.	8:19 a.m.
30	60	12/15/65	Newport, Va.	8:37 a.m.

* In seconds.

Table 2. Adult "assembly call", May 1, 1965, Prices Fork, Virginia

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	3	3	0	0	15	250
2	83	83	0	0	20	500
3	15	15	0	0	70	500
4	20	18	0	0	20	500
5	31	25	0	0	15	400
6	7	7	0	0	15	350
7	45	45	0	0	10	300
8	26	26	0	0	25	100
9	17	17	0	0	3	150
10	5	5	0	0	4	350
11	3	3	0	0	5	280
12	8	8	0	0	5	350
13	4	4	0	0	8	400
14	485	450	0	35	12	350
15	4	4	0	0	30	400
16	6	6	0	0	20	400
17	3	3	0	0	8	400
18	4	4	0	0	20	1600
19	9	9	0	0	30	1200
20	7	7	0	0	10	300
21	6	6	0	0	10	200
22	7	7	0	0	60	2000
23	4	4	0	0	4	100
24	9	9	0	0	20	350
25	6	6	0	0	6	150
26	1	1	0	0	20	300
27	5	5	0	0	2	250
28	10	10	0	0	3	500
29	5	5	0	0	35	300
30	11	11	0	0	15	200

* To nearest second.

Estimated yards.

Table 3. Classification of adult "assembly call"
Prediction: Aggregation to sound source

Broadcast Number	Class of Response				
	I	II	III	IV	V
1	X	-	-	-	-
2	X	-	-	-	-
3	X	-	-	-	-
4	-	X	-	-	-
5	-	X	-	-	-
6	X	-	-	-	-
7	X	-	-	-	-
8	X	-	-	-	-
9	X	-	-	-	-
10	X	-	-	-	-
11	X	-	-	-	-
12	X	-	-	-	-
13	X	-	-	-	-
14	X	-	-	-	-
15	-	-	X	-	-
16	X	-	-	-	-
17	X	-	-	-	-
18	X	-	-	-	-
19	X	-	-	-	-
20	X	-	-	-	-
21	X	-	-	-	-
22	X	-	-	-	-
23	X	-	-	-	-
24	X	-	-	-	-
25	X	-	-	-	-
26	X	-	-	-	-
27	X	-	-	-	-
28	X	-	-	-	-
29	X	-	-	-	-
30	X	-	-	-	-
Total	27	2	1	-	-
Percent	91	06	03	-	-

for all subsequent statements of seasonality of vocalizations.

The crow, when giving the "assembly call" from a perched and erect position, holds the contour and wing feathers close to the body. The tail is retained approximately one inch below the body plane, and the rectrices spread laterally about two inches beyond the tail's closed position. The tail flicks up and down during call duration. The wings are moved rapidly up and over the back and down to closed position during assembly vocalization. Crows emitting "assembly calls" while diving at a predator show a dihedral wing angle, and the legs are extended with open claws in the manner of a raptor pursuing prey (Fig. 6). Crows, when responding positively to the "assembly call," approach the sound source with a steady, flapping flight.

"Simple Scolding Call"

One of the first responses to the presence of an enemy is to announce the enemy and expose the danger. This is a primary function of the "simple scolding call."

The sharp and continuous "simple scolding call" is one of three "mobbing calls" emitted by the common crow (Figs. 7-9). It is not as grating as the longer "assembly" notes, although raucous "scolding" notes are common to both calls. The "scolding" series is normally given when a crow hears a predator, but is also emitted while harassing a predator at a distance. At close range, "scolding" vocalization is generally abandoned to "assembly calls," as the latter call is apparently more effective in driving a predator from a location.

Fig. 6. A crow giving "assembly calls" near a mounted great horned owl.

Fig. 7. "Simple scolding call." One crow, sex and age unknown, April 19, 1966, Myaaka River State Park, Florida. Given at the vocalizations of a red-shouldered hawk (Buteo lineatus).

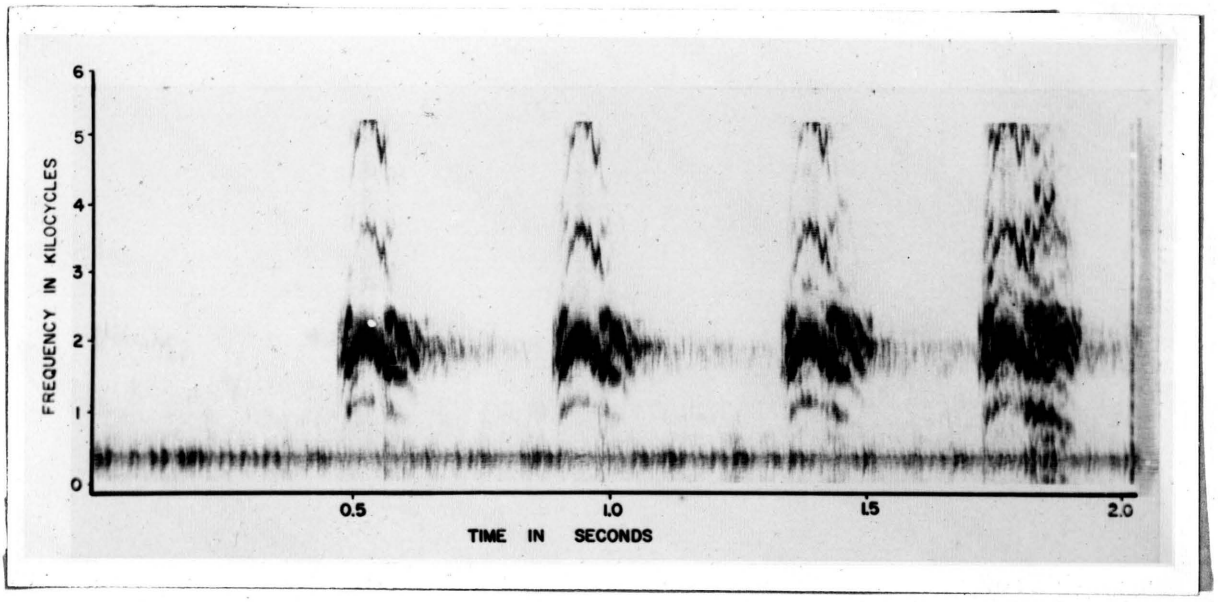

Fig. 8. "Simple scolding call." One crow, sex and age unknown, October 26, 1965, Prices Fork, Virginia. "Mobbing" a mounted great horned owl.

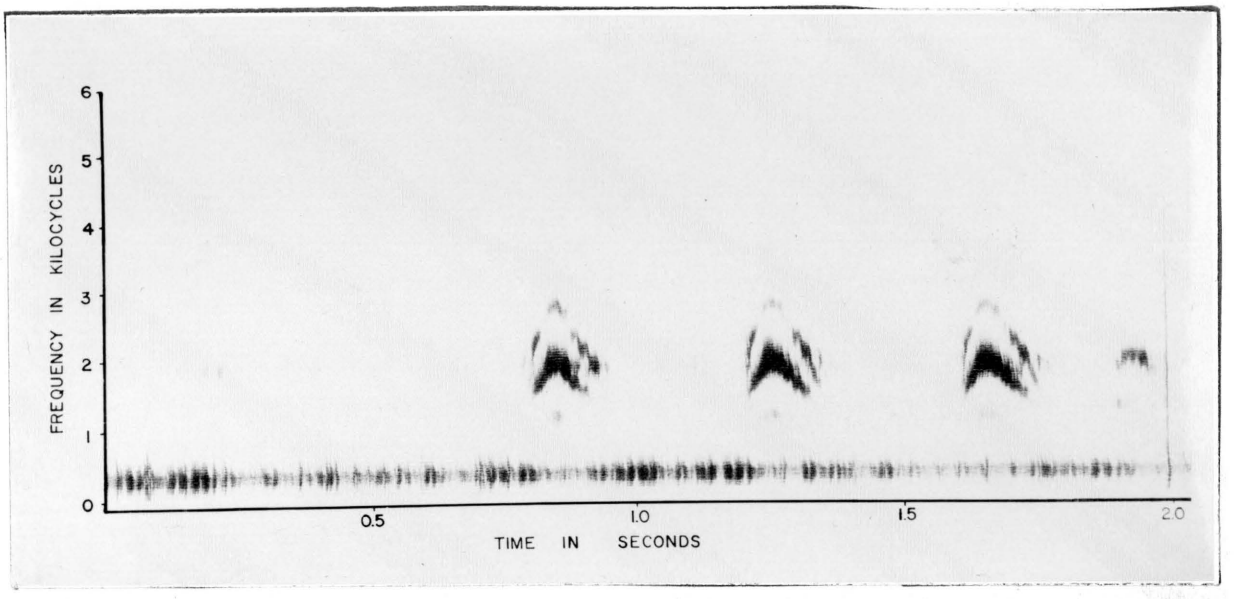

Fig. 9. "Simple scolding call." One crow, sex and age unknown, March 13, 1966, Deerfield, Virginia. "Mobbing" a mounted great horned owl.

"Simple scolding" and "assembly calls" are delivered at various degrees of intensity depending on the type of predator, its distance from the crows, and its movements. For example, common crows often emit intense, staccato "scolding calls" when they hear great horned owl "hoots", but less rapid and intense calls when they hear sharp-shinned hawk (Accipiter striatus) "clucks." Apparently, this variation in the intensity of calling is due to the fact that the great horned owl is a large predator which often feeds on crows in winter roosts or spring nesting areas, whereas the sharp-shinned hawk is a small raptor which rarely attacks common crows.

The "simple scolding call" is given throughout the year, day or night, and is not restricted to the nesting season as stated by Good (1952). Common crow "simple scolding calls" aggregate common and fish crows to the sound source (Tables 4-6). Crows do not remain near the source of the "simple scolding call" for as long a time as with an "assembly" vocalization. For example, the dispersed before the field test terminated in five of 15 tests. "Simple scolding" and "assembly calls" are emitted five to ten minutes after cessation of the visual or auditory stimuli causing these responses.

When the crow is perched and erect, the head moves up and down and forward while giving the "simple scolding call." When the head moves toward the tail and up, the wings flick up and away from the body. The beak closes when the head moves forward and down and opens when the head moves back and up. Crows showed alternate flapping and gliding flight

Table 4. Adult "simple scolding call," June 8, 1965, Cambria, Virginia

No.	Duration*	Broadcast Date	Location	Time
1	60	1-9-66	Staunton, Va.	12:15 p.m.
2	60	1-9-66	Churchville, Va.	12:35 p.m.
3	60	1-9-66	Churchville, Va.	12:45 p.m.
4	60	1-9-66	Churchville, Va.	1:10 p.m.
5	60	1-9-66	Mt. Solon, Va.	1:30 p.m.
6	60	1-9-66	Mt. Solon, Va.	1:53 p.m.
7	180	1-9-66	Harrisonburg, Va.	1:13 a.m.
8	60	1-10-66	Staunton, Va.	10:25 a.m.
9	60	1-10-66	Headlands, Va.	10:55 a.m.
10	60	1-10-66	Deerfield, Va.	12:40 p.m.
11	60	1-12-66	Mt. Lake, Va.	2:23 p.m.
12	60	1-12-66	Mt. Lake, Va.	3:17 p.m.
13	60	2-25-66	Roanoke Valley, Va.	1:30 p.m.
14	60	2-25-66	Roanoke Valley, Va.	1:45 p.m.
15	60	2-25-66	Roanoke Valley, Va.	2:15 p.m.

* In seconds.

Table 5. Adult "simple scolding call," June 8, 1965, Cambria, Virginia

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	6	6	0	0	8	200
2	7	7	0	0	15	350
3	10	7	0	0	9	200
4	8	8	0	0	14	200
5	2	2	0	0	35	350
6	9	3	0	0	24	480
7	29	26	0	0	50	180
8	2	2	0	0	13	250
9	4	4	0	0	14	200
10	7	7	0	0	10	250
11	65	65	0	0	70	350
12	5	5	0	0	17	400
13	4	4	0	0	4	250
14	2	2	0	0	5	150
15	2	0	2	0	15	300

* To nearest second.

Estimated yards.

Table 6. Classification of adult "simple scolding call"
Prediction: Aggregation to sound source

Broadcast Number	Class of response				
	I	II	III	IV	V
1	X	-	-	-	-
2	X	-	-	-	-
3	-	X	-	-	-
4	X	-	-	-	-
5	X	-	-	-	-
6	-	X	-	-	-
7	-	X	-	-	-
8	X	-	-	-	-
9	X	-	-	-	-
10	X	-	-	-	-
11	X	-	-	-	-
12	X	-	-	-	-
13	X	-	-	-	-
14	X	-	-	-	-
15	X	-	-	-	-
Total	12	3	-	-	-
Percent	80	20	-	-	-

when aggregating to "scolding calls" during four of 15 field tests.

"Modified Scolding Call"

"Modified scolding" is a "simple scolding call" with an inflection on all syllables of the call series (Fig. 10).

This series is uttered throughout the year, day or night, in response to the vocalization or distant sightings of crow predators. Postures are similar to that of the "simple scolding call."

The "modified scolding call" or third "mobbing call," is functionally identical to the "simple scolding call," except that crows do not aggregate as rapidly to, or remain near, the sound source as long as in response to "simple scolding."

"Alert" or "Warning Call"

The conversational "warning" or "alert call" gives expression to the reaction of crows to danger within their environment. "Alert" vocalization does not cause a dispersal reaction among crows.

"Alert" signals are extremely variable in intensity, frequency, duration and number of notes (Figs. 11-16). They are subject to variation in delivery dependent on the immediacy and type of danger. For example, "warning notes" are sharp, intense and are given close together by a perched crow surprised by a ground predator. "Warning notes" are less sharp and intense, and are emitted with a greater time interval between notes when given by a crow that sees a hunter approaching at a distance. My observations indicate that the number of notes per "alert" series does not convey differences in meaning or degree of danger.

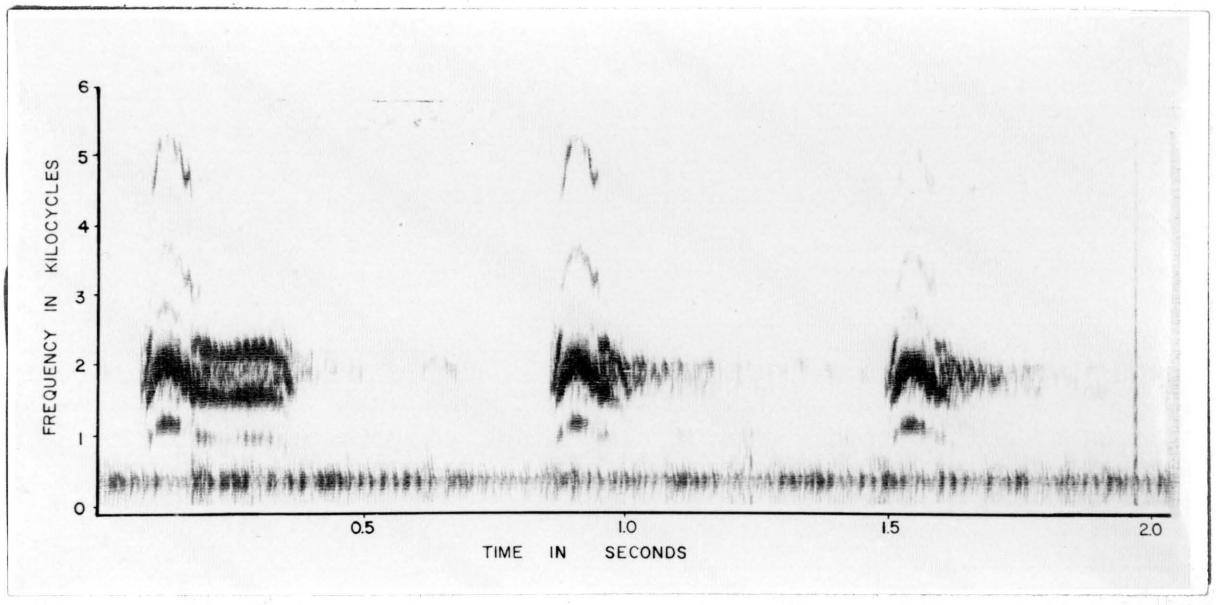

Fig. 10. "Modified scolding call." One crow, sex and age unknown, October 26, 1965, Prices Fork, Virginia. "Mobbing" a mounted great horned owl.

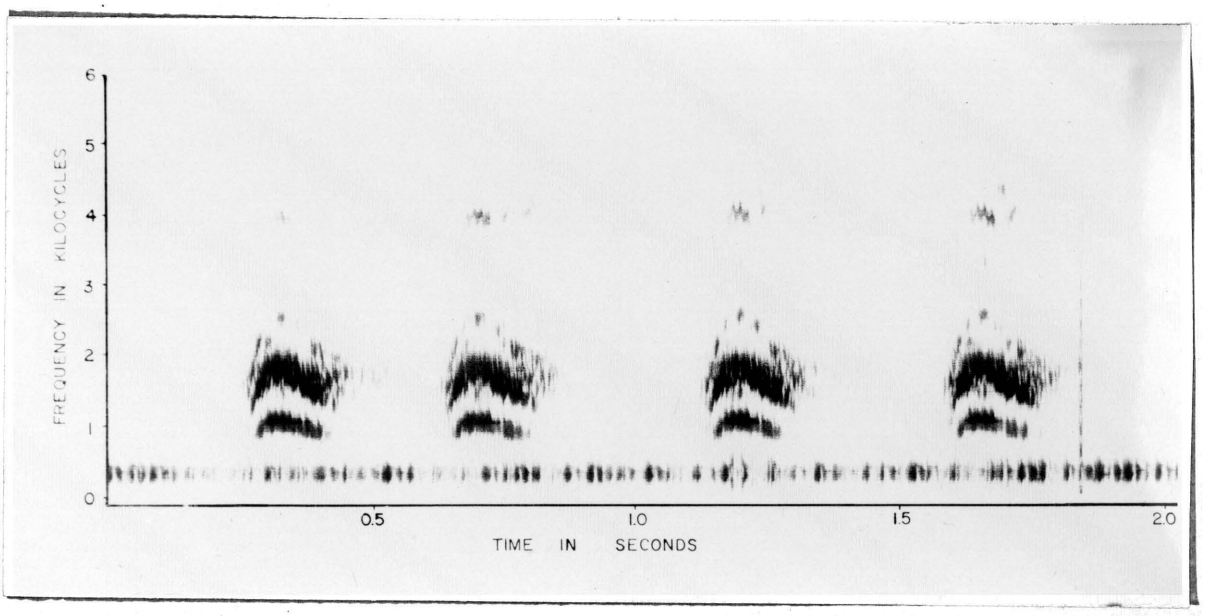

Fig. 11. "Alert" or "warning call." One crow, sex and age unknown, April 21, 1966, Myaaka River State Park, Florida. Given at my approach.

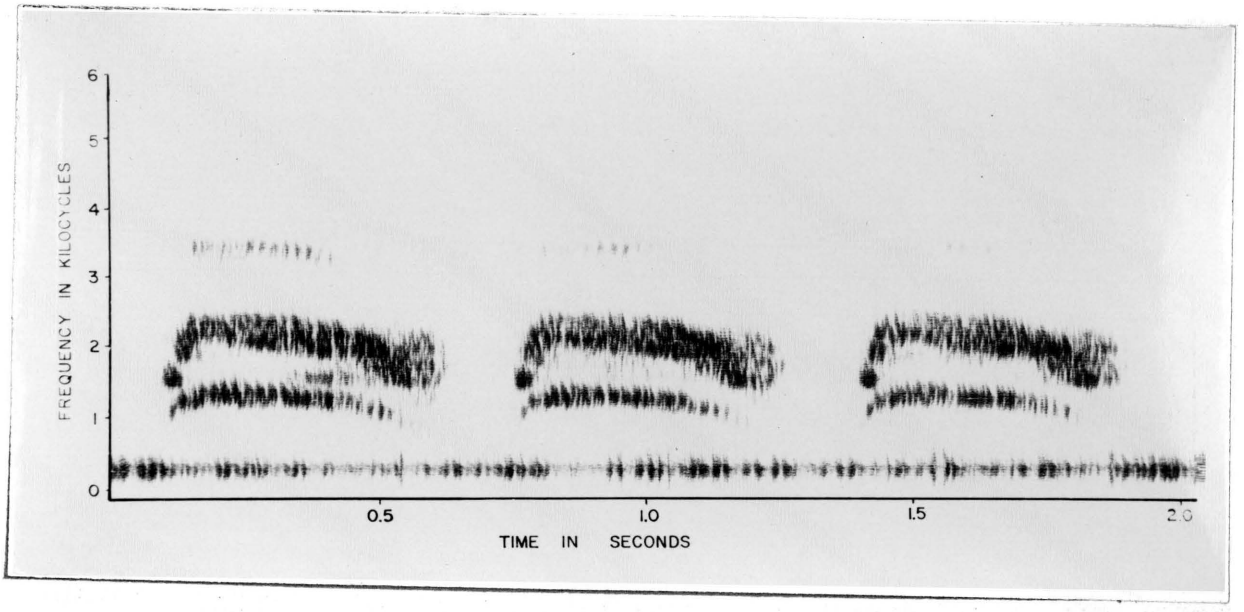

Fig. 12. "Alert" or "warning call." One adult male, October 12, 1965, Lexington, Virginia. Given at my approach.

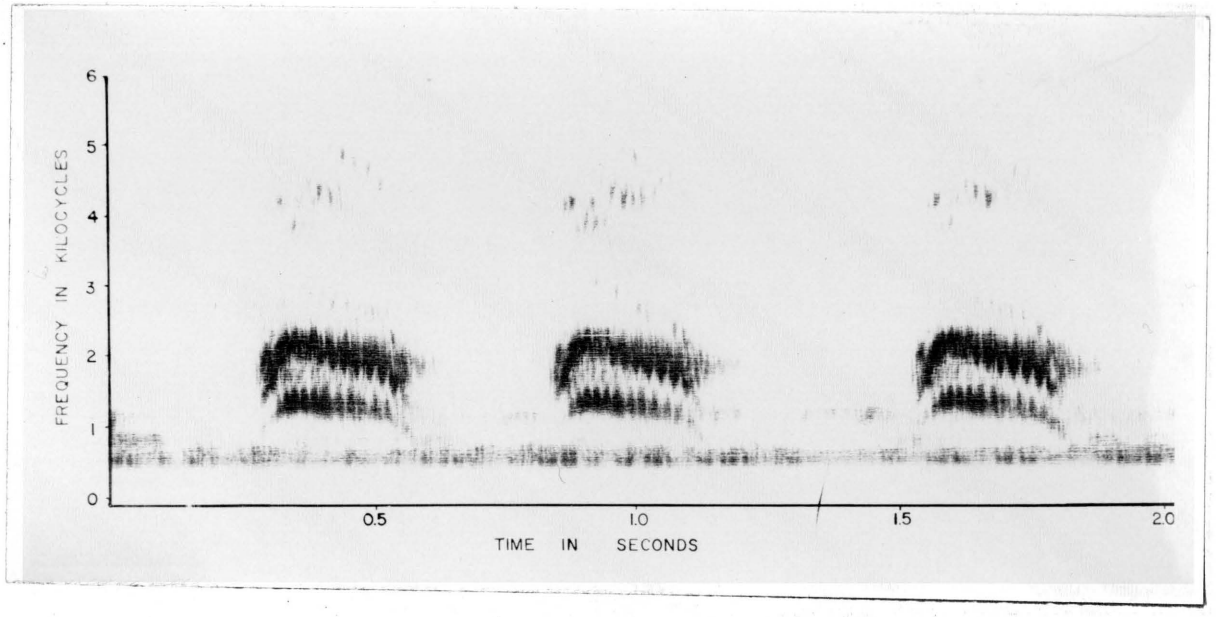

Fig. 13. "Alert" or "warning call." One adult male, July 10, 1965, Wolcott, New York. Given at my approach.

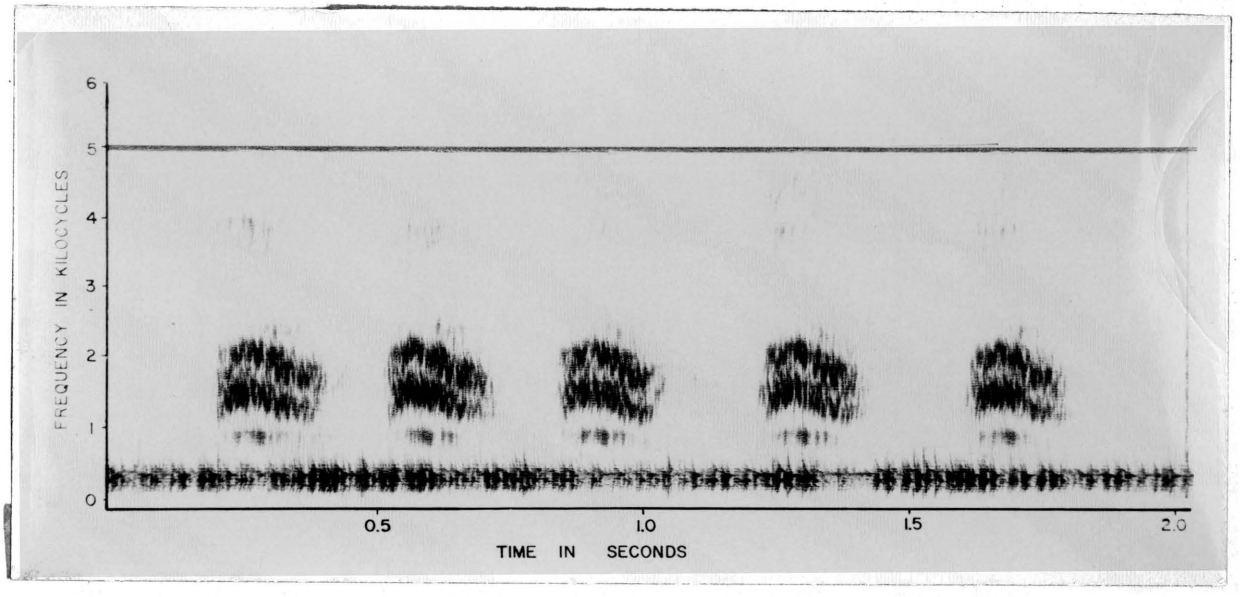

Fig. 14. "Alert" or "warning call." One adult male, October 12, 1965, Lexington, Virginia. Given at my approach.

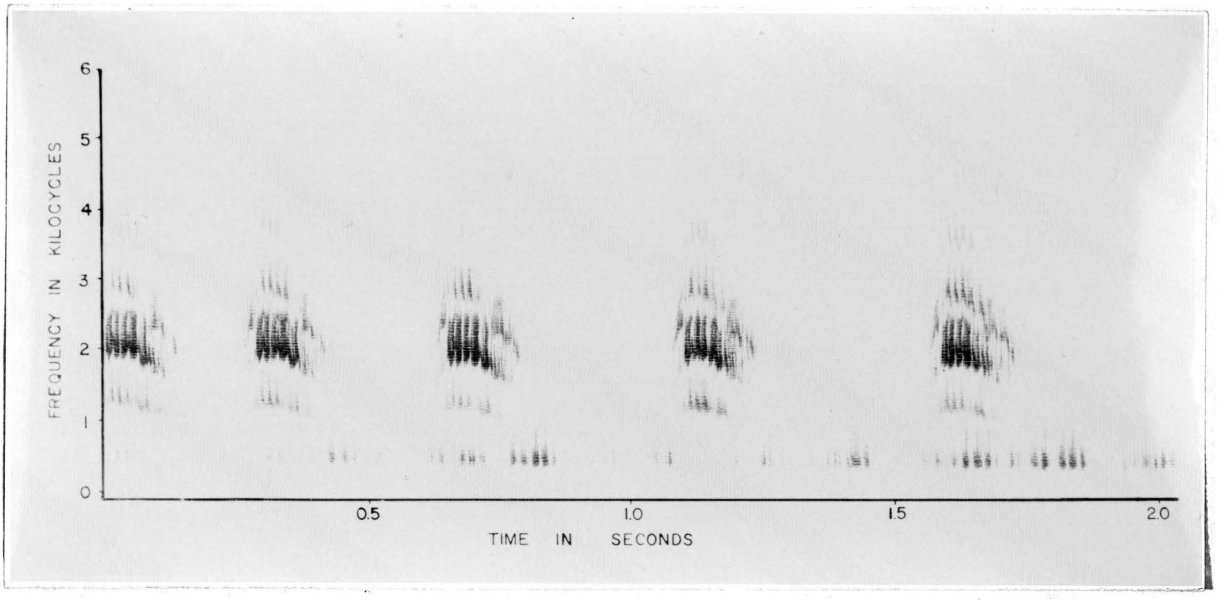

Fig. 15. "Alert" or "warning call." One crow, sex and age unknown, April 19, 1966, Myaaka River State Park, Florida. Given at my approach.

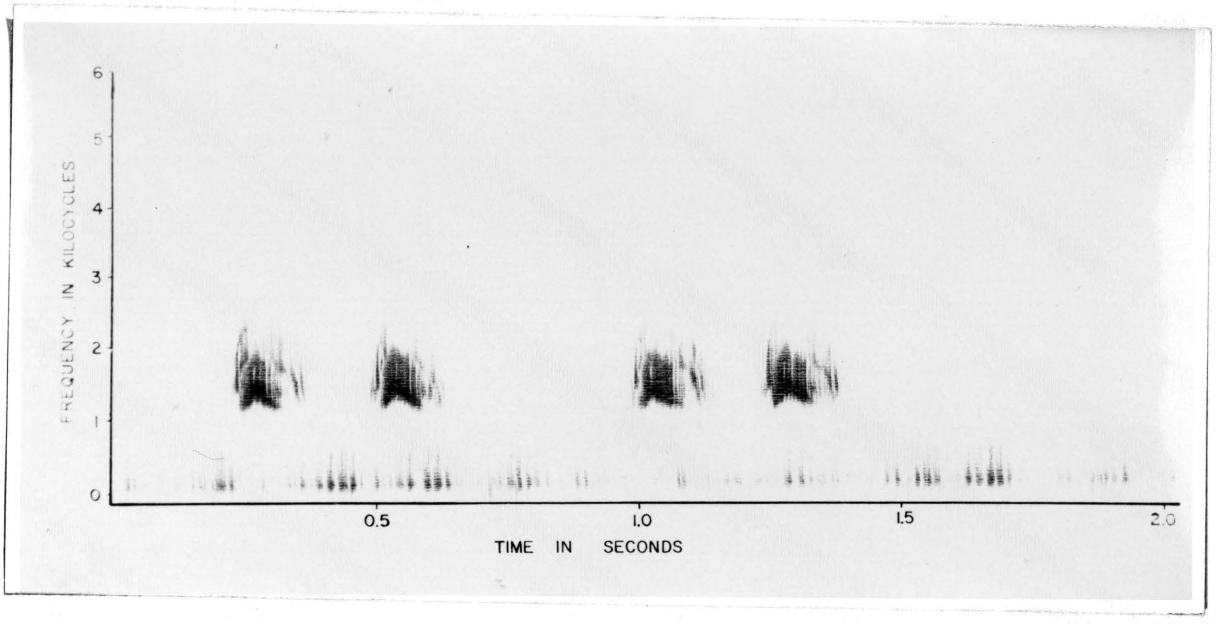

Fig. 16. "Alert" or "warning call." One crow, sex and age unknown, April 19, 1966, Myaaka River State Park, Florida. Given at the approach of a great blue heron (Ardea herodias).

The function of "alert" vocalization is to warn crows of danger. Crows respond to this signal by emitting "alert" or "simple scolding calls," flying up into trees if on the ground, flying away from and back to an arboreal perch, manifesting "nervous" postures such as rapid wing and tail flicking, and frequent defecation.

In 12 of 17 tests, crows responded positively to the "alert call" giving "assembly" and "simple scolding calls," apparently searching for the prospective predator (Tables 7-10).

Sonagraphically, "warning" signals are very similar to "simple scolding calls" but the former are not as continuous as the latter.

The postures associated with the "alert" or "warning call," are similar to the "simple scolding call."

"Dispersal" or "Alarm Call"

The "dispersal" or "alarm call" (Figs. 17-22) generally causes crows to fly away from a given area, but in three of 12 field tests, common crows aggregated to the call. It is the extreme degree of the "alert" or "warning" series. "Alarm" signals are sharper, with each note shorter than the preceding note, and they are delivered closer together than are "alert notes." The first syllable of the "dispersal call" is often inflected (Fig. 20). The variability in sound intensity between "warning" and "alarm" signals was not measured.

"Alarm" vocalization is emitted by crows that apparently sense immediate and grave danger, e.g., a hunter's sudden appearance near a crow. Crows responded in eight of 12 tests by flying rapidly away from

Table 7. Adult "alert call," March 10, 1966, Lexington, Virginia. No prediction.

Number	Duration*	Broadcast Date	Location	Time
1	60	7/25/66	Alexandria Bay, N. Y.	3:15 p.m.
2	16	7/25/66	Camp Drum, N. Y.	4:00 p.m.
3	36	7/25/66	Pulaski, N. Y.	4:30 p.m.
4	120	7/26/66	Melrose, Md.	5:55 p.m.
5	120	7/26/66	Lineboro, Md.	6:20 p.m.
6	60	8/7/66	Lexington, Va.	7:45 p.m.
7	30	8/8/66	Staunton, Va.	9:50 a.m.
8	30	8/8/66	Stuart's Draft, Va.	10:43 a.m.
9	30	8/8/66	Stuart's Draft, Va.	10:59 a.m.
10	30	9/29/66	Deerfield, Va.	5:10 p.m.
11	30	9/29/66	Deerfield, Va.	5:50 p.m.
12	30	9/30/66	Deerfield, Va.	8:55 a.m.

* In seconds.

Table 8. Adult "alert call," March 20, 1966, Lexington, Virginia. No prediction

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	2	2	0	0	4	250
2	3	3	0	0	10	100
3	5	5	0	0	11	280
4	5	4	0	1	30	100
5	8	6	0	2	5	200
6	5	5	0	0	25	380
7	7	0	0	7	3	100
8	7	3	0	4	7	280
9	2	0	0	2	28	220
10	4	0	0	4	9	200
11	5	2	0	1	13	125
12	4	4	0	0	17	200

* to nearest second.

to nearest yard.

Table 9. Adult "alert call," April 19, 1966, Myaaka River State Park, Florida. No prediction.

Broadcast				
Number	Duration*	Date	Location	Time
1	60	10/4/66	Blacksburg, Virginia	10:29 a.m.
2	60	10/4/66	Walton, Virginia	10:40 a.m.
3	120	10/5/66	Newport, Virginia	12:30 p.m.
4	60	10/5/66	Newport, Virginia	12:50 p.m.
5	60	10/5/66	Newport, Virginia	1:07 p.m.

* In seconds.

Table 10. Adult "alert call," April 19, 1966, Myaaka River State Park, Florida. No prediction.

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	2	2	0	0	2	150
2	20	0	0	0	0	150
3	60	2	0	0	60	200
4	15	0	0	15	35	250
5	4	4	0	0	15	300

* In seconds.

\# In yards.

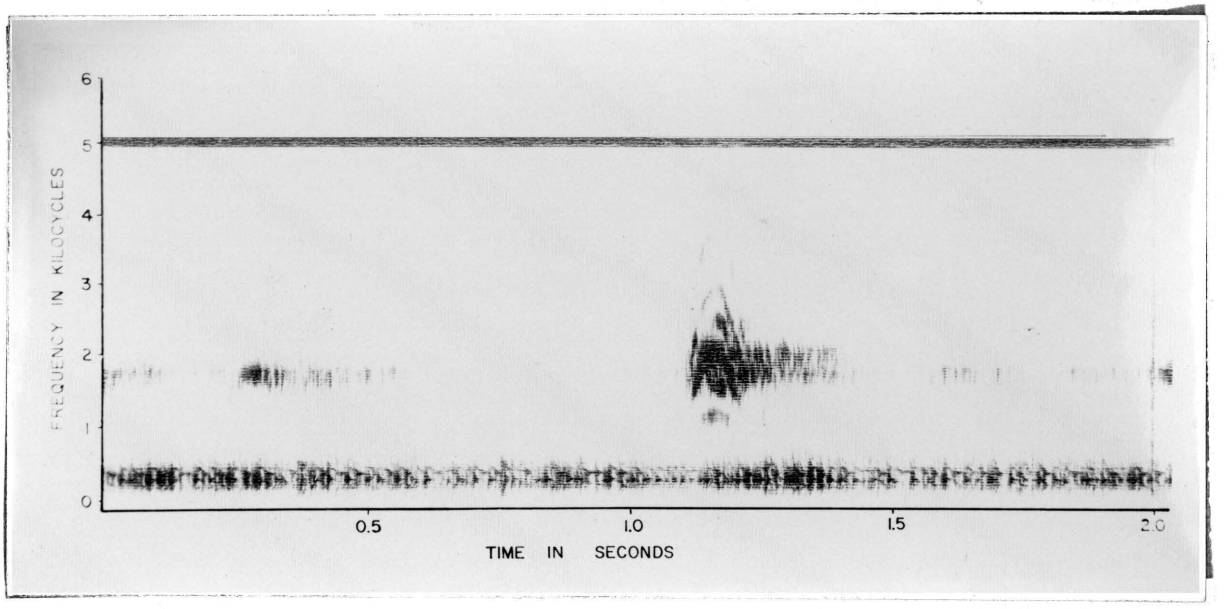

Fig. 17. "Dispersal" or "alarm call." One crow, sex and age unknown, October 30, 1965, Blacksburg, Virginia. Given at my approach to a crow.

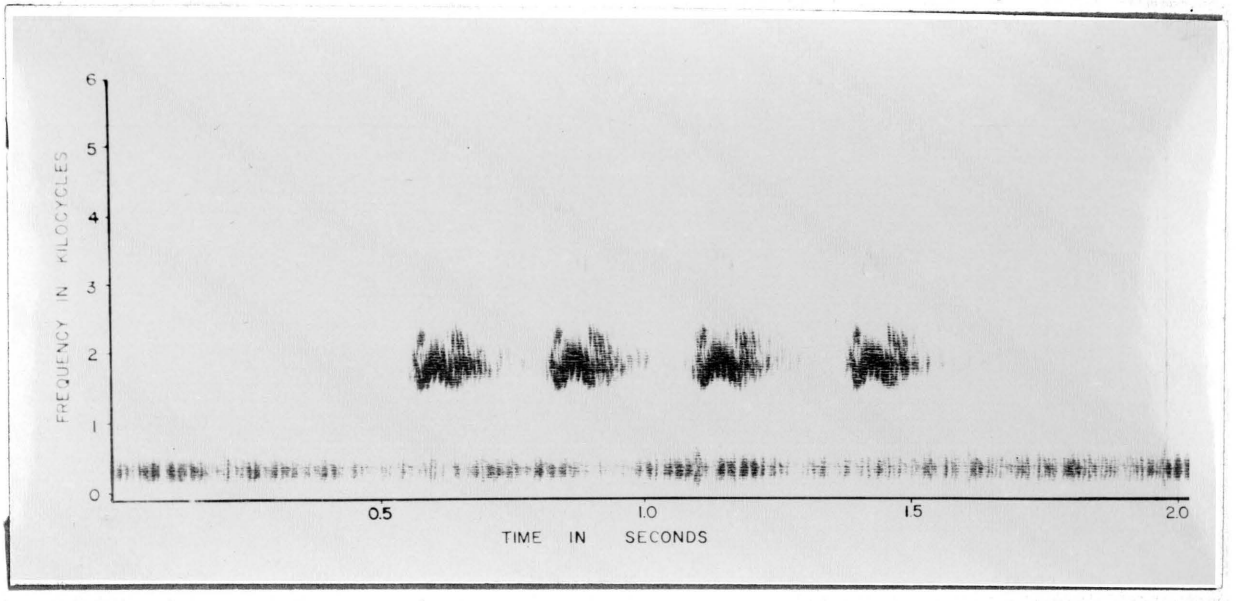

Fig. 18. "Dispersal" or "alarm call." One crow, sex and age unknown, October 30, 1965, Blacksburg, Virginia. Given at my approach to a crow.

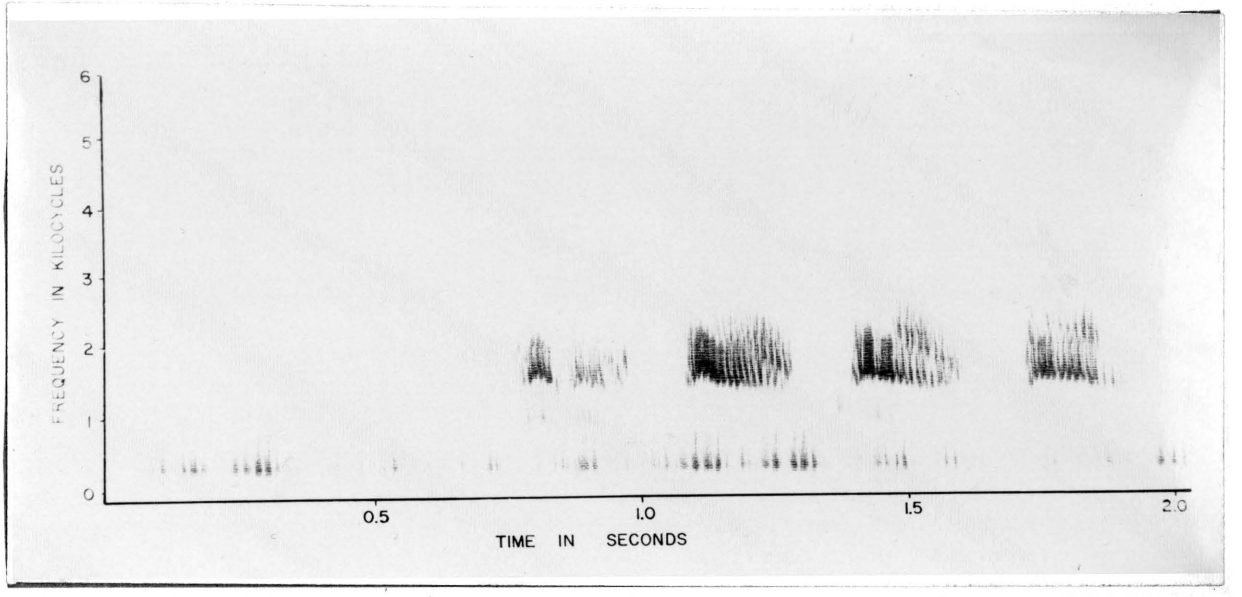

Fig. 19. "Dispersal" or "alarm call." One crow, sex and age unknown, April 18, 1966, Myaaka River State Park, Florida. Given at my approach to a crow.

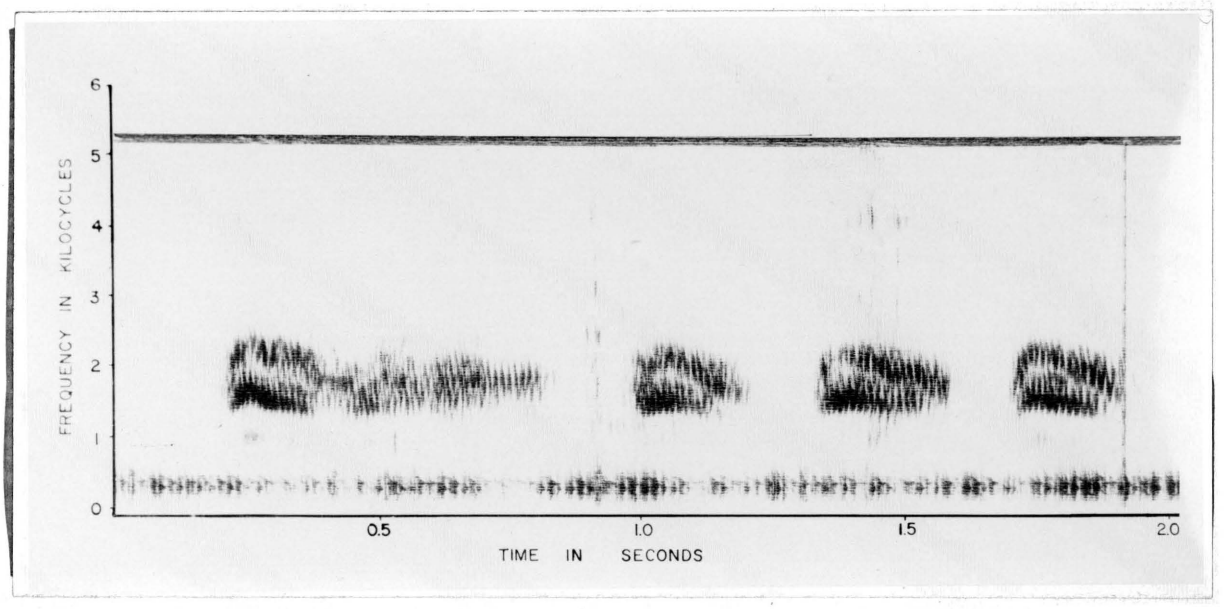

Fig. 20. "Dispersal" or "alarm call." One crow, sex and age unknown, April 18, 1966, Myaaka River State Park, Florida. Given at my approach to a crow.

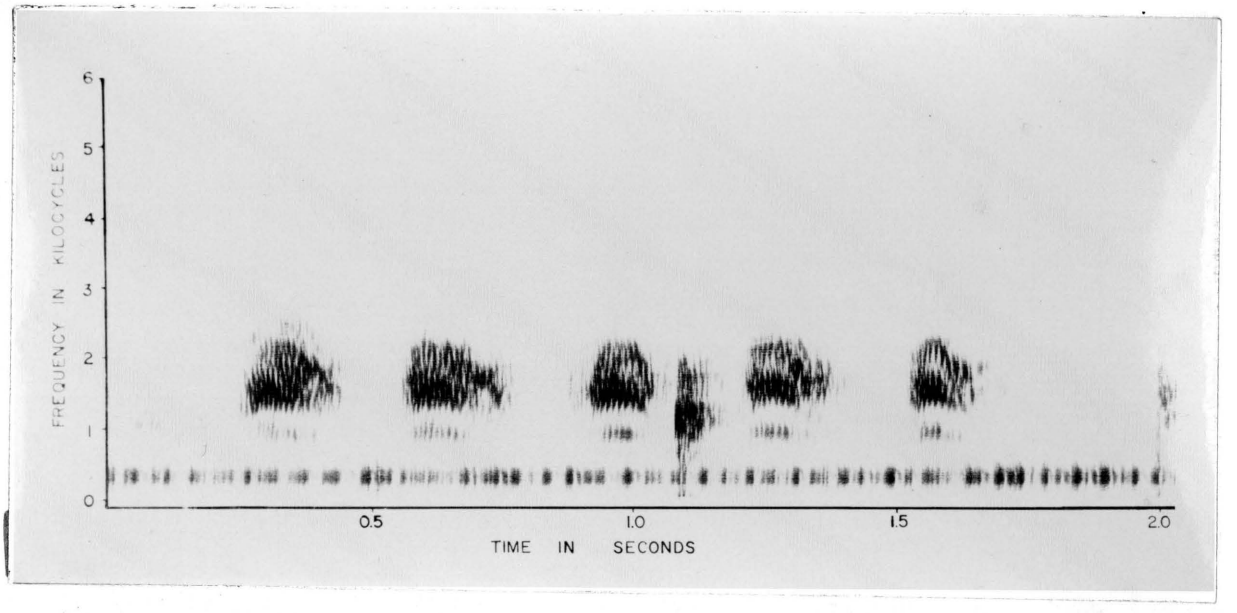

Fig. 21. "Dispersal" or "alarm call." One crow, sex and age unknown, April 20, 1966, Myaaka River State Park, Florida. Given at my approach to a crow.

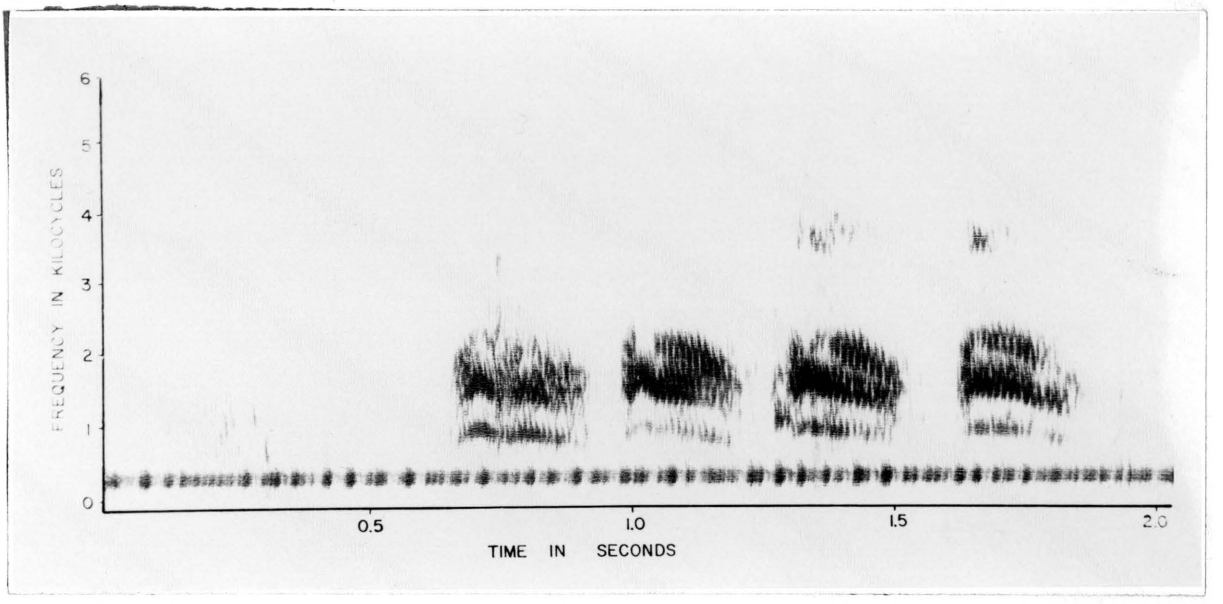

Fig. 22. "Dispersal" or "alarm call." One crow, sex and age unknown, April 18, 1966, Myaaka River State Park, Florida. Given at my approach to a crow.

the "alarm call" (Tables 11-15). Note number apparently does not convey different degrees of danger to responding crows.

"Dispersal calls" are commonly given by crows in roosts after sighting danger. These calls result in hundreds of crows rising out of trees and flying high in the air with members of the disturbed flock giving "simple scolding" and "assembly calls."

Frings (1964) stated, "If a crow suddenly flies away from the group without making any sound, the others usually take off with it. It has silently spread an alarm--the fastest and safest way." I have caused the "sentry" of ground feeding crows to fly three times during this study without emission of a dispersal call. The other flock members generally left the area only after sighting the danger, and not the fleeing "sentry."

Postures associated with the "dispersal call" were not noted.

"Distress Call"

"Distress calls" vary widely dependent on the gravity of the distress situation. For example, "distress" notes are delivered intensively and rapidly by a crow which has been shaken vigorously, but less intensively and rapidly when shaken slowly (Figs. 23-24, 26-28). It should be noted that variation in the intensity of "distress calls" is not well documented in the literature.

Common and fish crows respond to immature and adult common crow "distress calls" by aggregating to this sound source (Tables 16-18). At night, common crows will fly to distress signals broadcasted near a

Table 11. Adult "dispersal call", April 18, 1966, Myaaka River State Park, Florida

Broadcast				
Number	Duration*	Date	Location	Time
1	60	6/2/66	McCoy, Virginia	8:31 a.m.
2	25	7/26/66	Lineboro, Maryland	6:55 p.m.
3	36	7/27/66	Lineboro, Maryland	7:30 a.m.
4	18	7/27/66	Lineboro, Maryland	7:50 a.m.
5	31	7/27/66	Hanover, Pa.	9:25 a.m.
6	31	7/27/66	Hanover, Pa.	9:45 a.m.
7	31	7/28/66	Manchester, Md.	6:00 p.m.
8	24	7/29/66	Frederick, Maryland	1;05 p.m.
9	20	7/29/66	Strasburg, Virginia	4:35 p.m.
10	6	7/30/66	Goshen, Virginia	10:20 a.m.
11	30	8/7/66	Broad Run, Virginia	10:05 a.m.
12	30	8/7/66	Broad Run, Virginia	10:20 a.m.

* In seconds.

Table 12. Adult "dispersal call", April 18, 1966, Myaaka River State Park, Florida

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	1	0	1	0	8	200
2	3	0	3	0	12	250
3	7	0	7	0	2	180
4	2	0	2	0	2	300
5	6	0	6	0	1	230
6	2	2	0	0	2	350
7	6	4	2	0	1	180
8	3	0	3	0	15	200
9	21 fish crows	21	0	0	20	180
10	6	0	6	0	1	200
11	8	0	8	0	6	400
12	4	4	0	0	1	430

* In seconds.

\# In yards.

Table 13. Classification of adult "dispersal call"
Prediction: Dispersal from sound source

Broadcast Number	Class of Response				
	I	II	III	IV	V
1	X	-	-	-	-
2	X	-	-	-	-
3	X	-	-	-	-
4	X	-	-	-	-
5	X	-	-	-	-
6	-	-	-	-	X
7	-	-	X	-	-
8	X	-	-	-	-
9	-	-	-	-	X*
10	X	-	-	-	-
11	X	-	-	-	-
12	-	-	-	-	X
Total	8	-	1	-	3
Percent	67	-	8	-	25

* Fish Crows

Table 14. Adult "dispersal call", February 6, 1966, Riner, Virginia. No Prediction

Broadcast				
Number	Duration*	Date	Location	Time
1	60	3/10/66	Christiansburg, Va.	1:45 p.m.
2	60	3/10/66	Christiansburg, Va.	2:10 p.m.
3	60	3/10/66	Christiansburg, Va.	2:25 p.m.
4	60	3/10/66	Christiansburg, Va.	2:45 p.m.
5	60	3/10/66	Christiansburg, Va.	3:05 p.m.
6	60	3/10/66	Riner, Virginia	3:15 p.m.
7	60	3/10/66	Riner, Virginia	3:25 p.m.
8	60	3/10/66	Riner, Virginia	3:35 p.m.

* In seconds.

Table 15. Adult "dispersal call", February 6, 1966, Riner, Virginia. No prediction.

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	1	0	1	0	15	125
2	2	0	0	2	12	100
3	7	0	7	0	15	250
4	3	0	3	0	5	150
5	5	1	4	0	11	200
6	3	0	3	0	10	300
7	1	0	1	0	5	100
8	4	0	0	4	10	300

* In seconds.

In yards.

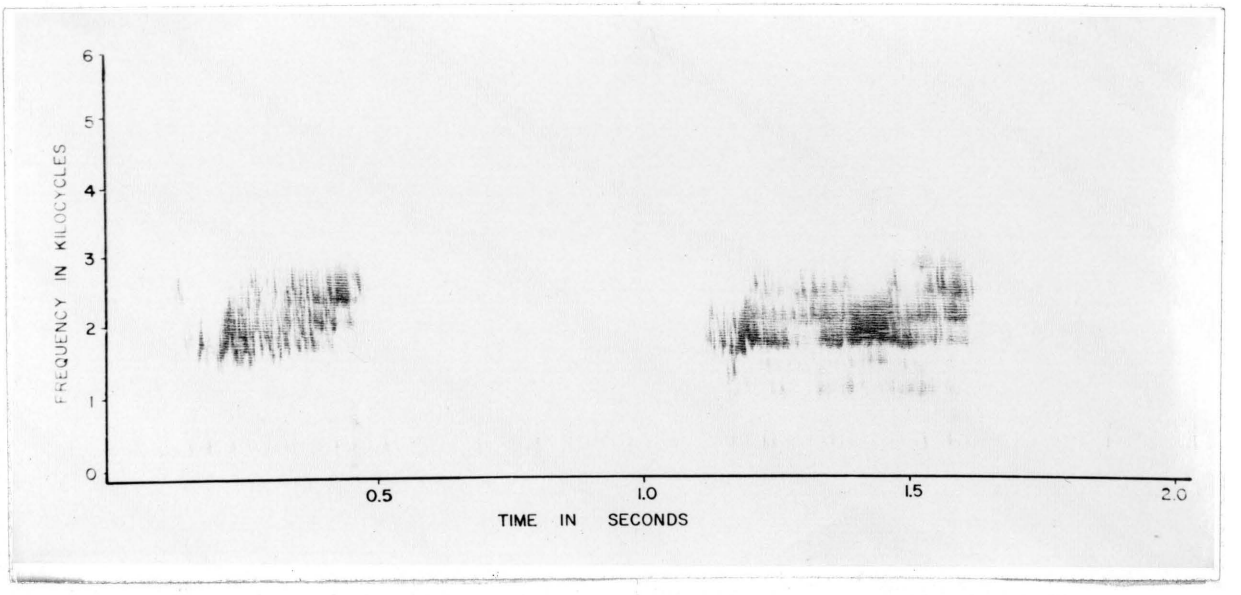

Fig. 23. "Distress call." One immature male, May 16, 1966, Blacksburg, Virginia. Held upside down by the legs and shook.

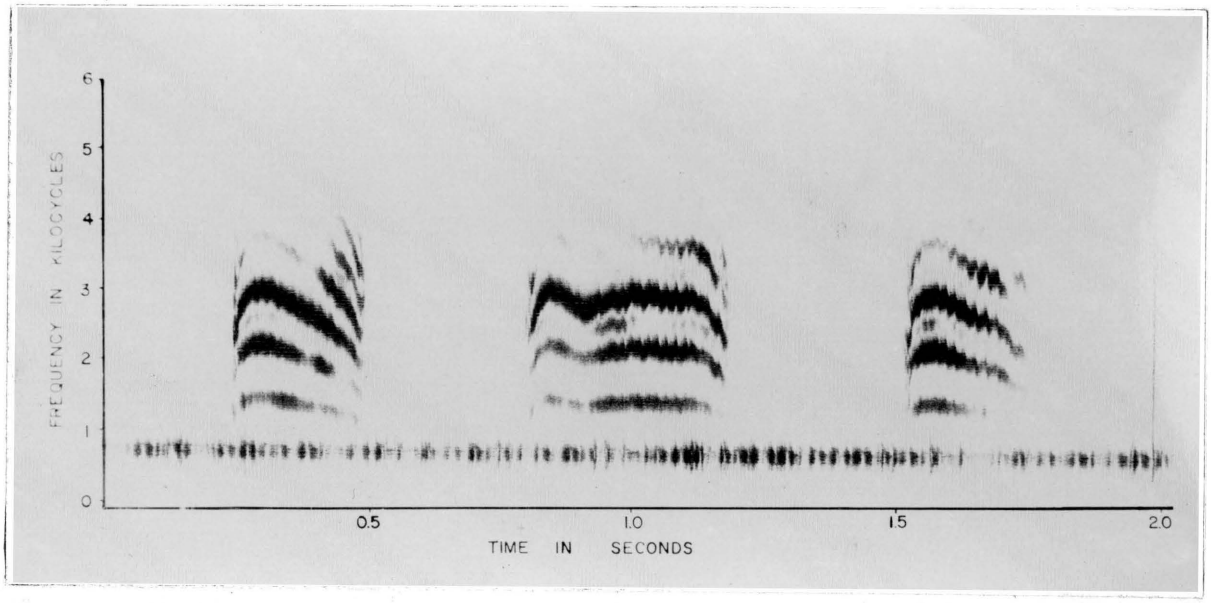

Fig. 24. "Distress call." One immature female, September 30, 1965, Blacksburg, Virginia. Held upside down by the legs and shook.

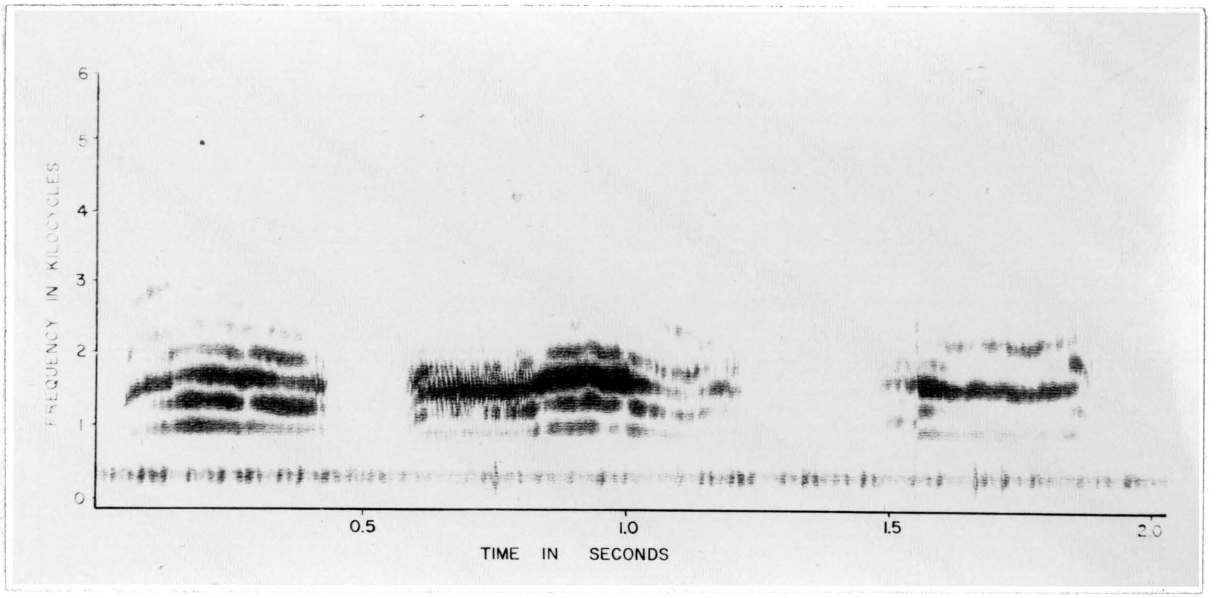

Fig. 25. "Distress call." One adult male, first week of July 1965, Wolcott, New York. Tape broadcasted in reverse at speed originally recorded. Held upside down by the legs and shook.

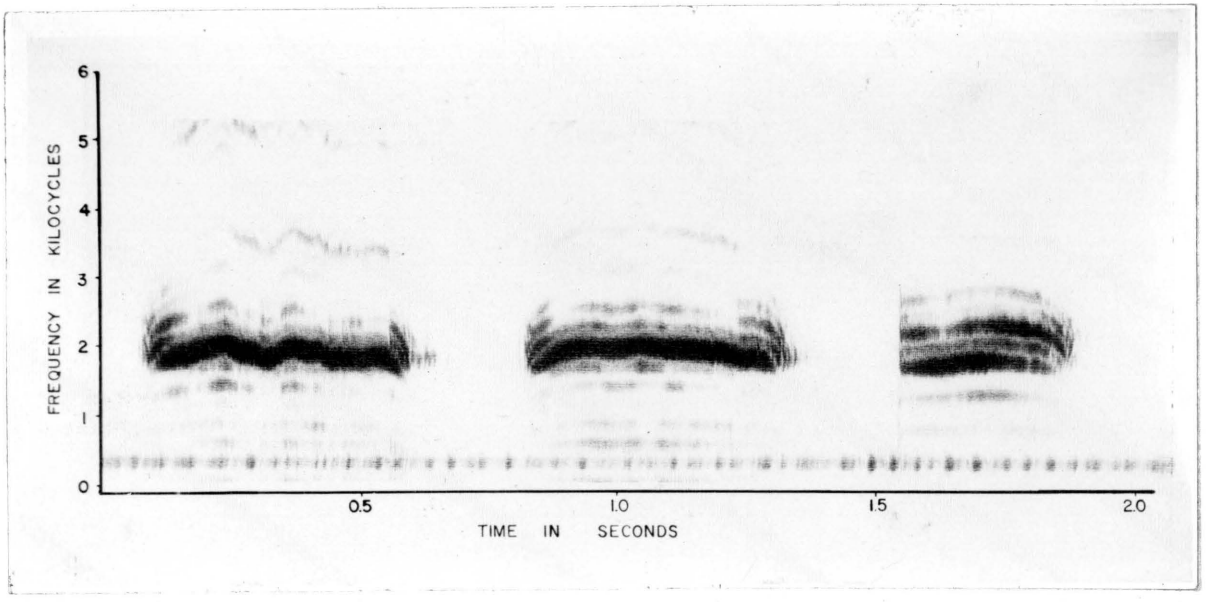

Fig. 26. "Distress call." One adult female, February 22, 1966, Riner, Virginia. Held upside down by the legs and shook.

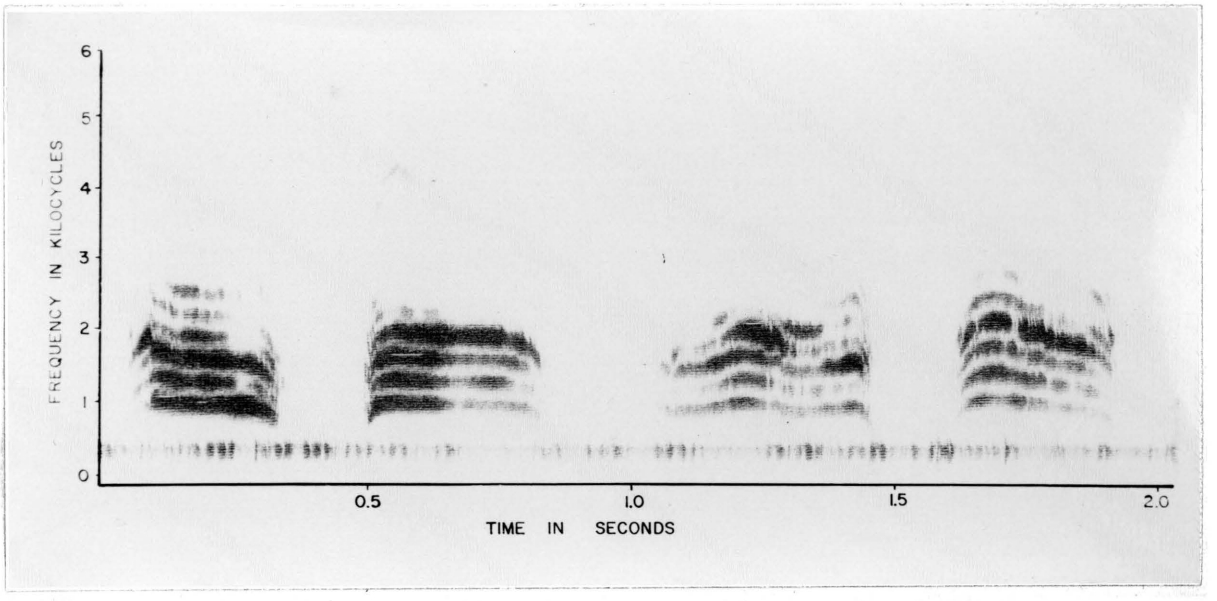

Fig. 27. "Distress call." One adult male, first week of July 1965, Wolcott, New York. Held upside down by the legs and shook.

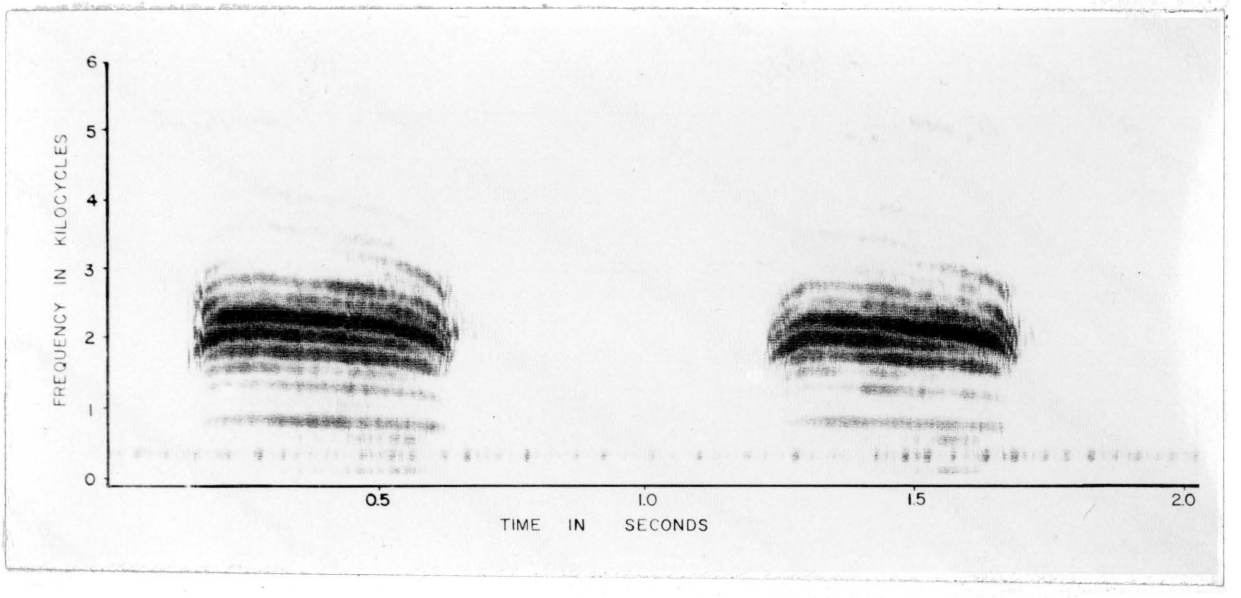

Fig. 28. "Distress call." One adult female, February 22, 1966, Blacksburg, Virginia. Held upside down by the legs and shook.

Table 16. Adult "distress call", first week of July, 1965, Wolcott, New York

Number	Duration*	Broadcast Date	Location	Time
1	300	2/3/66	Blacksburg, Virginia	1:30 p.m.
2	300	2/3/66	Blacksburg, Virginia	2:00 p.m.
3	300	2/3/66	Blacksburg, Virginia	2:50 p.m.
4	300	2/3/66	McCoy, Virginia	3:20 p.m.
5	300	2/3/66	McCoy, Virginia	3:50 p.m.
6	300	2/3/66	McCoy, Virginia	4:10 p.m.
7	300	2/3/66	McCoy, Virginia	4:30 p.m.
8	60	12/19/65	Staunton, Virginia	2:12 p.m.
9	60	12/19/65	Staunton, Virginia	2:45 p.m.
10	60	12/19/65	Staunton, Virginia	3:10 p.m.
11	60	12/19/65	Greenville, Virginia	3:31 p.m.
12	60	12/19/65	Staunton, Virginia	4:10 p.m.
13	60	1/8/66	Newport, Virginia	1:26 p.m.
14	60	1/8/66	Newport, Virginia	1:32 p.m.
15	60	1/8/66	Newport, Virginia	1:40 p.m.
16	60	12/17/65	Staunton, Virginia	2:05 p.m.
17	60	12/17/65	Staunton, Virginia	2:30 p.m.
18	60	12/17/65	Staunton, Virginia	2:35 p.m.
19	60	12/17/65	Staunton, Virginia	2:45 p.m.
20	60	12/17/65	Staunton, Virginia	2:55 p.m.
21	60	12/18/65	Staunton, Virginia	11:24 a.m.
22	60	12/18/65	Staunton, Virginia	11:31 a.m.
23	60	12/18/65	Middlebrook, Va.	11:50 a.m.
24	60	12/18/65	Middlebrook, Va.	12:07 p.m.
25	60	12/18/65	Middlebrook, Va.	12:15 a.m.

* In seconds.

Table 17. Adult "distress call", first week of July, 1965, Wolcott, New York

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	12	12	0	0	5	250
2	32	32	0	0	20	300
3	9	9	0	0	11	75
4	50	25	0	25	3	125
5	7	7	0	0	5	100
6	5	5	0	0	10	150
7	3	3	0	0	7	200
8	6	2	0	4	4	600
9	6	6	0	0	5	150
10	1	1	0	0	6	600
11	4	4	0	0	4	400
12	275	275	0	0	5	300
13	4	4	0	0	4	280
14	92	92	0	0	10	500
15	47	47	0	0	47	350
16	250	250	0	0	3	150
17	7	7	0	0	15	150
18	450	450	0	0	10	300
19	400	400	0	0	8	150
20	55	55	0	0	8	150
21	6	6	0	0	3	250
22	8	8	0	0	5	200
23	3	3	0	0	15	200
24	63	53	0	10	1	150
25	6	6	0	0	2	250

* To nearest second.

Estimated yards.

Table 18. Classification of adult "distress call" Prediction: Aggregation to sound source

Broadcast Number	Class of Response				
	I	II	III	IV	V
1	X	-	-	-	-
2	X	-	-	-	-
3	X	-	-	-	-
4	-	-	X	-	-
5	X	-	-	-	-
6	X	-	-	-	-
7	X	-	-	-	-
8	-	-	X	-	-
9	X	-	-	-	-
10	X	-	-	-	-
11	X	-	-	-	-
12	X	-	-	-	-
13	X	-	-	-	-
14	X	-	-	-	-
15	X	-	-	-	-
16	X	-	-	-	-
17	X	-	-	-	-
18	X	-	-	-	-
19	X	-	-	-	-
20	X	-	-	-	-
21	X	-	-	-	-
22	X	-	-	-	-
23	X	-	-	-	-
24	-	-	X	-	-
25	X	-	-	-	-
Total	22	-	3	-	-
Percent	88	-	12	-	-

roost. This response was noted at 9:45 p.m. on January 11, 1966 at a crow roost near Staunton, Virginia. Crows emitted "mobbing calls" over the sound source before settling back into conifers approximately 200 yards from those previously occupied. The roost was not abandoned the following night. The broadcasting of "distress calls" of the European jackdaw elicited a negative response at night near French crow roosts, causing birds of several species to desert the roosts permanently (Frings, et al., 1958).

Crows emit "assembly" and "simple scolding calls" in response to "distress" signals. They apparently are attracted to the sound source with intent to "mob" the intruding predator. Between 4:30 and 6:00 p.m. on January 15, 1965, adult "distress calls" were broadcasted, by reversing the tape, to a crow roost near Staunton, Virginia. Crows within broadcast range responded by aggregating to the sound source in spite of tape reversal (Fig. 25).

"Distress calls" are given by common crows throughout the year, day and night.

Common crows emit "distress calls" when they are caught by a predator such as a hawk or fox. Holding an immature (Fig. 29) or adult crow upside down by its legs and shaking it causes a similar vocalization. "Distress calls" are uttered by a crow that is trying to escape from such a predator while struggling and fighting.

Fig. 29. A crow giving "distress calls."

"Pre-mortality" or "Death Call"

Crows show variable response to this vocalization. In 20 tests, crows exhibited positive phonotaxis in five, negative phonotaxis in seven, and eight other responses (Tables 19-21).

"Pre-mortality calls" are uttered throughout the year, day and night, by common crows.

"Pre-mortality" vocalization (Fig. 30) is the extreme "distress call" of the common crow. It is given by a crow in any situation just prior to death. "Pre-mortality calls" are less intense, and more raucous and gurgling than the screaming "distress" notes. A crow normally does not struggle with or fight off a predator while giving these calls because of its weakened condition.

"Defensive Threat Call"

"Defensive threat" vocalization is variable in delivery. Crows responded to five field tests in an unpredictable manner (Tables 22-23). Subjectively, it is given as screams, cackles, staccato variations, coos, and sounds not unlike a degree of the "distress call." It is uttered by a crow either under attack or while attacking a predator or another crow (Figs. 31-32).

"Threat calls" are the principal vocalization heard among night roosting crows. Just before and after sundown, crows in nocturnal roosts apparently compete for roosting perches. Crows attempt to dislodge established crows from their roosting perches. Crows, either under attack or themselves attacking a roosting crow, utter "defensive threat

Table 19. Immature "pre-mortality call", December 15, 1965, Blacksburg, Virginia

Number	Duration*	Broadcast Date	Location	Time
1	60	12/18/65	Newport, Virginia	1:20 p.m.
2	60	12/18/65	Newport, Virginia	1:54 p.m.
3	60	12/18/65	Newport, Virginia	2:08 p.m.
4	60	12/18/65	Newport, Virginia	2:20 p.m.
5	60	12/18/65	Newport, Virginia	3:00 p.m.
6	60	2/2/66	Riner, Virginia	1:30 p.m.
7	60	2/2/66	Christiansburg, Va.	2:00 p.m.
8	60	2/2/66	Christiansburg, Va.	2:20 p.m.
9	60	2/2/66	Christiansburg, Va.	2:40.p.m.
10	60	2/2/66	Christiansburg, Va.	3:00 p.m.
11	60	2/2/66	Christiansburg, Va.	3:10 p.m.
12	60	2/2/66	Christiansburg, Va.	3:30 p.m.
13	60	6/7/66	Craig Springs, Va.	2:52 p.m.
14	60	6/7/66	Simmonsville, Va.	4:33 p.m.
15	60	6/7/66	Simmonsville, Va.	4:57 p.m.
16	60	10/3/66	Prices Fork, Va.	11:01 a.m.
17	60	10/3/66	McCoy, Virginia	11:30 a.m.
18	60	10/3/66	Newport, Virginia	11:59 a.m.
19	120	10/3/66	Spruce Run, Va.	12:37 p.m.
20	60	10/3/66	Spruce Run, Va.	12:55 p.m.

* In seconds.

Table 20. Immature "pre-mortality call", December 15, 1965, Blacksburg, Virginia

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	3	3	0	0	15	350
2	4	4	0	0	35	300
3	3	3	0	0	5	200
4	1	0	1	0	2	200
5	21	7	13	0	2	250
6	1	0	1	0	1	125
7	100	1	0	2	12	300
8	15	3	12	0	20	400
9	2	0	0	0	0	250
10	30	8	22	0	2	250
11	60	0	25	20	7	300
12	2	0	0	0	0	200
13	10	7	3	0	1	250
14	3	0	3	0	1	250
15	4	0	4	0	1	125
16	16	1	15	0	7	175
17	3	0	3	0	20	175
18	8	8	0	0	12	300
19	80	10	0	70	12	400
20	1	0	1	0	14	450

* To nearest second.

Estimated yards.

Table 21. Classification of immature "pre-mortality call"
Prediction: Aggregation to sound source

Broadcast Number	Class I	II	III	IV	V
1	-	X	-	-	-
2	X	-	-	-	-
3	X	-	-	-	-
4	-	-	-	-	X
5	X	-	-	-	-
6	-	-	-	-	X
7	-	X	-	-	-
8	-	-	X	-	-
9	-	-	-	X	-
10	-	-	X	-	-
11	-	-	-	-	X
12	-	-	-	X	-
13	-	-	X	-	-
14	-	-	-	-	X
15	-	-	-	-	X
16	-	-	X	-	-
17	-	-	-	-	X
18	X	-	-	-	-
19	X	-	-	-	-
20	-	-	-	-	X
Total	5	2	4	2	7
Percent	25	10	20	10	35

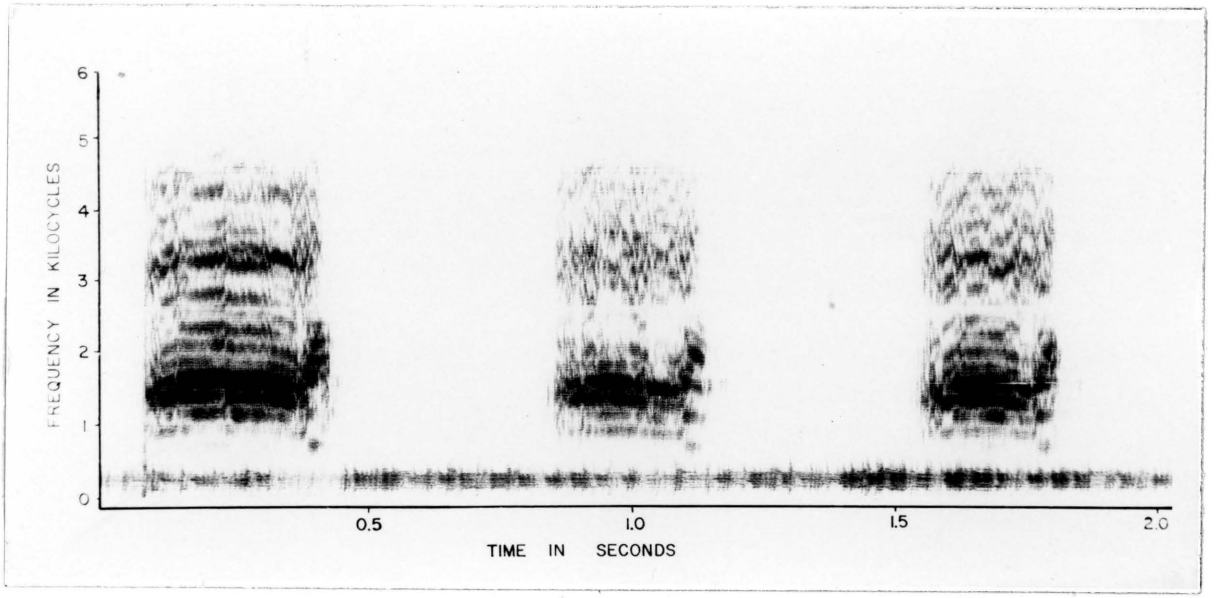

Fig. 30. "Pre-mortality" or "death call." One immature female, December 15, 1965, Newport, Virginia. A crow bleeding to death.

Table 22. Adult "defensive threat call", March 6, 1966, Blacksburg, Virginia. No prediction.

Number	Duration*	Broadcast Date	Location	Time
1	60	3/18/66	Roanoke Valley, Va.	6:30 p.m.
2	60	3/18/66	Roanoke Valley, Va.	7:00 p.m.
3	60	3/18/66	Roanoke Valley, Va.	7:30 p.m.
4	60	3/18/66	Roanoke Valley, Va.	7:45 p.m.
5	60	9/29/66	Churchville, Va.	1:35 p.m.

* In seconds.

Table 23. Adult "defensive threat call", March 6, 1966, Blacksburg, Virginia. No prediction.

Broadcast number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	3	1	2	0	4	300
2	4	3	1	0	7	400
3	3	2	0	1	30	300
4	6	5	1	0	10	400
5	3	2	1	0	12	300

* In seconds.

\# In yards.

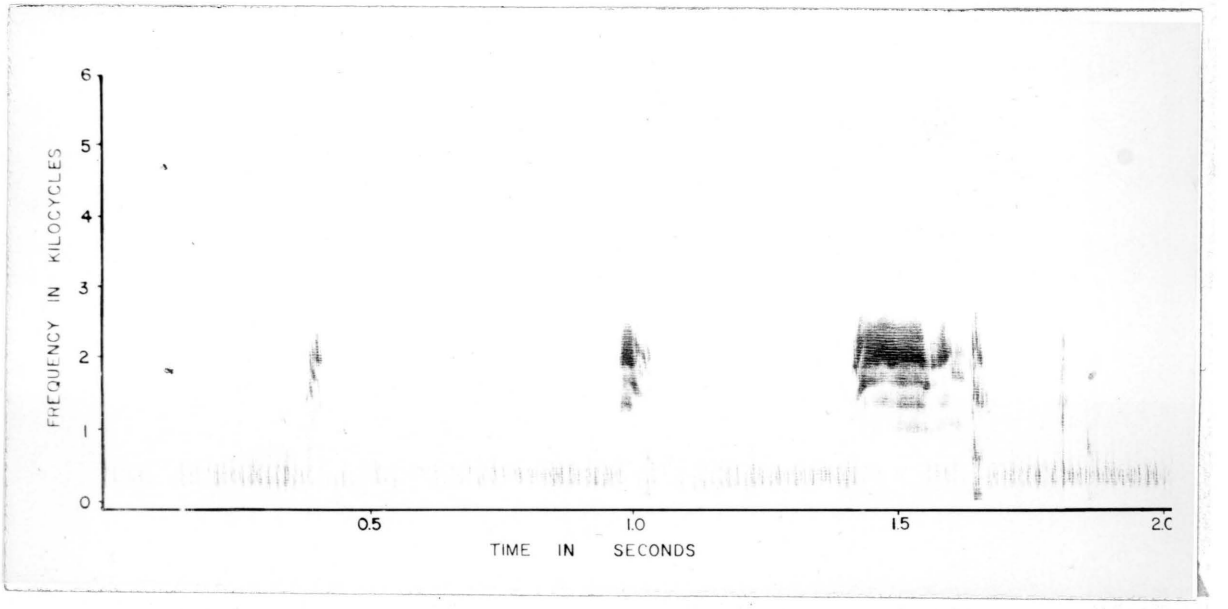

Fig. 31. "Defensive threat call." One adult female, May 20, 1966, Blacksburg, Virginia. A crow being slapped.

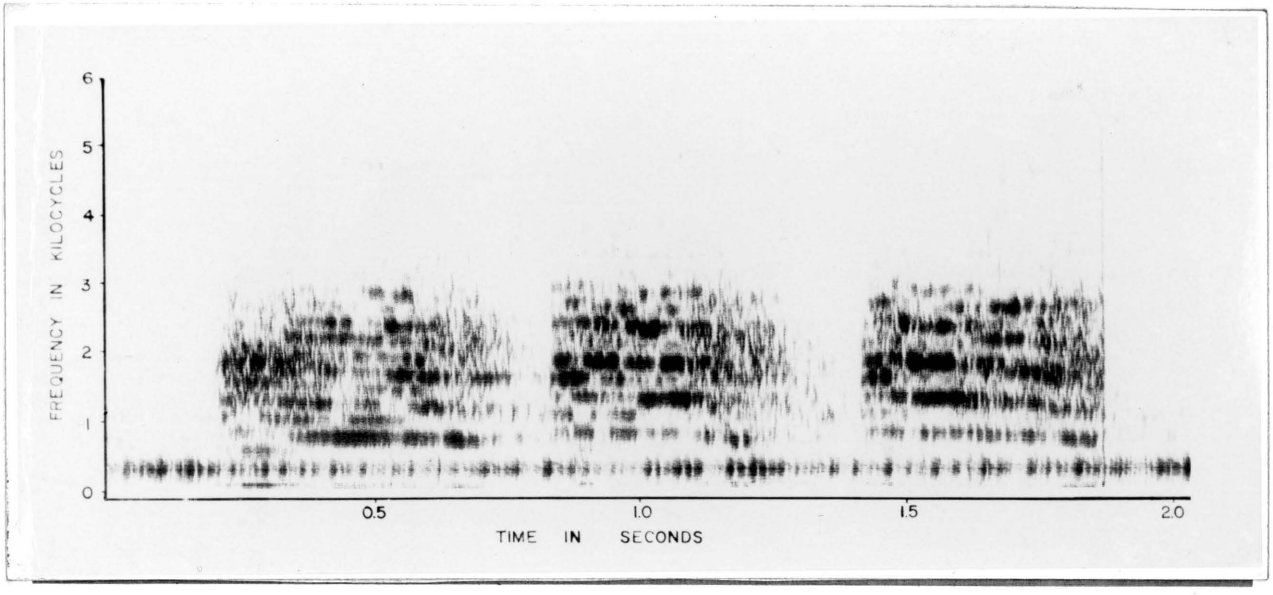

Fig. 32. "Defensive threat call." One adult female, March 6, 1966, Blacksburg, Virginia. Fighting an adult male in a cage.

calls." The function of these signals is apparently to cause threatened crows or predators to avoid this sound.

On April 20, 1966 the investigator noted an adult common crow emitting "defensive threat" signals when diving upon a turkey vulture (Carthartes aura). This attack occurred near a crow's nest containing three fledglings.

"Modified defensive threat" or "growl calls" (Good, 1952) are given by common crows when diving at or pursuing at very close range (Fig. 33) a predator such as a hawk or owl. Prior to diving at a flying predator, a crow will hover on beating wings, followed by an erratic descent with dihedral wings closed over the rump. The legs were observed extended with open claws in eight observations and the "growl call" emitted when the crow passed close to the predator. The crow flaps to regain altitude after the dive. "Assembly" and "simple scolding calls" are also emitted by crows while mobbing a raptor, but give way to "growl calls" when a crow is within striking distance of a predator.

"Growl calls" are emitted throughout the year.

During "defensive threat" vocalization the neck, nape, throat, and head feathers are erect and appear ruffled. The wings move back and up when the bird rears back while under attack by another crow or predator. The wings may be drooped and spread, and the head lowered between the legs prior to attacking or being attacked by a predator or another crow.

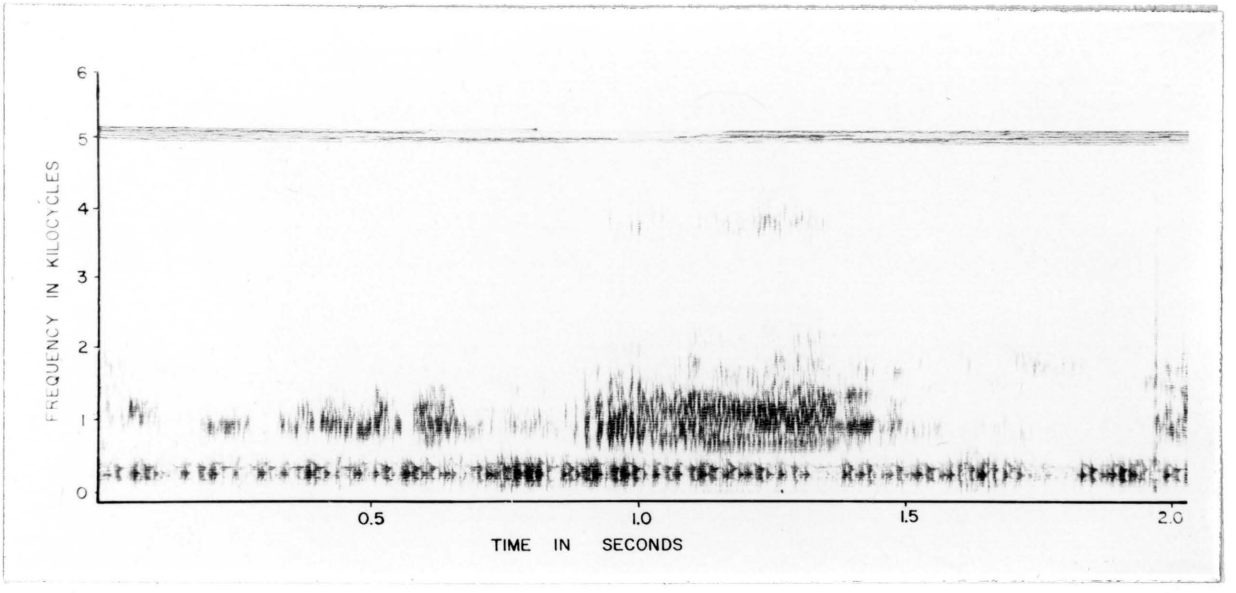

Fig. 33. "Modified defensive threat" or "growl call." One crow, sex and age unknown, April 20, 1966, Myaaka River State Park, Florida. One crow aerially pursuing another crow.

"Frustration Notes"

"Frustration notes" (Fig. 34) represent a mild degree of the "defensive threat" series emitted when a crow apparently is frustrated by a situation. For example, on September 29, 1965 in Blacksburg, Virginia, I attempted unsuccessfully to pull a dried bread roll from an immature female pet crow. It resisted my efforts by pulling on the roll and uttered "frustration notes" during the attempted withdrawal of food. The crow did not try to bite or claw me.

"Frustration notes" are given throughout the year.

Immature "Hunger" and "Feeding Call"

Immature common crows beg for food when stimulated by hunger, seeing food, seeing or hearing objects associated with food, or by a combination of any or all of these factors (Figs. 35-39).

I have raised pet crows that associated food with a human voice when talking accompanied hand feeding. The birds would cease their insistant "hunger calls" when I concealed myself or didn't talk, but they promptly resumed their vocalization when I reappeared or talked.

"Hunger calls" elicited variable responses among crows (Tables 24-27). Frings, et al. (1958) stated that "hunger calls" showed no observable effects on the movements of crows when field tested. However, during my research these calls resulted in a positive phonotaxic response among immatures out of the nest. On July 11, 1966 near Simmonsville, Virginia, I observed a juvenile common crow perched in a tree giving "hunger calls." They were delivered slowly at first but

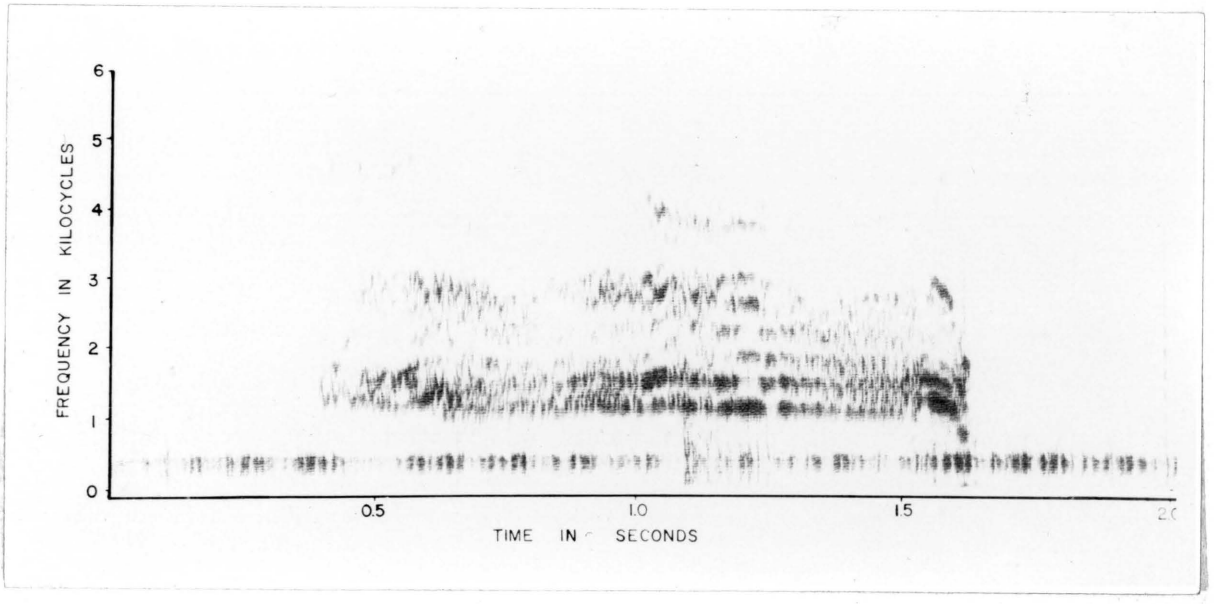

Fig. 34. "Frustration notes." One immature female, September 29, 1965, Blacksburg, Virginia. Given when pulling a bread roll away from a crow.

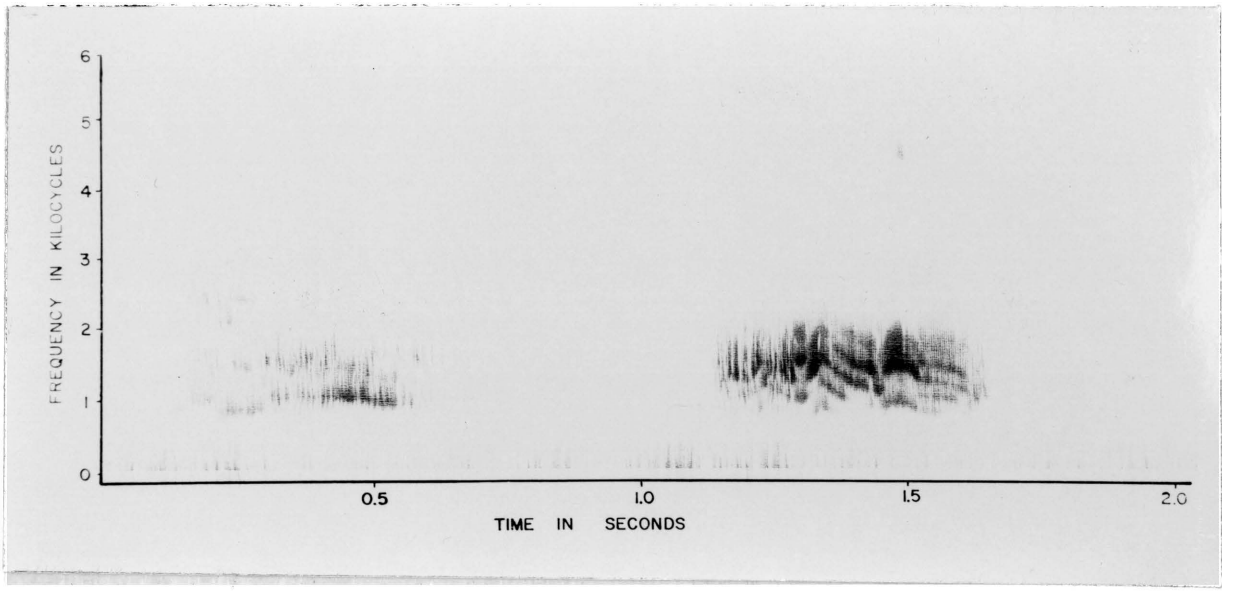

Fig. 35. "Hunger call." One adult female, September 4, 1965, Rochester, New York. Given prior to being fed.

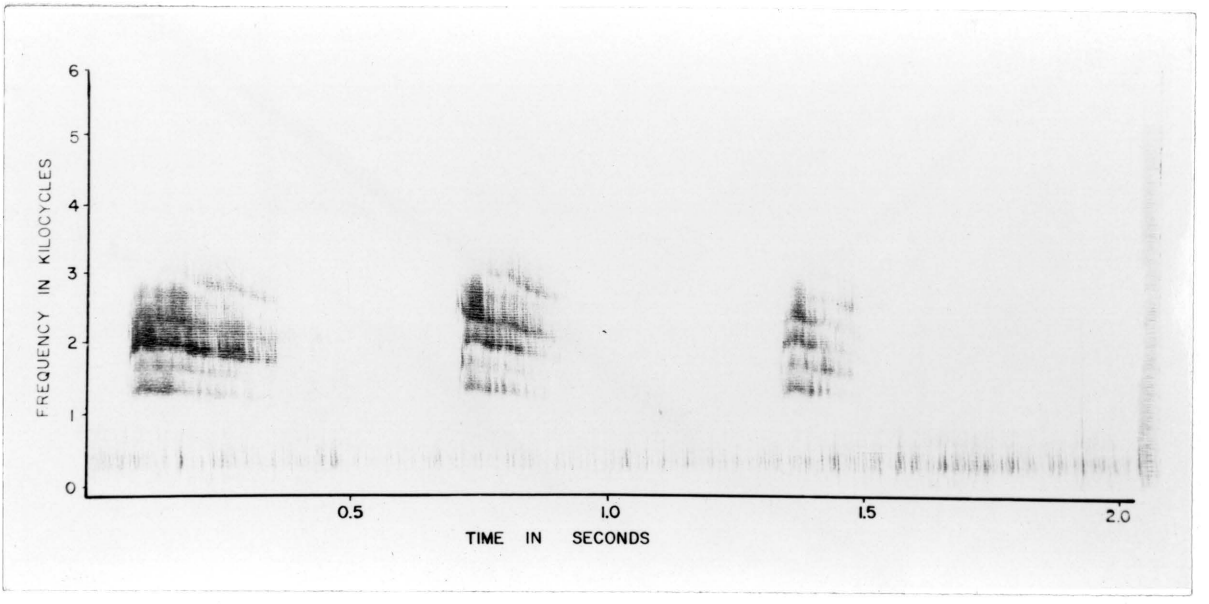

Fig. 36. "Hunger call." One immature male, May 28, 1966, Blacksburg, Virginia. Given prior to being fed.

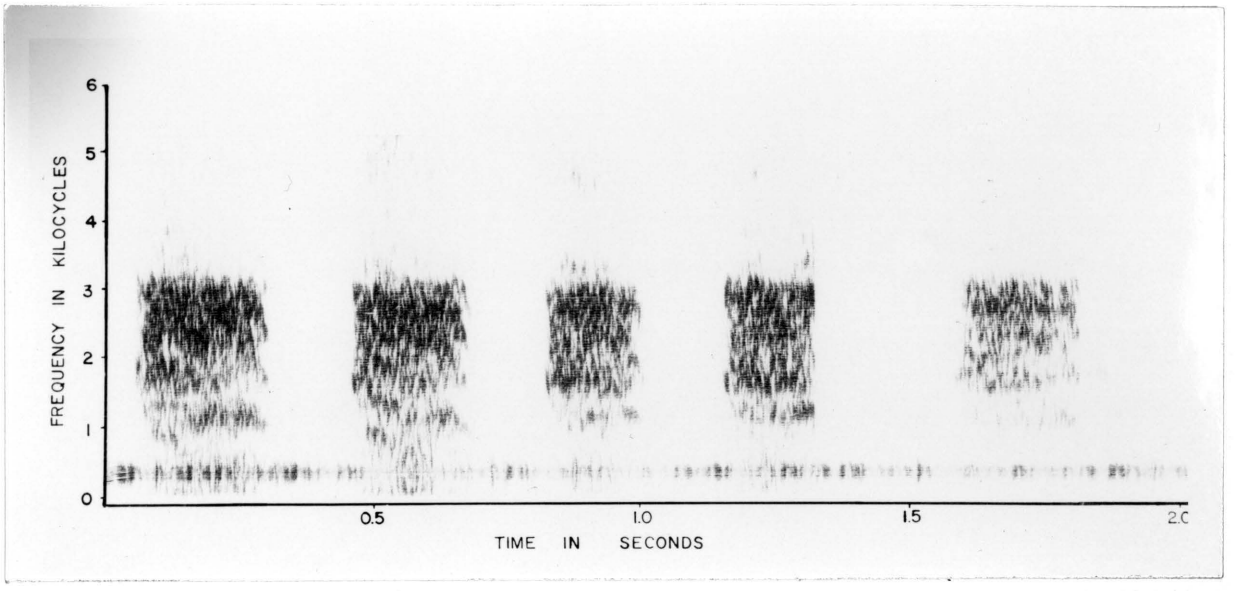

Fig. 37. "Hunger call." One immature female, fourth week of May 1965, Lexington, Virginia. Given prior to being fed.

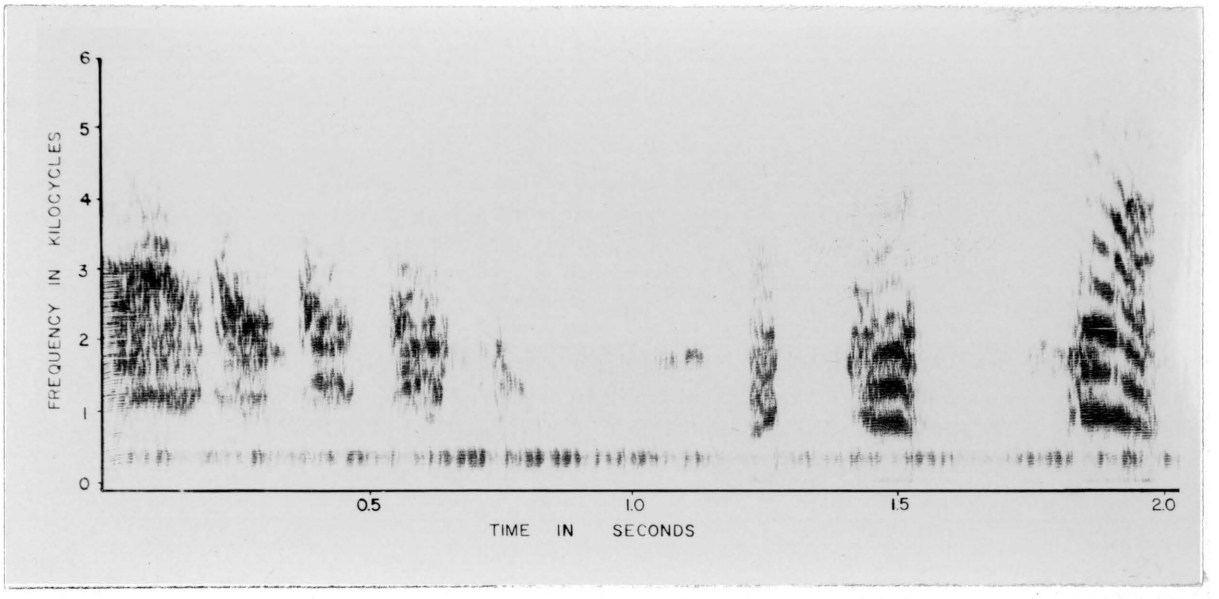

Fig. 38. "Feeding call." One immature female, fourth week of May 1965, Blacksburg, Virginia. Given by a crow swallowing food.

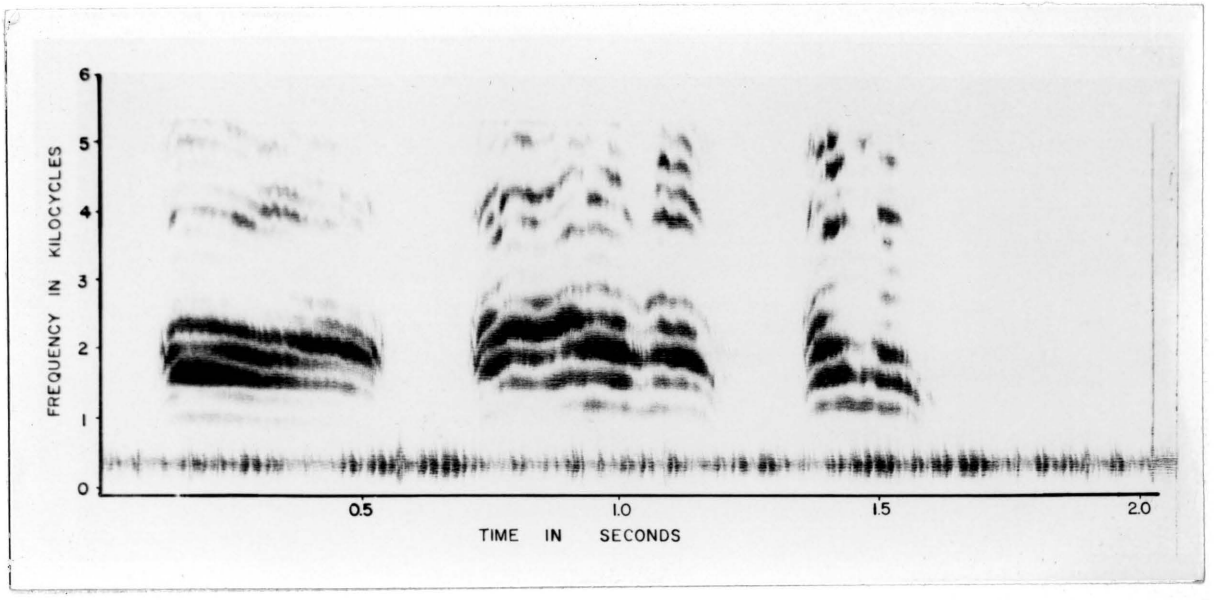

Fig. 39. "Hunger" and "feeding calls." One immature crow, sex unknown, April 21, 1963, Everglades National Park, Florida. Given before and after being fed.

Table 24. Immature "hunger" and "feeding call", May 1965, Blacksburg, Virginia. No prediction.

Number	Duration*	Broadcast Date	Location	Time
1	60	2/13/66	Prices Fork, Virginia	11:50 a.m.
2	60	2/13/66	Prices Fork, Virginia	12:10 p.m.
3	60	2/13/66	Radford, Virginia	12:25 p.m.
4	60	2/13/66	Radford, Virginia	1:00 p.m.
5	60	2/13/66	Radford, Virginia	1:35 p.m.
6	90	2/20/66	Weyer's Cave, Va.	11:00 a.m.
7	60	2/20/66	Harrisonburg, Va.	11:30 a.m.
8	60	2/20/66	Harrisonburg, Va.	12:00 noon
9	60	2/20/66	Harrisonburg, Va.	12:25 p.m.
10	180	2/20/66	Blacksburg, Virginia	1:50 p.m.
11	60	3/26/66	Hayfield, Virginia	8:00 a.m.
12	60	3/26/66	Hayfield, Virginia	8:30 a.m.
13	60	3/36/66	Gainsboro, Virginia	8:50 a.m.
14	60	3/26/66	Gainsboro, Virginia	9:15 a.m.
15	60	3/26/66	Gainsboro, Virginia	9:35 a.m.

* In seconds.

Table 25. Immature "hunger" and "feeding call", May 1965, Blacksburg, Virginia. No prediction. Continued.

Broadcast				
Number	Duration*	Date	Location	Time
16	60	3/1/66	Shawsville, Virginia	1:00 p.m.
17	60	3/1/66	Shawsville, Virginia	1:20 p.m.
18	60	3/1/66	Shawsville, Virginia	2:20 p.m.
19	60	3/1/66	Shawsville, Virginia	3:00 p.m.
20	60	3/8/66	Mt. Lake, Virginia	1:15 p.m.
21	120	5/13/66	Blacksburg, Virginia	4:15 p.m.
22	120	5/13/66	Prices Fork, Virginia	5:30 p.m.
23	120	5/14/66	Deerfield, Virginia	2:05 p.m.
24	120	5/14/66	Deerfield, Virginia	2:33 p.m.
25	120	5/14/66	Deerfield, Virginia	2:51 p.m.
26	120	5/15/66	Lexington, Virginia	12:34 p.m.
27	120	5/16/66	Blacksburg, Virginia	5:50 p.m.
28	120	5/16/66	Blacksburg, Virginia	6:25 p.m.
29	60	3/24/66	Gore, Virginia	12:30 p.m.
30	60	3/24/66	Gore, Virginia	12:50 p.m.

* In seconds.

Table 26. Immature "hunger" and "feeding call", May 1965, Blacksburg, Virginia. No prediction.

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	2	0	2	0	4	200
2	5	1	4	0	3	150
3	3	0	3	0	7	250
4	4	0	4	0	2	200
5	11	0	11	0	3	100
6	17	0	0	17	8	180
7	5	0	5	0	7	200
8	5	4 fish crows	1	0	25	250
9	4	2	0	2	4	350
10	2	0	0	2	10	350
11	3	0	0	3	10	200
12	5	2	0	3	17	250
13	11	0	0	11	15	180
14	3	3	0	0	10	200
15	20	0	0	20	20	300

* In seconds.

\# In yards.

Table 27. Immature "hunger" and "feeding call", May 1965, Blacksburg, Virginia. No prediction. Continued.

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
16	9	0	0	0	0	400
17	7	1	0	6	3	200
18	5	5	0	0	5	100
19	30	0	0	30	10	300
20	3	3	0	0	4	70
21	80	3	0	77	5	250
22	2	2	0	0	20	400
23	3	3	0	0	5	250
24	1	0	0	0	0	300
25	4	0	0	4	15	300
26	2	0	2	0	7	250
27	3	1	0	2	16	300
28	4	0	0	2	30	300
29	3	0	0	0	0	250
30	3	3	0	0	15	200
31	7	2	5	0	25	150

* To nearest second.

Estimated yards.

more rapidly toward the end of the vocalization. A second immature walking in a cattle pasture approximately 100 yards from the first crow, flew toward the begging crow and lit near it in the same tree. It then emitted "hunger calls" in apparent anticipation of being fed by an adult nearby.

"Hunger calls" are subject to different degrees of delivery, dependent on the amount and proximity of food in relation to the calling bird. The greater the stimulus, the faster and more intense is the delivery of these calls.

Generally, "hunger calls" are not uttered after an immature common crow attains 14 weeks of age. It then has the ability to forage for itself.

"Hunger calls" are given by adult crows when they are deprived of food. This statement is based on my observation of three crows in captivity.

Nestling crows commonly give "hunger calls" in response to other crow vocalizations, e.g., the "simple scolding" and "assembly calls" of adults near the nest.

Immature "hunger calls" also function as "location notes," allowing parental crows to re-establish contact with their young.

While food begging in or out of the nest, immature common crows move their wings rapidly and repeatedly dorsally and ventrally away from the body. The tail also moves dorsally and ventrally during the pre-feeding posture. The beak is open during food begging until approximately

ten weeks old, when "hunger calls" are emitted with a closed beak. The bright-red mouth is evident during this period of open-mouthed food begging (Fig. 41).

Adult "Food Call"

Many bird species are known to utter food calls that stimulate feeding responses of the young, such as the yellow warbler (Dendroica petechia) and least flycatcher (Empidonax minimus) (Collias, 1960). I did not note a particular vocalization given by parent crows to their young that might be interpreted as a "food call." I did note, however, that almost any vocalization of parental adults elicited a feeding reaction by the nestlings. However, R. C. Stein and W. W. H. Gunn recorded a call series consistently uttered by an adult common crow which apparently caused immature crows, out of the nest, to open their mouths prior to feeding by the parent (Fig. 40). The recordings were made at a parking lot near West Lake, Everglades National Park, Florida on April 21, 1963.

"Announcement Call"

"Announcement calls" are emitted by crows flying to an aggregation of crows such as those in nocturnal roosts or diurnal feeding areas (Figs. 42-43). Two hundred and eighty three samples of "announcement calls" were tabulated as to: syllable sequence number, sequence delivery, sequence quality, sequence intensity, syllable duration, and contextual and behavioral comments. These results will be presented in another study.

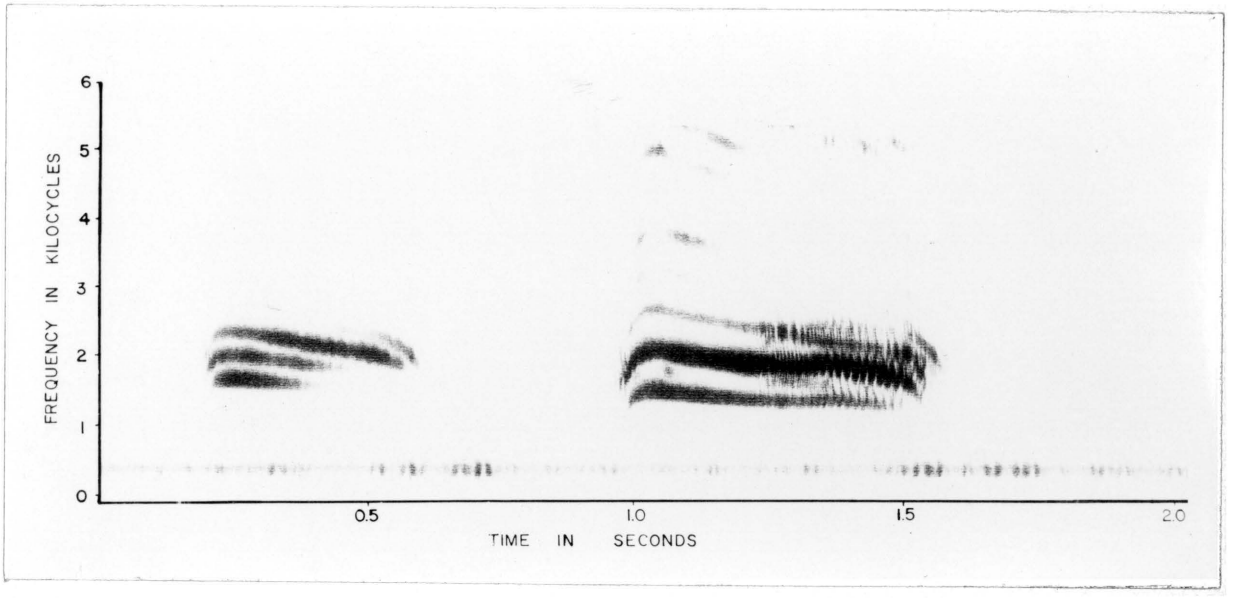

Fig. 40. "Food call." One adult crow, sex unknown, April 21, 1963, Everglades National Park, Florida. Given by a crow before feeding immatures out of the nest.

Fig. 41. Two immature crows giving "hunger calls."

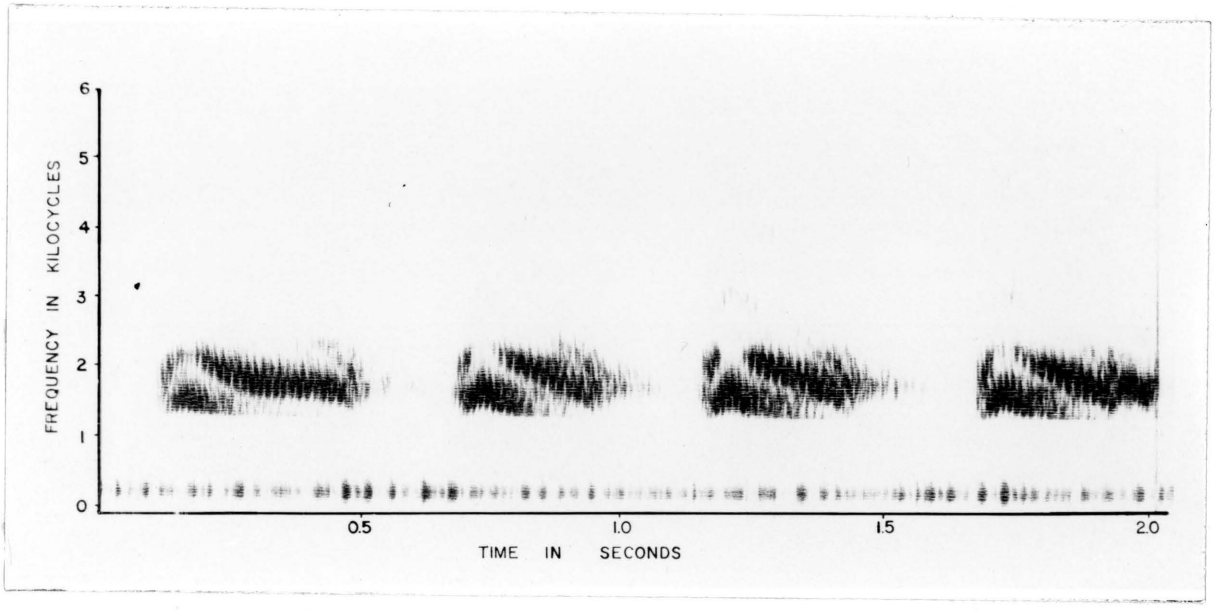

Fig. 42. "Announcement call." One crow, sex and age unknown, October 30, 1965, Blacksburg, Virginia. Given by a crow flying into a nocturnal roost.

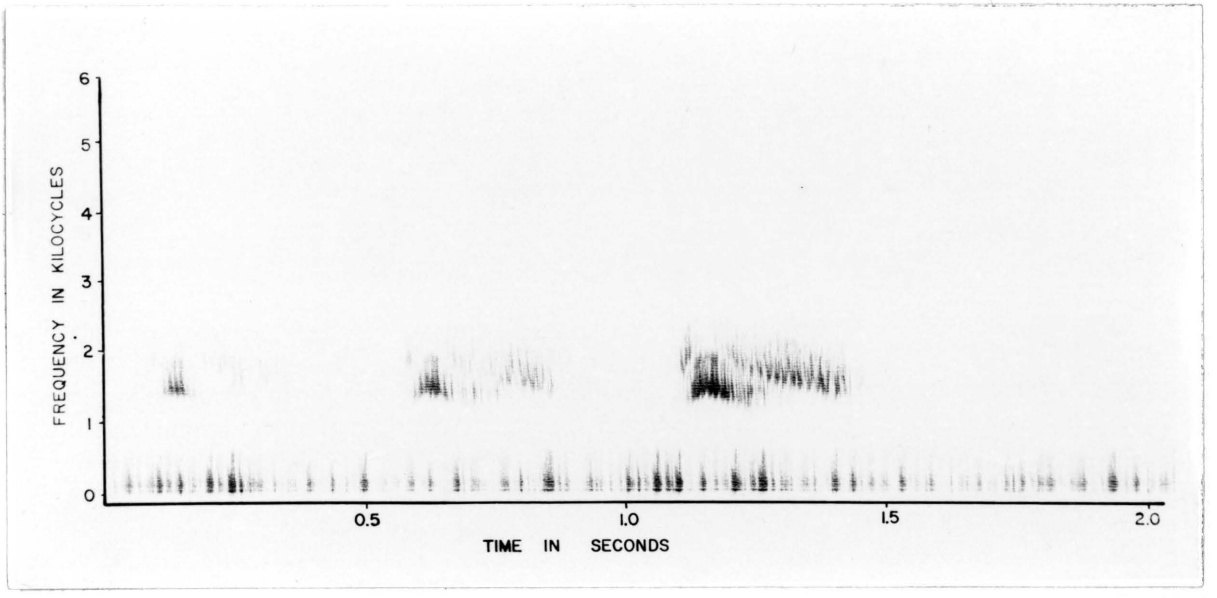

Fig. 43. "Announcement call." One crow, sex and age unknown, February 6, 1965, Riner, Virginia. Given by a crow flying into a nocturnal roost.

"Announcement calls" function as part of group contact vocalization as a form of recognition between crow flock members and approaching crows.

"Announcement calls" are rendered throughout the year.

"Announcement" vocalization often resembles "assembly" and "simple scolding calls" to the ear, but it differs sonagraphically. These differences are known to crows since they do not assemble to the "announcement call."

"Announcement calls" are given by common crows when engaged in gliding or flapping flight. Often, an answer is received before noisy, flapping flight is resumed. During gliding flight the bird descends at about 45 degrees with wings held in a dihedral position; the tail is level with the body or angled slightly dorsally.

"Contact Call"

The components of group movements by crows are assembly, preparation for movement, initiation, liaison while moving, and cessation. Land birds which travel in flocks seem to place heavy reliance on "contact notes" between individuals. Common crows are no exception. This behavior is particularly evident in nocturnal roosts. "Contact" notes which apparently function to keep the flocks together are common in migrating crows (Figs. 44-46). Common crows maintain group cohesion by "answering" each other with identical or nearly identical "contact" notes.

"Contact calls" may be used by crows in night roosts or migrating flocks when pairs become separated, and are given throughout the year.

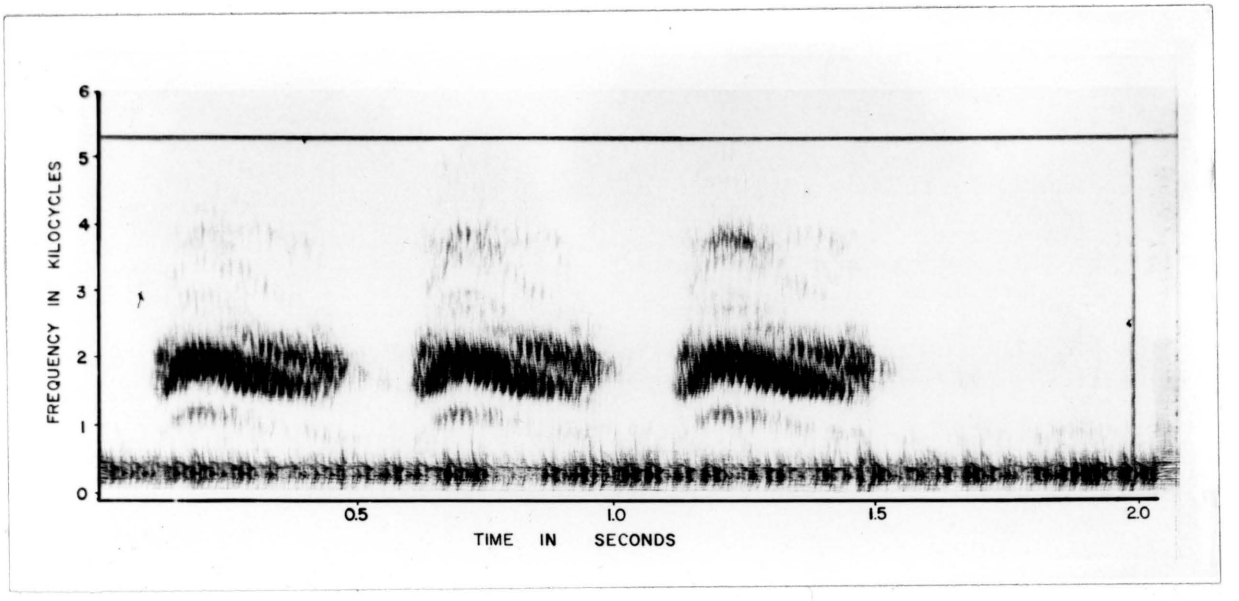

Fig. 44. "Contact call." One adult male, October 12, 1965, Lexington, Virginia. Answering calls between a tame crow and members of a crow flock.

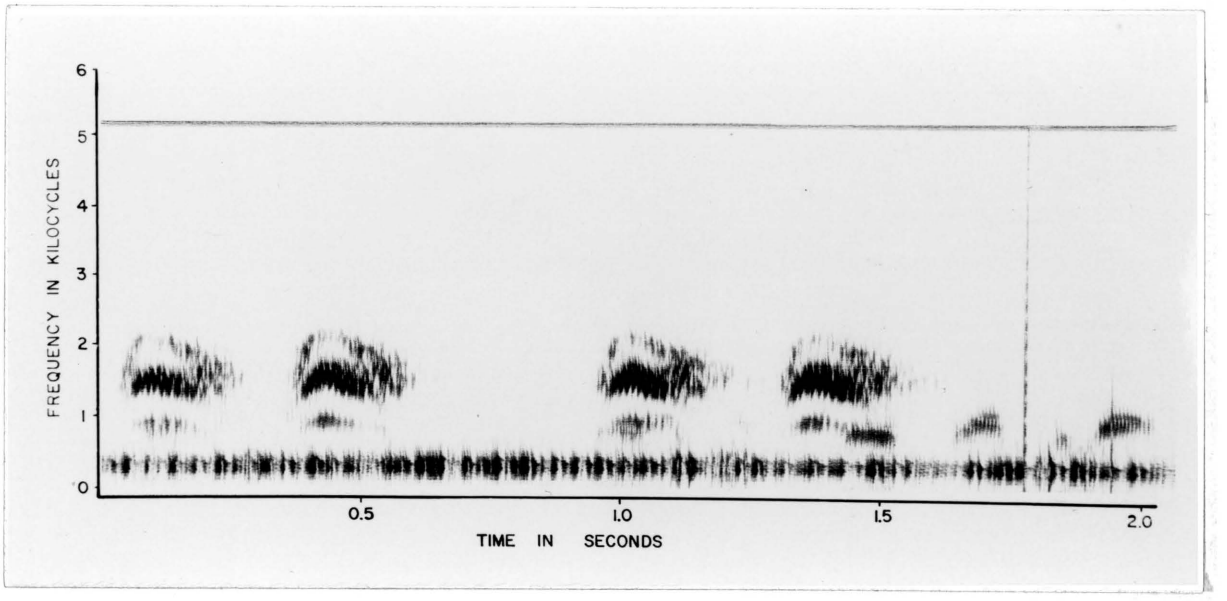

Fig. 45. "Contact call." One crow, sex and age unknown, April 20, 1966, Myaaka River State Park, Florida. Answering calls between members of a crow flock.

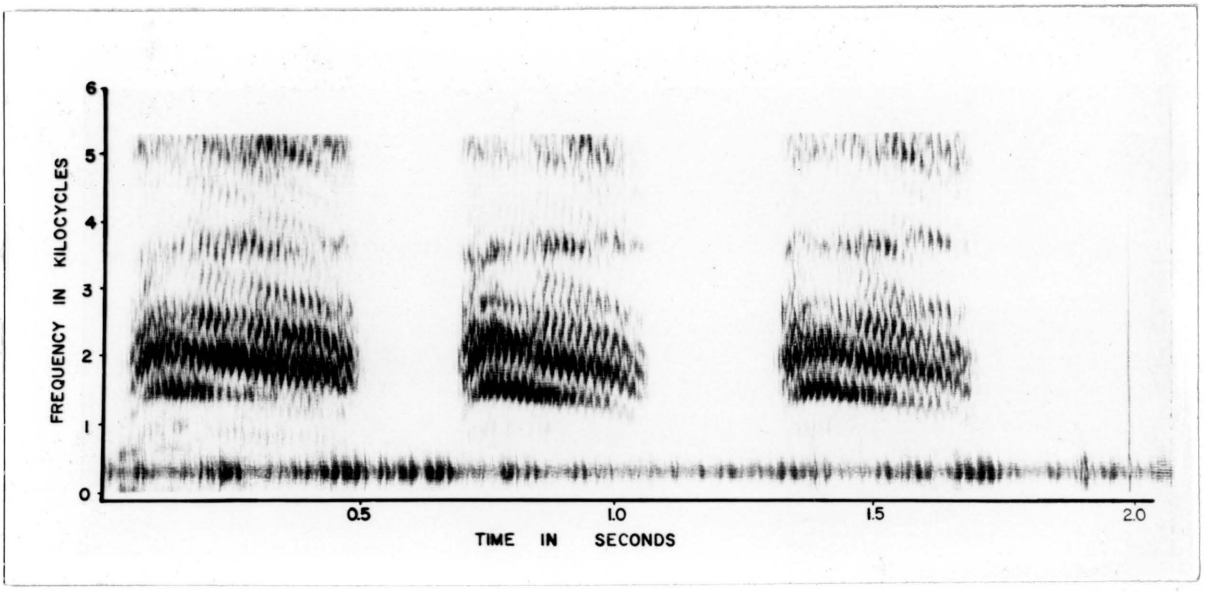

Fig. 46. "Contact call." One crow, sex and age unknown, February 12, 1964, Everglades National Park, Florida. Answering calls between members of a crow flock.

"Contact calls" are emitted by crows while in flight or perched. When the birds are perched, the associated postures are similar to those used in "simple scolding calls."

"Duet Notes"

I heard these notes between two adult common crows which were caged and separated by an opaque partition (Fig. 47). Both birds were tame and appeared to be males, as determined by body size and other sex-associated characteristics. They have never shown sexual behavior. These two unpaired crows have developed many "duet" combinations. They have an extensive vocabulary which, it seems, is utilized whenever the birds are not in sight of each other, thereby making mutual recognition possible. Apparently, these "duets" are used by paired wild crows in similar situations, e.g., nocturnal roosts or large diurnal feeding flocks. On February 19, 1966, I heard "duet" combinations between two crows perched in a crow roost near Riner, Virginia. Other "duets" were heard in winter roosts during this study.

Many species of birds cooperate in uttering "duet" vocalizations, generally when paired (Thorpe and North, 1965). Common crows appear to be no exception. In a "duet" series, one crow emits a certain vocalization which stimulates another crow to utter a following vocalization. "Duets" are repeated for varying lengths of time.

"Courtship Vocalization"

Vocalizations associated with courtship and pre-copulatory behavior in the common crow will be treated at another time. My observations of

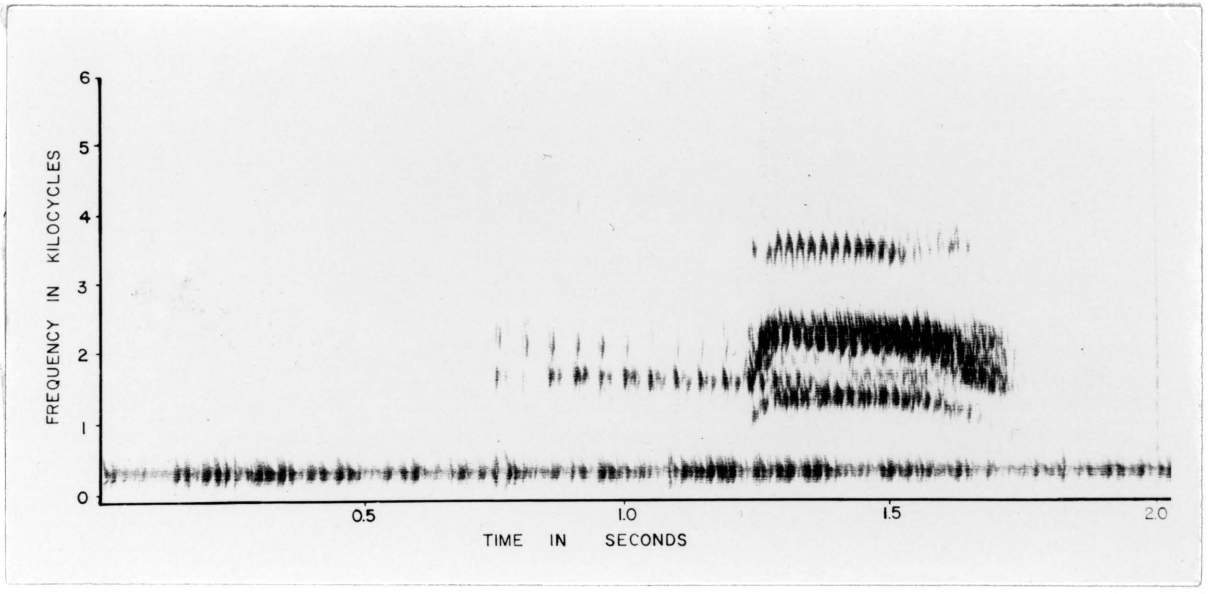

Fig. 47. "Duet notes." Two adult male crows, October 12, 1965, Lexington, Virginia. Duet recognition between two tame crows.

courtship vocalization were too few to justify reporting herein. See Bent (1946: 227-229) for a cursory report of the behavior and vocalizations accompanying common crow mating.

Other Vocalizations

"Juvenile Notes"

These variable vocalizations are emitted by immature crows in their first summer and fall. "Juvenile notes" may function as "practice" notes to gain experience at vocalization prior to actual use (Figs. 48-49). For example, on July 14, 1966 near Craigs Creek, Virginia, I heard an immature common crow emitting "juvenile notes" resembling "assembly" and "contact calls." On April 20, 1966 at Myaaka River State Park, Florida, I heard and recorded an immature common crow gurgling, and attempting to emit, the odd "screams" associated with the Florida race of the Common Crow (p. 134).

When "juvenile notes" are given, the head is lowered with the beak open. The wings flick up and away from the body and down to a closed position.

"Contentment Notes"

"Contentment notes" are given by a crow that has been fed to capacity (Fig. 50), is having its feathers stroked (September 29, 1965, Blacksburg, Virginia, immature pet crow), or is otherwise apparently satisfied with its state or condition.

These notes are plaintive to the ear, and are uttered throughout the year.

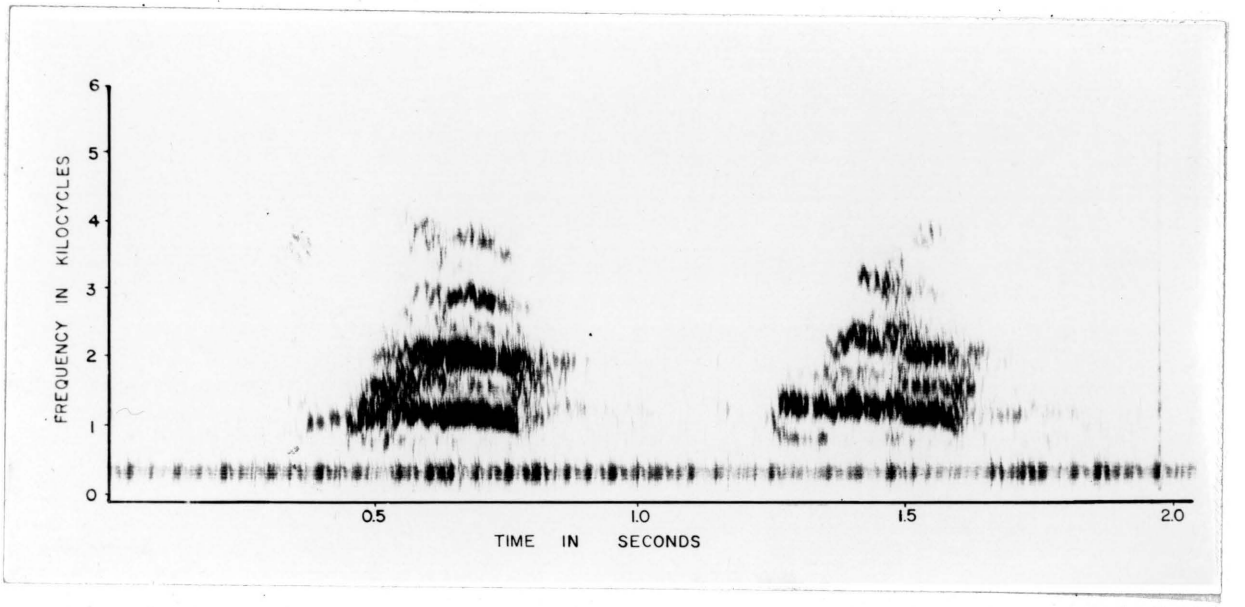

Fig. 48. "Juvenile notes." One immature crow, sex unknown, April 20, 1966, Myaaka River State Park, Florida. Experiments at adult vocalizations.

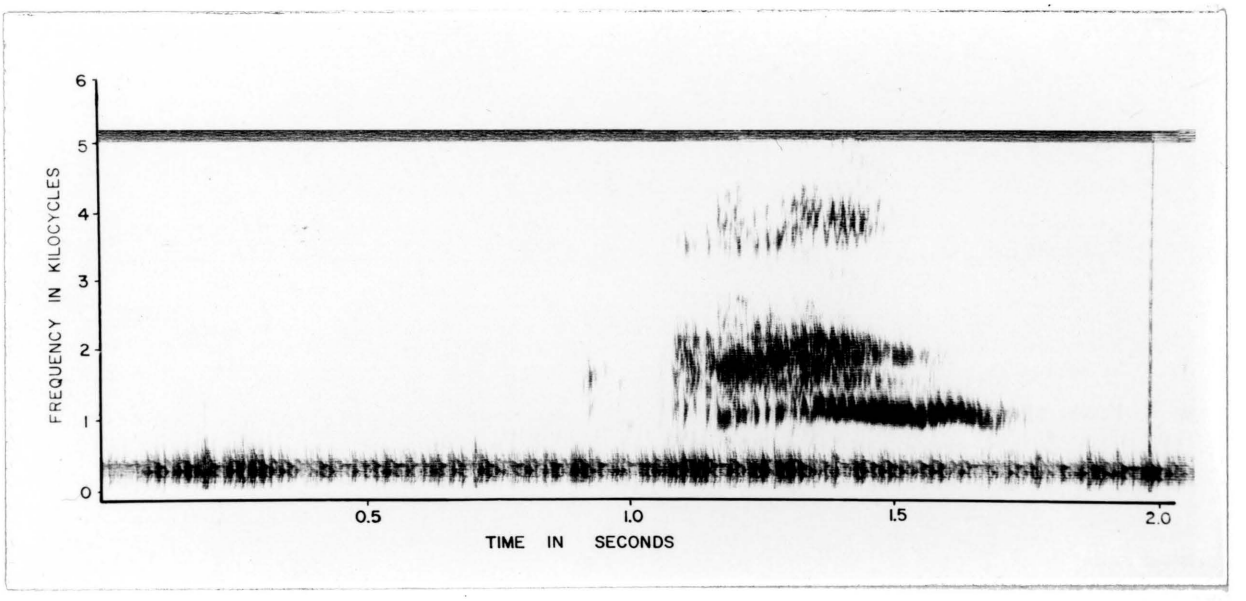

Fig. 49. "Juvenile notes." One immature crow, sex unknown, April 18, 1966, Myaaka River State Park, Florida. Experiments at adult vocalizations.

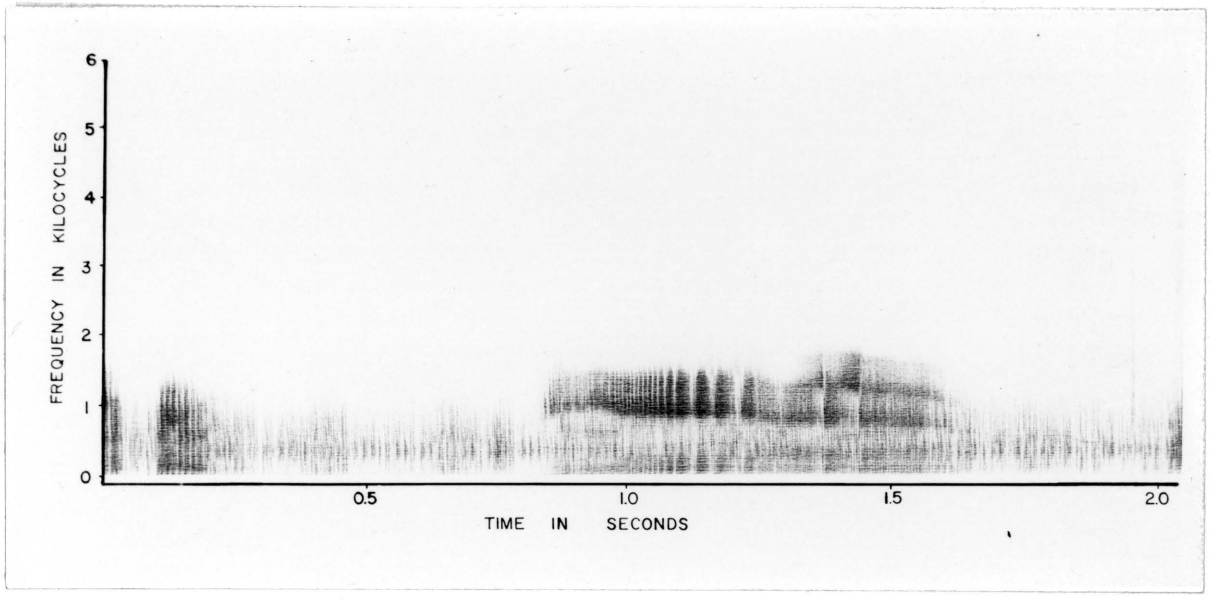

Fig. 50. "Contentment notes." One immature male, May 25, 1965, Blacksburg, Virginia. Given by a crow after feeding to capacity.

While emitting "contentment notes" (Fig. 50), a crow sits low on a perch in contrast to the erect position for the "alert call."

"Rattling Notes"

"Rattling notes" are given by male and female common crows; a fact determined by observations of pet crows of known sex.

"Rattling notes" are heard within nocturnal crow roosts as well as from flocks of feeding or migrating crows (Figs. 51-52). "Rattling notes" are given by apparent paired crows when diving at each other while descending into nocturnal roosts or diurnal feeding aggregations. Clucking sounds, intermediate between "rattling" and "growl" notes, are uttered by common crows within feeding or migrating flocks. On July 12, 1966 near Craigs Creek, Virginia, I noted a juvenile crow giving "hunger calls" while approaching an adult in a tree. The adult responded by emitting "rattling notes" with its beak open.

These vocalizations apparently elicit no response from crows in the wild except, possibly, during the spring mating period (Tables 28-29).

"Rattling notes" may be one of the male courtship calls addressed to the female prior to mating in the spring. The female responds by uttering submissive calls similar to those given by an immature begging for food (Townsend, 1927). Townsend states that "rattling notes" may also be emitted by males in their second fall, coming into sexual maturity for the first time, while aerially pursuing females. On September 29, 1966 near Deerfield, Virginia, I observed 12 to 16 common crows diving upon and erratically pursuing each other. The crows were giving

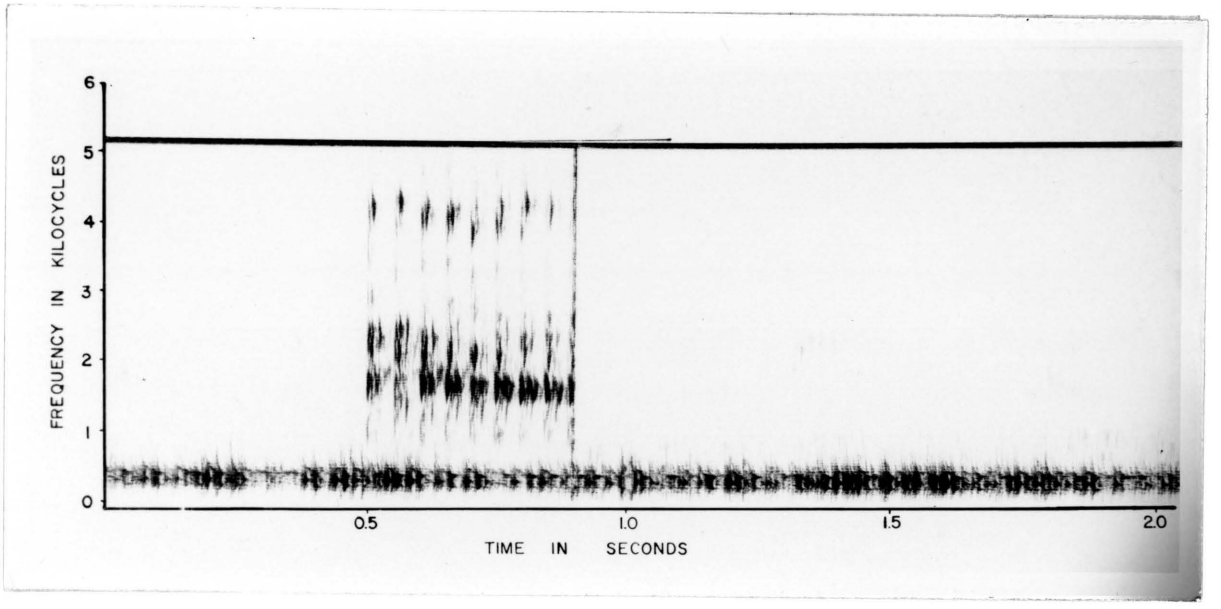

Fig. 51. "Rattling notes." One adult male, October 12, 1965, Lexington, Virginia. Given by crows in many contexts.

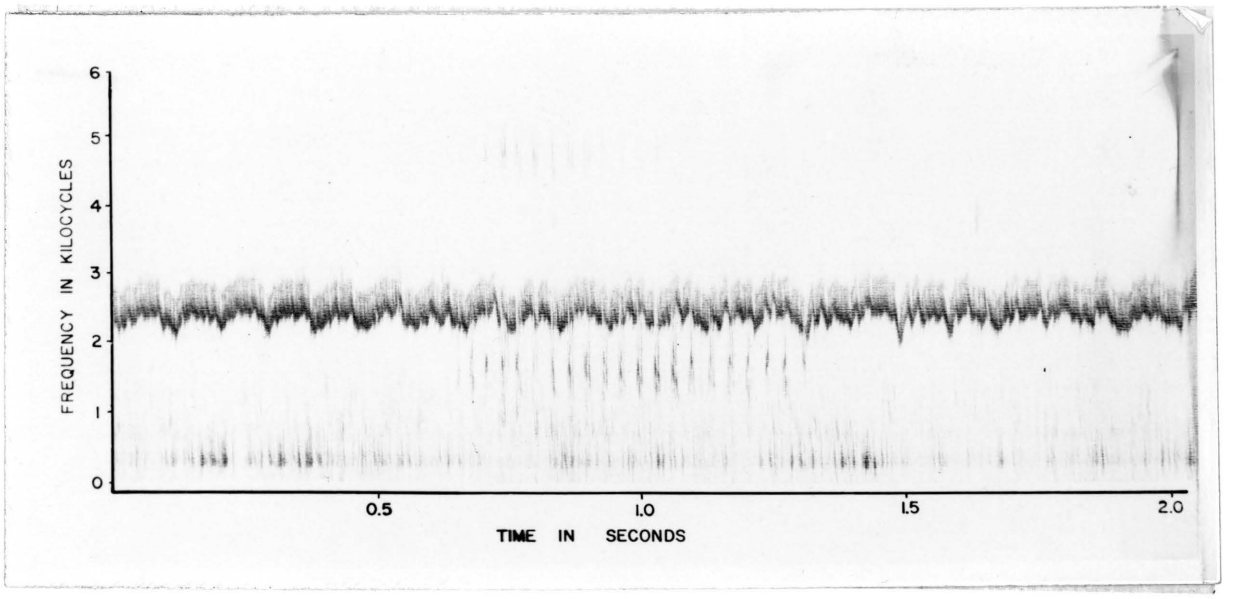

Fig. 52. "Rattling notes." One adult male, April 30, 1963, Lake Wales, Florida. May have been male pre-copulatory notes.

Table 28. Adult "rattling notes", October 12, 1965, Lexington, Virginia. No prediction.

Number	Duration*	Broadcast Date	Location	Time
1	60	3/8/66	Pearisburg, Virginia	3:20 p.m.
2	60	3/8/66	Pearisburg, Virginia	3:30 p.m.
3	60	3/8/66	Pearisburg, Virginia	4:00 p.m.
4	60	3/21/66	Hayfield, Virginia	8:10 a.m.
5	60	3/21/66	Hayfield, Virginia	8:30 a.m.
6	60	3/21/66	Hayfield, Virginia	8:50 a.m.
7	60	3/21/66	Hayfield, Virginia	9:30 a.m.
8	60	2/17/66	Shawsville, Va.	11:25 a.m.
9	60	2/17/66	Shawsville, Va.	11:40 a.m.
10	60	2/17/66	Shawsville, Va.	12:05 p.m.
11	60	3/21/66	Hayfield, Virginia	10:05 a.m.
12	60	3/21/66	Mt. Falls, Virginia	10:25 a.m.
13	60	3/21/66	Mt. Falls, Virginia	11:00 a.m.
14	60	3/21/66	Mt. Falls, Virginia	11:15 a.m.
15	30	8/6/66	Blacksburg, Virginia	10:20 a.m.
16	30	8/6/66	Prices Fork, Virginia	11:10 a.m.
17	30	8/6/66	Blacksburg, Virginia	11:45 a.m.
18	60	2/17/66	Blacksburg, Virginia	8:27 a.m.
19	60	2/17/66	Blacksburg, Virginia	8:50 a.m.
20	60	2/17/66	Blacksburg, Virginia	9:30 a.m.
21	60	2/17/66	Midway, Virginia	10:02 a.m.
22	60	2/17/66	Shawsville, Virginia	10:30 a.m.
23	60	2/17/66	Shawsville, Virginia	10:45 a.m.
24	60	2/17/66	Shawsville, Virginia	10:58 a.m.
25	60	2/17/66	Shawsville, Virginia	11:10 a.m.

* In seconds.

Table 29. Adult "rattling notes", October 12, 1965, Lexington, Virginia. No prediction.

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	1	0	0	0	0	100
2	1	0	0	0	0	150
3	2	0	0	0	0	350
4	7	0	0	0	0	200
5	4	0	0	0	0	200
6	25	0	0	0	0	400
7	2	0	2	0	20	100
8	3	0	0	3	15	100
9	2	0	0	2	3	75
10	9	0	0	0	0	300
11	3	0	0	0	0	150
12	9	0	2	0	20	75
13	4	0	0	0	0	150
14	1	0	0	0	0	200
15	2	0	0	0	0	350
16	1	0	0	0	0	350
17	2	0	0	0	0	380
18	2	0	0	0	0	75
19	4	0	0	0	0	300
20	25	0	0	0	0	400
21	4	0	0	0	0	350
22	1	0	0	0	0	125
23	2	0	0	2	8	250
24	6	1	0	5	15	200
25	4	0	0	4	8	200

* To nearest second.

Estimated yards.

"rattling" and "growl" calls while engaged in this activity. The sex and age of these birds could not be determined.

"Wow-Wow Notes"

No function could be associated with this vocalization. I have never heard "wow-wow notes" emitted by crows in the wild, but repeatedly by three tame crows (Fig. 53). This series sounds like a dog barking, but I do not believe this vocalization to be a case of "mimicry," based on its similarity in New York and Virginia. Tame crows emit many odd sounds which apparently do not function as "mimicry."

While giving "wow-wow notes", the head is moved up and down as if bowing and the beak is opened and closed. The tail feathers are spread laterally, and the wings frequently move up and away from the body and down to a closed position. The nictitating membrane covers the cornea during vocalization. The belly shakes noticeably while giving "wow-wow notes."

"Carr-Carr Notes"

I heard "carr-carr notes" at a nocturnal crow roost located on Betsy Bell Mountain in Staunton, Virginia on September 18, 1965. No response among roosting crows was noted (Figs. 55-56).

Several repetitions of three syllabled "carr-carr notes" were uttered near a crow nest by an adult crow on May 15, 1965 in Staunton, Virginia. I noted no response by other adult crows near the nest.

Two syllabled "carr-carr notes" were given by an adult crow within a flock of eight to ten crows feeding in elm trees on September 19, 1965

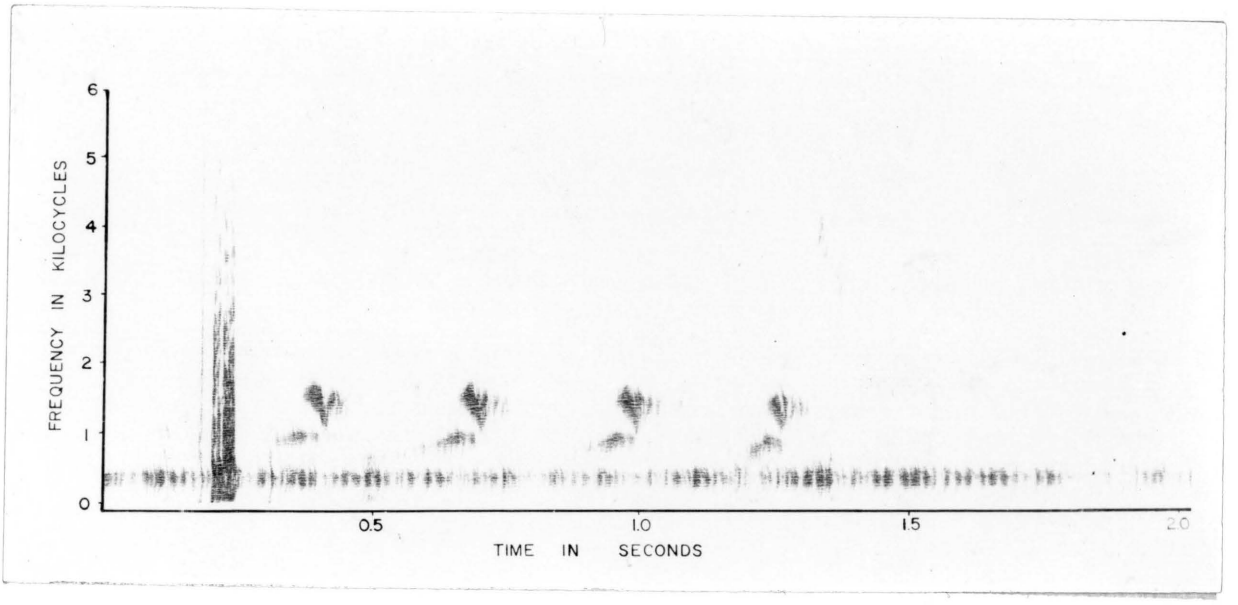

Fig. 53. "Wow-wow notes." One adult male, July 10, 1966, Wolcott, New York. Given by tame crows in New York and Virginia.

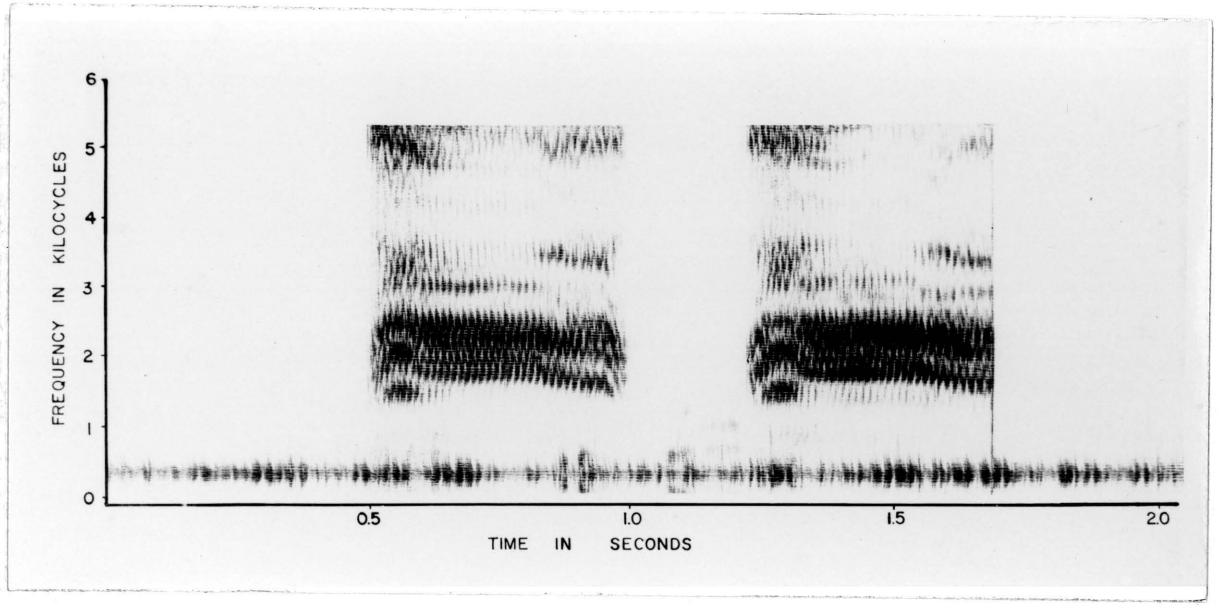

Fig. 54. "Carr-carr notes." One crow, sex and age unknown, February 12, 1964, Everglades National Park, Florida. No response to these notes by individual crows.

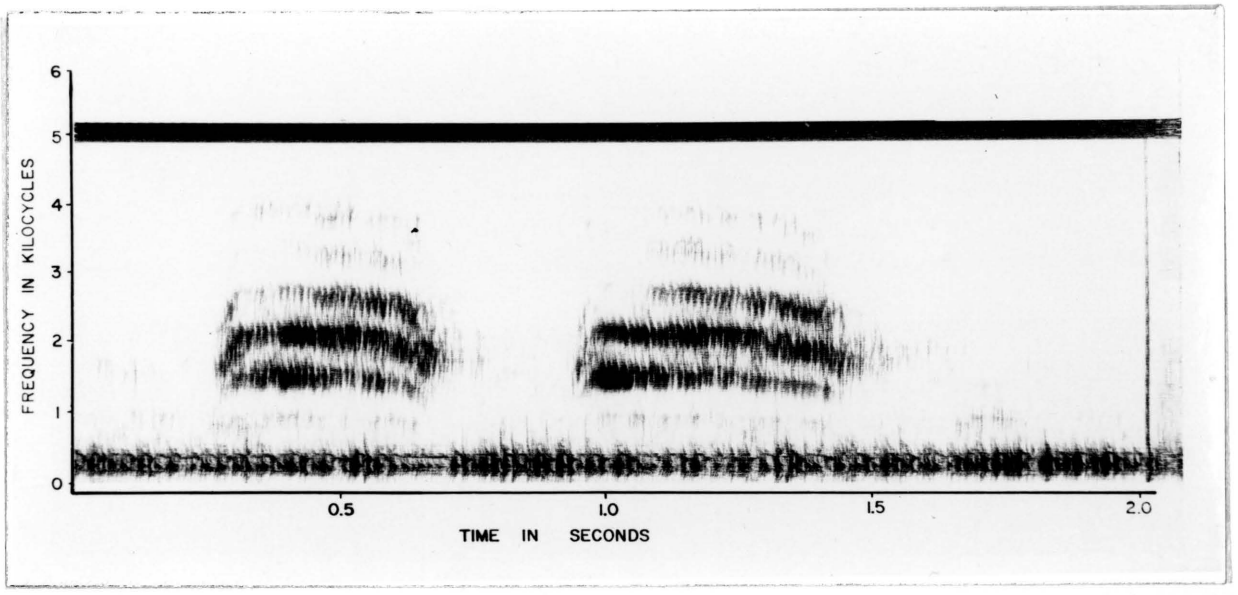

Fig. 55. "Carr-carr notes." One crow, sex and age unknown, September 18, 1965, Staunton, Virginia. Given by a crow in a nocturnal roost.

in Staunton, Virginia. No response was noted among flocked individuals.

"Whisper Notes"

On March 20, 1966 near Lexington, Virginia an adult crow was recorded giving "whisper notes" (Fig. 56). "Whisper notes," as implied, are muted.

Staccato "whisper notes" were also heard in a nocturnal crow roost on February 19, 1965 near Riner, Virginia.

No response was noted among individual crows in either instance to this vocal series.

I have heard, during this investigation, "whisper notes" uttered by common crows during the spring, summer, and early fall of the year.

Postures associated with "whisper notes" were not observed.

"Coo Notes"

On April 18, 1966 in Myaaka River State Park, Florida, I walked near a family group of crows. The adults uttered "assembly" and "simple scolding calls" at my presence. One adult gave a two syllabled "coo" series (Fig. 57) between "mobbing calls." I noted no response among other crows nearby.

A "coo note" was given on April 21, 1966 in Myaaka River State Park, Florida by a crow prior to giving an "alert call" directed at me.

"Coo notes" may be associated with danger. I have noted similar sounds given by pet crows when seeing strange people, dogs, etc. (Two adult crows, October 12, 1965, Lexington, Virginia).

Townsend (1927) describes similar "coo notes" as one of the male

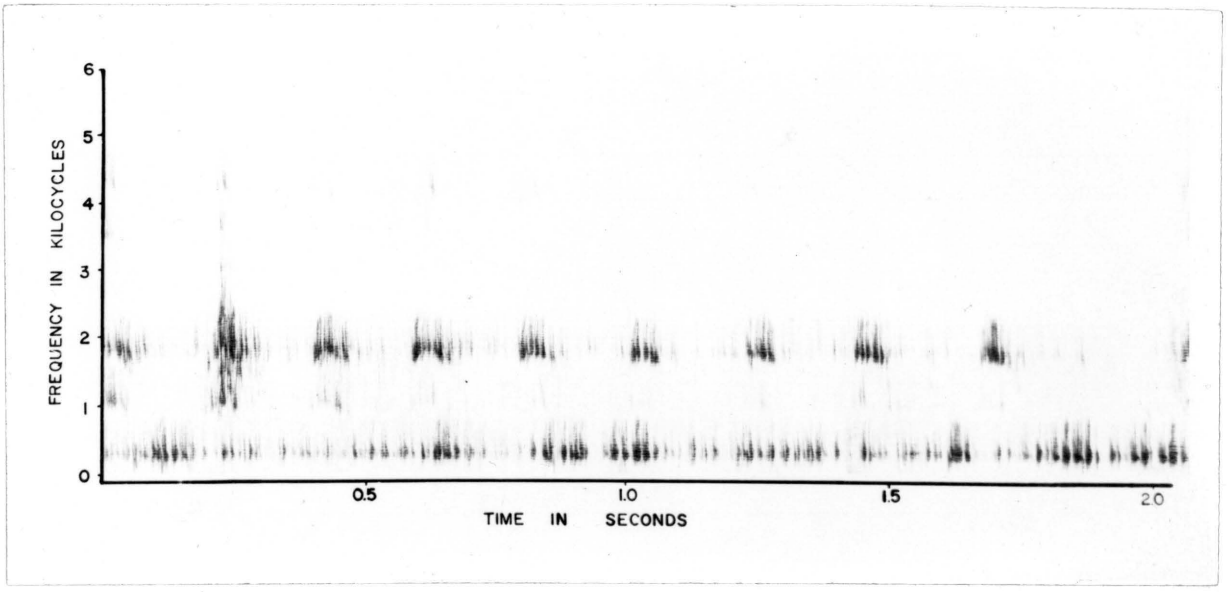

Fig. 56. "Whisper notes." One crow, sex and age unknown, March 20, 1966, Lexington, Virginia. Given in a woodlot used by nesting crows.

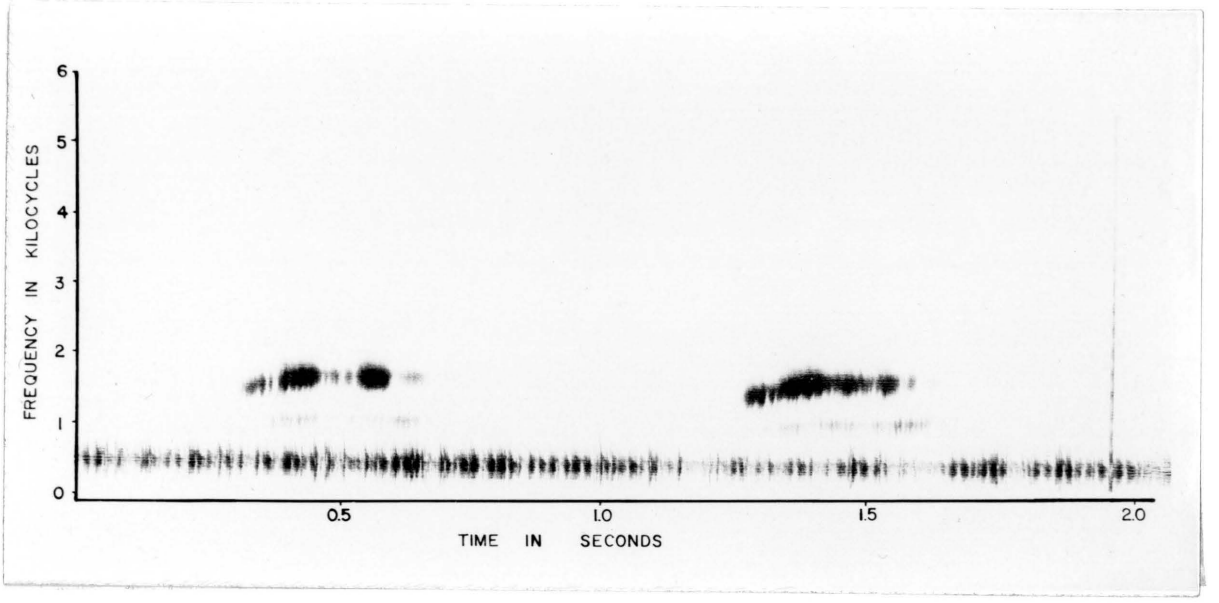

Fig. 57. "Coo notes." One crow, sex and age unknown, April 18, 1966, Myaaka River State Park, Florida. Given with "assembly calls."

courtship calls.

Postures associated with "coo notes" were not observed.

"Organ Notes"

On March 13, 1966, the investigator used a crow call to lure crows to a mounted great horned owl. The crows emitted "simple scolding" and "assembly calls" while "mobbing" the owl. During "mobbing" vocalization, one crow within a flock perched in conifers and repeatedly uttered "organ notes" (Fig. 58). "Organ notes" may be similar to "coo notes" in that they are associated with danger.

No response by individual crows perched near the crow uttering "organ notes" was observed.

Postures associated with "organ notes" were not observed.

"Woo-ah Notes"

On February 19, 1965 near Riner, Virginia, I heard a single crow give one "woo-ah note" (Fig. 59) in a nocturnal roost prior to sundown.

A careful listener can hear many odd vocalizations emitted by crows in nocturnal roosts, including sounds associated with defensive threat as well as others. I have heard many crepuscular crow sounds similar to "woo-ah notes" which were not recorded during this study. For example, on December 31, 1965, I heard high-pitched, four syllabled chipping notes uttered by one crow within a flock of crows flying into a roost located in Genessee Valley Park, Rochester, New York. On January 10, 1966 at Christians Creek near Staunton, Virginia, I heard several squeaky, short notes emitted by a crow in a crow roost.

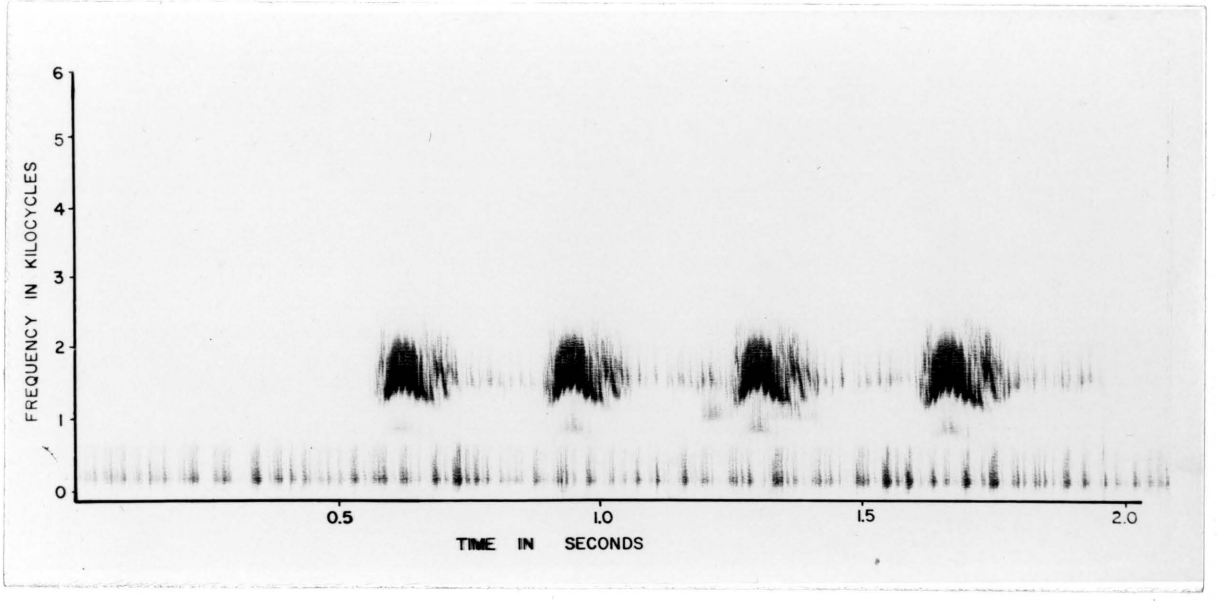

Fig. 58. "Organ notes." One crow, sex and age unknown, March 13, 1966, Deerfield, Virginia. Given with "scolding" and "assembly calls."

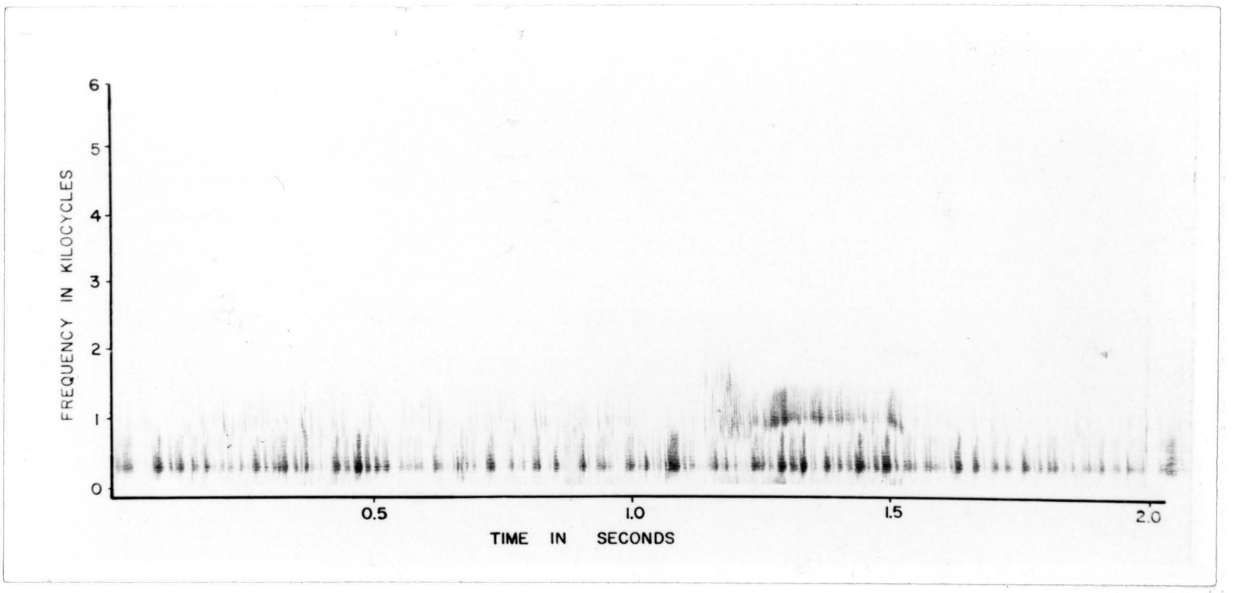

Fig. 59. "Woo-ah notes." One crow, sex and age unknown, February 19, 1965, Riner, Virginia. Given in a nocturnal roost.

Postures associated with "organ notes" were not observed.

C. b. pascuus "Screams"

Intense "screams" (Fig. 60) are commonly given by the Florida race of the Common Crow (C. b. pascuus). No response by individual crows near this sound source was noted.

Bent (1946) states that several observers have noted a vocalization peculiar to the Florida Crow. Mortimer (1890) heard a sound like the cry of a cuckoo (Coccyzus) sp. These may have been the same "screams" which I heard in Myaaka River State Park, Florida.

I have only once heard similar "screams" emitted by a common crow north of the Florida Peninsula. On December 17, 1966, at a crow roost near Riner, Virginia, I heard a perched crow emit a single C. b. pascuus "scream" in a deciduous tree from a ridge top near the roost.

Postures associated with C. b. pascuus "screams" were not observed.

"Ordinary Cawing"

Common crows often vocalize when alone. Frings (1958) tested "ordinary cawing" given by all individuals at times and noted negligible responses.

I have noted "ordinary cawing" emitted by single crows when alone or grouped whether tame or wild, frequently during this study. Its function is not known.

Ordinary cawing is uttered day or night throughout the year.

Postures associated with "ordinary cawing" are similar to those accompanying "alert" and "simple scolding calls" (p. 36).

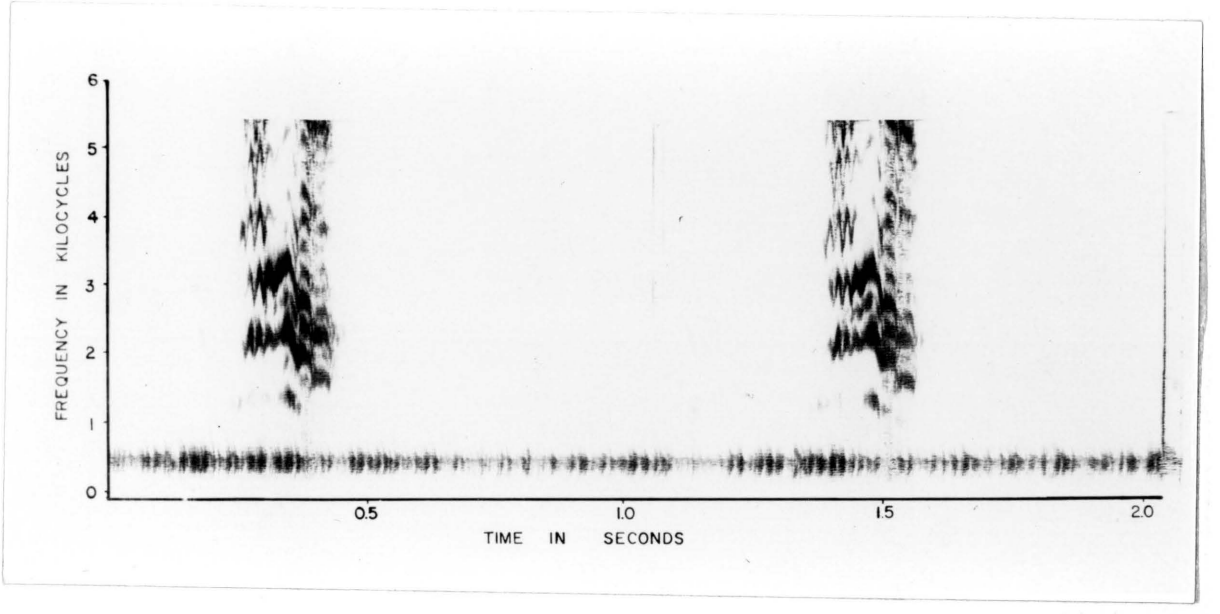

Fig. 60. Pascuus "screams." One crow, sex and age unknown, February 2, 1964, Everglades National Park, Florida. Given commonly by the Florida crow.

"Mimicry"

Common crows often mimic other birds and mammals. On October 20, 1903, Forbush (1927) heard and observed a crow give an excellent imitation of the whine of a dog. He also heard crows emit a varied assortment of notes, some of which were imitations, such as the cry of a child, the squawk of a hen, and the crow of a young rooster.

In captivity, crows are known to mimic the human voice. I noted this behavior among eight tame crows studied. One crow in Lexington, Virginia could say "oh my God, oh Lord" very clearly. A pet adult male crow in Wolcott, New York could say "hello" loud and clear. The myth regarding splitting a crow's tongue before it will "talk" is probably attributed to the natural slit at the tip of the tongue.

One of the functions of "mimicry" may be to establish and strengthen the individual pair bond. This is particularly so in those species where territorial aggressiveness is not very marked--as with the common crow (Good, 1952). In certain species, this ability enables each bird to learn the vocal contribution of its mate as well as its own. Crows may use this for maintaining contact with a mate. If so, the extreme of this unusual imitative ability of birds in parrots (Psittacidae), starlings, and crows is plausibly explained. Perhaps in the wild, common crows use these powers for imitating the idiosyncrasies and inflections in the vocalizations of their mates or other members of a flock (Thorpe and North, 1965).

Postures associated with "mimicry" were not noted.

Distress Calls of Sympatric Species

Starling (Sturnus vulgaris) "Distress Call"

Common crows showed unpredictable responses to starling "distress calls" (Fig. 61), but fish crows responded positively in all tests (Tables 30-31).

Starling "distress calls" are emitted throughout the year.

The calls were produced by shaking an adult male starling by its legs. The intensity of the "distress call" was directly proportional to the intensity of shaking.

Bluejay (Cyanocitta cristata) "Distress Call"

Immature male bluejay "distress calls" (Fig. 62) were field tested with common crows for possible interspecific responses.

Common crows responded by aggregating to this signal in five of ten tests while emitting "simple scolding" and "assembly calls" in apparent search of an expected predator (Tables 32-33).

The calls were produced by holding the bluejay by its legs and shaking it. The degree of "distress" was directly proportional to the intensity of shaking.

Common Grackle (Quiscalus quiscula) "Distress Call"

Immature common grackle "distress calls" (Fig. 63) were field tested with common crows for possible interspecific responses.

Common crows showed no response in five of six tests to immature grackle "distress calls" (Tables 34-35).

The calls were produced by holding the bird by its legs and

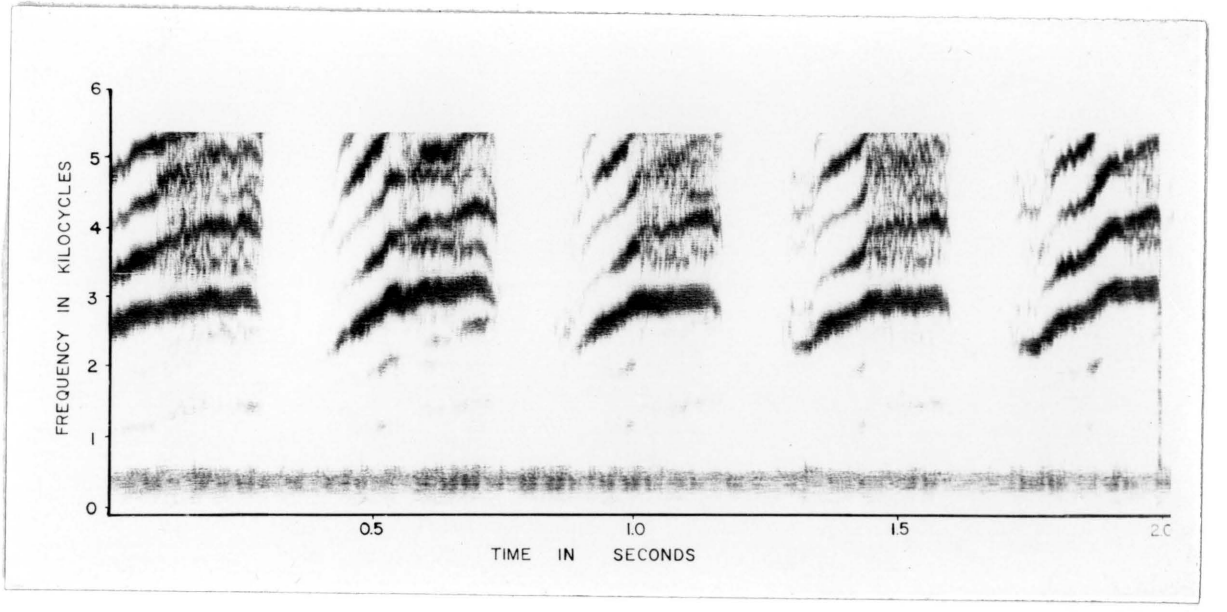

Fig. 61. Starling "distress call." One male, age unknown, January 30, 1966, Staunton, Virginia. Held upside down by the legs and shook.

Table 30. Adult starling "distress call", January 30, 1966, Staunton, Virginia. No prediction.

Broadcast				
Number	Duration*	Date	Location	Time
1	120	7/21/66	Manchester, Maryland	7:05 a.m.
2	60	7/21/66	Manchester, Maryland	9:30 a.m.
3	60	7/21/66	Pleasant Hill, Pa.	9:50 a.m.
4	120	7/21/66	Lineboro, Maryland	10:20 a.m.
5	120	7/21/66	Manchester, Maryland	7:55 p.m.
6	120	7/22/66	Pleasantville, Pa.	7:55 a.m.
7	120	7/22/66	York, Pa.	8:25 a.m.
8	60	7/27/66	Glennville, Pa.	8:20 a.m.
9	60	7/27/66	Glennville, Pa.	10:25 a.m.
10	60	7/27/66	Manchester, Maryland	5:50 p.m.

* In seconds.

Table 31. Adult starling "distress call", January 30, 1966, Staunton, Virginia. No prediction.

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	9	0	0	0	0	300
2	6	6	0	0	4	280
3	16 Fish Crows	16	0	0	5	300
4	4	0	0	0	0	300
5	5	3	2	0	4	200
6	1	0	0	0	20	400
7	4	0	1	3	4	300
8	1 Fish Crow	1	0	0	7	280
9	5 Fish Crows	5	0	0	6	120
10	8	0	1	0	25	400

* In seconds.

\# In yards.

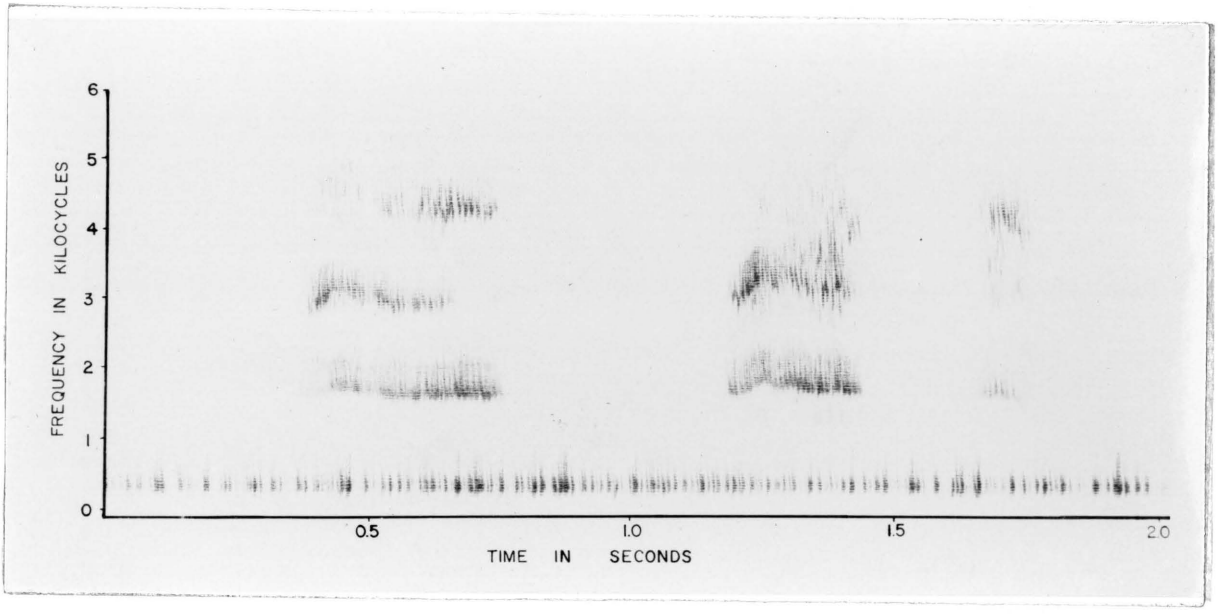

Fig. 62. Bluejay "distress call." One immature, sex unknown, May 28, 1966, Blacksburg, Virginia. Held upside down by the legs and shook.

Table 32. Immature bluejay "distress call", May 28, 1966, Blacksburg, Virginia. No prediction.

Broadcast				
Number	Duration*	Date	Location	Time
1	60	6/17/66	Deerfield, Virginia	11:13 a.m.
2	60	6/17/66	Deerfield, Virginia	12:25 p.m.
3	60	6/17/66	Deerfield, Virginia	2:15 p.m.
4	60	6/17/66	Deerfield, Virginia	2:35 p.m.
5	90	6/17/66	Deerfield, Virginia	3:20 p.m.
6	120	6/17/66	Deerfield, Virginia	3:37 p.m.
7	120	6/19/66	Craig Springs, Virginia	11:30 a.m.
8	60	7/28/66	Reisterstown, Maryland	9:05 a.m.
9	120	7/28/66	Fowblesburg, Maryland	9:55 a.m.
10	60	7/28/66	Manchester, Maryland	10:26 a.m.

* In seconds.

Table 33. Immature bluejay "distress call", May 28, 1966, Blacksburg, Virginia. No prediction.

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	2	0	1	1	35	300
2	5	0	0	0	0	200
3	4	2	2	0	35	200
4	4	1	3	0	10	350
5	8	8	0	0	10	250
6	1	1	0	0	40	350
7	2	0	0	2	20	350
8	5	5	0	0	8	180
9	5	0	2	1	40	200
10	3	0	0	0	0	200

* In seconds.

\# In yards.

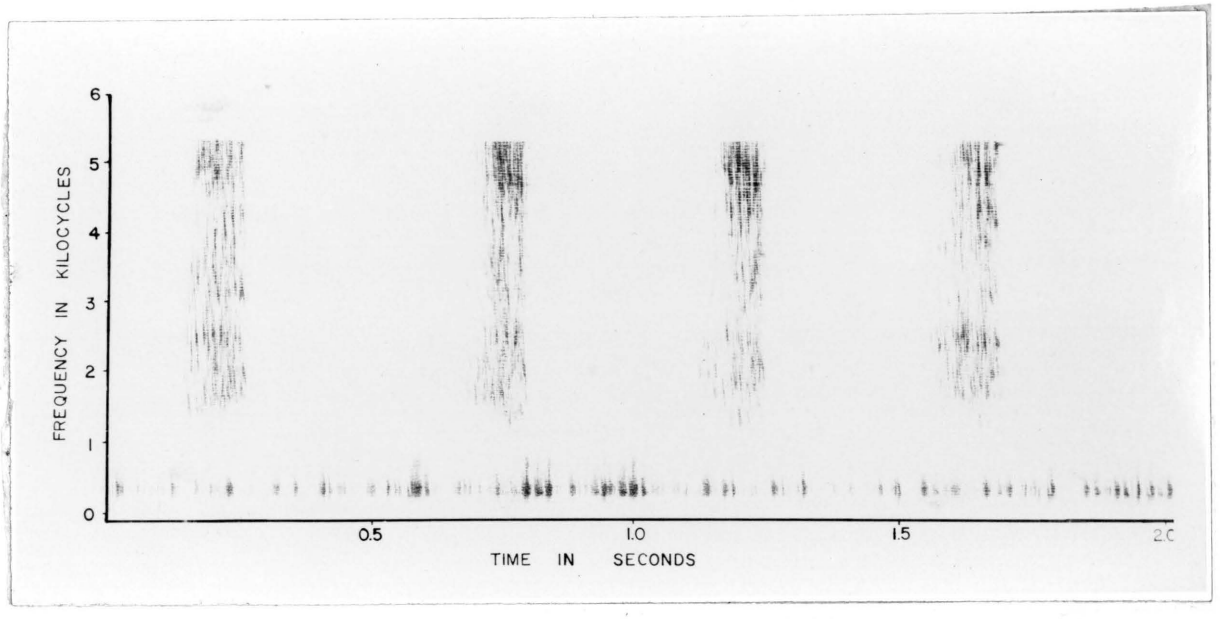

Fig. 63. Common grackle "distress call." One immature, sex unknown, June 3, 1966, Blacksburg, Virginia. Held upside down by the legs and shook.

Table 34. Immature common grackle "distress call", June 3, 1966, Blacksburg, Virginia. No prediction.

Broadcast Number	Duration*	Date	Location	Time
1	120	9/30/66	Deerfield, Virginia	9:25 a.m.
2	120	9/30/66	Williamsville, Va.	9:52 a.m.
3	120	9/30/66	Williamsville, Va.	10:12 a.m.
4	120	9/30/66	Williamsville, Va.	10:30 a.m.
5	120	9/30/66	Deerfield, Virginia	11:24 a.m.
6	120	9/30/66	Deerfield, Virginia	12:12 p.m.

* In seconds.

Table 35. Immature common grackle "distress call", June 3, 1966, Blacksburg, Virginia. No prediction.

Broadcast Number	Crows within Broadcast Range	Number responding to call			Initial Response Time*	Distance from Broadcast to Crows#
		+	-	Other		
1	2	0	0	0	0	450
2	4	0	0	0	0	380
3	50	0	0	0	0	100
4	4	0	0	0	0	250
5	60	0	0	0	0	400
6	2	0	1	0	30	350

* In seconds.

\# In yards.

shaking. Degrees of "distress" were directly related to the amount and intensity of shaking.

Syringeal Anatomy

The most common syrinx is bronchotracheal. In this type the last three to six rings at the base of the trachea enlarge to form the tympanum. Posterior to the tympanum is added the enlarged first three crescent-shaped rings of each bronchus. The syrinx in the common crow is bronchotracheal (Figs. 64-65).

All of the tracheal rings in the area of the syrinx, as well as the first four bronchial rings, are ossified and contain bone marrow. The tympanum is composed of fused masses of the first four tracheal rings and first bronchial ring. This structure serves as a firm anterior support of the syrinx. Anteriorly the trachea is composed of rings which slide over each other allowing considerable anterior-posterior flexibility. Posteriorly, the third and fourth bronchial rings are slightly movable so that syrinx can be shortened and still remain rigid (Figs. 66-67).

The external tympaniform membrane (e.t.m.) is attached anteriorly to the posterior edge of the first bronchial half ring and posteriorly to the middle of the fourth bronchial ring (Fig. 66). Most of the membrane is lined with a thin layer of stratified squamous epithelium, instead of columnar ciliated cells. The latter are present only in the tracheal-bronchial region (Fig. 66). Columnar ciliated cells line the extreme dorsal and ventral portion of the bronchi in the vocal area.

Figure Legend for the Anatomy of the Crow Syrinx

Figure 64. Ventral photograph of the syrinx.

Figure 65. Lateral photograph of the syrinx.

Figure 66. Diagram of the ventral view of the bones and cartilages in the syringeal area.

T 1 -- = Tracheal rings (bone)

B 1 -- 4 = Bronchial bones

B 5 -- = Bronchial rings (cartilage)

P = Pessulus bone

E T M = External tympaniform membrane

L = Interbronchial ligament

Figure 67. Diagram of the lateral view of the bones and cartilages in the syringeal area.

T 1 -- = Tracheal rings (bone)

B 1 -- 4 = Bronchial bones

B 5 -- = Bronchial rings (cartilage)

P = Pessulus bone

E T M = External tympaniform membrane

Transverse diagrams of the syrinx showing three stages of sound production.

T 1 = Tracheal ring 1 (bone)

B 1 -- 4 = Bronchial bones

B 5 = Bronchial ring 5 (cartilage)

P = Pessulus bone

E T M = External tympaniform membrane

I T M = Internal tympaniform membrane

A M = Auxillary membrane

Arrows = Direction of air

Figure 68. Syrinx during normal breathing. Sound cannot be produced.

Figure 69. Syrinx ready for sound production. During sound production the membranes are brought close together by the intrinsic muscles.

Figure 70. Rapid passage of air brings the membranes close together (Bernoulli effect) and causes the membranes to vibrate, thereby producing sound in the column of air.

Figure 71. Ventral diagram of muscles of syrinx.

I -- III = Intrinsic muscles

VI = Sternotrachealis muscle

Figure 72. Lateral diagram of muscles of syrinx.

I -- V = Intrinsic muscles

VI = Sternotrachealis muscle

Figure 73. Frontal diagram of syrinx.

II -- V = Intrinsic muscles

B 1 -- 3 = Bronchial bones

S M = Semilunar membrane

Fig. 64. Ventral view of the syrinx.

Fig. 65. Lateral view of the syrinx.

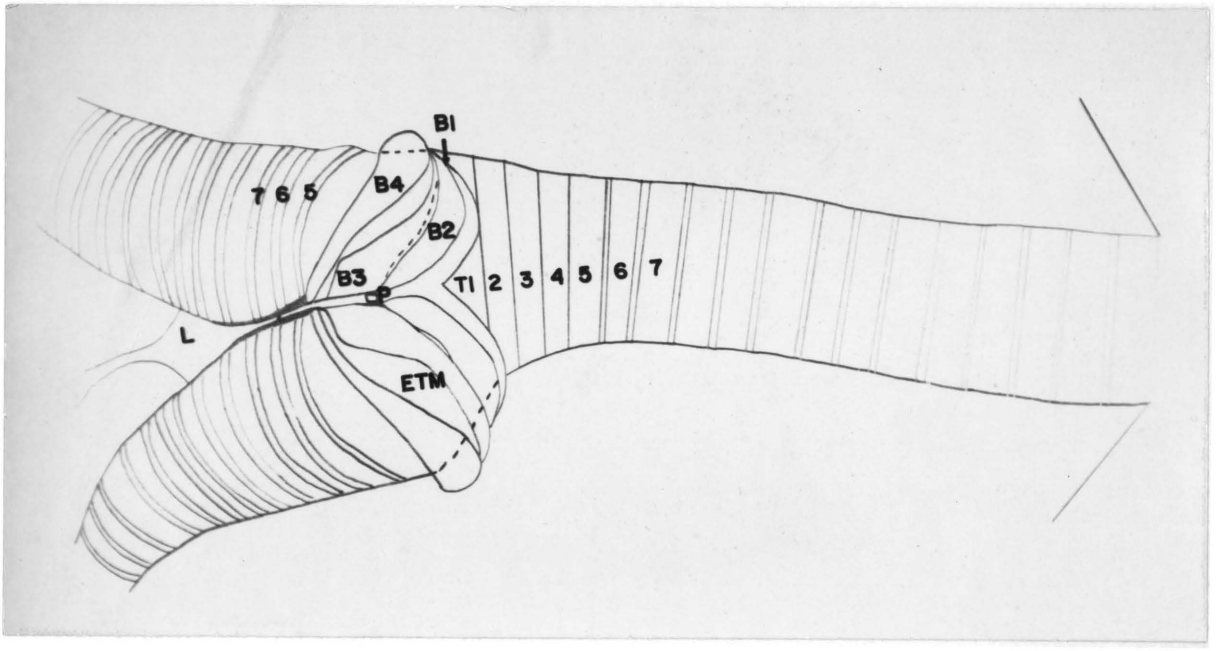

Fig. 66. Ventral view of the bones and cartilages in the syringeal area.

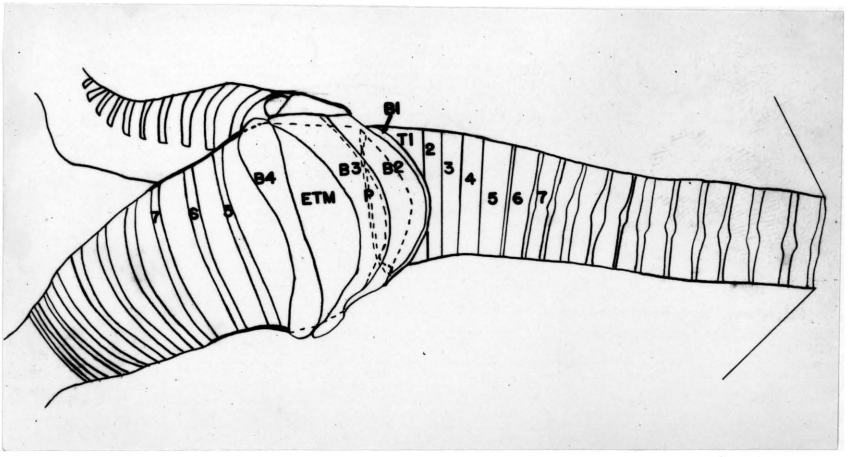

Fig. 67. Lateral view of the bones and cartilages in the syringeal area.

The internal tympaniform membrane (i.t.m.) extends posteriorly from the semilunar membrane to the bronchial wall (Fig. 66). Midway between the dorsal and ventral margins, opposite the e.t.m., there is a fibrinous bar which extends posteriorly from the semilunar membrane and pessulus (Fig. 66). This structure tends to stiffen the membrane.

The ventral end of bronchial ring 3 (B3) is connected to the ventral end of bronchial ring 4 (B4) by a ligament that rotates B4 up to 80 degrees when B3 is pulled approximately 1 mm. anteriorly.

Muscles I and IV draw B3 toward the tympanum (Figs. 71-72). B3 is attached to and pulls auxiliary membrane (VII) which is also attached to B4. This action turns B4 inward which results in increased tension on the e.t.m., and also brings it closer to the i.t.m. Tension on the auxiliary membrane steadies B4 during sound production.

Muscle V, by its attachment to the ventral end of B3 via a ligament, rotates B4 inward. This action brings the e.t.m. closer to the i.t.m., thus adjusting the tension of the e.t.m. which alters the pitch of the sound. Muscle V is the heaviest syringeal muscle (Table 36).

Muscle III is the second heaviest muscle in the syrinx (Table 36). It relaxes and pulls the e.t.m. away from the i.t.m. In this way, it functions as a "spoiler" muscle--allowing an abrupt cut-off of sound.

Muscle II draws the posterior margin of B3 outward and forward, thereby rotating the i.t.m. closer to the e.t.m. Muscle II is the third heaviest muscle in the syrinx (Table 36).

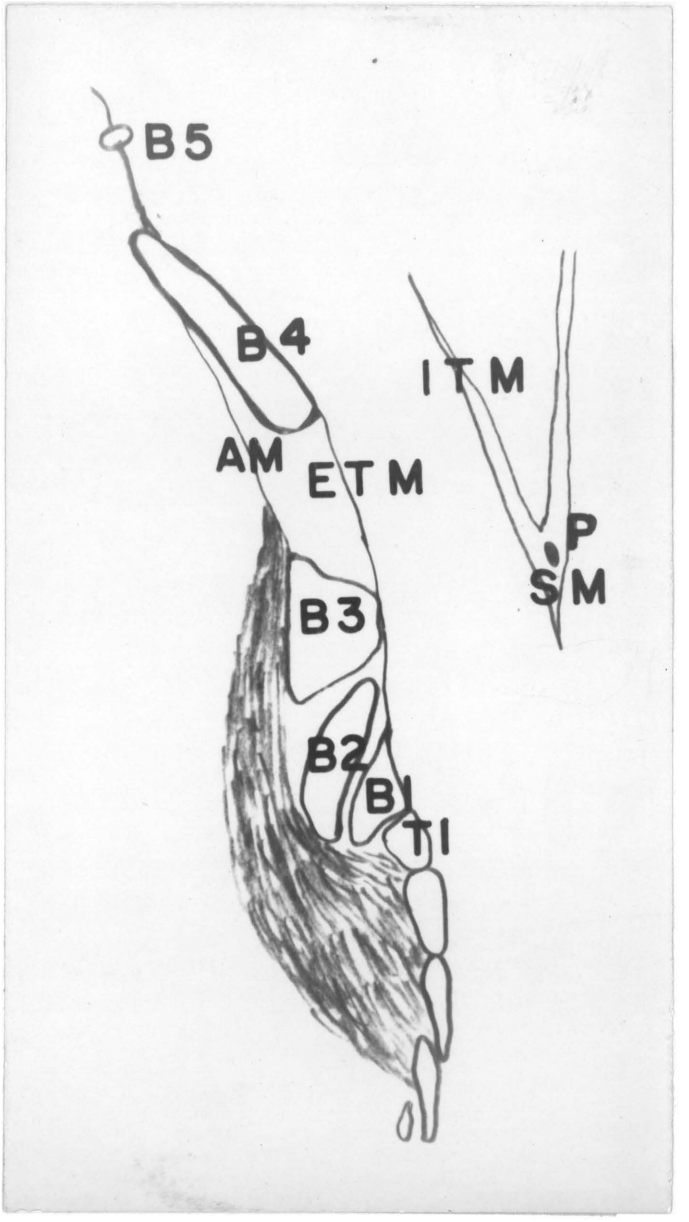

Fig. 68. Syrinx during normal breathing period. Sound cannot be produced.

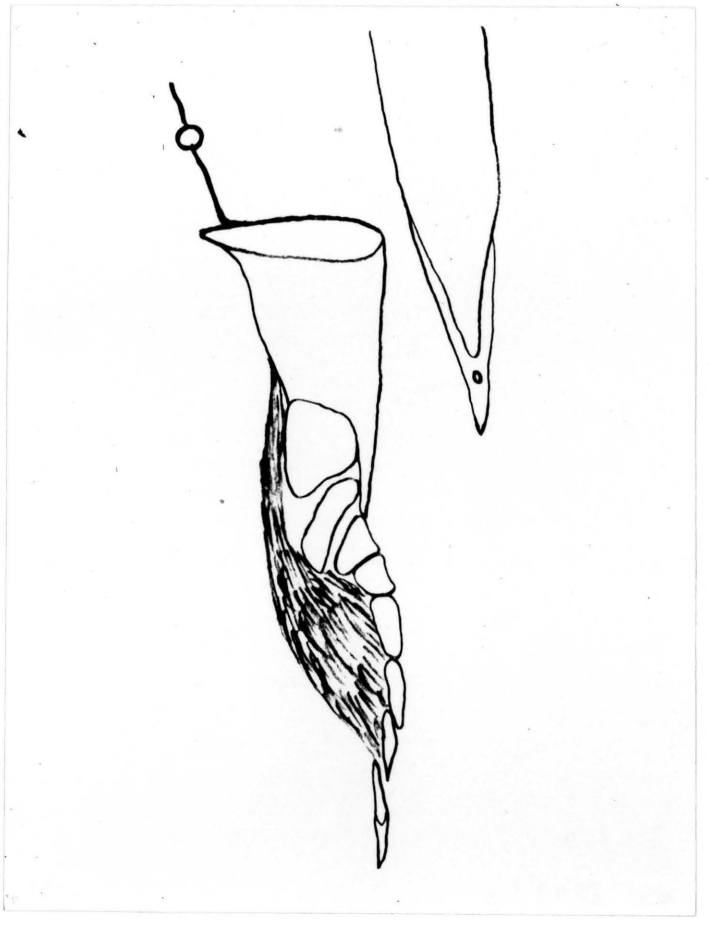

Fig. 69. Syrinx ready for sound production. During sound production the membranes are brought close together by the intrinsic muscles.

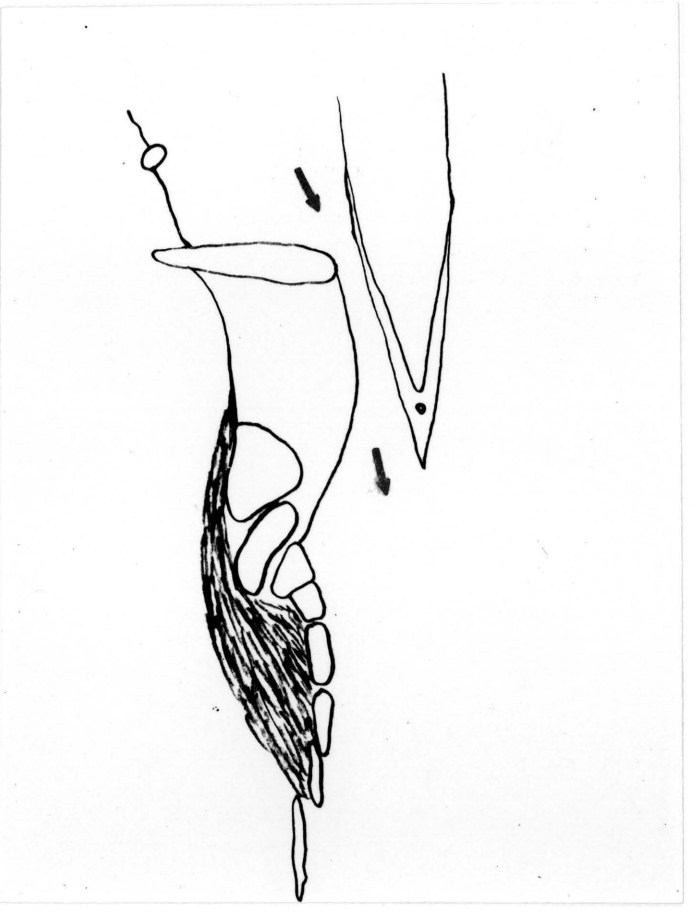

Fig. 70. Rapid passage of air brings the membranes close together and causes the membranes to vibrate, thereby producing sound in the column of air.

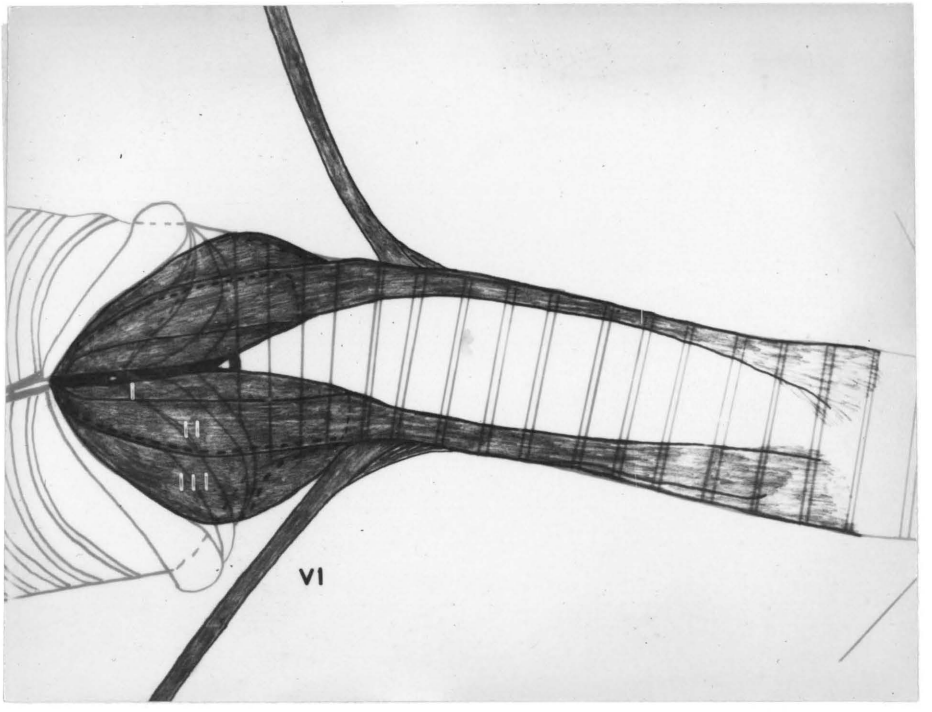

Fig. 71. Ventral view of the muscles in the syrinx.

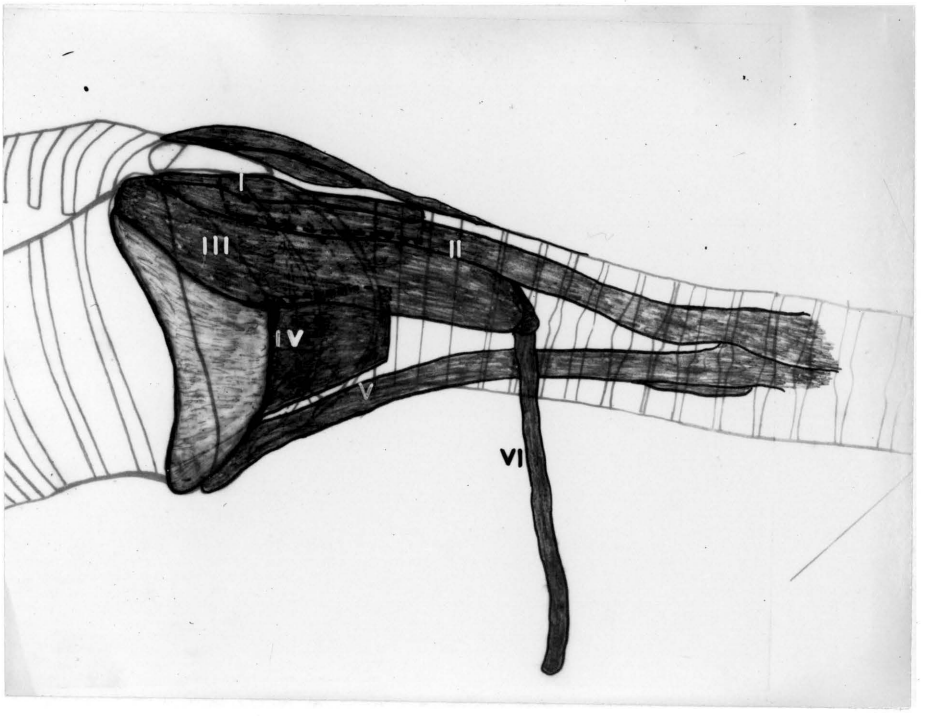

Fig. 72. Lateral view of the muscles in the syrinx.

Table 36. Weights[1] of Syringeal Muscles in the Common Crow

Muscle number	Bird						Mean	Standard deviation
	A	B	C	D	E	F		
1	3.0	2.7	2.0	2.3	2.7	6.6	3.2	± 1.69
2	10.2	8.6	12.2	15.9	8.7	9.8	10.9	± 2.78
3	13.9	19.0	16.0	22.1	20.2	21.3	18.8	± 3.19
4	5.4	2.9	4.0	3.9	3.0	3.0	3.7	± 0.963
5	27.7	21.9	40.7	53.6	40.3	33.3	37.9	±12.6
6	7.9	7.4	11.4	9.4	6.5	8.1	8.5	± 1.73
Total	68.1	62.5	86.3	107.2	91.4	82.1	83.0	±16.1

[1] Weights of single muscles in milligrams.

Muscle VI (sternotrachealis) is a long, slender muscle which steadies the syrinx (Fig. 73). It is the fourth heaviest muscle in the syrinx (Table 36).

When the syrinx is at rest, the e.t.m. (vocal membrane) is not close to the i.t.m. and sound is not produced. Air passing rapidly caudocephalically between the e.t.m. and i.t.m. tends to draw these membranes close together during exhalation (Bernoulli effect) (Fig. 73). The intrinsic muscles bring the e.t.m. and i.t.m. closer together, thereby causing the e.t.m. to vibrate, thus producing sound in the column of air (Figs. 68-70). The pitch is increased by lengthening the e.t.m., thereby increasing tension. Pressure must be nearly equal in the bronchi and intraclavicular air sac before sound can be produced. A thorough knowledge of function (Table 37) is necessary before the anatomy of the syringeal components can be accurately understood.

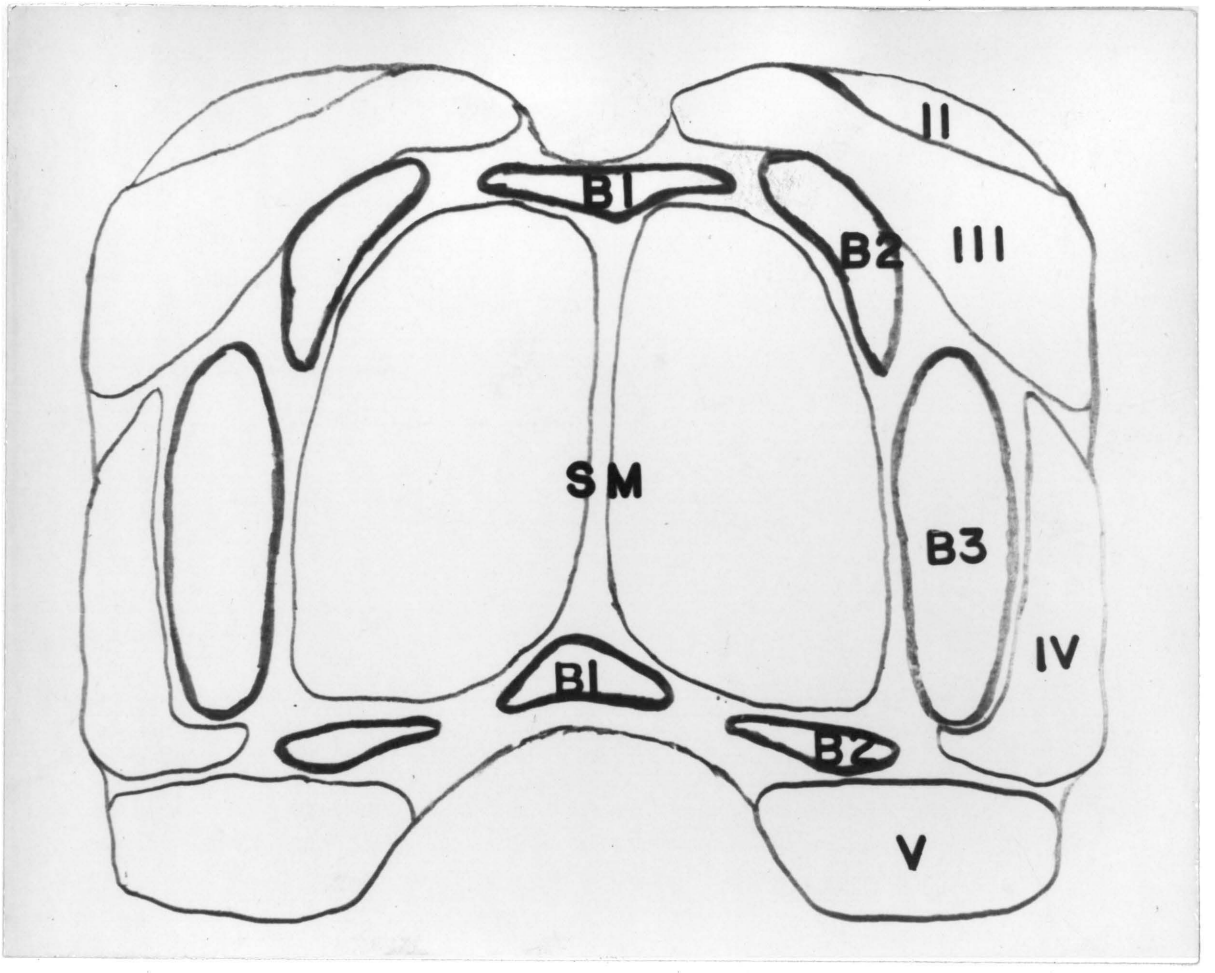

Fig. 73. Frontal view of the syrinx.

Table 37. Syringeal Muscles in the Common Crow

Muscle[1]	Origin	Insertion	Relative Weight	Probable Function
I	T[2] 1 2 3[3]	B3 Anterior side at lateral end	6	Tenses e.t.m.[4]
II	T 13 14 15	B3 Posterior lateral side of ventral end	3	Draws posterior margin of B3 outward and forward. B3 has a large ventro-medial cartilage which turns the i.t.m.[5] close to the e.t.m.
III	T 6	B4 Ventral lateral end and to auxiliary membrane	2	Relaxes e.t.m. and pulls it away from i.t.m.
IV	T 1 2	B4 Posterior middle to posterior ventral edge and adjacent to auxiliary membrane	5	Tenses e.t.m. dorsally
V	T 12 13 14 15	B3 Posterior dorsal margin, and by a ligament to dorsal end of B4	1	Turns anterior margin of B4 medially up to 80° on its longitudinal axis to push e.t.m. medially

Table 37. Syringeal Muscles in the Common Crow (continuation)

Muscle[1]	Origin	Insertion	Relative Weight	Probable Function
VI	Sternum 1 cm posterior to clavicle	T 6 7	4	Steadies Syrinx
VII[7]	B[8]3 Posterior lateral margin	B4 Posterior lateral margin	7	Steadies e.t.m. Turns e.t.m. close to i.t.m.

[1] In order; ventral to dorsal aspect.

[2] Tracheal ring

[3] T rings 1-5 are from tympanum; T rings 6- are from trachea

[4] External tympaniform membrane

[5] Internal tympaniform membrane

[6] Sternotrachealis

[7] Auxiliary membrane (not muscle) exterior to e.t.m.

[8] Bronchial ring

GENERAL DISCUSSION

Bird sounds are often functionally associated with life essentials such as detecting and avoiding enemies, food seeking and feeding, reproducing and social organizing. Other bird sounds do not lend themselves to functional analysis and may not be communicative.

The type of enemy is indicated by some birds with "warning calls." Many birds use a specific call for an aerial predator. I found no difference in the delivery of crow "warning calls" for land or avian predators. The hawk call of the domestic fowl is an intense, harsh scream; but, a cackling "warning call" is given to a dog or man (Collias and Joos, 1953). The degree of crow "warning calls" convey the proximity of a predator. Catbird (Dumetella carolinensis) "warning calls" change abruptly from short notes to protracted cat-like "meows" as an intruder approaches the nest (Collias, 1960). Presumably, survival value is enhanced in those birds that heed the "warning calls" of other coinhabiting species (Collias, 1960), such as crows and herring gulls in Maine.

Sounds indicating hunger are well known. Muir (1954) found that unfed fledged tawny owls (Strix aluco) called more often than fed ones, thereby expressing their degree of hunger. I noted similar behavior in nestling common crows. He believes this behavior may result in a more even food apportionment among the young by the adult owls. Frings et al. (1955) notes that herring gulls emit a three-noted "food-finding call" when they see food.

Group cohesion through vocal contact between individuals in a flock is well known among gregarious species of birds; common crows are no exception. The migrations of small, flocked birds at night apparently place heavy reliance on "contact notes" between migrating individuals (Collias, 1960). Odum (1942) observed "that the "chick-a-dee-dee-dee" call of the black-capped chickadee, (Parus atricapillus), is often given when one bird becomes separated or the flock scattered, with the result that the flock tends to consolidate again." Hinde (1952) observed the flock movements of the European great tit (Parus major) and found that the birds emitted characteristic "starting" and "stopping notes." This behavior was not noticed in crow flocks.

Thorpe (1956) stated that bird sounds have two main functions: to arouse an emotional state and to convey precise information. Communicative calls and signals have been documented for some species of birds. Marshall (1964) exemplifies this type of research in his excellent treatise on vocal communication among brown towhees. He noted five vocalizations that impart information to other towhees: an "ordinary call" which is locative in function, but when more intense, signifies alarm; a "seep" note which has the effect of keeping mated birds in contact when they are a short distance apart, but hidden from each other; a "pair reunion duet," a "food call" which guides adults to the fledglings under their care; a "nest note" emitted by a parent towhee when a human approaches with 25 yards of a nest containing

fledglings about to leave the nest; and a "shriek" that is given by some brown towhees when handled by a human or closely pursued by a hawk. The "ordinary call" and "seep note" are functionally similar to common crow "group contact calls" (p.109). The "pair reunion duet" may be similar in function to "duet notes" in the common crow (p113). The "food call" is functionally analageous to the crow immature "hunger call" (p. 92). "Nest notes" are similar to common crow "simple scolding calls" uttered near a nest with progeny (p. 36). The "shriek" is analogous to the common crow "distress call" (p. 64). Marshall also documented other vocalizations of the brown towhees that are functionally similar to vocalizations in the common crow.

Other workers have tested vocal responses of some birds to recorded vocalizations of their own and coinhabiting species. Weeden and Falls (1959) and Frings et al. (1955, 1958) used recorded field sounds to evoke behavior commensurate to the natural responses of a vocalizing bird. Collias and Collias (1956) and Hinde (1958) used recordings in experiments with laboratory birds with positive results. Frings et al. (1958) have studied the responses of American and French "crows" to each other's vocalizations, as tested in the field. They tested the following Eastern Common Crow (C. b. brachyrhynchos) vocalizations: the "assembly call," given when crows sight an owl or cat; the "alarm call," given by a single crow which has sighted danger; "ordinary cawing" given by all individuals at times; and the "begging cries" of nestlings.

I found that crows uttered "assembly" and "simple scolding calls" after sighting a crow predator (p. 28). In addition, I noted that crows can be induced to approach the sound source and remain nearby without visual reinforcement. Frings et al. (1958) states that this behavior only occurs with visual reinforcement--such as placing a mounted great horned owl near the sound source. My research showed that crows impart degrees of sighted danger with "warning" and "alarm calls" (p. 45). Frings and Frings (1957) state that the "alarm call" functionally associated with repelling consists of four short notes. I found "alarm calls" to be variable in syllable number (p. 53). Frings et al. (1958) states that "begging calls" of nestlings had no observable effects on the movements of crows. My tests showed variable responses among adult common crows tested with "hunger calls" of fledglings.

It appears that the crow is better equipped to convey more and varying degrees of information than a majority of avian species, based on my study and literature review. It should be noted, however, that bird vocabulary studies reported in the literature are not numerous. Therefore, a positive statement regarding the sophistication of common crow language when compared to other species is not justifiable.

Biologically significant sounds may have practical value for attracting desirable species and repelling pest species. Attractant bird sounds may also be used to lure pest species to traps or other collecting devices. These sounds are generally specific, harmless and easily controlled in application. The French have been successful in

using biosonics to control "crows" around croplands and airfields.

Crow calls which are attractive to crows may be used to successfully hunt this species. "Assembly", "simple and modified scolding" and "distress calls" are employed by crow hunters to lure crows within shotgun range. Mounted great horned owls are used as decoys. Numerous crow hunting articles appear in hunting and sporting magazines (Popowski, 1939; Sweigard, 1967; Kernam, 1967). It is my opinion that crows, like other species of wildlife, should be locally evaluated as "beneficial" or "harmful" to man's interests, and the appropriate management procedures initiated.

RECOMMENDATIONS

The vocalizations described in my thesis are not all the sounds of the common crow known to me, or other workers. I recommend that further study be initiated to define additional sounds as well as to document further the vocalizations described herein.

In addition, I recommend a detailed study of common crow courtship vocalization which was omitted herein.

Finally, an investigation to determine which sounds are innate, learned, or evolved from combinations of both should follow the complete documentation of common crow vocalizations. The study of sound variation in passerine populations is important for the analysis of developmental, genetic,and comparative aspects of vocalization as a biological phenomenon.

SUMMARY AND CONCLUSIONS

1. This study in part attempted to document the vocalizations and signals of the common crow, and describe the appropriate environmental and behavioral context for each. It also attempted to determine the way in which sound is produced in the common crow, and to work out the anatomy and probable function of the syringeal components in this species.

2. Fifty-five common crows were collected and their syringes examined during this study. The birds were taken within 25 miles of Blacksburg, Virginia. Proposed functions of the syringeal muscles were based on a careful determination of origin and insertion, and by manipulating the muscle while attempting to produce sound.

3. The "assembly call" is given by crows that detect nearby crow predators. This call causes crows to aggregate to the sound source. Responses to tests were: Class I - 91%, Class II - 6%, and Class III - 3%.

4. The "simple scolding call" is emitted by crows that detect a crow predator at a distance. This call causes crows to aggregate to the sound source. Responses to tests were: Class I - 80% and Class II - 20%.

5. The "modified scolding call" is "simple scolding" with an inflection on all syllables of the call series. The "modified scolding call" is functionally identical to the "simple scolding call." This call was not tested in the field.

6. The "alert" or "warning call" conveys information of immediate and latent danger to crows. The number of notes per "alert" series apparently does not convey differences in the degree of danger. In 12 of 17 tests, crows responded by aggregating to "alert calls."

7. The "dispersal" or "alarm call" causes crows to fly from an area. It is the extreme degree of the "alert" or "warning" series. Alarm calls are uttered by crows that apparently sense immediate and grave danger. Responses to 12 tests were: Class I - 67%, Class III - 8%, and Class V - 25%.

8. The "distress call" is emitted by a crow that is caught by a predator. It causes crows to aggregate and remain over the sound source. Responses to 25 tests were: Class I - 88% and Class III - 12%.

9. The pre-mortality" or "expiration call" is emitted by a crow just prior to death. This call is the extreme degree of "distress vocalization. Responses to 20 tests were: Class I - 25%, Class II - 10%, Class III - 20%, Class IV - 10%, and Class V - 35%.

10. The "defensive threat call" is emitted by a crow perched erect or flying under attack or attacking a predator or another crow. Crows failed to respond in a predictable manner to the "defensive threat call" when field tested.

11. The "modified defensive threat" or "growl call" is uttered by a common crow when diving upon or pursuing a perched or flying predator within striking distance.

12. "Frustration notes" are given by a common crow which apparently is frustrated by a situation.

13. Immature "hunger calls" are emitted by common crows when stimulated by hunger, seeing food, seeing or hearing objects associated with food, or by a combination of any or all of these factors. Crows failed to respond in a predictable manner to "hunger calls" tested in the field.

14. Immature "feeding calls" are emitted by common crows when ingesting food through the esophagus. Crows failed to respond in a predictable manner to "feeding calls" tested in the field.

15. Adult common crows may rarely emit a "food call" which stimulates feeding responses of the young.

16. "Contact calls" apparently function to keep crow flocks cohesive. Common crows maintain group cohesion by answering each other with identical or close to identical "contact calls."

17. The "announcement call" is given by a crow flying to an aggregation of crows. "Announcement calls" apparently function as part of "contact" vocalization by recognition between crow flock members and approaching crows ("salute" and "reply").

18. "Duet notes" were recorded between crows.

19. "Juvenile notes" may function as "practice" sounds allowing the immature crow to gain experience at calls prior to actual use.

20. "Contentment notes" are given by a crow that has been fed to capacity or otherwise is apparently content.

21. "Rattling notes" may be given by the male prior to mating in the spring. "Rattling" vocalization is emitted by the male and female common crow throughout the year. Twenty-five tests showed seven responses.

22. "Wow-wow notes" were emitted by New York and Virginia tame crows studied. This vocalization was never heard in the wild.

23. "Carr-Carr notes" were given by adult common crows while feeding, nesting and roosting. No response was noted by other crows to this vocalization.

24. "Whisper notes" were heard during the spring, summer, and early fall. No response among individual crows was noted to this vocal series.

25. "Coo notes" were given intermittently during "assembly", "simple scolding", and "alert" vocalizations. "Coo notes" were given most commonly by C. b. pascuus.

26. "Organ notes" were delivered intermittently during "assembly" and "simple scolding calls" directed at a mounted great horned owl. "Organ notes" may be functionally similar to "Coo notes" in association with danger.

27. "Wah-oo notes" are similar to other odd, non-associative vocalizations heard in nocturnal crow roosts during this study.

28. Intense "screams" are commonly given by C. b. pascuus. No response to this vocalization was noted among individual crows.

29. "Ordinary cawing" is common to individual crows when alone or grouped. Its function is not known.

30. "Mimicry" is well known among tame and wild common crows. Common crows may use this vocal mechanism for recalling and maintaining contact with the mate.

31. Common crows showed variable responses when tested with an adult starling "distress call". Fish crows reacted positively in all field tests.

32. Common crows responded positively in five out of ten tests to an immature male bluejay "distress call" tested in the field. "Simple scolding" and "assembly calls" accompanied crow aggregation.

33. Common crows showed no response in five of six immature common grackle "distress calls" tested in the field.

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THE VOCALIZATIONS AND SYRINGEAL ANATOMY OF THE COMMON CROW, CORVUS BRACHYRHYNCHOS

by

Dwight R. Chamberlain

ABSTRACT

A study of the vocalizations and syringeal anatomy of the common crow was conducted between 1964 and 1966. Intensive documentation of the sounds produced by the common crow, related to the appropriate behavioral context in which each sound occurs in the wild, was the primary objective of this research. Wild crows were tested with recordings of captive and wild crow vocalizations to determine the nature of the important calls and signals of this species. Common crows were also tested with "distress calls" of three sympatric species.

The objectives of the syringeal research was to 1) determine how sound is produced by the common crow and 2) work out the anatomy and probable function of the syringeal components in this species.

Fifteen "primary vocalizations" were documented in the common crow. They were defined as sounds which caused responses among crows. Twelve "other vocalizations" were documented in this species. They were defined as sounds which caused no responses among crows. All of the vocalizations of the common crow were not documented in this study.

Careful dissections of 55 common crows collected in the field revealed that four pairs of bronchial rings, five tracheal rings, one pair of external tympaniform membranes, one pair of auxiliary membranes,

and six pairs of muscles are the components of sound production in the syrinx. Probable functions of these and other syringeal parts are discussed.