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Analysis of coyote calling as a game management technique

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AN ANALYSIS OF COYOTE CALLING

AS

A GAME MANAGEMENT TECHNIQUE

By

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CHAPTER I

INTRODUCTION

Predator calling of one sort or another has been used by sport and professional hunters for years as a method of attracting various carnivores and scavengers to the close proximity of the caller. Anecdotal and instructional articles frequently appear in popular sportsmen's magazines (see Appendix for a partial bibliography), but there have been few critical analyses of this apparently valuable research and management technique and the behavioral responses upon which it is based.

The earliest reference in the technical literature to the use of predator calls (Alcorn, 1946) was limited to a description of a few different types of coyote calls and personal experiences in their use. Benson (1948) constructed a call according to Alcorn's instructions, but, not satisfied with the results obtained, discarded it in favor of a commercially produced call, with which he subsequently had moderate success in attracting coyotes (*Canis latrans*). He noted, however, that the call was also effective in calling deer, particularly females with fawns hidden in the area. Nearly all of the other references to the technique are short notes or passing comments regarding the use of calls (Wetmore, 1952; Robinson, 1952; Diem, 1954).

Working with foxes (*Urocyon cinereoargenteus* and *Vulpes fulva*) in Minnesota, Morse and Balser (1961) attempted a quantitative appraisal of the factors influencing calling success. After a year of field work and a total of 401 calling trials, they reported an overall success rate of 14.4 per cent. Of the many environmental parameters measured, most failed to correlate significantly with successes. They concluded that the factors most conducive to success were (1) calling in the late afternoon and evening, (2) calling when the air was essentially calm, and (3) making a careful approach to the calling site.

The current controversy regarding predator control programs (Leopold, 1964; Cain et al., 1971; Olson, 1971) suggests that a similar detailed analysis of this technique and its efficacy in decoying coyotes is appropriate. It is evident that coyote management will continue to consist mostly of population control measures in response to damage complaints. It is also apparent that the most effective coyote control method, poisoning, will be curtailed and rigidly controlled in the future. Calling and selectively shooting particular coyotes will probably become increasingly important as an alternative and supplementary control method. Providing wildlife managers with a realistic assessment of the merits of this technique necessitates a critical and controlled evaluation of its effectiveness and some identification of the factors which influence its successful use.

In addition, a review of the biological and wildlife management literature reveals a paucity of basic information on coyotes; a great number of ecological and behavioral questions remain unanswered. The use of a coyote call to attract coyotes so that they may be captured or marked without injury to the animal may well prove to be an exceedingly valuable research technique. Again, a critical examination of the method is suggested.

This report describes the results of an intensive field study to evaluate the use of coyote calls. The project was designed to provide the following information:

1. A determination of which, if any, environmental variables influence calling success. The null hypotheses to be tested were that specific weather factors, time of day, ground cover, and terrain features have no significant influence on calling success.

2. A determination of the overall effectiveness of distress-type coyote calls; the relative effectiveness of a commercially produced, mouth-blown predator call as opposed to tape recordings of actual rabbit distress calling; and the effectiveness of close-range, hand-mouth squeaking (to be described later).

3. A description and characterization of the observed behavior of responding coyotes.

4. A detailed sonographic examination and comparison of some of the coyote calls commonly used and readily available.

CHAPTER II

STUDY AREA

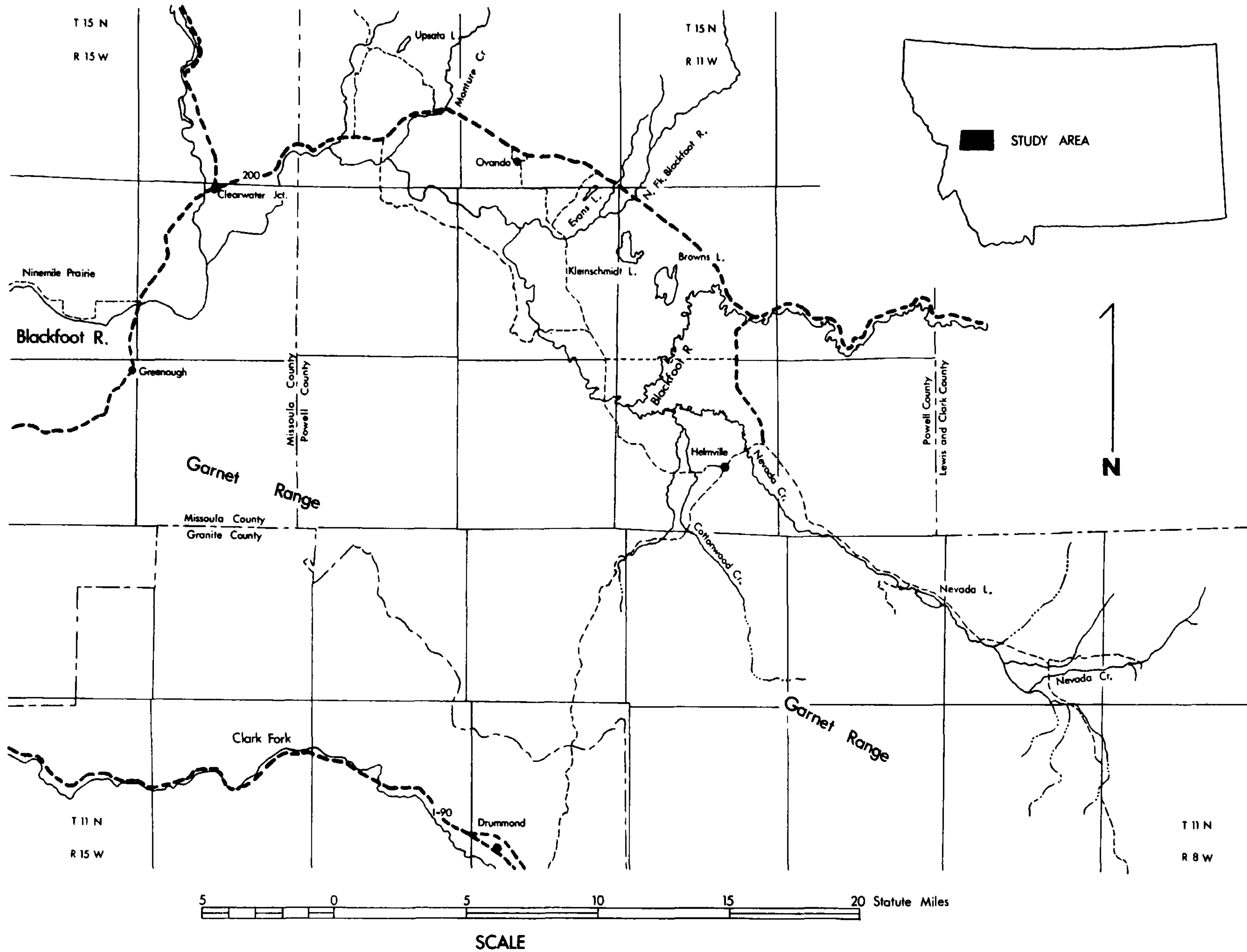
The study area was located in the upper Blackfoot River drainage in western Montana, and was centered in the vicinity of Ovando, approximately 50 miles east of Missoula on Montana Highway 200 (Figure 1). The area extended from Nine Mile Flats (T14N, R15W) in Missoula County, to the mountain prairies north of Avon (T11N, R8W) in Powell County, a distance of approximately 60 miles by highway.

Selection of this particular area was based upon several factors. Local residents, coyote hunters, and Fish and Wildlife Service personnel indicated that the area supported a ubiquitous, comparatively high density coyote population. Secondly, the entire area appeared to consist of relatively homogeneous coyote habitat. Lastly, the open vegetation and terrain features permitted relatively unobstructed observation of the behavior of any responding coyotes.

Topographically, the area consists of a long mountain valley with wide draws and low rolling hills, surrounded by the much higher mountains of the Swan Range, Garnet Range, and the Continental Divide.

Sagebrush (*Artemisia* spp.) and grass species dominate the flora, with large patches and fingers of coniferous forest (predominately *Pinus ponderosa*) extending into the valley from the surrounding mountains, particularly along creek drainages. Sagebrush provides moderate to

Figure 1. Map of the study area.



T 15 N
R 15 W
Upsata L.
Monture Cr.
T 15 N
R 11 W
STUDY AREA
200
Ovando
Clearwater Jct.
N. Fk. Blackfoot R.
Evans L.
Browns L.
Kleinschmidt L.
Ninemile Prairie
Blackfoot R.
Greenough
Missoula County
Powell County
Blackfoot R.
Powell County
Lewis and Clark County
N
Helmville
Nevada Cr.
Garnet
Range
Missoula County
Granite County
Cottonwood Cr.
Nevada L.
Nevada Cr.
Garnet
Range
Clark Fork
I-90
Drummond
T 11 N
R 15 W
T 11 N
R 8 W
5
0
5
10
15
20 Statute Miles
SCALE

heavy ground cover from 1 to 3 feet in height. Grasses seldom grow higher than 6 to 8 inches. The density of coniferous tree stands varies from widely scattered individual trees to dense thickets in which visibility is less than 50 yards. Dense willow (*Salix* spp.), aspen (*Populus tremuloides*) and cottonwood (*P. trichocarpa*) thickets occur sporadically throughout the area.

Field work was done during the first four months of the year, under a wide range of winter and spring weather conditions. Temperatures varied from -30° to +18° C; wind speeds occasionally ranged upward to more than 60 miles per hour; blizzards and rain squalls were common. During the latter few weeks of the study, severe winter weather abated somewhat and conditions became more moderate and spring-like.

During most of the study, the area was covered by abnormally deep snow. Depths up to 41 inches were recorded at calling sites; measurements over 36 inches were common. The heavy snow greatly reduced the amount of cover available to both coyotes and caller and closed many roads in the area.

CHAPTER III

FIELD METHODS

To minimize experimental variation, it was necessary to use tape recordings of the calls for all field trials. A Uher 4000 Report-L, battery-operated, portable tape recorder, especially lubricated for extreme cold weather operation, was used. Playback volume was increased with a Sinclair Model IC-12 integrated circuit external amplifier. This amplifier, powered by a 12-v dry cell power source, was connected to a Calectro, 3.2-ohm, 8-w, 6-in external speaker by an 18-ft lead. The entire unit was carried in a knapsack and weighed approximately 28 pounds. For recording, a Uher M-514 microphone was used. All recordings were made at 7½-ips tape speed.

Part of the study was designed to compare the effectiveness of a commonly used, commercially produced, mouth-blown predator call with actual small animal distress cries.

Tape recordings of the commercially produced calls were made with the assistance of personnel of the Bureau of Sport Fisheries and Wildlife, Wildlife Services Division. An expert, experienced coyote caller used several different coyote calls commonly employed by Wildlife Services personnel; all of these calls were recorded. From this collection, the single recording that provided the highest quality reproduction, made with the call with which the caller felt he had had the most success in the field, was selected for use as a field stimulus. This call was manufactured by Weems, Ft. Worth, Texas. All the calls were analyzed with the aid of a sonograph.

Tape recordings of actual distress calling were difficult to obtain. A variety of taped distress noises are available commercially, particularly from the Burnham Brothers, Inc., Marble Falls, Texas. However, to minimize possible recording and equipment variation, new distress recordings were made with the equipment described above. Through the cooperation of personnel of the Stella Duncan Memorial Institute, the distress cries of domestic rabbits, lightly anesthetized and undergoing cardiac puncture in conjunction with other studies, were recorded.

Both the commercial call tape and the rabbit distress tape were duplicated and edited for field use. Each stimulus, as presented in the field, consisted of a 6- to 7-sec series of harsh cries, followed by a 10-sec pause, and another 6- to 7-sec series of cries.

Output volumes for both tapes were equated as closely as possible. Sound intensity peaks of 107 dBC, as measured one foot from the speaker with an H. H. Scott, Type 450-B Sound Level Meter, were used as the basis for comparison. Intensities of both tapes ranged downward from that value to approximately 101 dBC. Tables 1 and 2 depict peak sound intensities from this system as measured at various distances and in different directions from the speaker. Although wind, precipitation, and variations in topography or ground cover will influence the sound transmission, the values presented give some indication of the intensity and range of the

Table 1. Intensity of Commercial Call Tape at Various Distances and Directions from the Speaker (dBA)[a]

Direction from Speaker	Distance from Speaker (Yards)									
	50	100	150	200	250	300	350	400	450	500
0°	68	54	42	44	38	35	32	30	30	<30
30° Right	62	56	44	38	34	30	<30			
60° Right	58	47	33	<35[b]						
90° Right	53	39	<35[b]							
120° Right	53	<40[b]								
150° Right	49	35	<30							
180°	52	40	33	<30						
150° Left	47	36	32	<30						
120° Left	48	<30								
90° Left	52	44	<35[b]							
60° Left	60	46	37	36	35	<30				
30° Left	66	52	44	36	34	34	32	<30		

[a]dBA used to minimize wind noise interference.

[b]Background noise sound pressure levels equalled or exceeded stimulus noise levels.

Table 2. Intensity of Rabbit Distress Tape at Various Distances and Directions from the Speaker (dBA)

Direction from Speaker	Distance from Speaker (Yards)									
	50	100	150	200	250	300	350	400	450	500
0°	67	54	44	39	38	36	32	32	30	<30
30° Right	61	52	42	36	34	32	<30			
60° Right	56	43	36	<30						
90° Right	51	37	<30							
120° Right	52	34	<35[a]							
150° Right	48	37	<30							
180°	53	39	34	<30						
150° Left	50	38	<30							
120° Left	49	<30								
90° Left	53	40	<35[a]							
60° Left	60	48	43	34	37	<30				
30° Left	64	53	43	37	33	33	30	<30		

[a]Background noise sound pressure levels equalled or exceeded stimulus noise levels.

stimuli presented. These tables were prepared with the speaker 50 inches above the ground, over level, grassy terrain, on a calm, clear day.

In the original design, 50 to 60 calling sites were located near roads throughout the study area. The plan called for repeatedly traveling this route, performing trials at alternate sites on alternate trips.

The severe winter, with heavy snow depths and resultant road closures, made much of the route inaccessible. Whenever possible, sites along the original route were used. These were supplemented by several roughly circular snowshoe sub-routes from 3 to 5 miles long, with 6 to 10 calling stations each. Stations along the sub-routes were located so that each site was beyond the effective calling range of the stimulus given at other sites along the route. The circular design permitted location of calling sites along the entire length of each sub-route, without requiring a return trip along the same path taken earlier in the day. Ultimately, a combined vehicle and snowshoe route comprised of 97 calling sites was established: 57 were along snowshoe routes and 40 were approachable by vehicle. During the later weeks of the study, the snowshoe routes were retained, even though the necessity for snowshoes was gone.

Occasionally, some stations were temporarily inaccessible and had to be by-passed. Others became conspicuous as snow cover melted, and were deleted. Still others were deleted because of new or increased logging activity in an area. As roads opened and more areas became accessible, some new stations were added to the route to replace those deleted.

Individual stations were selected to provide the largest possible unobstructed view of the surrounding area, while providing some degree of cover and concealment at the site and along the approach to the site. The rolling, open terrain generally permitted clear observation of the approach and behavior of coyotes, but often made it difficult for the observer to reach the site inconspicuously. Site locations were recorded on U. S. Geologic Survey topographic maps.

The observer proceeded consecutively from one station to the next until trials had been performed at all accessible sites. This procedure was then repeated, beginning with the first calling site. A minimum of two weeks elapsed between successive trials at the same station.

Each calling site was approached with care to reduce the likelihood of disturbing coyotes near the station. Equipment was set up quietly and unobtrusively. Camouflaged clothing, appropriate for prevailing background conditions, was worn during all trials. Attempts were made to make successive trials at the same location as identical as possible. Particular emphasis was given to positioning the speaker in the same location and direction each time.

The commercial call and rabbit distress tapes were played alternately at successive trials. Care was taken to equalize output volumes of the two tapes. Marks on the recorder volume control indicated equal peak volume levels as determined in prior testing.

The first part of all trials consisted of playing the appropriate tape, then remaining motionless, waiting and looking for coyotes, and recording the behavior of any coyotes observed. A trial was considered successful if, during this first phase, (a) coyotes, under observation at the time the call was given, approached the calling site, or, (b) coyotes, not observed prior to the call, appeared and/or approached the calling site.

In all but the first 17 trials, a second stimulus noise, the "hand-mouth squeak." was presented. A series of low-intensity (82 to 88 dBC), high-pitched squeaks were created by moistening the lips and sucking lightly on, or "kissing," the back of the hand for 7 to 10 seconds. This technique was first described by Loring (1946) and claimed by Burnham (personal communication) to be an extremely effective calling method. This call was used whether coyotes had been observed during the first phase or not. All observed responses were carefully recorded.

The determination of when to give the hand-mouth squeak depended upon the responses observed during the first phase of the trial. The first phase was terminated, and the hand-mouth squeak given, under one of four conditions:

1. If a coyote (or coyotes) approached the calling site, the first phase was terminated when the approach terminated, and the coyote began to move away. Approach termination was usually a radical change in behavior, as a result of scenting the caller, and was easily identifiable.

2. If a coyote (or coyotes) approached the calling site, but continued past as if it had not located the stimulus source, or at least had not become obviously aware of the caller's presence, the first phase was terminated when the coyote passed out of sight. In these cases, it was obvious to the observer that the coyote was going to by-pass the site completely if it were not called back.

3. If a coyote (or coyotes) approached the calling site, and remained in the vicinity of, but at some distance from, the site, and showed no indication of approaching closer or moving away, the first part of the trial was terminated 30 minutes after the first appearance.

4. If no coyotes were observed within 10 minutes after the stimulus presentation, or if coyotes which had been observed prior to stimulus presentation failed to approach or perceptibly alter their behavior in response to the call within 10 minutes, the first phase was terminated.

In unsuccessful trials, the observer remained in position for at least 3 to 4 minutes after presentation of the hand-mouth squeak.

After each trial, the following data were recorded: station number; time of trial; tape used for the first phase; temperature, degree and kind of precipitation; wind direction, speed, and character; percentage of cloud cover; snow depth and character; presence of coyote sign, and other wildlife observed in the area prior to the trial; and other comments deemed noteworthy. Barometric pressure data for the study area were obtained by averaging station pressure readings recorded at the Missoula and Helena offices of the National Oceanic and Atmospheric Administration. Because the area was located approximately midway between the two cities, Weather Bureau personnel suggested this method of pressure determination. In successful trials, coyote approach routes and pertinent topographic features were also noted.

No attempt was made to kill or molest any of the coyotes observed or called, and every effort was made to avoid disturbing them. Whenever possible, the observer remained concealed until the coyotes had moved out of sight at the end of a successful trial.

Field work began on January 21, 1972 and ended on April 26, 1972. During that time, 302 field trials were performed: 150 trials with the commercially produced call tape, and 152 with the rabbit distress tape. The hand-mouth squeak was used at the end of the last 285 trials.

Sound spectrograms of a variety of decoying predator calls were prepared with a Kay Elemetrics Vibralyzer, Model 7030A, equipped with a Model 6070-A contour display unit. Conventional spectrograms were used to examine the structural detail of individual cries; wide-band spectrograms were used for precise temporal measurements; contour displays were used to examine the patterns of sound energy intensity. Included in the comparison are the two tapes used in the field trials, a tape of hand-mouth squeaking, several taped distress noises provided by the Burnham Brothers, and tapes of two other mouth-blown, simulated distress calls.

CHAPTER IV

RESULTS AND DISCUSSION

Of the 302 field trials performed, only 17, or 5.6 per cent, were successful. These successful trials resulted in decoying a total of 36 coyotes, an average of one coyote for every 8 or 9 trials.

Type of Call

The recording of the commercially produced call was approximately 1.9 times as effective as the rabbit distress cries, yielding 11 successful trials (7.3%) as opposed to only 6 successful trials (3.9%) for the rabbit cries.

Although this observed difference is not statistically significant (z test for differences between binomial parameters) (Snedecor and Cochran, 1967) at normally accepted ($p \leq .05$) significance levels, it must be emphasized that statistical procedures, either parametric or non-parametric, may be misleading when dealing with such small numbers of successful trials. As Snedecor and Cochran (ibid., p. 28) appropriately warn, "with a small sample, the test is likely to produce a significant result only if the null hypothesis is very badly wrong." Because the absolute value of the success probabilities is so small, the number of trials performed, although seemingly large, is too small to permit tests to be sensitive to relatively large proportional differences between the two binomial estimators. Particularly when test results come very close to permitting null hypothesis rejection, small data variations can substantially alter test outcomes. In the analyses presented here, no differences were statistically significant. However, well-guarded conclusions are drawn when the data do approach rejection criteria. Whenever appropriate, the values of test statistics and associated test probabilities will be included in the discussion.

In the comparison of response to rabbit distress cries and the commercially produced call, $Z = 1.2797$ ($p = .2008$). These values suggest that there may be a real difference in effectiveness.

There appeared to be some difference in typical behavior patterns in response to the two calls. Coyotes responding in 82 per cent of the successful commercial call trials approached the calling site directly and with little hesitation. Those responding to the rabbit cries, however, typically (in 67 per cent of the successful trials with this stimulus) stopped frequently to sniff the ground, or make short excursions to either side of a straight approach route. It appeared that most of the coyotes responding to the commercial call were intent upon locating the source of the noise, whereas those responding to the rabbit cries were more easily distracted by other stimuli.

At least two possible explanations may account for these variations. The two noises may differ in their basic attractiveness to coyotes. It may also be that coyotes responding to the commercial call located the sound source more accurately during initial presentation and were able to make a more direct approach with fewer spurious searching efforts.

This could also explain the difference in the effectiveness of the two calls in luring coyotes to the calling site.

Environmental Factors

Most environmental parameters failed to correlate with calling success. The most strongly correlated factor was time of day (Table 3).

Prior to solar mid-day, overall calling success was 8.0 per cent. After mid-day, success dropped to 2.9 per cent. Testing the null hypothesis of no difference in success ratios between morning and afternoon trials, yields $z = 1.9392$ ($p = .0524$).

Observations of several groups of coyotes and numerous fresh tracks suggest that greater calling success in the morning may be a result of greater coyote activity and movement during these hours. There was considerable evidence that coyotes had been out in open areas during the night and early morning hours, and that within a few hours after sunrise, had retreated into wooded or protected areas. During the study, 61 coyotes were observed, of which 50 were observed before mid-day. Only one of the remainder was observed later than 4:00 p.m. Coyote howls were heard only during the mornings.

Although a comprehensive study of coyote activity patterns is necessary to confirm the contention, all information available from this study suggests that coyote calling will be most successful when coyotes are most active. In this case, that time appeared to be during the four hours immediately after sunrise.

There was some indication that calling success might be dependent upon changes in barometric pressure (Table 4). Chi-square testing,

Table 3. Calling Success Throughout the Solar Day

Time of Trial	Number of Trials	Number of Successful Trials	Success Ratio
Dawn to 2 hours after sunrise	41	5	.1220
2 to 4 hours after sunrise	58	6	.1034
4 hours after sun-rise to mid-day	63	2	.0317
Mid-day to 4 hours before sunset	60	3	.0500
2 to 4 hours before sunset	46	0	.0000
2 hours before sunset to dark	34	1	.0294

Table 4. Calling Success Under Various Conditions of Barometric Pressure Change

Change	Number of Trials	Number of Successful Trials	Success Ratio
Rising ($\Delta > .02$ in Hg/3 hr)	66	2	.0303
Falling ($\Delta > .02$ in Hg/3 hr)	131	11	.0840
Steady ($\Delta < .02$ in Hg/3 hr)	105	4	.0381

with rising and steady pressure categories combined, yields $.10 > p > .05$.

More information on this subject is needed before valid conclusions can be drawn. Whether the differences in success rates are because of real variations in coyote behavior resulting from pressure changes, or are merely statistical artifacts, cannot be answered. The data do suggest, however, that coyotes may be responsive to barometric pressure changes, either directly or through some environmental clue concurrent with those changes. A detailed examination of this potential, with precise pressure data, would seem to be warranted.

There were no significant or suggested differences in success rates under different wind velocity conditions (Table 5; Kolmogorov-Smirnov test, $p > .20$).

It can be expected, however, that success rates should decline at wind speeds above 25 to 30 mph. Distortion and reduction of the effective range of the call, increased background noise levels, and increased outer ear turbulence, should all contribute to reducing the efficiency of any given call. Because of an extremely small sample during very high wind velocities. this hypothesis could not be tested adequately.

None of the other environmental parameters measured correlated with calling success. Temperature, amount and type of precipitation, wind character, degree of cloud cover, depth and consistency of snow cover all exhibited $p > .20$ in appropriate tests. Furthermore, there was no subjective impression that these factors influenced calling success.

Table 5. Calling Success Under Various Wind Conditions

Wind Velocity (mph)	Number of Trials	Number of Successful Trials	Success Ratio
0-4	148	10	.0676
5-9	92	4	.0435
10-14	29	1	.0345
15-19	15	1	.0667
20 and above	18	1	.0556

Coyote Responses to Calls

In 8 of the 17 successful trials, more than one individual responded (Table 6). Half of the multiple responses consisted of pairs. In all multiple responses, the coyotes approached together, suggesting that they comprised discrete social groups.

In 5 of the 17 trials, the coyotes were observed before the call was presented. In the remainder, elapsed time from stimulus presentation to first observation of responding coyotes ranged from 1 to 10 minutes (Table 7). Average elapsed time to first observation for these 12 trials was between 5 and 6 minutes. No first observations occurred later than 10 minutes, even though the observer remained in location for at least 13 to 14 minutes.

Distance from the calling site to the location of coyotes at first observation, or to the location of those in sight before the call, varied from approximately 85 to 1050 yards; backtracking revealed that coyotes had responded from distances as great as 1200 to 1250 yards.

Elapsed time from the call to the time at which the coyotes approached most closely to the calling site varied with the distance traveled and with the type of approach made. The elapsed time to closest approach ranged from 1 to 29 minutes. The distance from the calling site to the point of closest approach ranged from 15 to 375 yards, and averaged approximately 140 yards.

Types of Response

Coyote response to the first call was variable, but three general types of response were evident. Most commonly (11 successful trials),

Table 6. Summary of Group Size

Number of Coyotes Responding	Number of Trials	Per Cent of Successful Trials
1	9	52.9
2	4	23.5
3	1	5.9
4	1	5.9
5	1	5.9
6	0	0.0
7	1	5.9

Table 7. Elapsed Time to First Observation of Responding Coyotes

Elapsed Time (min)	Number of Trials	Number of Coyotes
Visible during call	5	19
1	1	2
2	1	2
3	2	2
4	1	1
5	0	0
6	1	1
7	2	2
8	2	4
9	0	0
10	2	3
Over 10	0	0

responding coyotes approached in a more or less direct route, until they detected the observer's presence. At this time, they immediately turned and began to run away from the calling site. Careful measurement of wind direction indicated that, unless the day was completely calm, coyotes invariably veered slightly so as to pass downwind from the calling site. The turn and flight nearly always took place when the coyotes were directly downwind. Awareness of wind direction permitted regular and accurate prediction of when the flight response would begin.

Approaching coyotes were often aware of the calling site, as indicated by frequent looking in that direction, even when the observer and equipment were extremely well concealed. Even with this awareness, the coyotes would continue to approach until the observer was scented.

The turn to begin flight was occasionally accompanied by a quiet, snort-like "woof" bark, sounding much as if the coyote were startled by the new scent. In pairs or packs, this bark did not appear to serve as a warning call to the others. The sight of a fleeing coyote would, however, alert other members of a group, and was sometimes sufficient to cause them to flee.

In three successful trials, coyotes approached as in the first response type, but apparently failed to detect the observer's presence, and continued past the site location. During one trial, 2 coyotes walked past within 15 yards of the site; in the other 2 trials, single coyotes passed at 87 and 150 yards, respectively. In all three cases, the coyotes had approached from within heavily forested areas. It appeared that they had been unable to locate the source of the call during the initial presentation, and were simply moving in the general direction of the noise.

In the other three successful trials, the coyotes stopped from 250 to 290 yards from the calling site. In two of these trials, the coyotes appeared to be either disinterested in or ignorant of the site. They remained in the area, and either sat, made short excursions in the immediate vicinity, or sniffed and dug at the ground, apparently hunting for small prey. In the third trial, the coyote appeared to be aware of the caller's presence, for it sat on a small knoll and continually barked and howled in the direction of the calling site. This coyote may have been called earlier in the morning, for a similarly noisy coyote had been called approximately two hours earlier at a site more than a mile away, and had last been seen traveling in the direction of the later site. Such barking-howling was rare. It was only observed during these two trials, and during a third trial, in the same area, more than two months later.

Variations in the Types of Responses

Responses varied within each of these three categories. Of the 36 coyotes responding, 15 (in 4 trials) approached by running until they were 80 to 150 yards from the site. In three of these four trials, the coyotes slowed to a walk at this point. While walking, they occasionally paused for a few seconds, and frequently sniffed the air and looked in the direction of the site. They continued to approach cautiously until they scented the observer, when they turned and fled. In the other trial, a pack of 5 turned at approximately 80 yards, and completely reversed direction without breaking stride.

In two trials, coyotes approached by trotting unhesitatingly. The single respondent in one of these trials continued to trot steadily until it detected the observer at 87 yards. In the other trial, a pack of 4 stopped trotting at 120 yards, and then walked cautiously to a distance of 52 yards before detecting the observer.

The 16 coyotes responding in the remaining 11 trials walked toward the site from where they were first observed. Some (6 coyotes in 5 trials) walked quickly and unhesitatingly. Others (10 coyotes in 6 trials) walked more slowly and tended to stop frequently to look around or sniff the ground, or to make short side excursions along the approach route.

Influence of Topography on Response

Many of the qualitative variations in response patterns were directly related to obstructions between the coyotes' initial locations and the calling site. In open areas, direct observation or backtracking frequently indicated that the calling site had been visible to the coyote at the time of the call. Under these conditions, coyotes demonstrated a remarkable ability to locate the sound source during the initial stimulus. In at least 9 trials (24 responding coyotes), the approach routes were very nearly straight lines. The responding coyotes moved directly toward the calling site from their initial location until the observer was detected.

In the other trials, a direct line of sight from the coyotes' initial locations to the calling site was impossible because of intervening hills or coniferous forest. Under these conditions, coyotes appeared unaware of the calling site location. Responses were typically slower and included more frequent stops and short side trips. None of these approach routes were straight paths as seen in the open area successes. In all three trials in which coyotes passed by the calling site, they had approached from within forested areas.

Responses of Coyotes Observed Prior to Call

In 5 of the 17 successful trials, the 19 responding coyotes were observed before the call was given. They responded immediately, and the approach began before the stimulus presentation was complete. In one of these trials, a pack of 7 coyotes was feeding on a freshly killed mule deer (Odocoileus hemionus). Prior observation of the chase indicated that the coyotes had killed the deer less than 20 min before the trial. During the first series of cries, the coyotes scattered from the carcass, ran 20 to 30 ft, stopped, and remained motionless. At the sound of the second series, the entire pack immediately began to run in the direction of the calling site.

In 5 additional trials, backtracking also indicated an immediate response, for there were clear indications of a sudden change in behavior. In one such trial, coyotes had been lying down; in the other 4 trials, the responding coyotes had been hunting (as indicated by irregular track paths and signs of digging in the snow) immediately prior to the call.

There were, however, three unsuccessful trials in which coyotes were observed prior to the call. In all of these instances, the coyotes responded by looking briefly in the direction of the stimulus, then ignoring it and making no move to approach. There was no indication that the coyotes had detected the observer during his approach, and the reason for this lack of response is not known.

The success rate for those trials in which coyotes were observed prior to the call was 62.5 per cent, considerably higher than the percentages obtained for all trials. Although it may seem self-evident, this suggests that perhaps the most important variable influencing calling success is simply whether or not coyotes are present to hear the call. If all trials at all stations where there was never any indication of coyote presence are eliminated, the overall calling success rate increases to 8.3 per cent, which is not significantly higher than the overall observed success rate of 5.6 per cent.

There are other indications that calling is more likely to succeed in areas frequented by coyotes. Six successes were located at stations in one area within 1 mile of each other, and 4 of those occurred at a single station. In another area, 3 successes at 3 stations were within 1 mile of one another. In a third area, 2 successes occurred at 1 station, and 2 other successes occurred at stations less than 1½ miles distant. In a fourth area, 2 successes occurred at the same station. This concentration of successes in a few areas regularly inhabited by coyotes supports the contention that calling is more likely to be successful in such areas.

On three known occasions, coyotes within 300 yards of a calling site detected the observer during his approach to the station. In each case, the trial was performed as usual. All were unsuccessful.

The coyotes, running or walking away, paused and looked in the direction of the call, then continued moving away until they were out of sight.

Observations on Coyote Perceptual Acuity

As the last example illustrates, chances of success can be destroyed by careless approach to the calling site. However, the caller, if he uses care in his approach, needs to worry only about being observed by coyotes within a few hundred yards of his location. At distances greater than 400 or 500 yards, coyotes appear to ignore or not detect the presence of a moving man. On at least 7 occasions, direct observation or backtracking indicated that the observer must have been plainly visible to the coyotes for at least 100 yards of his approach to the calling site. Those coyotes were at distances of 450 to 1300 yards. It is unknown whether the coyotes actually observed his approach or not. If they did, that stimulus was insufficient to stop their subsequent response to the call. There were no indications that any other coyotes at these distances were deterred from responding by detection of the observer's approach.

This suggests that coyotes may not rely heavily on vision, particularly at great distances. Further indication of a lack of responsiveness to visual stimuli is provided by several instances in which coyotes approached the caller closely. As has been pointed out, approaching coyotes frequently looked in the direction of the site, but continued to approach until they scented the observer. On three such occasions, the observer, although motionless, was very poorly concealed. On a calm day, for example, one pair of coyotes passed slowly within 15 yards. One even stopped at that distance to lie down briefly before walking on. The observer was lying motionless among the small rocks of high road embankment, and the only cover provided was a single fencepost. In another instance, a single coyote circled behind the observer and approached to 10 yards. From that direction, there was absolutely no cover, yet the coyote did not flee until the observer turned to see what was behind him.

In a third case, 2 coyotes, intent on chasing a deer, ran past the observer at 125 and 50 yards respectively, even though the observer was caught unaware, standing upright in knee-high sagebrush. These coyotes gave no indication of having seen the observer.

In contrast, the coyotes' senses of smell and hearing are extremely acute. At distances up to 300 yards, coyotes began to flee as soon as they scented the observer, even though the breeze was often less than 2 mph. Keenness of hearing was most clearly demonstrated by the response to hand-mouth squeaking (described in the next section). Responses to this relatively low-intensity noise were observed in coyotes as distant as 400 yards.

Response to Hand-Mouth Squeaking

No additional successes were recorded as a result of hand-mouth squeaking; that is, no coyotes were observed that had not already responded to the initial call. However, the response to squeaking was marked.

Three different levels of response to squeaking were observed in coyotes which had approached until they detected the observer. The squeak was given as quickly as possible after the coyotes had begun to flee. The weakest response (observed in 9 coyotes during 6 trials) was to slow slightly and look back over the shoulder while running. These coyotes usually turned the forequarters as well, resulting in a peculiar, semi-sideways run, with the body somewhat diagonal to the direction of travel. Although slightly slower than normal, the coyotes continued to run this way for a few seconds before resuming normal running.

Six different coyotes, responding during 3 trials, came to a complete stop, usually broadside to the line of flight. They remained motionless, looking at the site, for at least several seconds, before running again.

Seven other coyotes (5 trials) came to a complete stop and then began a second approach to the calling site. Although this approach was more wary than the first, 4 of the 7 approached the observer more closely than they had during the first response.

In 2 of the 3 trials where coyotes approached to a certain distance and failed to come closer within 30 minutes, the coyotes immediately approached more closely. The coyotes then fled when they detected the observer's presence. In the other trial, the barking, howling coyote showed no response to the squeak.

In all 3 trials where coyotes traveled past the calling site, the hand-mouth squeak was given as soon as the coyotes disappeared from sight. In 2 trials, the single respondents returned at once. One approached to 85 yards before fleeing. The other circled to one side and was not observed again for 3 minutes, when it reappeared 10 yards behind the observer. In the third trial, one of the two original respondents reappeared, running directly toward the station. It stopped at 17 yards, circled a short distance until it scented the observer, and then fled.

Coyotes, in their final departure, would typically run out of sight, or, in open flat areas, until 300 to 500 yards away. At that distance, they slowed to a walk, or stopped briefly and then continued to walk or trot on. At these distances, they showed little fear or concern, casually moving away and occasionally stopping to look in the direction of the site.

Description of Calls and Sonographic Analyses

Commercial Call

The commercial call field stimulus consisted of six cries, followed by a 10-sec pause, and another series of six cries. The two series lasted 6.40 and 6.30 sec respectively. Individual cries averaged 0.98 sec (range 0.67 to 1.38 sec) and the intervals between cries averaged 0.09 sec (range 0.07 to 0.12 sec) (Table 8).

Subjectively, the individual cries of this call are harsh screams, much like the urgent screams of a baby, but more rapidly repeated and at a slightly higher pitch. The quality of the noise changes within most of the cries, and two distinct, qualitatively different components are usually audible. One is a raucous and grating, caw-like shriek and the other is a shrill, but purer, more music-like scream. Typically,

Table 8. Temporal Measurements of the Commercial and Rabbit Distress Field Stimuli in Seconds

	Commercial Call				Rabbit Distress Call			
	1st Series		2nd Series		1st Series		2nd Series	
Cry Number	Cry Duration	Interval Duration	Cry Duration	Interval Duration	Cry Duration	Interval Duration	Cry Duration	Interval Duration
1	0.91	0.12	0.67	0.11	0.60	0.39	0.61	0.41
2	0.93	0.09	0.83	0.08	0.61	0.41	0.60	0.38
3	1.06	0.08	0.97	0.09	0.63	0.39	0.65	0.38
4	0.94	0.10	0.96	0.07	0.61	0.39	0.61	0.38
5	0.69	0.10	1.10	0.09	0.63	0.39	0.61	0.39
6	1.38	----	1.34	----	0.66	0.36	0.65	0.49
7	----	----	----	----	0.61	----	0.47	----
mean	0.98	0.10	0.98	0.09	0.62	0.39	0.60	0.40

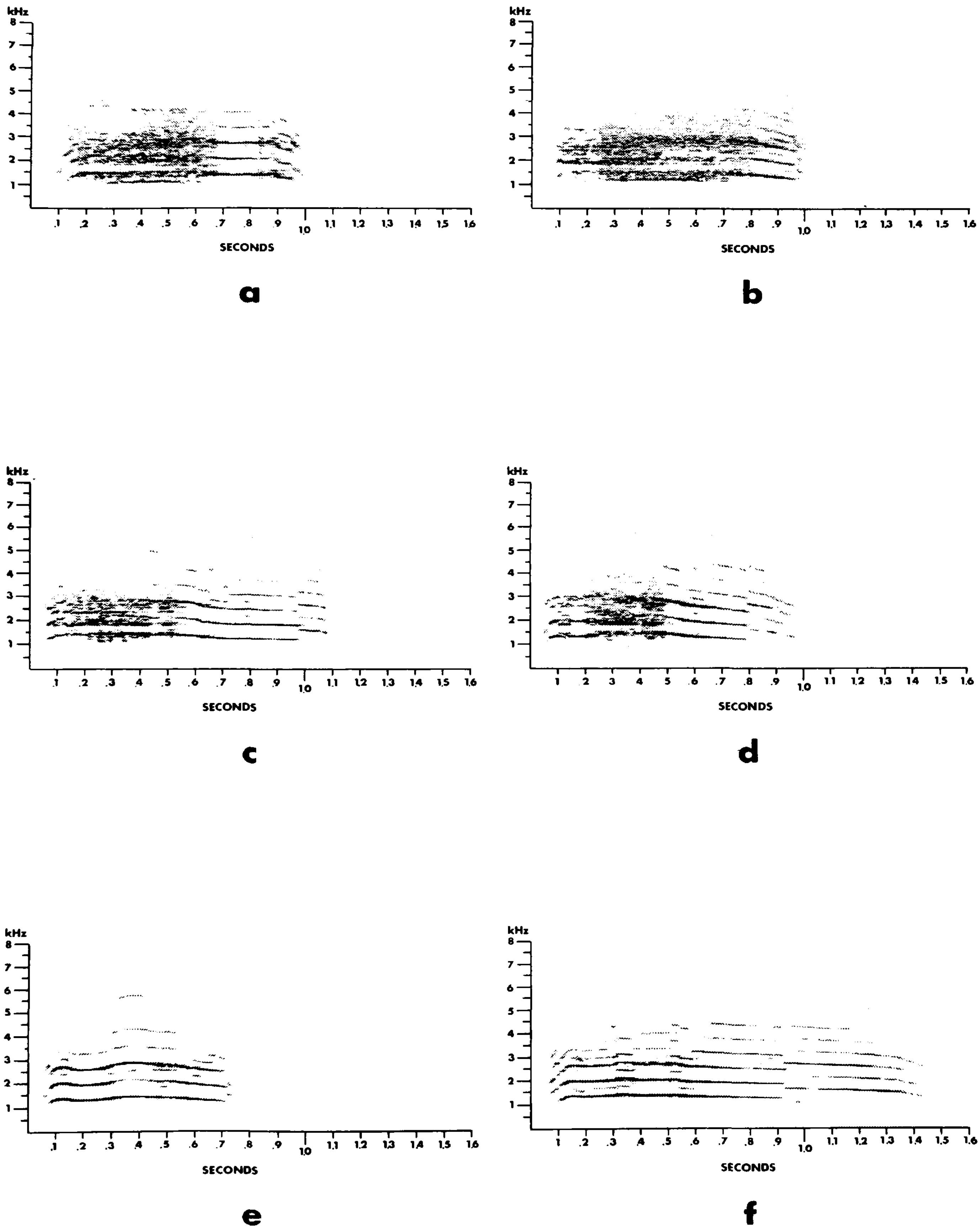
individual cries begin with the raucous shriek, and suddenly shift, mid-way through the cry, to the more musical scream. The arrangement and relative proportions of the two components vary irregularly, however, and in a few cries, the raucous component is missing.

Sound spectrograms have been analyzed to determine the structural detail of the different cries. Conventional spectrograms of the six cries of the first series are presented in Figure 2. Spectrograms of the second series are very similar.

The structural differences between the raucous shriek and the music-like scream components are evident. The former appear on the spectrograms as unstructured mottled regions, without clear differentiation into distinct tones or bands. In contrast, the music-like screams appear as several well-defined bands or tones. Usually, one tone (the dominant tone) is more intense than the others, with varying numbers of overtones of lesser intensity occurring regularly at higher and lower frequencies. The structure of these tonal noises is remarkably similar to the structure of the musical noises produced by several wind and string instruments (Marler, 1969).

Individual cries may contain either or both of these components to varying degrees. A typical cry begins with an extremely brief tonal noise, during which the sound intensity and tonal frequencies increase sharply. This is followed by variable combinations of raucous, unstructured shrieks and tonal screams, most frequently beginning with the shriek component. Cries usually terminate with a short tonal component of sharply decreasing intensity and pitch.

Figure 2. Conventional sound spectrograms of the six cries comprising the first series of the commercial call field stimulus. (a) through (f), cries 1 through 6, respectively.


kHz
8
7
6
5
4
3
2
1
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS
a
b
c
d
e
f

The frequency of the unstructured shrieks ranges from approximately 1.0 to 6.0 kHz, with most of the sound energy located between 1.0 and 3.0 kHz[1]. Frequency dominance in this component varies from one occurrence to the next. The most intense frequencies are often approximately the same as the more intense tones of adjacent tonal noise, but isolated, short intensity peaks occur irregularly at frequencies between 1.0 and 3.0 kHz. The duration of the component and the temporal location of peak noise intensities within the component also vary irregularly.

The transition from unstructured shrieks to tonal noise is usually abrupt.

The dominant tones of the tonal component range from approximately 1.2 to 2.9 kHz, and the overtones extend upward to approximately 6.0 kHz. The tones exhibit wavering frequency fluctuations that vary the subjective pitch of the cry. Sudden addition and elimination of overtones is common, producing, respectively, abrupt increases and decreases in the harsh, raucous quality of the noise. Abrupt frequency jumps are also common, resulting in breaking pitch changes similar to the sudden pitch changes used in yodeling. The pitch of the tonal components tends to decrease gradually, but irregularly, as the cry progresses. One of the tones is usually dominant throughout, but sudden shifts of emphasis

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[1]Most of the sound energy is arbitrarily defined as the two most intense levels appearing on contour display spectrograms. Sound level dominance refers to the single, most intense contour of the contour display. Both measures are used here to help define the relative, subjective pitch of the noises.

to the next higher or lower tones is also common, again producing distinct pitch changes. Temporal location of peak sound intensities within the component varies irregularly from cry to cry.

Rabbit Distress Call

The rabbit distress stimulus consisted of seven cries, followed by a 10-sec pause, and another series of seven cries. The two series lasted 6.70 and 6.62 sec respectively. Individual cries averaged 0.61 sec. The last cry of the second series was only 0.47 sec, and all other cries were between 0.60 and 0.66 sec. Intervals between cries averaged 0.40 sec (range 0.36 to 0.49 sec) (Table 8).

Subjectively, the stimulus consists of harsh squeals at slightly lower pitch than the commercial call. The harsh quality of the noise is intermediate between the shriek and music-like components of the commercial call.

The most distinguishing difference between this stimulus and the commercial call is the regularity and uniformity of the rabbit squeals. There are no sudden, obvious inflections or quality changes within any one of the cries. Furthermore, each cry sounds very similar to all the others; the only noticeable difference from cry to cry is a slight increase in pitch in the last few cries, and, in the final cry, a more music-like quality. The cries are shorter, and the intervals between cries are longer than the commercial call, with little variation in either parameter. These factors combine to produce a monotonous and measured call, with less force than the commercial call. Anthropomorphically, it seems to convey noticeably less urgency and distress.

Conventional sound spectrograms of the first six cries of the first series are shown in Figure 3. Except for the shorter final cry, the structure of the other cries does not differ significantly.

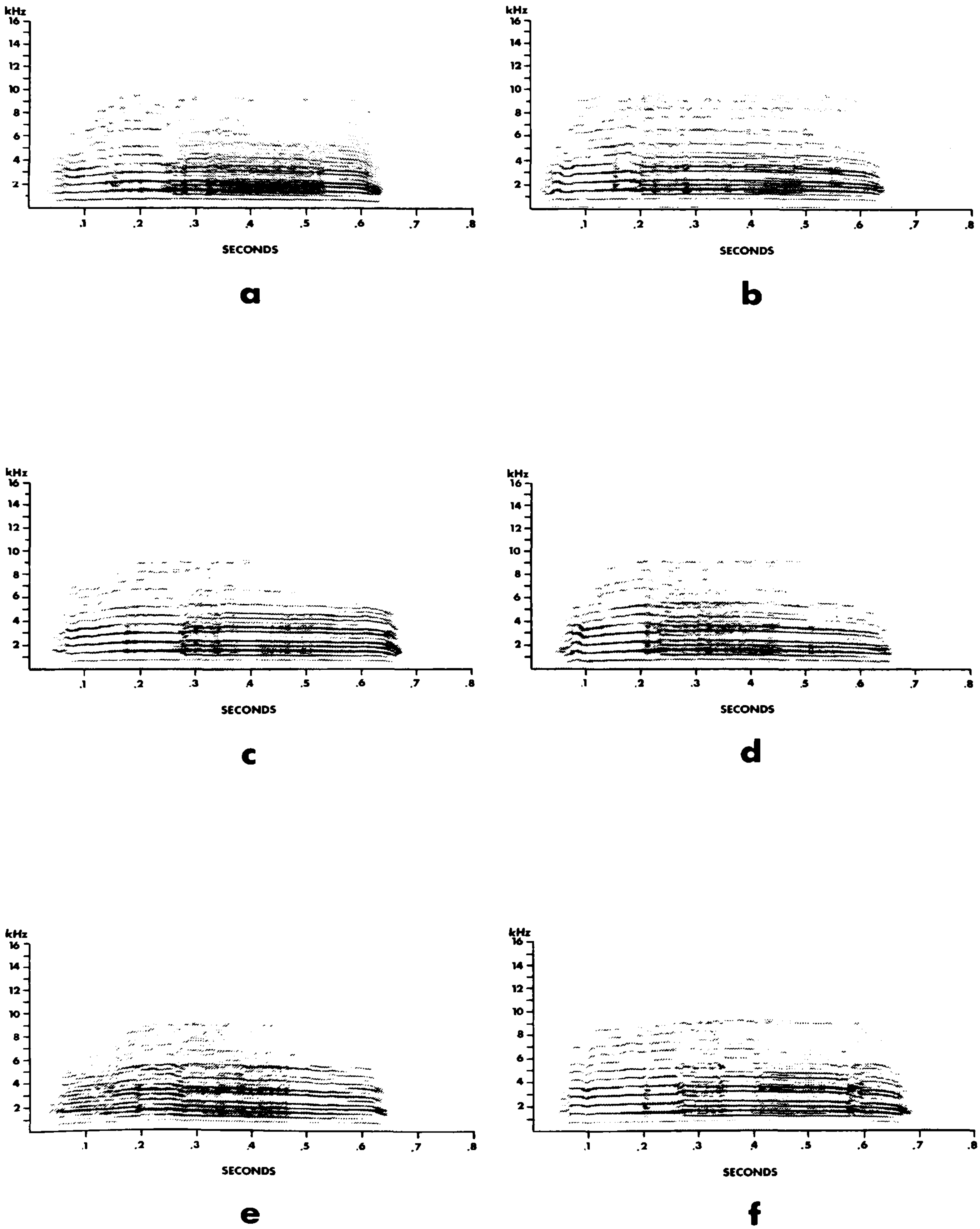
The similarity of the cries is evident; there is little structural variation from one cry to the next. Each cry consists of a dominant tone at approximately 0.7 to 1.1 kHz, and numerous overtones extending upward to approximately 10 kHz. Most of the sound energy is located below 5 kHz.

In each cry, the frequency of the tones gradually rises and then falls, producing an even and gradual pitch fluctuation. Irregular, small-amplitude frequency vacillations are common throughout. Overtones appear and disappear irregularly, but in many of the cries, numerous overtones appear abruptly at approximately 0.2 sec into the cry. The number of overtones decreases in the last cry of the second series, producing a purer, more music-like quality.

Variations in sound intensity occur in a simple and repetitive pattern. In typical cries, the sound increases to a maximum intensity in the first 0.1 to 0.2 sec, and is maintained at that level for most of the duration of the cry. Cries terminate with a sharp, rapid decrescendo. As the sequence of cries progresses, peak intensities tend to occur later in the individual cries.

The relative quality of a cry is determined in part by the number of overtones present in the noise. As the number of overtones increases, and the frequency difference between adjacent overtones decreases, the quality of the noise becomes progressively more harsh (Wood, 1947; Bartholomew, 1942). Eventually, overtones can become so numerous that

Figure 3. Conventional sound spectrograms of the first six cries of the first series of the rabbit distress field stimulus. (a) through (e), cries 1 through 6, respectively.



kHz
16
14
12
10
8
6
4
2
.1
.2
.3
.4
.5
.6
.7
.8
SECONDS
a
b
c
d
e
f

they become undistinguishable, producing a broad-spectrum, extremely harsh "white noise" (Josephs, 1967).

The intermediate subjective harshness of the rabbit distress cries, compared with the commercial call cries, can be explained by comparison of the spectrographs. The rabbit squeals contain more overtones than the tonal components of the commercial call, but the overtones are not numerous enough to merge and form the raucous white noise of the shriek component.

Hand-Mouth Squeaking

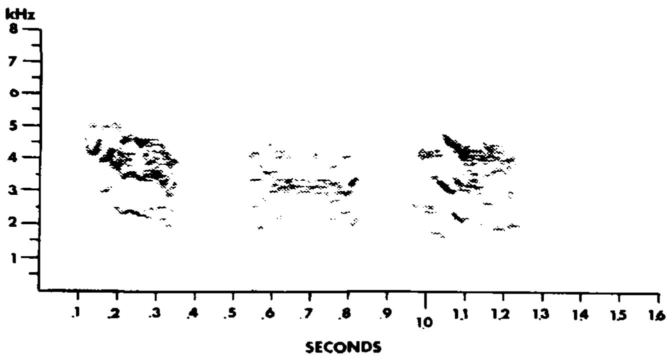
The hand-mouth squeak stimulus was produced in the field by sucking lightly on the back of the hand. The noise created was a series of raspy, irregular, chirp-like squeaks, conspicuously higher-pitched than either the rabbit distress or commercial calls. Hand-mouth squeaks were given for 7 to 10 sec, during which 15 to 20 squeaks were usually produced.

Although tape recordings of the hand-mouth squeaks were not used in the field, several series were recorded in the laboratory. A representative series, consisting of 18 squeaks, was selected for spectrographic analysis (Figure 4).

The cadence of this sample is much quicker than either the commercial or rabbit distress calls. Individual squeaks averaged only 0.32 sec and the intervals between squeaks, only 0.11 sec (Table 9).

The frequency of the squeaks ranges from 1.0 to 5.5 kHz. The subjective impression of higher pitch results from emphasis on the higher frequencies. Most of the sound energy typically occurs from

Figure 4. Conventional sound spectrograms of 18 cries from a sample series of hand-mouth squeaks.


kHz
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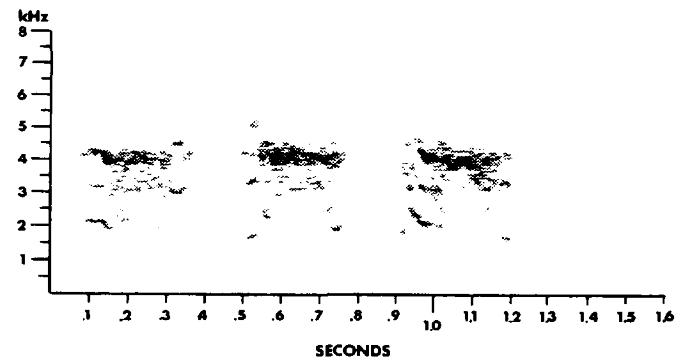
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

a


kHz
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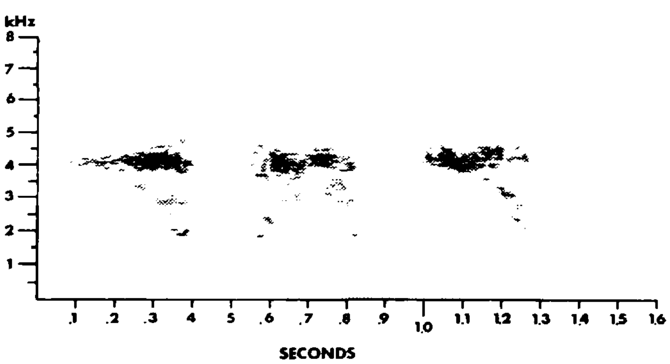
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

b


kHz
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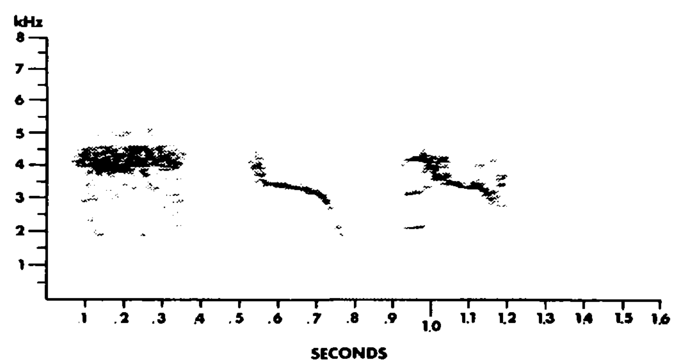
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

c


kHz
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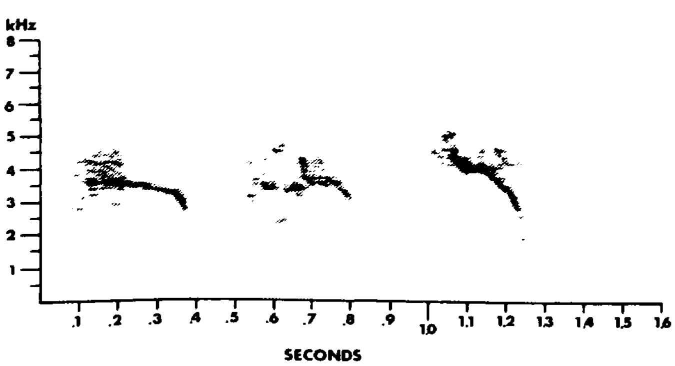
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

d


kHz
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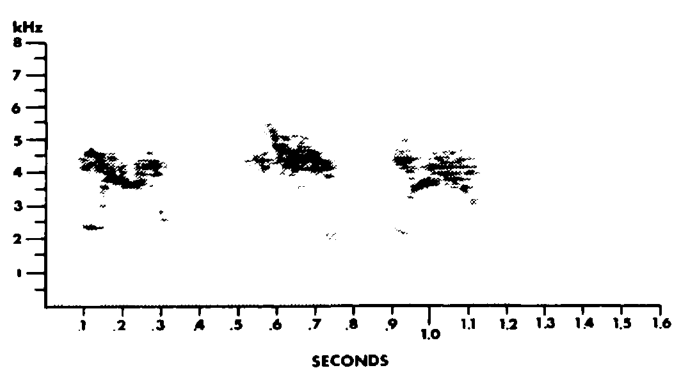
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

e


kHz
8 7 6 5 4 3 2 1
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

f

Table 9. Summary of Temporal and Frequency Measurements of Additional Calls

Call	Duration of Cries (sec)		Duration of Intervals (sec)		Range of Frequencies (kHz)	
	Mean	Range	Mean	Range	Overall	Dominant
Field Stimulus						
Hand-Mouth Squeaking	0.32	0.26-0.38	0.11	0.09-0.17	1.0-5.5	3.5-4.7
Call Blown by E. E. Seyler						
Burnham Bros. Long-Range Fox Call	1.10	0.09-1.20	0.09	0.06-0.11	1.0-5.1	1.0-3.4
Homemade Plastic Coyote Call	1.38	0.74-1.92	0.09	0.08-0.09	0.9-4.6	1.1-1.6
Tapes by Burnham Bros.						
Hand-Mouth Calling	0.43	0.33-0.50	0.14	0.11-0.19	0.4-4.7	1.6-3.4
Half-Grown Jackrabbit	0.62	0.54-0.74	0.17	0.16-0.20	0.5-5.4	1.8-2.7
Grown Jackrabbit	1.07	0.52-1.64	0.23	0.14-0.50	0.3-5.3	1.5-3.6
Baby Cottontail	0.23	0.20-0.27	0.11	0.06-0.14	1.0-7.5	2.0-5.8
Grown Cottontail	0.43	0.41-0.46	0.25	0.22-0.28	0.7-5.7	2.2-3.6

Table 9. Continued.

Call	Duration of Cries (sec)		Duration of Intervals (sec)		Range of Frequencies (kHz)	
	Mean	Range	Mean	Range	Overall	Dominant
Gray Woodrat	1.08	0.44-1.44	2.07	1.14-3.80	0.3-6.3	1.7-2.4
Yellowhammer Woodpecker	0.35	0.28-0.47	0.17	0.14-0.22	0.5-5.7	2.0-4.0
Baby Javelina	Continuous				0.1-4.7	0.1-2.0
Chicken	0.84	0.77-0.93	0.52	0.47-0.58	0.1-3.7	0.7-1.4
Fawn	0.45	0.31-0.65	0.66	0.30-0.96	0.4-4.5	1.0-3.8

3.5 to 4.7 kHz, although occasional loud tones extend below this range.

Structurally, the squeaks consist of highly variable combinations of unstructured, broad-spectrum noise, and one or two short tonal components. Most commonly, the tones are weakly emphasized, and, in the spectrographs, they appear to be only slightly differentiated from the unstructured component. In a few squeaks, a single, prominent whistle-like tone is evident.

The number of overtones, the temporal location of tonal noise, and the patterns of frequency change within the tonal noise vary irregularly from cry to cry.

Sound intensity patterns are also irregular. Peak intensities can occur at any time within the cry. Frequency dominance varies within cries and from cry to cry.

Because recordings were not used, considerable variation in most stimulus parameters occurred in the field. Loud, uniform squeaks were particularly difficult to produce with dry or chapped lips, and audible variations in the quality, cadence, and intensity of the squeaks were common.

Additional Calls

A wide variety of coyote calls are available to potential callers. Homemade calls of different designs, toy noisemakers (e.g. the plastic reed unit used in "ma-ma" talking dolls), numerous commercial mouth-blown calls, and recordings of small animal distress noises are all purported to be effective. To help define the kinds of noises to which coyotes are attracted, a number of these other calls have been compared with the field stimuli. Included in the comparison are nine commercial recordings of different animal noises, a commercially produced tape of hand-mouth calling, and recordings of a second mouth-blown commercial call and a homemade plastic call. Scientific nomenclature was not included with the commercial tapes, and the animal names appearing in this analysis are those used by the tape producer.

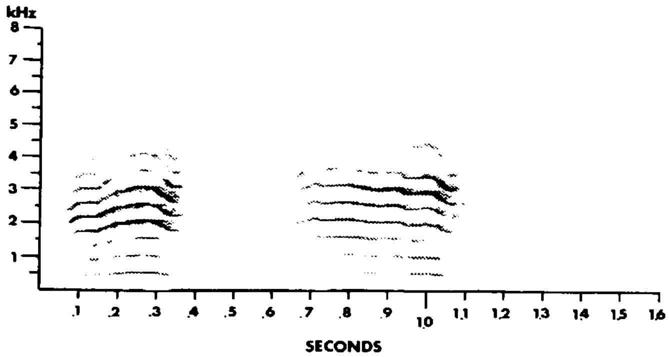
Like the field stimuli, all of the calls examined either imitate or reproduce small animal distress cries. To the human ear, most are similar and consist of repeated, relatively high-pitched screams or squeals of short duration. Variations in pitch, harshness, and cadence, however, give each call a distinct and perceptibly different quality.

Subjectively, the cries of the gray woodrat, javelina, chicken, and fawn are particularly distinct. The woodrat and javelina calls consist of irregular, harsh, strained grunts; the chicken call is a series of familiar squawks; and the fawn cries are repeated, lamb-like bleats.

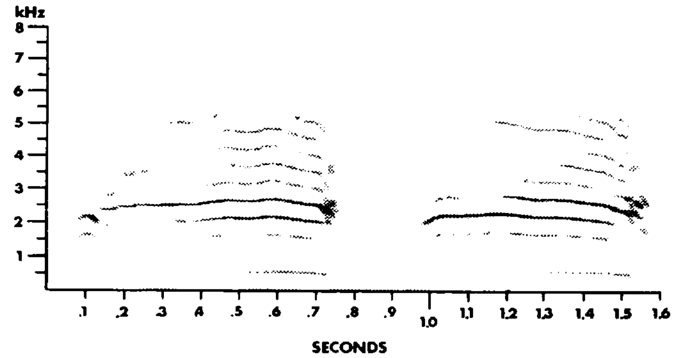
Conventional sound spectrograms of representative cries reveal strong structural similarities among many of the calls (Figures 5 and 6). Nearly all are composed of discrete tones and overtones. The detectable differences in the harshness of the different calls are attributable to differences in the numbers of overtones present and in the frequency differences between adjacent overtones. In some calls (e.g. the woodpecker, javelina, and chicken), an unstructured, extremely raucous component is present. Subjectively, the quality of the noises

Figure 5. Conventional sound spectrograms of representative cries from six different predator calls: (a) hand-mouth calling; (b) half-grown jackrabbit; (c) grown jack-rabbit; (d) baby cottontail; (e) grown cottontail; (f) fawn. These cries were from tapes furnished by Burnham Brothers, Inc.

Figure 6. Conventional sound spectrograms of representative cries from six different predator calls: (a) gray woodrat; (b) yellowhammer woodpecker; (c) baby javelina; (d) chicken; (e) Burnham Brothers Long-Range Fox Call; (f) homemade plastic call. Cries (a) through (d) were from tapes furnished by Burnham Brothers, Inc.; cries (e) and (f) were from tape recordings of calls blown by E. E. Seyler.


kHz
SECONDS

a


kHz
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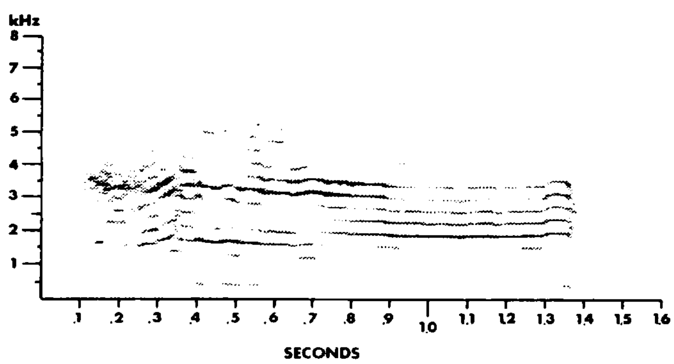
b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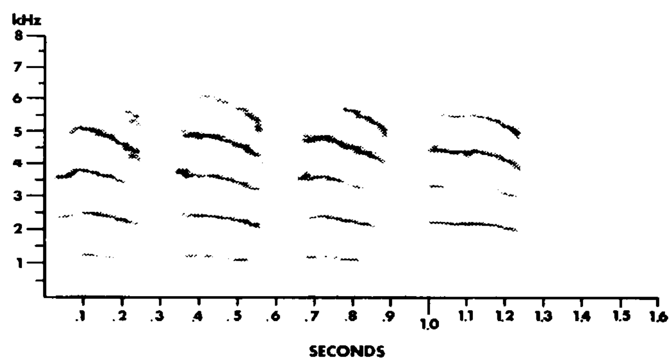
kHz
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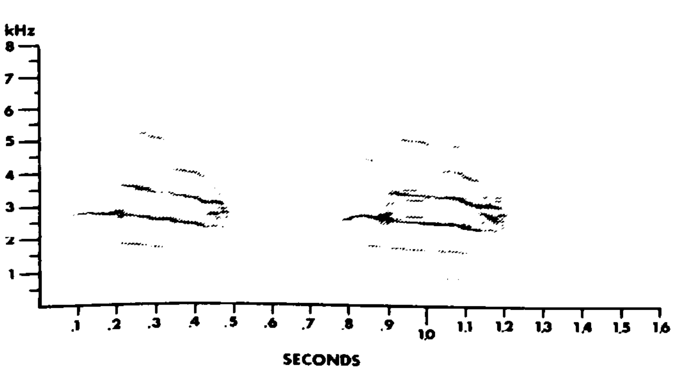
kHz
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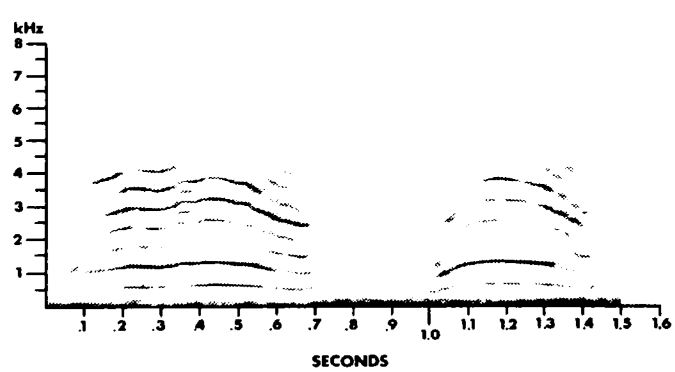
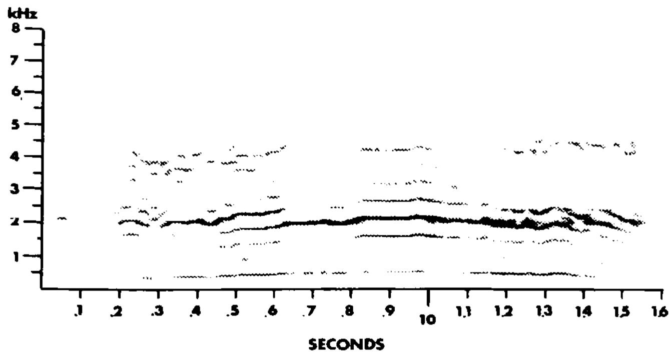
e


kHz
SECONDS

f


kHz
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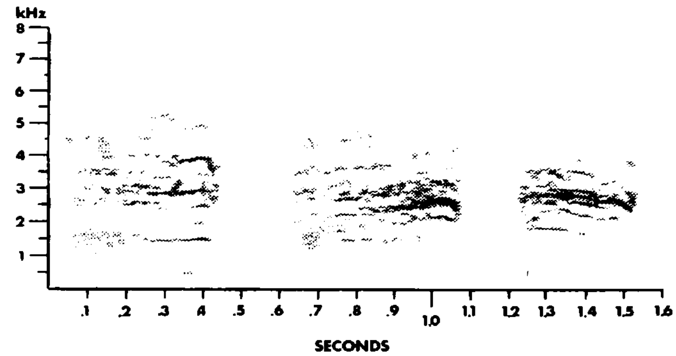
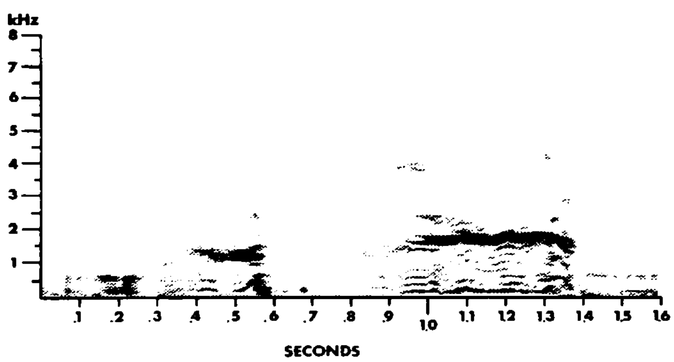
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

a


kHz
8 7 6 5 4 3 2 1
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

b


kHz
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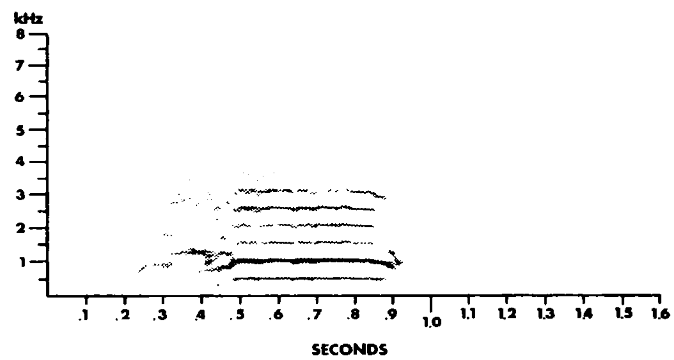
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

c


kHz
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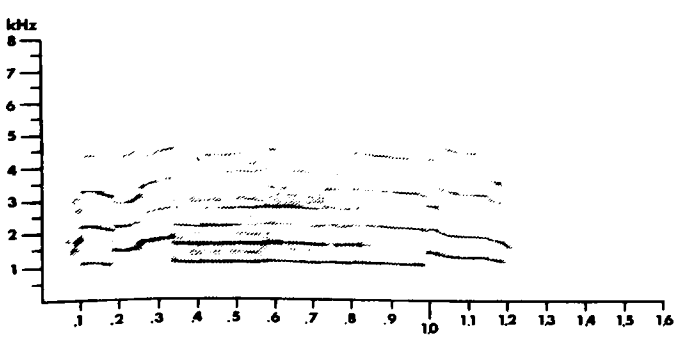
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

d


kHz
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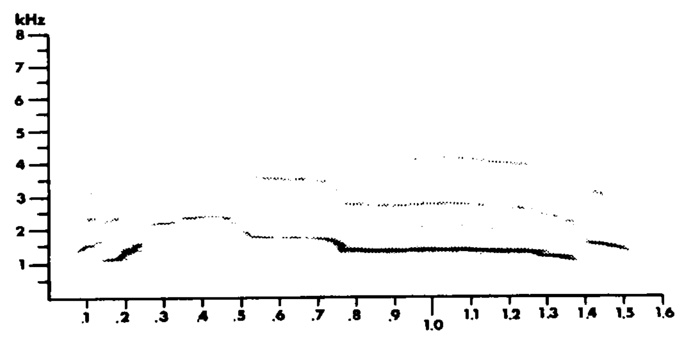
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
SECONDS

e


kHz
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SECONDS

f

ranges from a pure, music-like tone of the homemade plastic call to the extremely harsh, raucous cawing of the woodpecker. Except for the homemade call, all the noises have a rough, dissonant quality.

The quality of the noise is relatively uniform throughout most cries. In some, however, sudden shifts from unstructured to tonal noise, or sudden addition and elimination of overtones produce abrupt, detectable changes in the noise harshness.

In the samples available, there was little variation in quality from cry to cry within the different calls. The quality of each cry is nearly identical to the quality of the other cries in the series. Only in the grown jackrabbit tape do the cries become progressively more harsh.

There is considerable variation in the subjective pitch of the different calls. As indicated by the emphasis on different frequencies (Table 9), the pitch ranges from the relatively low-pitched noise of the javelina and chicken to the much higher-pitched cries of the baby cottontail.

Within individual cries, irregular patterns of frequency modulation are common to nearly all tonal noises. In some calls, the frequency modulation patterns are of sufficient duration and amplitude to produce audible wavering pitch changes as the cries progress. Usually, these modulations are superimposed on a more general pattern in which the frequency of the tones (and, hence, the pitch) gradually rises and falls throughout the cry. In the two mouth-blown calls, abrupt frequency shifts are present. In most other cries, irregularly changing emphasis on different frequencies produces slight, but detectable pitch changes.

There is little variation in the patterns of frequency emphasis from cry to cry in the different series. All of the cries in any one sequence have approximately the same pitch with similar patterns of pitch fluctuation.

Temporal patterns of peak noise intensities are most often relatively constant from one cry to another within any one series, but vary from call to call. In some calls, the most intense noise occurs at the beginning of each cry, and in others, at the end. In a few, intensity peaks occur at irregular intervals in the different cries.

The most variable parameters of the different calls are the cadence and duration of the individual cries (Table 9). Average duration of cries ranges from the very short cries of the baby cottontail to the longer screams of the grown jackrabbit and the mouth-blown calls. The duration of individual cries is considerably more regular in some calls than in others; in some, the individual cries vary less than 0.1 sec, and in others, they vary more than 1.0 sec. Intervals between cries are typically shorter than the cries, but durations of intervals are highly variable. Calls comprised of irregular cries typically contain even more irregular intervals between cries. The resultant cadence of the different calls varies from the slow-paced, irregular cries of the woodrat and javelina to the rapid, repetitious cries of the baby cottontail, woodpecker, and the hand-mouth calls.

Success of the Different Calls

Although a statistically significant difference is not demonstrable, the field results suggest that a real difference in effectiveness may exist between the rabbit distress and the mouth-blown commercial calls. Sonographic examination indicates several structural and temporal differences between the two, any of which could, potentially, contribute to differential success rates. The most obvious differences are (a) the distinctive lack of quality variation both within and among the individual rabbit cries, (b) the noticeably higher pitch of the commercial call, and (c) the slower-paced, measured cadence of the rabbit cry.

The other calls examined share many characteristics. All are composed of a series of relatively short, harsh noises. The tonal quality of individual cries is usually uniform, with noticeable intra-cry changes in pitch and intensity. Within the different calls, the quality, pitch, and patterns of pitch fluctuation in the individual cries are usually quite similar. Most often, the cries in any given call are nearly identical. With a few exceptions, the cadence of the cries is relatively regular, with little variation in cry and interval durations.

From call to call, however, there are conspicuous variations in nearly all acoustic parameters. Differences in pitch, cadence, and tonal quality are particularly evident. The values of the measurable parameters of the two field stimuli are more similar than those of many of the other calls examined.

Clearly, firm conclusions regarding differential success rates, or the influence of specific acoustic variables on coyote responsiveness are unwarranted. Extensive, carefully controlled experiments are necessary to identify the important acoustic parameters, and determine their influence on calling success. Because of low success rates, however, field tests of specific, alternative hypotheses are highly impractical.

At this time, however, a few broad conclusions can be drawn. It is reasonable to conclude that nearly any series of loud, shrill distress screams will be effective to some degree in calling coyotes. An effective, general call should probably have the following characteristics: (1) it should be relatively high-pitched; (2) individual cries should last less than 2 sec and should be rapidly repeated; (3) the cries should have a relatively harsh tonal quality; and (4) the pitch, tonal quality, and noise intensity should vary within each cry, to create audible fluctuations in the noise produced.

There is probably little need for a caller to have extensive experience or to know subtle techniques in the use of mouth-blown calls. Common technique is to hold the call in one hand, and, with the call in the mouth, cup the other hand around the open end. Blowing vigorously through the call will produce loud, scream-like noises. The quality, pitch, and intensity of the noise can be changed by varying the force with which the call is blown, and a wavering, muting effect can be created by opening and closing the hand that cups the open end.

Which commercially produced call is used is probably of little importance; only marginal differences in success rates should be expected.

Discussion of Calling Technique

In addition to call selection and use, there are several other considerations that will help ensure calling success. Although seemingly self-evident, the most important consideration is that coyotes must be within hearing distance of the call. Callers should be alert for tangible evidence of coyotes, and avoid calling in areas where there is none. To maximize the effective range, the first call should be as loud as possible. In the absence of other evidence, if repeated calling efforts in a given area fail to produce responses, the caller can probably assume that few or no coyotes frequent that area, and that further attempts are likely to be futile.

Coyotes may not respond even when they are present. Three trials have been cited in which coyotes were visible during the call, and obviously heard the noise, but failed to approach. There are no obvious explanations for this lack of response. In addition, from early February to early March, numerous trials were performed, and only one success was recorded. In at least some of those trials, tracks and howling indicated that coyotes must have been within hearing range of the calls. Again, there is no clear explanation for this lack of response. The breeding season, however, generally occurs between February and April (Hall and Kelson, 1959), and it is possible that seasonal reproductive or social behavior interfered with response patterns.

The evidence indicates that only a few environmental parameters need to be considered. During winter daylight hours in this area, calling was considerably more effective in the mornings. There is a suggestion that calling during periods of falling barometric pressure may be more effective, but further investigation of this point is needed before a conclusion can be made. For physical reasons, any environmental variable that interferes with transmission of the noise, or reduces its carrying power, can be expected to reduce the effectiveness of any calling effort. No other measured environmental parameters had demonstrable influence on calling success.

Actual field technique is, in large part, dictated by the sensory capabilities of the coyotes. Calling sites should always be approached with caution. Coyotes' senses of hearing and smell are extremely acute, and noise or the scent of a man can ruin chances for a successful call. Similarly, coyote vision is acute at close range, and they seem particularly alert to movement. If the caller is observed during his approach, and the coyotes alarmed, subsequent calling efforts will probably fail. Once on the site, callers should remain as quiet and motionless as possible. Attempts at camouflage and concealment are probably helpful, but appear to be less important than silence and a lack of movement.

Following a call, the caller must remain alert; coyotes approach silently. Although bold, straightforward approaches are common, some coyotes approach cautiously, and callers should be alert for small, inconspicuous movements in the surrounding area. Various popular articles suggest that callers should remain in position for at least 20 to 30 minutes. The evidence from this study, however, indicates that coyote response is immediate, and that few, if any, additional successes will be obtained by waiting longer than 10 to 15 minutes. Callers should pay particular attention to prevailing wind conditions;

coyotes will typically approach so as to pass downwind from the site, and will flee as soon as they scent the caller.

A hand-mouth squeak, or a suitable, short-range substitute, should probably be used during any calling effort. Its usefulness to call coyotes closer in open areas, or to stop retreats, has been clearly demonstrated. In heavy cover or forested areas, its use to allow coyotes to locate the source of the stimulus and to approach within visible range seems especially important.

CHAPTER V

SUMMARY AND CONCLUSIONS

In the winter and spring of 1972, 302 coyote calling trials were performed at a series of stations in the Blackfoot Valley in western Montana. Seventeen trials, or approximately 5.6 per cent, were successful, during which a total of 36 coyotes were attracted to calling sites.

A tape recording of a commercially produced, mouth-blown predator call was nearly twice as effective as a recording of actual rabbit distress cries. Subjective and sonographic analyses of the two stimuli reveal several acoustic differences which could, potentially, contribute to differential success rates. The most obvious differences were (1) the harsh, but highly irregular tonal quality of the commercial call, (2) the higher pitch of the commercial call, and (3) the slow-paced, measured cadence of the rabbit distress cries.

A third field stimulus, the hand-mouth squeak, and 12 other, purportedly effective predator calls were also examined in detail. Although most calls consisted of rapidly repeated, shrill cries, there was considerable variation in pitch, tonal quality, and cadence from call to call. The relatively wide variation in stimulus parameters suggested that probably any series of more or less harsh, high-pitched, irregular cries could be expected to call coyotes with some degree of success.

Low-intensity, hand-mouth squeaking was an extremely effective calling technique at close ranges. No additional successes were attributable to this call, but coyotes that had responded to the initial rabbit distress or commercial calls showed marked responses. Fleeing coyotes either turned to look back as they ran, stopped temporarily, or reapproached the calling site. Coyotes that had stopped approaching, but were not fleeing, usually approached more closely. Coyotes that had by-passed the calling site invariably returned and approached more closely.

Time of day was the environmental factor most strongly correlated with calling success. Trials between pre-dawn and solar mid-day were considerably more successful than afternoon and evening trials. Calling may be more successful during periods of falling barometric pressure, but a definitive conclusion is not possible. Ambient temperature, precipitation, wind velocity and character, snow depth and consistency, and cloud cover all failed to correlate with calling success. Vegetative cover and terrain did not influence success rates noticeably, but did seem to influence the behavior of responding coyotes. In flat, open areas, coyotes typically approached the calling site directly; in irregular terrain or forested areas, the approach was slower and less direct, as if the coyotes were unaware of the location of the stimulus source.

The behavior of responding coyotes varied. Most approached until they scented the observer, and then turned and ran away. Others approached to within a few hundred yards, stopped, and did not approach more closely until the hand-mouth squeak was given. A few by-passed the calling site, and were recalled with the hand-mouth squeak. Most approaches were bold and unhesitating, but many included frequent stops and side trips. In some trials, coyotes ran to the calling site, and in others, they trotted or walked. Frequently, more than one coyote approached during a trial, but all the multiple responses consisted of coyotes obviously traveling or hunting together. In almost all trials, coyotes approached so as to pass downwind from the calling site. In successful trials where coyotes were observed prior to call presentation, response was immediate. In a few trials, however, observed coyotes failed to respond.

Experience and field results indicate that the chances of calling coyotes to close range may be maximized by (1) calling where there is a reasonable expectancy that coyotes are present; (2) calling in the early morning; (3) making a quiet, cautious approach to the calling site; (4) presenting a loud initial distress call; (5) remaining alert, motionless and quiet after the call has been given; and (6) using the hand-mouth squeak as a supplemental, close-range stimulus.

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APPENDIX

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