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An Observational Study of the American Black Bear (*Ursus americanus*)

Robert Herbert Jordan
University of Tennessee - Knoxville

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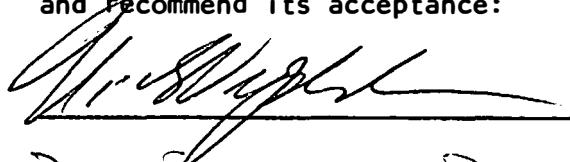
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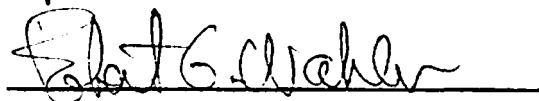
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Gordon M. Burghardt, Major Professor

We have read this dissertation
and recommend its acceptance:







Accepted for the Council:


Vice Chancellor
Graduate Studies and Research

d

AN OBSERVATIONAL STUDY OF THE AMERICAN BLACK BEAR
(URSUS AMERICANUS)

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Robert Herbert Jordan
June 1979

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To My Parents

ACKNOWLEDGMENTS

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Doris Gove accompanied me on long treks into the mountains and helped in making field observations. Rex Sentell spent many hours making observations with me so that I could measure the observer agreement of the data. Tanya Bassett labored for two months to type the systematic data onto computer cards. Don Broach, my computer consultant at the U.T. Computer Center, patiently explained the use of the computer and helped put my data in analyzable form. Joe Babb of the U.T. Speech and Hearing Clinic helped with the sonogram analysis. Claudia Peck typed the original versions of many of the tables and typed the first draft of part of the text. Ann Lacava and company typed and published the final manuscript. Peter Jorgensen developed several of the photographs that illustrate the dissertation.

Marion "Junior" Morgan, who maintained the bears at Goldrush Junction, and Mr. Fox, the manager of Goldrush, permitted me to observe their two bears, Ben and Sally, at any time. "Junior" also spent hours telling me of the bears' activities when I wasn't present and the bear lore of the mountains.

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ABSTRACT

This study describes the relationship of the human observer to observed black bears (Ursus americanus), and describes social investigation and autogrooming behavior in black bears and relates these to aspects of chemical communication. The subjects were two pairs of captive black bears kept at separate locations--a male-female pair and a female-female pair, all of approximately the same age. They were sexually immature during most of the study. Both pairs were usually observed on the same days, for comparison. Observations were typically one hour long and behavior was recorded on paper every 30 seconds using a time-sampling technique. One hundred and forty-six hours of systematic observation were completed over a two-year period.

For non-human species there has been little, if any, quantitative research done on the problem of the reactivity of the observed to the observer or to the presence of humans. In the present study the effect was measured by pooling the 146 hours of data for all categories of behavior and groupings of categories by activity level for each of the 30 2-minute divisions within hour-long observation sessions. A linear regression analysis was performed on the rates for behaviors from the first 2-minute period through the last. At one location, Tremont, measures of certain categories of behavior and groupings of categories by activity level were highly correlated with time period within the observation session hour. Many of the correlations were steeply positively or negatively sloped. Behaviors which indicated resting or "relaxed" behavior increased from beginning to end of observations while behaviors requiring more energy decreased. The

large changes in rates of some behaviors are interpreted as habituation to the presence of the observer. At the other location, Goldrush, there was far more stimulation from sources other than the observer and the bears were physically more distant from the observer. These bears were less responsive to the observer's presence.

Between bears, especially the females at Tremont, direct social investigation (less appropriately referred to as allogrooming), which consisted solely of social sniffing and social licking, decreased to very low rates as they got older. The head/neck region was investigated most by two of the females. The male investigated his female cagemate's perianal/genital-rump/tail region most often, though still at low rates. The perianal/genital region, which is the site of socially attractive pheromone-producing glands in most species of Carnivora, might have been expected to be investigated at higher rates. The low rates may have been related to the absence or inactivity of such glands in the perianal/genital region and on the rest of the body surface.

Autogrooming, including rubbing (thought by some to function additionally in marking), was observed in order to determine its functions. Black bears have a varied repertoire of autogrooming behavior which is made possible by their postural flexibility and the dexterity of the plantigrade front paw. The various methods of autogrooming are each most effective at reaching certain parts of the body. The dorsal areas of the body were most easily groomed by rubbing against objects. Rates of scratching during quarterly periods of the year were related to rates of rubbing, especially during periods when the skin was known to be irritated by infection. It was concluded that rubbing is a

significant form of grooming that relieves skin irritation, although other evidence was presented to suggest that rubbing may also function as a relatively unstereotyped form of marking that does not involve specialized skin glands.

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CHAPTER 1

INTRODUCTION

Black bears are creatures adapted to forests and forest edges. Except for brief forays they avoid treeless areas (Herrero, 1978). They move with seeming ease through thickets of laurel and rhododendron that are virtually impenetrable to people and travel rapidly for long distances. Under these conditions an observer can rarely follow them sufficiently closely to do extended direct observation. In the mountainous areas of the Eastern United States the difficulties of trying to follow bears are additionally aggravated by the rugged terrain. Consequently most of the information gathered about black bear behavior in the wild has been done indirectly. Rogers (1977) has had some success with direct field observation of bears fitted with collars containing radio transmitters. By using an airplane, the researchers located the collared bears from the air by tracking the radio signal and then observing them. In spite of the advantages of this elaborate and expensive method, Rogers admits repeated frustration because the bears frequently moved under the forest canopy while engaging in behaviors of great interest to him (e.g., courtship and mating). His observations were done in Minnesota which is characterized by flat terrain. Aerial observation in the Smokies would be more difficult, less productive, and even dangerous.

Traditionally bear behavior has been inferred from bear "signs," such as scats, paw prints, torn branches, "bear trees," and wallows. Today most scientific field observation of bear behavior is still indirect

but the data are obtained primarily from mark and recapture studies, radio-telemetry, and scat analysis (Pelton, 1972; Beeman and Pelton, 1977; Mathews, 1977).

Given the limitations on direct field observation of black bear behavior, studies of captive bears are the only option for continuous direct observation of most aspects of behavior. A quantitative record of the behavior of an individual, which can be compared with similar records of other individuals and with itself, is very advantageous. Unfortunately, captive bears historically have been kept in small stimulus-poor cages which limited the expression of behavior. Despite this disadvantage some very useful studies of the behavior of captive bears in small enclosures have been done in the last 50 years (Kuckuck, 1937; Meyer-Holzapfel, 1957; Tschanz et al., 1970; Henry and Herrero, 1974). Recently bears have been observed in larger enclosed areas which more nearly resemble natural habitat (Chapter 2). A rich variety of behavior can occur in such surroundings (Bacon, 1973; Ludlow, 1974; Pruitt, 1974; Jordan, 1976).

Several behavioral studies of tame black bear cubs living in or adjacent to the observer's residence have been done (Leyhausen, 1948; Burghardt and Burghardt, 1972; Jordan, personal observation) but this method has its own peculiar drawbacks; observer effects are built into the situation since the observer usually has a close relationship with the bear, which influences the behavior expressed.

Of course, even under the most ideal conditions of captivity, many aspects of behavior cannot be expressed, and others will be distorted. Any behavior requiring long-distance travel obviously could not occur. But this disadvantage is matched by an opposite and

seldomly recognized advantage: accurate knowledge of the behavior of animals in captivity will be indispensable in maintaining healthy and maximally functioning animals in captivity in the future. Accidental and deliberate deprivation experiments in captive animals have helped in understanding the needs of animals in ways which would not be apparent from field observation. Captive animals may be indispensable for future scientific research on and breeding of species on the verge of extinction or of those inaccessible to people in their natural habitat.

Except for associations of mothers and cubs, adult males and females during the mating season, siblings after weaning in occasional instances, and older members of families in even rarer instances, bears either do not seek or actively avoid close proximity or physical contact with each other (Herrero, 1978). Contrast this with the behavior of wolves whose deeply ingrained social attraction to each other and actively maintained physical contact transfers easily to humans. Lorenz (1957) believes that a dog's devotion to his human master is identical to the submissiveness shown by a wolf to the alpha animal of its pack.

It is likely that ethological interest in Carnivora, especially canids, with a high degree of social organization, has preceded interest in bears in part because it was thought that the former could be usefully compared with social organization of human behavior. Actually bears may provide another kind of comparison. Their locomotion and forelimb-eye coordination, hence cognitive development, are analogous to stages in the evolution of hominids. There are many parallels. Bears, like humans, are plantigrade. They can stand and walk bipedally, although this occurs much less frequently than the quadripedal mode. A cub observed in the present study developed these behaviors in an

ontogenetic sequence that was parallel to human, starting with quadrupedal locomotion (equivalent to crawling on hands and knees), through standing upright with support, standing upright without support, and finally bipedal locomotion.

Bears possess considerable dexterity for an animal with long claws (Bacon, 1973). They climb trees "hand over hand," hang by their front paws, and even brachiate, although with insufficient coordination for this to be called a significant form of locomotion (personal observation). These are patterns of behavior characteristic of perhaps two stages of early hominid evolution, the tree-climbing/brachiating stage preceding and overlapping the erect bipedal locomotion stage.

Bears resemble humans in other ways. Their omnivorous diet (e.g., Beeman and Pelton, 1977) and dentition resemble ours. Females give birth to one to four cubs at a time, rarely more, and generally stay with them until the mating season of the cubs' second year while they develop the skills necessary for survival (Leslie, 1968). In only a few mammalian species, the largest primarily, does the offspring remain with the parent for such an extended period (Matthews, 1975).

Although black bears are not carnivores in the sense that their diet consists primarily of animal food, they are members of Order Carnivora and their behavior must be understood in this evolutionary context. Therefore, an account of the evolution of black bears from the earliest member of Order Carnivora is given here (based on Stains, 1979).

All members of Order Carnivora descended from Family Miacidae in the Upper Eocene. Included in the Order are Canidae, Felidae,

Hyaenidae, Mustellidae, Procyonidae, Ursidae, and Viverridae. Pinnipeds are an Order closely related to Order Carnivora. Two families of Pinnipeds, those that include seals and walruses, may have descended from a primitive bear.

The seven families are divided into two superfamilies (Ewer, 1973): the Feloid line and the Canoid line. During the Upper Eocene the Feloid line, which includes Felidae, Hyaenidae, and Viverridae, diverged from the Canoid line, which includes Mustellidae, Procyonidae Ursidae, and Canidae. Mustellidae diverged from the other Canoidea in the Lower Oligocene. Canidae diverged from the Ursid-Procyonid branch during the Middle Oligocene and Procyonids diverged from Ursidae in the Lower Miocene. The appearance of bears similar to modern bears occurred in the Middle Miocene.

The primitive ancestor of all bears, Ursavus, first appeared in the Lower Miocene (Herrero, 1972). By the Upper Pliocene Ursavus had evolved into two Subfamilies: Ursinae, which includes all but one presently surviving species of bear; and Tremarctinae, which is represented by the remaining species, the South American spectacled bear (Tremarctos ornatus). About 2 million years ago the ancestor of the present black bear and grizzly (Ursus arctos horribilis) speciated. The Himalayan black bear (U. thibetanus) appeared about 1 million years ago. Ursus thibetanus crossed the land bridge to North America about 500,000 years ago and evolved into the American black bear.

The present dissertation is a study of selective aspects of data collected in a broader context. Its objectives are to (1) describe the relationship of the observer to the observed and (2) to describe

social investigation and autogrooming behavior and relate these to aspects of chemical communication.

CHAPTER 2

SUBJECTS, SETTINGS, AND METHODS

I. SUBJECTS AND SETTINGS

Over a three-year period about 30 black bears were observed in a variety of contexts. Four wild-caught captive bears, reared by humans from the time of capture, were studied most intensively. These included a male-female pair and a female-female pair, all of whom were born in late January or early February 1970.

The male-female pair was acquired from the Gallop Animal Farm in Vermont when they were less than a year old (Ludlow, 1974). During the period of the study they were located at Goldrush Junction (now called Silver Dollar City), an amusement park with a mountain or folk theme located in Pigeon Forge, Tennessee. (In the remainder of the dissertation Goldrush Junction will be referred to as Goldrush.) Ben, the male at Goldrush, is referred to as Bear A in the present study, and Sally, the female, as Bear B. They were permitted free access to the entire enclosure during daylight hours. At night they were kept in closed dens. During the "tourist season" from May through October they were on public display during daylight hours.

The female-female pair, named Kit and Kate and referred to as Bear C and Bear D respectively in this study, were found together in mid-April 1970 by a National Park Service Ranger in the Great Smoky Mountains National Park (hereafter referred to as the Park). Presumably they were siblings who had been abandoned. The ranger turned the cubs over to a graduate student in Wildlife Biology at The University of

Tennessee who cared for them for two weeks until they were received by Dr. Gordon M. Burghardt of The University of Tennessee Department of Psychology for behavioral study. The bears were kept in his home until June 1970 (Burghardt and Burghardt, 1972). Then, for a short time, they were housed in a large garage at the Tremont Environmental Education Center in the Park until a specially designed enclosure could be completed for them there. They were moved to the enclosure in July 1970. Responsibility for the care of the cubs was assumed by Ellis Bacon from the time they first arrived at Tremont (Burghardt and Burghardt, 1972; Bacon, 1973; and Pruitt, 1974).

The enclosure at Tremont, erected in and enclosing forest, measured 18.3 x 18.3 m. Most of the trees and other vegetation were preserved intact to simulate as closely as possible the environment typically inhabited by wild black bears (Bacon, 1973; Burghardt, 1975). The captive male-female pair at Goldrush was enclosed in a 17 x 88 m. grassy space.

The altitude of Camp Townsend where the Tremont Environmental Education Center (Tremont) is located is 411 m., while the altitude at Goldrush is 311 m. Goldrush is 24 km. N40E of Tremont. The driving distance is approximately twice as far (45 minutes). At a given moment the weather patterns at the two locations are usually quite similar. Most of the meteorological data was obtained from the National Weather Service located at the Knoxville Airport in Alcoa, Tennessee (altitude 290 m.). The airport is 38 km. N86W of Goldrush and 39 km. N54W of Tremont.

Both enclosures provided far more space, access to living plants, and stimulus diversity than is normally provided by most zoos and other

enclosures used for captive bears. Photographs of the enclosures at Tremont and Goldrush are shown in Figures 2.1 and 2.2 and diagrams in Figures 2.3 and 2.4.

For the present study, systematic observations of the bears at Goldrush began in July 1971 when they were about 18 months old and continued until July 1973. In October 1971, systematic observations of the Tremont bears, at 22 months of age, began and continued until May 1973. Table 2.1 shows the number of systematic observations per month during 1971, 1972, and 1973 at Goldrush and Tremont.

Other captive bears were studied. An adult male, age unknown, was kept and observed on two occasions at Goldrush. Another adult male, a former pet, was observed at the Tremont enclosure during the spring and summer of 1973. Two wild-caught cubs, both females, were introduced into the enclosure at Tremont in late October 1972 at nine months of age and observed until May 1973 when they were released in the wild. They were observed for an hour or more each day for the first six weeks. Thereafter they were observed once a week. A third cub was introduced into the Tremont enclosure in late January 1973 and was released at the same time as the others. Bears kept at the Knoxville Zoological Park were observed on three occasions in 1976 in order to tape-record their vocalizations and other sounds. Finally, an orphaned wild cub born in January or February of 1974, donated by the Georgia State Game and Fish Commission, was kept and observed by the author from April until July 1974.

Approximately 20 wild, free-roaming bears, mostly subadults and females with or without cubs, were sighted on 53 separate occasions in



Figure 2.1. View across the length of the Goldrush bear enclosure.



Figure 2.2. View of a portion of the Tremont bear enclosure.

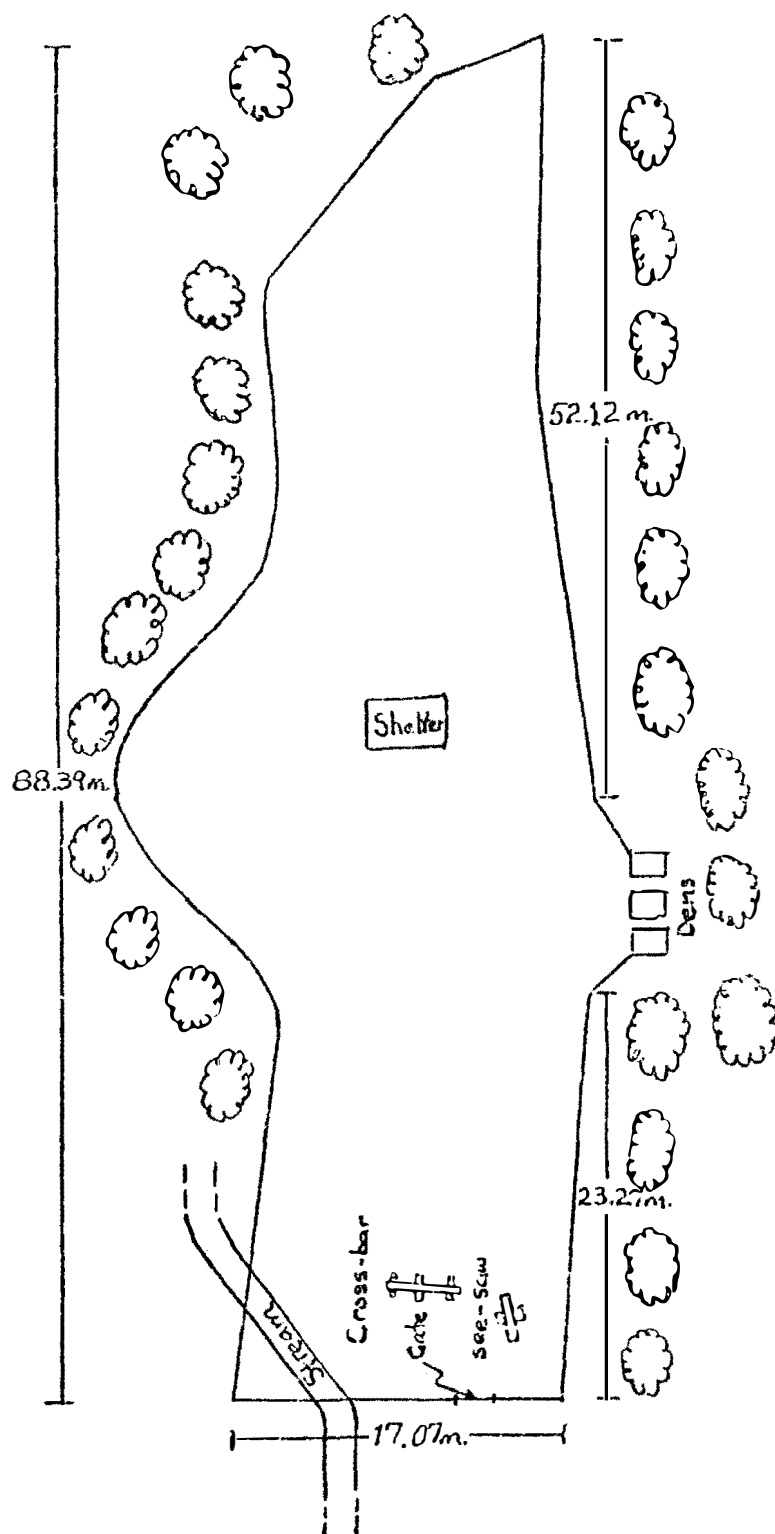
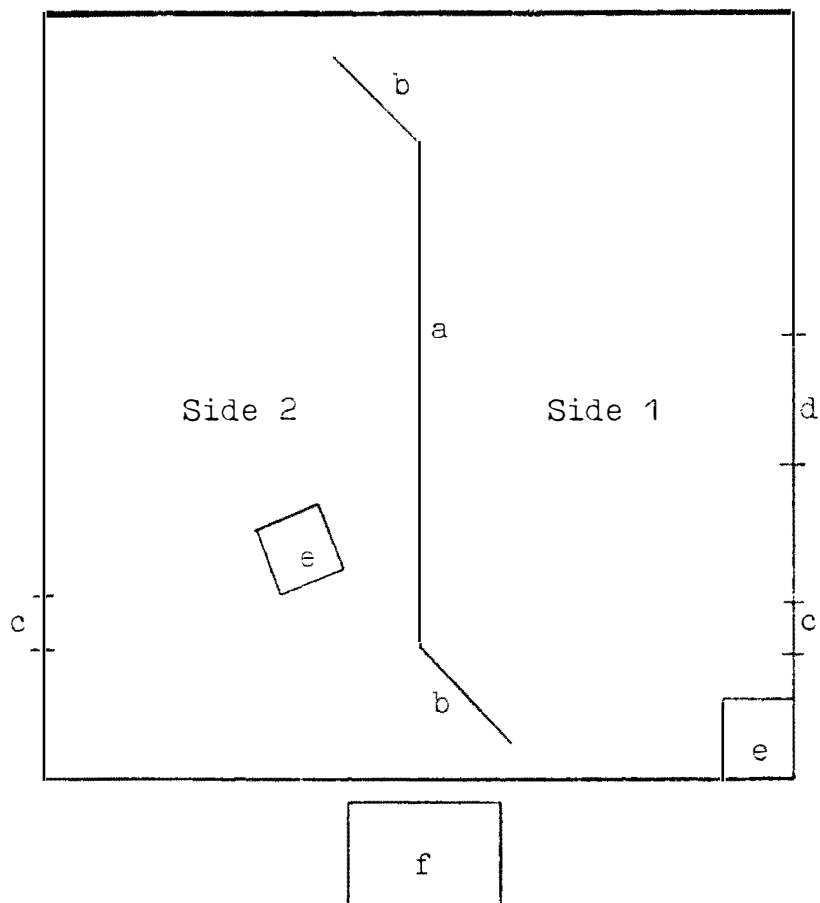


Figure 2.3. Diagrammatic representation of the Goldrush bear enclosure.



- a = center fence
- b = gate of center fence
- c = entrance gate
- d = vehicle entrance
- e = shelter
- f = observation and storage shed

Figure 2.4. Diagrammatic representation of the Tremont bear enclosure (reproduced from Bacon, 1973).

TABLE 2.1
HOURS OF SYSTEMATIC OBSERVATION PER MONTH AT
GOLDRUSH AND TREMONT

Year	Month	Goldrush	Tremont	Total
1971	7	4	0	0
	8	10	0	10
	9	5	0	5
	10	7	2	9
	11	7	3	10
	12	3	5	8
1972	1	2	5	7
	2	0	7	7
	3	0	0	4
	4	2	3	5
	5	6	4	10
	6	5	5	10
	7	6	6	12
	8	6	6	12
	9	6	6	12
	10	3	5	8
	11	2	2	4
	12	0	0	0
1973	1	0	1	1
	2	0	1	1
	3	2	3	5
	4	0	2	2
	5	0	3	3
	6	0	0	0
	7	1	0	1
Total		77	69	146

various areas within the Park, including Cades Cove camp and picnic grounds, the shelter and lodge areas of Mt. LeConte, Rt. 441 near Newfound Gap, Russell Field, Siler's Bald shelter area, the Clingman's Dome road, and Spence Field. At the primary study area at Spence Field many of the bears observed had identifying colored ear tags that had been attached by Wildlife Biology researchers from The University of Tennessee.

Spence Field was selected as the primary study area for several reasons. Both human-produced and native wild food were available in abundance, and Spence Field could be reached by hiking a short distance from the Cades Cove picnic ground. Certain aspects of behavior were easily observable there since many of the bears who frequented the area seemed unafraid of humans and entered the clearings surrounding the two shelters and the shelters themselves with little hesitation.

An abundance of blueberries (Vaccinium spp.), blackberries (Rubus spp.) and mountain ash berries (Sorbus spp.) grew in season on the grassy, saddle-back ridge of Spence Field. The observer sat on the elevated parts of the ridge and watched the activities of the bears from a distance. The behavior observed most frequently from this vantage was foraging for and eating berries. If the observer desired he could easily approach the area where the bears had been spotted. The behaviors that could be observed at close range were again foraging and feeding, alerting and alarm, interactions between mother and offspring, and threat. Other categories of behavior were not observed at Spence Field either because of insufficient observation or because the behaviors did not occur there. The observer could probably not hope for eventual acceptance or tolerance of the sort reported by Van Lawick-Goodall (1971), Schaller

(1964) and others. The bears were aware of the presence of humans in most instances. The question of the effect of presence of humans on the behavior of bears is discussed in more detail in the Introduction and in Chapter 3.

II. METHODS

At different times behavior was recorded by using systematic time-sampled written descriptions, field notes, tape-recordings, super-8mm films, and videotapes. These are described below and in Appendices D and E.

Time-Sampled Written Descriptions

Systematic time-sampling paper and pencil descriptions employed stick figures to represent postures, and letter or syllable abbreviations to represent locomotions, other behaviors, and objects. The stick figures permitted considerable accuracy in recording behavior, while remaining simple to remember and record. Both the stick figures and letter abbreviations were later translated into number codes that could be counted by computer. A listing of all behavior categories in all classes can be found in Tables 2.2, 2.3, 2.4, and 2.5. This listing consists of the categories that were found useful in observing the two sets of bears and could serve as the basis of an ethogram. A list of rank order of occurrence of behaviors in Classes A and C is found in Appendix A. The stick figure and letter/syllable abbreviation system is shown in Appendix B and a sample page of the recording system is shown in Appendix C.

The behavior of both members of the penned pairs was recorded simultaneously, usually for one hour. Each observation session was

TABLE 2.2

CLASS A: POSTURES AND LOCOMOTIONS OF BLACK BEARS WITH
IDENTIFYING CODE NUMBERS

Behavior Name	Code Number
Standing bipedally erect or semi-erect while touching an object with the forelimbs	P1
Standing bipedally erect or semi-erect with no support from the forelimbs	P2
Standing quadrupedally	P3
Sitting erect or semi-erect with the forelimbs elevated	P4
Sitting with the forelimbs touching the ground	P5
Dorsal lying with all legs extended upward	P6
Ventral lying with the legs extended forward on both sides or with the front legs extended forward but the rear legs both to one side	P7
Lateral lying with the front and rear legs all to one side	P8
Walking	P11
Walking toward a bear (or person)	P12
Walking away from a bear (or person)	P13
Walking stiffly with the front legs locked	P18
Running	P19
Running toward a bear (or person)	P21
Running away from a bear (or person)	P23
Ascending trees and other objects	P24
Ascending trees slowly	P25
Ascending trees quickly	P26
Descending trees and other objects	P27
Lying or sitting in a tree or similarly elevated object	P28
Standing with the forelimbs up or down in a tree or similarly elevated object	P29
Running a short distance then walking quickly	P32
Rolling over	P33
Backing up	P34
Jumping with all legs off the ground simultaneously	P35

TABLE 2.3

CLASS B: SOUNDS OR COMBINATIONS OF SOUNDS PRODUCED BY
BLACK BEARS WITH IDENTIFYING CODE NUMBERS

Name of Sound	Code Number
Panting: quick, heavy breathing	S1
Slapping front paw against ground or other object	S2
*Huffing: a short vigorous exhalation of air from mouth and nose	S3
*Jaw-popping: a repeated sound in which the jaws are vigorously brought together and opened producing a popping of lips and clicking of teeth	S4
*Bellowing: a low, continuous, oscillating sound	S5
*In-out huffing: a rapid inhalation of air followed immediately by a rapid exhalation which may be repeated	S6
*Grunting: a low-pitched, low intensity brief sound produced low in the throat, with mouth closed	S7
*Moaning	S8
*Purring: a low-intensity, rapidly oscillating continuous sound	S10
*Screech: hoarse sound of relatively long duration	S11
A short hoarse moan ("yelp")	S12
Slap and huff occurring nearly simultaneously	S13
Slap and huff (as in S13) followed immediately by jaw-popping	S14
Huff followed by jaw-popping	S15
Bellow followed by jaw-popping	S16
Huff followed by in-out huffing	S17
Huff followed by in-out huffing followed by jaw-popping	S18
In-out huffing followed by jaw-popping	S19
Snorting: exhaling air vigorously and briefly from the nose	S20
Slapping followed immediately by panting	S21
Sigh: a very light, high-pitched moan	S22

*Sounds preceded by asterisks are represented by sonograms in Appendix D.

TABLE 2.4

CLASS C: FUNCTIONS OF BLACK BEARS INCLUDING FORAGING, RECEPTOR ORIENTATION, MANIPULATION, BODY MAINTENANCE, SEX, SOCIAL INVESTIGATION, AGGRESSION, SOCIAL AND SOLITARY PLAY, PACING, AND RESTING, WITH IDENTIFYING CODE NUMBERS

Behavior Name	Code Number
Pawing object using one or both front paws	F1
Biting object	F2
Alternately pawing and biting object	F3
Alternately pawing and sniffing object	F4
Alternately pawing and sniffing soil	F5
Sniffing object	F6
Alternately biting and sniffing object	F7
Licking object	F8
Alternately sniffing and licking object	F9
Alternately sniffing and looking	F10
Looking at object	F11
Alerting, "freezing" body and orienting ears and eyes toward a sudden and/or novel visual or auditory stimulus	F12
Drinking	F15
Eating	F16
Alternately eating and looking	F17
Alternately biting and licking	F18
Threatening to bite with mouth oriented toward face or upper body of other bear	F25
Defecating	F26
Urinating normally	F27
Dribble-urinating (urine dribbling down hind legs)	F28
Walking stiffly while urinating	F29
Threatening, using sounds S1 through S6 and S13 through S21 listed in Class B	F30
Slapping other bear	F32
Autogrooming	
Sniffing self	F35
Scratching self with hind paw	F36
Pawing self	F37, F38
Licking self	F39
Biting self	F40

Table 2.4 (Continued)

Behavior Name	Code Number
Rubbing	
Standing bipedally or quadrupedally while rubbing rump, back, shoulders, and/or neck up and down against object	F42
Standing or sitting bipedally or standing quadrupedally while rubbing rump, back, shoulders, and/or neck from side to side against object (dorsal surface of body)	F43
Standing quadrupedally while rubbing flank, shoulder, neck, and/or head against object (lateral surface of body)	F44
Social Investigation, Play, and Touching Other	
Sniffing other	F46
Licking other	F47
Pawing other	F48
Biting other	F49
Touching other	F50
Stereotyped pacing	F51
Stereotyped behavior other than pacing (e.g., swinging head from side to side)	F52
Mounting other bear and, on some occasions, thrusting	F54, F55
Standing bipedally begging for food	F57
Resting	
With head supported	F60
Without head supported	F61
Stretching	F63
Rapid withdrawal of body from a sudden and/or novel proximal stimulus ("surprise response")	F65
Opening mouth and retracting lip ("disgust response")	F67
Yawning with mouth opened widely and breathing suspended	F70
Immersing self in water	F74
Shaking entire body or part of body	F78
Licking muzzle while looking	F80
Visually scanning surroundings	F81
Turning object over	F82
Sucking object	F84

TABLE 2.5

CLASS D: OBJECTS THAT BLACK BEARS SENSED OR INTERACTED
WITH AND IDENTIFYING CODE NUMBERS

Object	Code Number
I. Soil or Ground	D1
II. Living Plant Matter	
A. Grass	D2
B. Other herbs	D3
C. Flower	D4
D. Shrub	D5
E. Tree trunk	D6
F. Limbs and branches attached to a tree	D9
G. Tree leaves	D10
H. Roots	D11
I. Other living plant matter (e.g., algae, moss)	D12
III. Dead Plant Matter	
A. Straw	D14
B. Unattached roots and branches, sticks, and other small pieces of wood	D15
C. Sawdust	D16
D. Boards and logs	D17
E. Leaves	D18
F. Other dead plant matter	D19
IV. Animals	
A. Observer	D24
B. All other people	D25
C. Self or other bear	D29
1. Mouth	D30
2. Nose	D31
3. Muzzle	D32
4. Eyes	D33
5. Ears	D34
6. Other or unknown parts of head	D35
7. Neck	D36
8. Shoulders	D37
9. Back	D38
10. Flank	D39
11. Rump and tail above perianal region	D40

TABLE 2.5 (Continued)

Object	Code Number
12. Perianal/genital region	D42
13. Belly	D43
14. Chest	D44
15. Rear leg	D45
16. Front leg	D46
17. Rear paw	D47
18. Front paw	D48
D. Mouse	D50
E. Dog	D51
F. Horse or Mule	D52
G. Mammals other than the previous	D53
H. Herptiles	D54
I. Insects	D55
J. Birds and animals other than the above	D56
V. Food consumed by the bears	
A. Chow (standard dog chow)	D58
B. Apples	D59
C. Raisins	D60
D. Fruit other than apples and raisins	D61
E. Meat and fish	D62
F. Nuts	D63
G. Vegetables	D64
H. Water	D65
I. Food other than the above	D66
VI. Nonorganic Objects	
A. Stone	D67
B. Fence	D69
C. Fence door	D70
D. Den	D71
E. Shed or shelter within the enclosure	D72
F. Tire hung on chain	D73
G. See-saw	D74
H. Small containers (e.g., pot, cup)	D75
I. Other objects meant to function as toys	D76
J. Wheeled vehicles (e.g., automobiles, trucks, and railroad trains)	D77
K. Cloth or paper	D78
L. Salt	D79
M. Testing apparatus at Tremont	D80

TABLE 2.5 (Continued)

Object	Code Number
N. Water tank	D81
O. Other nonorganic objects	D82
P. Food box	D83
Q. Post	D84
R. Hole	D85
S. Soil and objects under fence	D86
T. Water trough or creek	D87
U. Chain	D88
VII. Air	D90
VIII. Body Excretions	
A. Bear excretions	
1. Feces	D93
2. Urine	D94
B. Human excretions	
1. Feces	D95
2. Urine	D96

divided into 30-second periods and behavior that occurred at the beginning moment of each 30-second period was recorded. Four classes or groupings of behavior and objects were simultaneously recorded: Class A, Postures and Locomotions; Class B, Sounds; Class C, Functions including foraging, receptor-orientation, manipulation, maintenance, sex, aggression, pacing, and resting; and Class D, Objects Interacted With. None of the behaviors in Classes A or B or objects in Class D could occur simultaneously, that is, they were mutually exclusive in time. However, the behaviors in Class C were only mutually exclusive by definition, so that it was possible for more than one behavior in Class C to occur at the same time. When this happened, the behavior that had occurred less often in previous observations took precedence. For example, if a bear simultaneously sniffed and looked at objects, sniffing took precedence and was recorded since it occurred less often than looking. In fact looking may be assumed to have occurred nearly always when the bear was active even when it was not recorded. The rationale for this system, derived from the definition of information theory, was that the information value of a given instance of behavior in terms of its social effects, at least, is inversely proportional to its frequency of occurrence (Hutt and Hutt, 1970). After two or three months of systematic observation a fixed system of precedence of categories was established. Some categories of Class C were combinations of two categories of behavior that quickly alternated or occurred simultaneously.

Starting in Fall 1971 both the male-female pair at Goldrush and the female-female pair at Tremont were systematically observed, usually on the same day. The objective was to observe first one pair, then

the other, then return to observe the first pair again on the same day in order to make comparisons of the responses of physically separated bears to variations in weather, time of day, and season (Table 2.1, page 13). A total of 146 hours of systematic observation was recorded.

The systematic written descriptions were analyzed with the Statistical Packages for the Social Sciences (S.P.S.S.) system that is available on The University of Tennessee Stokely Management Center's Digital Equipment Corporation computer (DEC-System 10 with KL-10 processor). The package most often used was crosstabulation which produces contingency tables. Most statistical analysis was done with a hand calculator using selected parts of the tables of data provided by the computer. In this way the behavior of the four systematically-observed bears could be compared. Nearly all of the quantitative analysis presented here is based on the contingency tables produced by the computer.

Field Notes

The field notes were simple narrative descriptions of behaviors and setting which occasionally included inferences about the causes of behavior. The descriptions and inferences were always clearly differentiated, a characteristic distinguishing these field notes from many anecdotal accounts of behavior. The notes were later indexed according to topic and listed chronologically for easy reference.

Field notes were analyzed in three ways. First, they were examined for critical events, that is, behaviors that were observed to occur at least once, thus establishing that black bears are capable of performing such behavior. Second, they were examined for patterns that could serve to generate hypotheses that could be tested with

quantitative analysis of systematic data from other sources. Third, the field notes themselves could in some instances be analyzed quantitatively. For example, sounds that occurred in threat could be counted and sequentially analyzed and comparison made of sequences of elements.

Tape Recordings and 8mm Movie Films

Bear sounds, visually represented by sonograms made from tape-recordings and methods used for creating sonograms, are described in Appendix D and methods of analysis of 8mm films are described in Appendix E.

III. INTEROBSERVER AGREEMENT

Observer agreement measures were taken on 12 occasions. A second observer was trained to use the observer's system of systematic observation consisting of stick figures for Class A (Postures) and letter/syllable symbols for Class A (Locomotions), Class B (Sounds), and Class C (Functions). He became thoroughly familiar with it before the test session took place. Three of the test sessions were done at Goldrush and nine at Tremont (Table 2.6). The test sessions were of various durations: seven were less than an hour; four, an hour; and one, more than an hour. Two bears were observed simultaneously in the test just as they were normally during systematic observations, except on June 2, 1973, when only one bear was observed. Class A, Class B, and Class C (but not Class D) were compared for each bear for each 30-second period. The observations were counted as agreed only if all three classes were identically matched. Nonmatching recordings in Class B or C but matching in Class A (Postures and Locomotions) were still counted as unagreed, although the difference is distinguished in

Table 2.6
MEASURE OF INTEROBSERVER AGREEMENT

Date	Location*	Nonmatch	Question- able Match	Total Unagreed (nonmatch plus questionable match)	Total Agreed	Total of 30-second Periods of Observation	Percent Agreed
2/3/73	1	21	15	36	204	240	87.92
3/1/73	2	19	5	24	216	240	90.83
3/3/73	1	6	7	13	181	194	94.85
3/8/73	2	26	5	31	209	240	87.92
3/31/73	1	5	8	13	107	120	92.50
4/28/73	1	25	2	27	139	166	84.44
5/15/73	1	24	10	34	114	148	80.41
5/19/73	1	30	4	34	244	278	88.49
5/26/73	1	10	1	11	229	240	95.42
6/2/73	1	0	3	3	118	121	98.35
7/4/73	2	14	2	16	110	126	88.10
date unknown	1	4	6	10	122	132	94.70
Total		180	62	242	1871	2113	88.55

*Location: 1 = Tremont; 2 = Goldrush

Table 2.6. The agreed observations were divided by the total number of observations in the session to obtain a percentage of agreement.

Agreed observations were divided by the total number of observations in the session to obtain a percentage of agreement.

The percentages of agreed observations range from 80.41 percent to 98.35 percent, averaging 88.55 percent across all sessions. This is taken as an acceptable error rate considering the difficulty of recording six pieces of information simultaneously every 30 seconds for an hour. Perhaps the relatively high degree of accuracy can be attributed to the representational nature of the symbols used in recording, especially the stick figures.

Accuracy was influenced by the observer's mood and alertness, reaction time, ability to observe separate events occurring approximately at the same moment within the enclosure, and the type of behavior performed by the two bears (Hollenbeck, 1978). Of these, the last is easiest to demonstrate. Generally the percentage of nonmatching observations was greater during social than during nonsocial behavior. Play and agonistic behavior were most difficult to record accurately, since elements in sequences of these behaviors changed rapidly. During the session with the lowest percentage of agreement (May 15, 1973, 80.41 percent) a good deal of play behavior occurred, while during the session with the highest percentage (June 2, 1973, 98.35 percent), only one bear was present in the enclosure and resting and grooming behaviors predominated.

CHAPTER 3

ACTIVITY LEVELS AND REACTIVITY TO THE PRESENCE OF HUMANS

I. INTRODUCTION

A major goal of any observation must be validity, that is, the behavior observed should approximate as closely as possible the naturally-occurring behavior of an animal without the intrusive interference of an observer. Any method of direct observation, no matter how unobtrusive, will have an effect on the observed if the observed notices either the observer or a machine which records behavior in the place of the observer. Different methods of observation alter the behavior of the observed in different ways. Scientists of all disciplines encounter this problem of methodology. In physics it is termed the "Heisenberg Principle," which refers to the difficulties Heisenberg encountered when his method of observing electrons altered the "behavior" of the electrons.

Ethologists have attempted to deal with the problem in a variety of ways. Van Lawick-Goodall (1971) noted progressive stages of response by chimpanzees to observation in the wild: (1) flight-avoidance; (2) irritation--aggressive threat and even attack; (3) ignoring the observer; (4) tendency to approach and investigate the observer; and (5) acceptance of the observer. The wild free-roaming bears observed in this study exhibited the first three of the five categories listed by Van Lawick-Goodall, but not the last two. Van Lawick-Goodall felt that her most productive observations were recorded after the chimpanzees had accepted her. Whether wild bears in their natural habitat could ever accept an observer in this sense seems doubtful. The acceptance that

Van Lawick-Goodall experienced was based on the natural tendency for seeking social contact that is characteristic of chimpanzees (sociopetal tendency). Hediger (1964, original, 1950), writing of his many years of experience with zoo and circus animals, believed that the members of one species could actually come to accept a member of another species, humans, for example, as if they were conspecifics. He called this zoomorphism and equated it with the process of anthropomorphism of other species by humans. The sexual and parental-offspring behavior displayed by tamed wild and domestic animals towards humans is indirect evidence that this process actually occurs.

Adult bears, unlike chimpanzees and other species that live in social groups as adults, may be incapable of acceptance of humans in the sense expressed by Van Lawick-Goodall, especially in the wild where the flight-avoidance response is the alternative chosen unless the bear has need of something that it can best (or only) obtain through close approach of humans. Captive bears may exhibit the first four response types in Van Lawick-Goodall's hierarchy but it is questionable whether as adults they actually "accept" humans just as they do not accept other adults of their own species. Even in the courtship before mating of the male-female pair observed in this study there was little mutual grooming except for some licking of the female by the male (Ludlow, 1974; personal observation). However, Eagar (personal communication) has observed courting wild black bears in the Park rubbing against each other and playing before mating.

According to Johnson and Bolstad (1975; p. 181) "Reactivity to observation is one of the most widely recognized concerns for those employing naturalistic observation." Accepting this, it is surprising

that observers of non-human animals have done little, if any, quantitative research on reactivity to human presence. In fact, the issue is seldom mentioned (Barlow, 1968).

Observers of human behavior have done a few quantitative studies. Johnson and Bolstad (1973) have defined the factors influencing reactivity in humans as follows:

- (1) the observer's conspicuousness;
- (2) the subject's characteristics;
- (3) the observer's characteristics; and
- (4) the reason given the subject for doing the observation.

All of these would apply to nonhuman subjects except for the last.

What constitutes conspicuousness would vary according to the perceptual abilities of a given species. Bears, for example, would be able to detect subtle changing odors from the observer. Blinds which are intended to visually obscure the observer would thus have considerably less effectiveness downwind for bears. The same would be true for other macrosmatic animals. No blind was used in this study.

Bears, like many of the other Carnivora, appear to be very responsive to movement in the visual field, which they seem to use as a cue more than pattern recognition when hunting. Prey is not pounced upon until it moves (personal observation). Similarly in the present observations, the bears tended to ignore the observer unless the observer moved. Unfortunately, one must move constantly when taking notes. Barlow (1968) has described how alert his fish were to his movements and vibrations even when almost totally obscured by a blind and darkness.

Observers of any animal that could possibly notice the observer or observing instruments should attempt to account systematically for

the effect of observation itself in order to maximize the validity of their observations. This is no less true for field observation than for observation of captive animals. In fact, a wild free-roaming animal who notices a human looking at it may react more strongly than a captive since there has been less opportunity for habituation to humans to occur. The animal would tend either to flee, threaten, or to approach and investigate the observer briefly before leaving the scene.

Even those tenacious observers of wild animals who succeed in getting close to their subjects after a long initial period of avoidance are not then ignored or treated as a neutral stimulus by the observed. The final stages in Van Lawick-Goodall's (1971) relationship with her chimps were curiosity and acceptance. She finally became positively attractive to them. But it is most desirable for an observer to become "as neutral a stimulus as possible by minimizing the interaction between the observer and the observed" (O'Leary, et al., 1971, quoted from Lipinski and Nelson, 1974; p. 345) so that the behavior of the observed occurs as if the observer were not present.

Several studies of human behavior have explored the effects of intrusiveness of the observer. Bechtel (1967) found that visitors within a room of a museum stayed longer and moved around more when they had not noticed the observer than when they had. He concluded that the observer was an aversive stimulus in this situation. Negative reactions of nursery school children in an unfamiliar situation were prolonged when they were aware of the presence of an observer (Arsenian, 1943), although generally children appear to be less reactive to observation than adults (Johnson and Bolstad, 1973). Patterson and Harris (1968) concluded that behaviors that occurred in families at home with the observer present

were different from those with the observer not present. They suspected that if the observer were an aversive stimulus to the people being observed, they might attempt to avoid or escape him. Alternatively, family members might interact more frequently in order to please the observer.

Two basic methods have been used to determine observer effects (Johnson and Bolstad, 1975; p. 181), "(a) . . .recording of behavior changes over time, and (b) . . .comparisons of data collected by differing methods that presumably differ in intrusiveness." The first method as it refers to within-session changes in rates of behavior was used in the present study. Johnson and Bolstad used the second method. In the previous observations they had discovered that an observer present in the home was particularly disturbing, so they tried comparing the results of alternative techniques of observation. They compared reactivity by measuring rates of certain vocal responses when an observer was present scoring conversation and when the observed self-activated a tape-recorder which recorded conversation. While the tape-recorder may have been less intrusive than an observer, the observed participants knew that their conversation was being recorded and this may have accounted for the nonsignificant differences in scores using the two methods. To counter this difficulty the authors proposed that participants constantly wear portable microphones which were monitored by a remote tape recorder that was automatically activated at random intervals so that the observed would be unaware of the periods of observation. Johnson, Christensen, and Bellamy (1976) tested this. Two conditions were compared: (1) times chosen by parents for tape-recording deviant behaviors of their children, and (2) random times of which they were not informed, although

they had been told that the tape-recorder randomly recorded conversation. From test to post-test conditions no statistically significant changes in deviant behaviors occurred as measured by the randomly-occurring recordings. However, there was a significant change in the parent-activated recordings, suggesting that the parents were responding to their own expectations about the outcome of the experiment.

In a review of the problem of reactivity Johnson and Bolstad (1973) found that there were a number of observational studies that uncovered reactivity effects and others where none could be detected. It must be emphasized however, that changes in activity "could be caused by other factors [than reactivity] and lack of change does not necessarily indicate no reactivity" (Selltiz, Wrightsman, and Cook, 1976; p. 264).

Johnson and Bolstad (1975; p. 181) report that White (1972) concluded that

the presence or absence of reactivity or observer effects appears to depend on many factors, including the setting employed, the intrusiveness of the observation procedures, the research paradigm employed, and the dependent variable employed.

The present study uses a technique of analysis made possible by the means of coding data on computer cards. While other studies have analyzed changes in rates of behaviors from session to session this may be the first in which within session changes in rates of behavior were measured across many observation sessions. Using this technique, patterns of habituation to the observer become very clear. It may be a valuable method for detecting reactivity to the presence of an observer in future observational studies. By grouping postural and movement categories into activity levels, the patterns of habituation or changes in rates of behaviors can be enhanced.

II. METHODS OF ANALYSIS

The data from Class A (Postures and Locomotions) were collapsed for purposes of analysis into four Activity Levels. The categories of behavior that were included in each Activity Level were judged to require roughly equivalent amounts of metabolic energy (Figure 3.1). Activity Level 1 represented behaviors which required the least energy and so on up to Activity Level 4 which required the most energy. The groupings are listed in Table 3.1. Activity Levels were useful in measuring the behavioral effects of environmental conditions such as the effect of human presence and of climatic conditions on the bears.

The rationale for the division of behaviors into several Activity Levels is based on studies of work physiology. Since the energy requirements of the various activities of bears have not been studied directly the data were drawn from studies of human activity. Figure 3.1 is adapted from the Textbook of Work Physiology (Astrand and Rodahl, 1970). It shows that although there is overlap between some of the activities, the mean values for each activity are ranked from lowest to highest in the following order: (1) sleeping; (2) lying; (3) sitting; (4) standing; (5) walking on the level at 2, 3, and 4 m.p.h.; (6) climbing stairs; (7) running on the level at 10 m.p.h. The data were for " $\dot{V}O_2$ " uptake, expressed in kilocalories per minute, of a variety of activities taken from various sources, but mostly from Passmore and Durnin [Durnin and Passmore] (1955) and Spitzer and Hettinger (1958). . ." (Astrand and Rodahl, 1970; p. 438).

Sleeping and lying are behaviors that would fall in Activity Level 1 according to the present classification. Sitting and standing

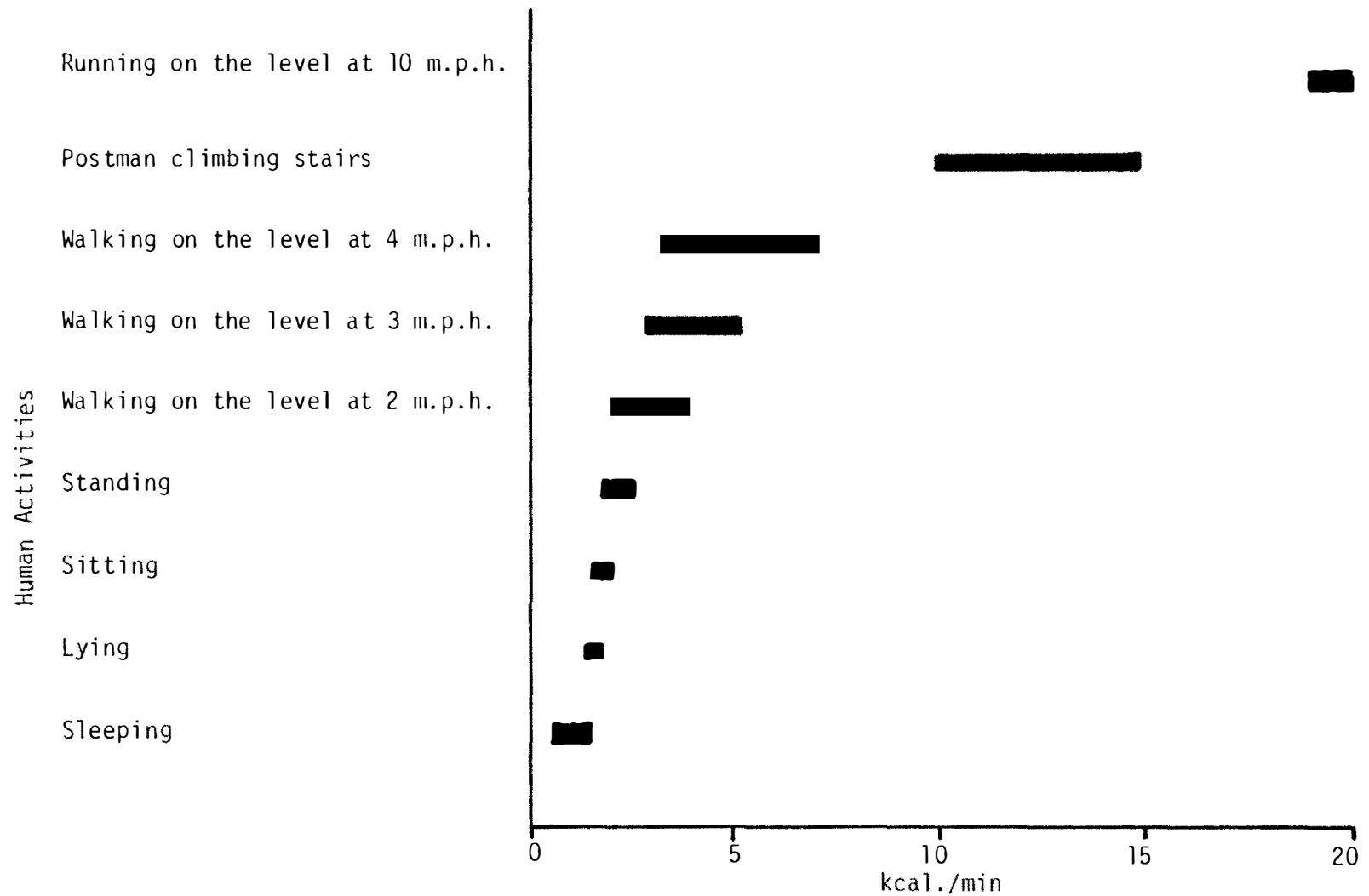


Figure 3.1. Energy expenditure of different human activities, kcal./min. (Adapted from Astrand and Rodahl, 1970)

TABLE 3.1

CLASSIFICATION OF CATEGORIES OF POSTURES AND LOCOMOTIONS
OF BLACK BEARS INTO FOUR ACTIVITY LEVELS

Description	Code Number
Activity Level 1: Lying Postures	
a. Dorsal lying with all legs extended upward	P6
b. Ventral lying with the legs extended forward on both sides or with the front legs extended forward but the rear legs both to one side	P7
c. Lateral lying with the front and rear legs all to one side	P8
d. Lying (or sitting) in a tree or other similarly elevated object	P28
Activity Level 2: Sitting and quadrupedal standing postures	
a. Standing quadrupedally	P3
b. Sitting erect or semierect with the forelimbs elevated	P4
c. Sitting with the forelimbs touching the ground	P5
d. Standing with the forelimbs up or down in a tree or similarly elevated object.	P29
Activity Level 3: Bipedal standing postures and slow locomotion	
a. Standing bipedally erect or semierect while touching an object with the forelimbs	P1
b. Standing bipedally erect or semierect with no support from the forelimbs	P2
c. Walking quadrupedally	P11
d. Walking toward a bear (or person)	P12
e. Walking away from a bear (or person)	P13
f. Walking stiffly, forelegs locked at the knee	P18
g. Rolling over	P33
h. Backing up	P34
Activity Level 4: Rapid or vigorous activity, including running, jumping, and climbing	
a. Running	P19
b. Running toward a bear (or person)	P20
c. Running away from a bear (or person)	P22
d. Ascending trees and other objects	P24
e. Ascending trees slowly	P25
f. Ascending trees quickly	P26
g. Descending trees	P27
h. Running a short distance, then walking quickly	P32
i. Jumping	P35

quadrupedally would fall within Activity Level 2, walking in Activity Level 3, and climbing and running in Activity Level 4. Only climbing and running are clearly differentiated from the behaviors in adjacent Activity Levels according to the data presented in Figure 3.1. Although there is overlap in the ranges of values for the behaviors in Activity Levels 1, 2, and 3, the overlap is not great and there is no overlap between behaviors in nonadjacent Activity Levels, between Activity Levels 1 and 3, for example. Therefore the distinction between behaviors according to Activity Levels was considered to be justified.

III. RESULTS AND DISCUSSION

Activity Levels

Categories of behavior that occurred within each Activity Level were ranked according to frequency of occurrence for each bear (Tables 3.2 and 3.3). Spearman rank order correlations compared the Goldrush bears with each other and the Tremont bears with each other for each Activity Level. The correlation within each pair for Activity Levels 1 and 2 at Goldrush and Tremont was 1.00 ($P < .05$). The rank order correlations for Activity Level 3 were .90 ($P < .01$) at Goldrush and .98 ($P < .001$) at Tremont with only one switch in order at Goldrush and none at Tremont. The rank order correlations for Activity Level 4 were .53 (n.s.) at Goldrush and .90 ($P < .05$) at Tremont. Thus, the behavior category rankings within pairs were very similar especially at Tremont.

The rankings between pairs at Goldrush and Tremont were also similar, though somewhat less so. The only difference in rankings of behavior for Activity Level 1 between Goldrush and Tremont was that

TABLE 3.2
FREQUENCY AND PERCENT FOR CATEGORIES OF CLASS A BEHAVIORS
(POSTURES AND LOCOMOTIONS) WITHIN EACH ACTIVITY
LEVEL AT GOLDRUSH

Activ- ity Level	Name of Behavior	Freq. Bear A (♂)	Percent	Freq. Bear B (♀)	Percent
1	Ventral lying	2492	75.70	2289	58.56
	Lateral lying	544	16.52	888	22.72
	Lying in a tree	200	6.08	532	13.61
	Dorsal lying	56	1.70	200	5.11
	Total	3292	100.00	3909	100.00
2	Standing quadrupedally	1965	69.71	2235	71.57
	Sitting down	696	24.69	697	22.32
	Sitting up	80	2.84	98	3.13
	Standing in a tree	78	2.77	93	2.98
	Total	2819	100.00	3123	100.00
3	Walking quadrupedally	2501	86.21	1627	84.78
	Walking toward	192	6.62	131	6.82
	Standing bipedally (P1)	95	3.27	66	3.44
	Standing bipedally (P2)	79	2.72	57	2.97
	Walking away	26	0.90	32	1.67
	Walking stiffly	7	0.24	1	0.05
	Backing up	1	0.03	2	0.10
	Rolling over	0	0.00	3	0.16
	Total	2901	100.00	1919	100.00
4	Ascending trees	28	27.18	41	25.47
	Descending trees	25	24.27	26	16.16
	Running toward	18	17.48	20	12.42
	Running away	11	10.68	22	13.66
	Running	9	8.74	8	4.97
	Running, then walking	6	5.83	40	24.84
	Jumping	6	5.83	4	2.48
	Total	103	100.00	161	100.00

TABLE 3.3

FREQUENCY AND PERCENT FOR CATEGORIES OF CLASS A BEHAVIORS
(POSTURES AND LOCOMOTIONS) WITHIN EACH ACTIVITY
LEVEL AT TREMONT

Activity Level	Name of Behavior	Freq. Bear C (♀)	Percent	Freq. Bear D (♀)	Percent
1	Lateral lying	1872	51.60	1251	46.70
	Ventral lying	1064	29.33	868	32.39
	Lying in a tree	602	16.59	462	17.24
	Dorsal lying	90	2.48	99	3.69
	Total	3268	100.00	2680	100.00
2	Standing quadrupedally	1352	61.40	1551	60.73
	Sitting down	612	27.79	909	35.59
	Sitting up	210	9.54	65	2.55
	Standing in a tree	28	1.27	29	1.14
	Total	2202	100.00	2554	100.00
3	Walking quadrupedally	1368	90.66	1896	90.41
	Standing bipedally (P1)	81	5.37	116	5.53
	Walking toward	45	2.98	61	2.91
	Walking away	8	0.53	14	0.67
	Standing bipedally (P2)	7	0.46	9	0.43
	Walking stiffly	0	0.00	1	0.05
	Rolling over	0	0.00	0	0.00
	Backing up	0	0.00	0	0.00
	Total	1509	100.00	2097	100.00
4	Ascending trees	37	46.84	29	29.00
	Descending trees	18	22.78	16	16.00
	Running, then walking	15	18.99	28	28.00
	Running toward	6	7.59	16	16.00
	Running	2	2.53	8	8.00
	Running away	1	1.27	3	3.00
	Total	79	100.00	100	100.00

the most frequently occurring behavior at Goldrush was Ventral lying (P7), while at Tremont it was Lateral lying (P8). There were no differences between rankings of pairs within Activity Level 2 at Goldrush and Tremont. The rankings within Activity Level 3 at Goldrush and Tremont were similar. Walking (P11) was ranked first by a wide margin at both locations. The rankings for Activity Level 4 at both locations were also similar. Generally, however, location of enclosures accounts for more of the variability in rankings of Class A behaviors (Postures and Locomotions) than individual or gender differences.

Effects of the Presence of Humans.

How did the bears respond to the observer's presence over time? Was there a difference between bears kept at the two locations? To assess this, the hour-long observation periods were divided into 30 2-minute periods and the data were pooled for all of the systematic observation sessions. In this way rates for each category of behavior and Activity Level per 2-minute period within sessions could be determined. The variability in increase or decrease of rates of behavior within sessions is indicated by the significance level (linear regression "r" test) and the degree of increase or decrease is indicated by the slope. Both of these are derived from linear regression analysis. Figures 3.2 through 3.7 show the scatter plots of Activity Levels 1, 2, and 3 by 2-minute periods within observations for each bear. It can be seen in Tables 3.4 and 3.5 that for slopes of more than ± 0.50 the significance level was $P < .001$ with only one exception.

The data show that no categories of behavior or Activity Levels for the bears of Goldrush had slopes of more than ± 1.00 . The rates of

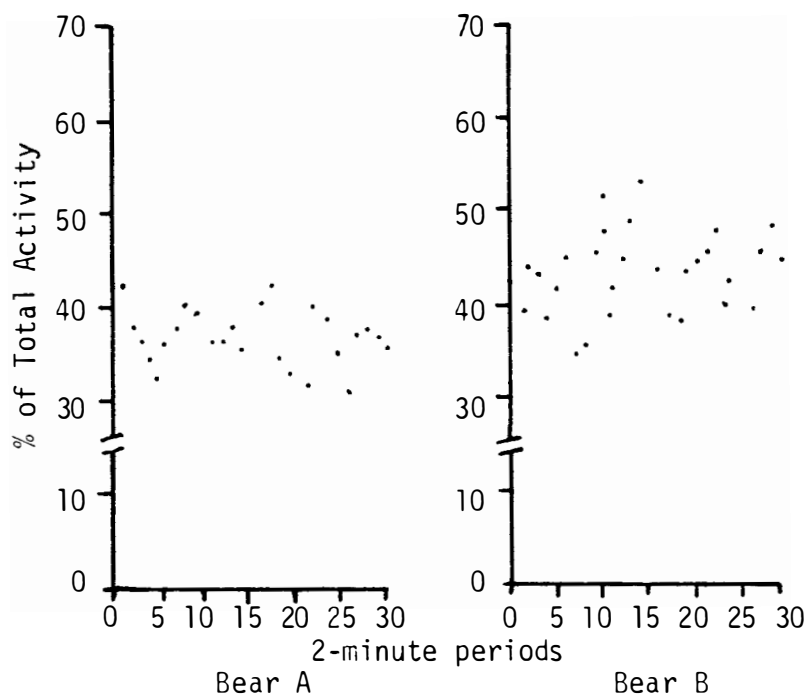


Figure 3.2. Activity level 1 for each 2-minute period within hour-long observation sessions at Goldrush.

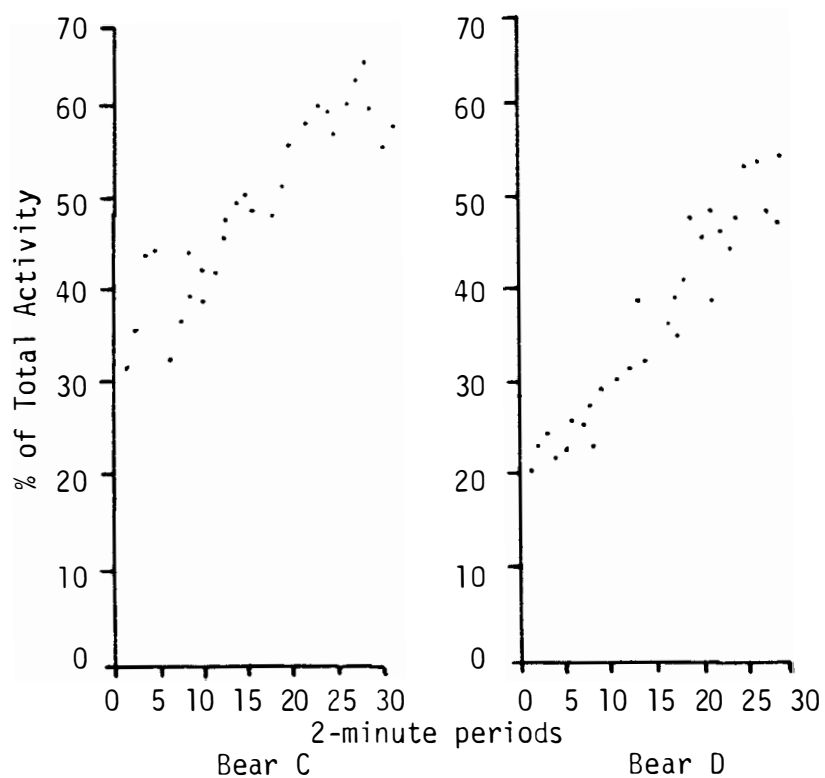


Figure 3.3. Activity level 1 for each 2-minute period within hour-long observation sessions at Tremont.

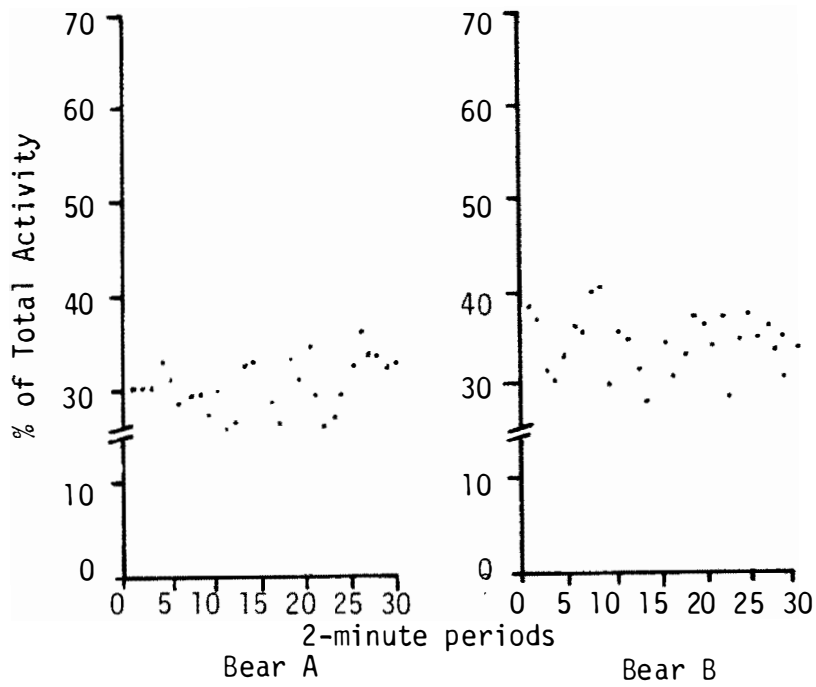


Figure 3.4. Activity level 2 for each 2-minute period within hour-long observation sessions at Goldrush.

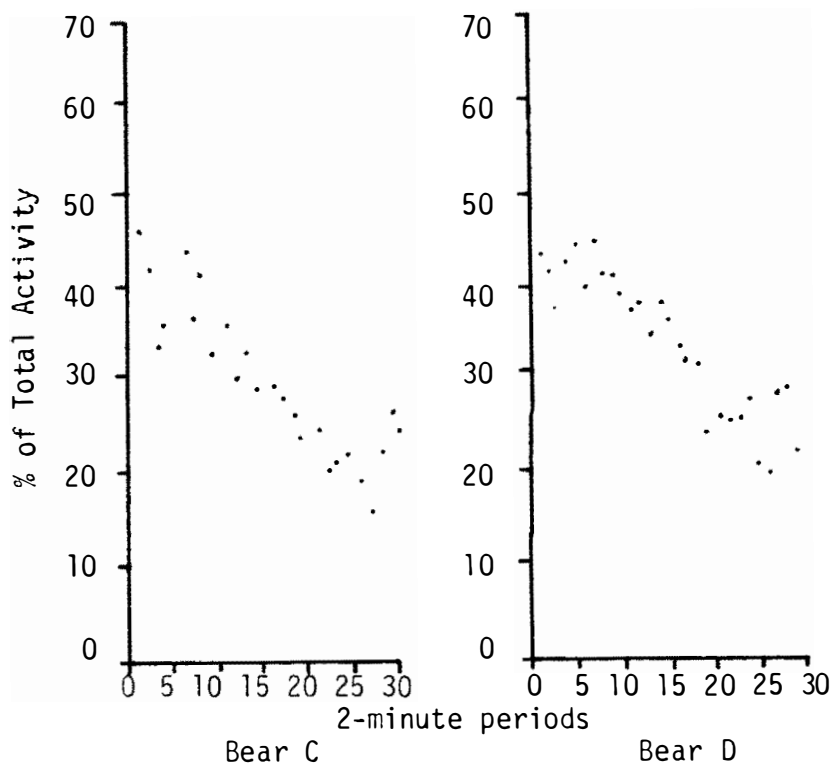


Figure 3.5. Activity level 2 for each 2-minute period within hour-long observation sessions at Tremont.

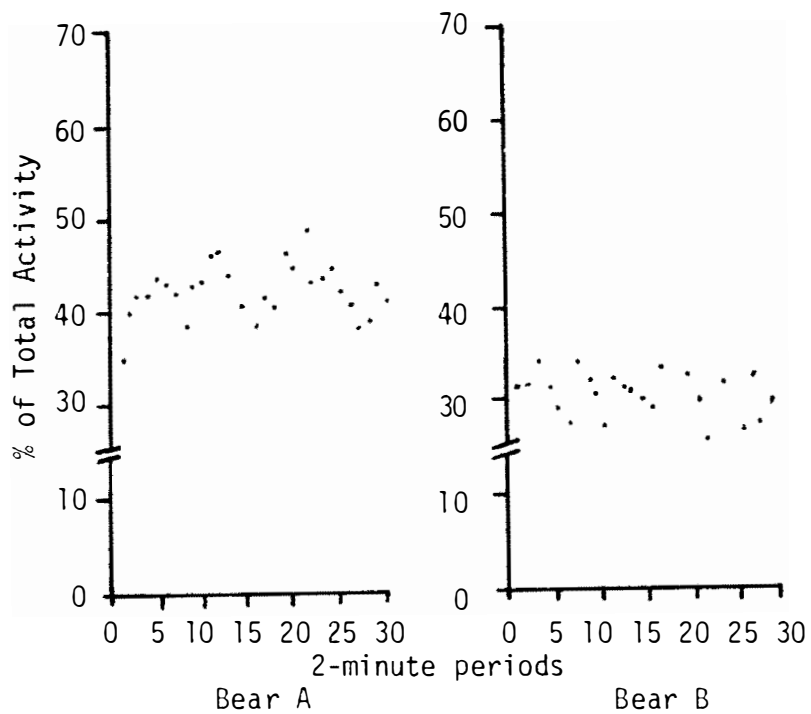


Figure 3.6. Activity level 3 for each 2-minute period within hour-long observation sessions at Goldrush.

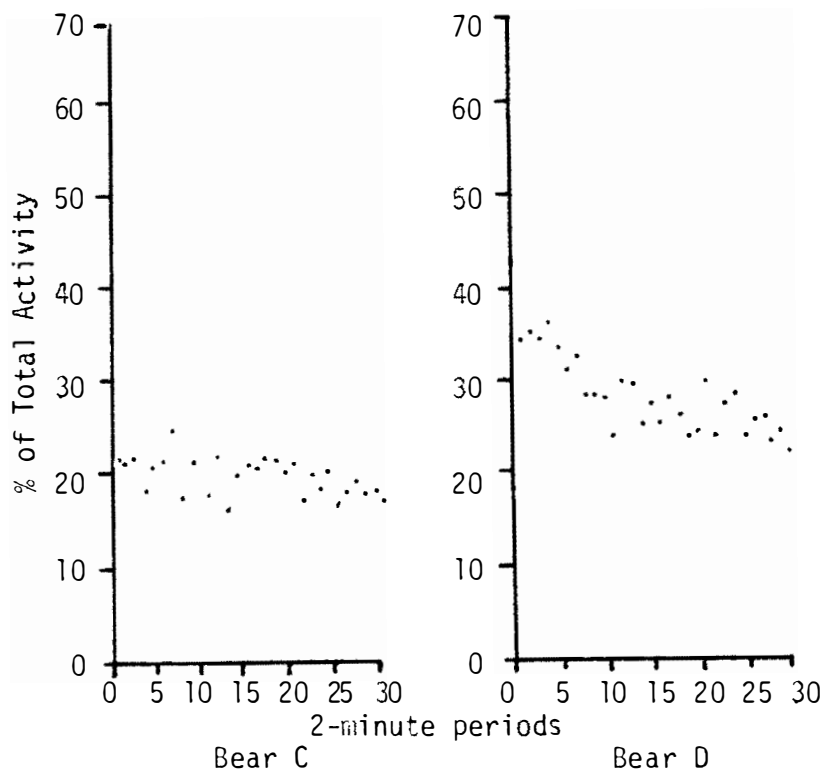


Figure 3.7. Activity level 3 for each 2-minute period within hour-long observation sessions at Tremont.

TABLE 3.4

SLOPE DIRECTIONS AND SIGNIFICANCE LEVELS ("r" TEST) DERIVED FROM LINEAR REGRESSION
ANALYSIS OF RATES OF BEHAVIORS AND ACTIVITY LEVELS AS A FUNCTION
OF 2-MINUTE PERIODS WITHIN HOUR-LONG OBSERVATION
SESSIONS AT GOLDRUSH

Slope	Bear A (♂)			Bear B (♀)		
	Activity Level or Behavior Code Number	Significance Level ("r" test)	Direction of Slope (+/-)	Activity Level or Behavior Code Number	Significance Level ("r" test)	Direction of Slope (+/-)
0.00- 0.49	P3	<.05	-	P4	<.05	-
	P5	<.05	-	P11	<.05	-
	F6	<.05	-	AL3	<.05	-
	D24	<.05	-			
0.50- 0.99	D29	<.001	+	F60	<.001	+
	AL1	<.01	-			
1.00- 2.99		---	---		---	---

TABLE 3.5

SLOPE DIRECTIONS AND SIGNIFICANCE LEVELS ("r" TEST) DERIVED FROM LINEAR REGRESSION
ANALYSIS OF RATES OF BEHAVIORS AND ACTIVITY LEVELS AS A FUNCTION OF
2-MINUTE PERIODS WITHIN HOUR-LONG OBSERVATION
SESSIONS AT TREMONT

Slope	Bear C (♀)			Bear D (♀)		
	Activity Level or Behavior Code Number	Significance Level ("r" test)	Direction of Slope (+/-)	Activity Level or Behavior Code Number	Significance Level ("r" test)	Direction of Slope (+/-)
0.00- 0.49	P4	<.001	-	P4	<.05	-
	P11	<.001	-	S3	<.01	-
	P28	<.001	+	F36, F37,		
	F2	<.01	-	F38	<.05	-
	F6	<.05	-	F49	<.05	-
	F42, F43,			D24	<.05	-
	F44	<.01	-	D29	<.05	-
	D24	<.001	-	AL4	<.05	-
	D29	<.01	-			
	D69	<.05	-			
	AL4	<.01	-			
0.50- 0.99	P5	<.001	-	P5	<.001	-
	F6	<.001	-	P28	<.001	+
	AL3	<.001	-	F6	<.001	-
1.00- 1.49	P3	<.001	-	P8	<.001	+
	F11	<.001	-	P11	<.001	-
				AL3	<.001	-

TABLE 3.5 (Continued)

Slope	Bear C (♀)			Bear D (♀)		
	Activity Level or Behavior Code Number	Significance Level ("r" test)	Direction of Slope (+/-)	Activity Level or Behavior Code Number	Significance Level ("r" test)	Direction of Slope (+/-)
1.50- 1.99	P8 AL1	<.001 <.001	+ +	P3	<.001	-
2.00- 2.49	F60 AL2	<.001 <.001	+ -	F11 AL1	<.001 <.001	- +
2.50- 2.99				F60 AL2	<.001 <.001	+ -

behaviors or Activity Levels of the Tremont bears that increased most (i.e., $\text{slope} > +0.50$) within sessions were Activity Level 1, Resting (F60), Lateral lying (P8), and Lying in a tree (P28). Activity Level 1 includes nearly all resting behaviors and therefore reflects the increases in rates of specific categories of postures which are typically used for resting. The behaviors or Activity Levels that decreased most at Tremont (i.e., $\text{slope} > -0.50$) were Activity Levels 2 and 3, Looking (F11), Standing quadrupedally (P3), Sniffing objects (F6), Walking (P11), and Sitting with forelimbs touching the ground (P5). Standing quadrupedally (P3), Looking (P11), and Sniffing objects (F6) may indicate vigilance. Both standing quadrupedally and looking are related to and typically follow Alerting (F12), which is a response to a sudden novel stimulus, and these two behaviors at times indicate incomplete habituation to a stimulus. Alerting, however, does not appear in Tables 3.4 and 3.5 because at Tremont at least it occurred in response to the approach of the observer before the observations began. Once the bears had determined the identity of the observer it did not occur again unless the observer made a sudden loud sound or moved quickly and unexpectedly. Of course, a sudden stimulus from a source other than the observer during the observation could also elicit alerting. Figure 3.8 shows that alerting, though never occurring at high rates, generally decreased from 1971 to 1973. The decrease was probably due to a decrease in reactivity related to maturation.

The bears at Goldrush apparently exhibited some reactivity to the observer but less ($\text{slopes} > +/-0.50$ and $< +/-0.99$) than those at Tremont ($\text{slopes} > +/-0.50$ and $< +/-2.99$). Bear A's Activity Level 1 decreased and attention paid the Other-bear (D29) increased. Bear B's

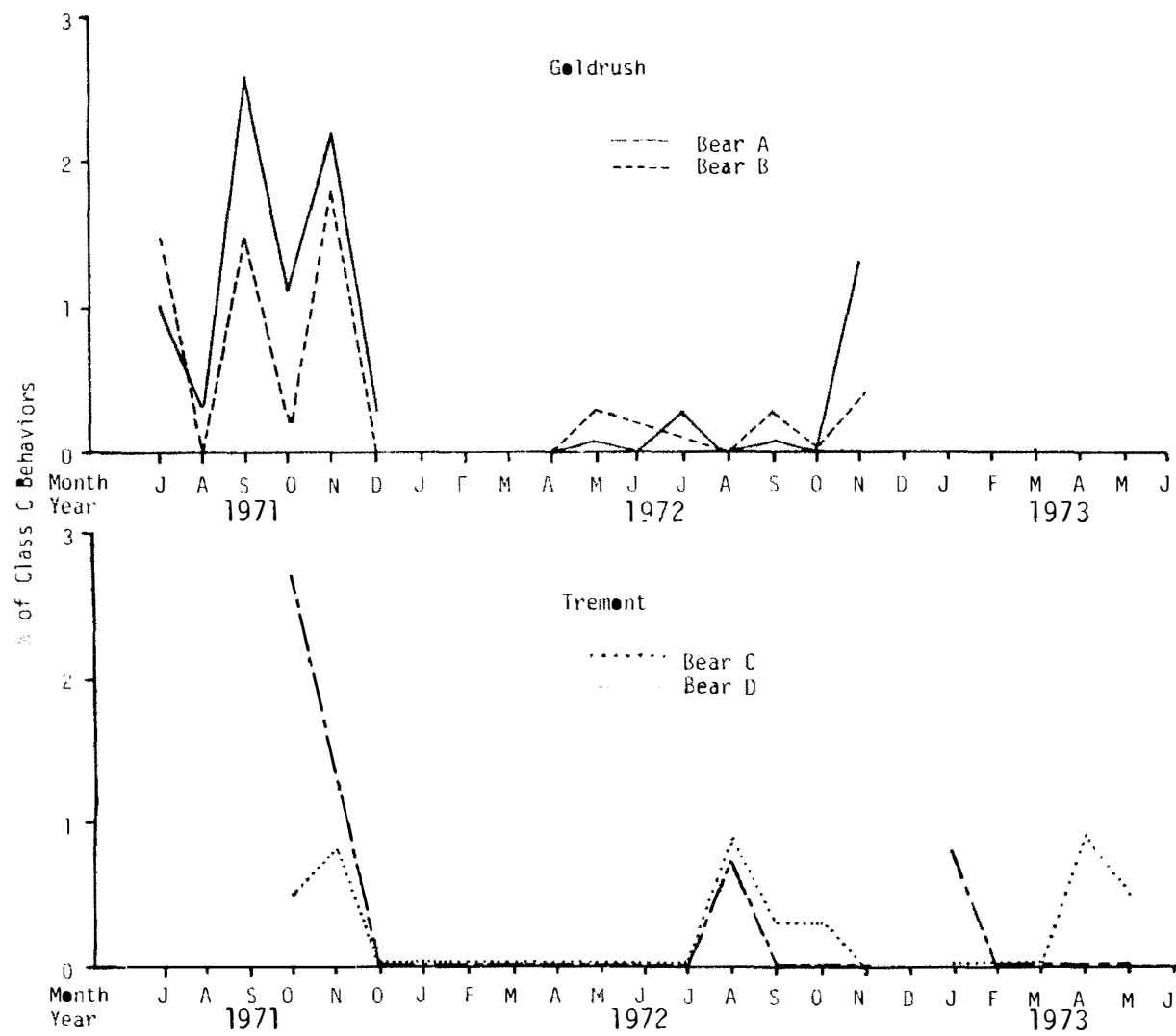


Figure 3.8. Rate of alerting behavior (F12) per month in 1971, 1972, and 1973 at Goldrush and Tremont.

Resting (F60) increased. All were within the range of slopes of ± 0.50 to ± 0.99 . The bears at Goldrush were apparently much more accustomed to people looking at them.

Other behaviors at Goldrush and Tremont increased or decreased, but not dramatically, and some which were expected to increase or decrease significantly (i.e., significance level $\leq .05$), Pacing (F51), for example, did not. The rates of some behaviors did not change significantly or were significant but at $P > .001$ level because the behaviors occurred at rates that were too low.

The patterns of increase and decrease of behaviors may have been influenced by or related to factors other than the presence of the observer: consistent changes in temperature or angle of the sun within observations, for example. Contradicting this hypothesis, however, is the fact that the bears at Goldrush were exposed more directly to the sun and the effects of climate, due to the absence of trees in their enclosure, yet their behavior did not change as dramatically as that of the bears at Tremont.

Activity Level 1 includes the postures of the bears requiring the least energy. At Tremont most behaviors in this group of postures increased during observation sessions. Complementing this pattern at Tremont is the decrease of some higher energy postures (in Activity Levels 2 and 3) and locomotions (in Activity Level 3 and 4) from the beginning to end of observation sessions (Figures 3.2 through 3.7, pages 41, 42, and 43). The bears at Tremont became less active as time within sessions progressed but at Goldrush there were few significant increases or decreases in rates. Therefore the bears at Tremont appeared to be

more disturbed than the bears at Goldrush by the arrival and presence of the observer. However, they appeared to habituate the observer's presence rather rapidly as shown by the increase in rates of most "relaxed" behaviors (i.e., behavior requiring relatively less energy) and the decrease in rates of some behaviors requiring relatively more energy during observation sessions. The behavior of the bears at Goldrush was not disturbed nearly as much by the presence of the observer. Several factors probably contributed to this. Their enclosure was much larger than at Tremont and was enclosed by two concentric fences. The inner one was a standard electrified fence which effectively kept the bears from escaping. The second was a chest-high chain link fence about one meter outside the first and was designed to keep the visitors from approaching the bears too closely. At Tremont there was a single fence consisting of 2.5 meters of chain-link fencing topped by 1.3 meters of sheet metal (Chapter 2), which kept the bears from climbing out of the enclosure. This permitted bears and people to approach each other closely short of contact. During the temporary absence of the caretaker in the Fall of 1972 the author was responsible for the care of the bears and entered the enclosure for maintenance of the enclosure, feeding, testing, and close interaction with the bears. Thereafter the bears associated the observer with food, but it is not known whether this affected the rate of habituation during observations. The bears were nearly always fed before observations took place in order to minimize the food association of the observer.

The olfactory, visual, and auditory stimuli produced by activities of people without question affected the activities of both sets of bears.

However, the relative effect of the observer on the bears at Goldrush was less because the environment was rich in unusual stimuli: park visitors passing by, workmen constructing and repairing buildings, craft people shaping their wares, farm animals moving about, and restored railway trains and a steam-driven lumber mill whistling and blowing smoke. In fact so much was going on during a typical day of the tourist season that the bears may have habituated partially to stimulation from outside the enclosure generally. The advantage of stimulation that distracts attention from the observer but which disturbs minimally the behavior of the observed has been discussed by Barlow (1968). Fish he was observing in an aquarium were obviously attending to his movements. This was apparent when they suddenly and for long periods "froze" in one position. He solved the problem by introducing a second, less disturbable, species of fish in a physically separated area of the tank. The constant motion of the introduced fish apparently helped habituate the fish being observed to the motions of the observer as well, and their behavior from then on appeared to be minimally disturbed by him. Barlow called the second fish species a "dither." Similarly, at Goldrush the continuity of the bears' behavior usually appeared to be unbroken by outside events.

At Tremont care had been taken to isolate the bears from the effects of human activity. The enclosure was hidden in a heavily wooded area which could only be approached by fording a stream, walking along an unmarked path, and then opening or climbing over a padlocked fence gate with an attached sign marked "Keep out--Authorized Personnel Only" and another saying "Research in Progress." The enclosure was not visited frequently by people who were not studying the bears. Thus, the bears were not as accustomed to human activity as the bears at Goldrush. In

spite of this they seemed to habituate rapidly to the presence of humans before and during the period of the observation session. Whether they habituated from one observation session to the next is addressed below.

Figure 3.9 indicates that at Goldrush rates for responding to the observer during 1971, 1972, and 1973, by Looking (F11) at him, Sniffing (F6) him, and performing other behaviors listed in Table 3.6 and Table 3.7 were roughly the inverse of responding to people other than the observer (Figure 3.10). These rates were related to the period of the tourist season. Generally in 1972, when Goldrush was closed to the public from October to May the bears responded to the observer. When it was open they responded to people other than the observer. Figure 3.11 shows the monthly rate of attending to the observer by black bears at Tremont. Unlike Goldrush this pattern indicates habituation of the observer across sessions, since the rate decreases rather sharply after an initially high rate of attending to the observer. Also, there appears to be a recovery effect when observations were resumed after being suspended for more than a month (December, 1972). This pattern fits the classical description of habituation: (1) response rates decrease within sessions; (2) overall response rates decrease between sessions although there is a spontaneous recovery of response from the end of one session to the beginning of the next.

At Tremont the increase in Activity Level 1 behaviors (those requiring the least energy) and the decrease in rates of behavior from other activity levels during observation sessions might be accounted for by two contrary explanations: either the bears withdrew from people into a quiescent but alert state or they habituated and responded progressively less to their presence.

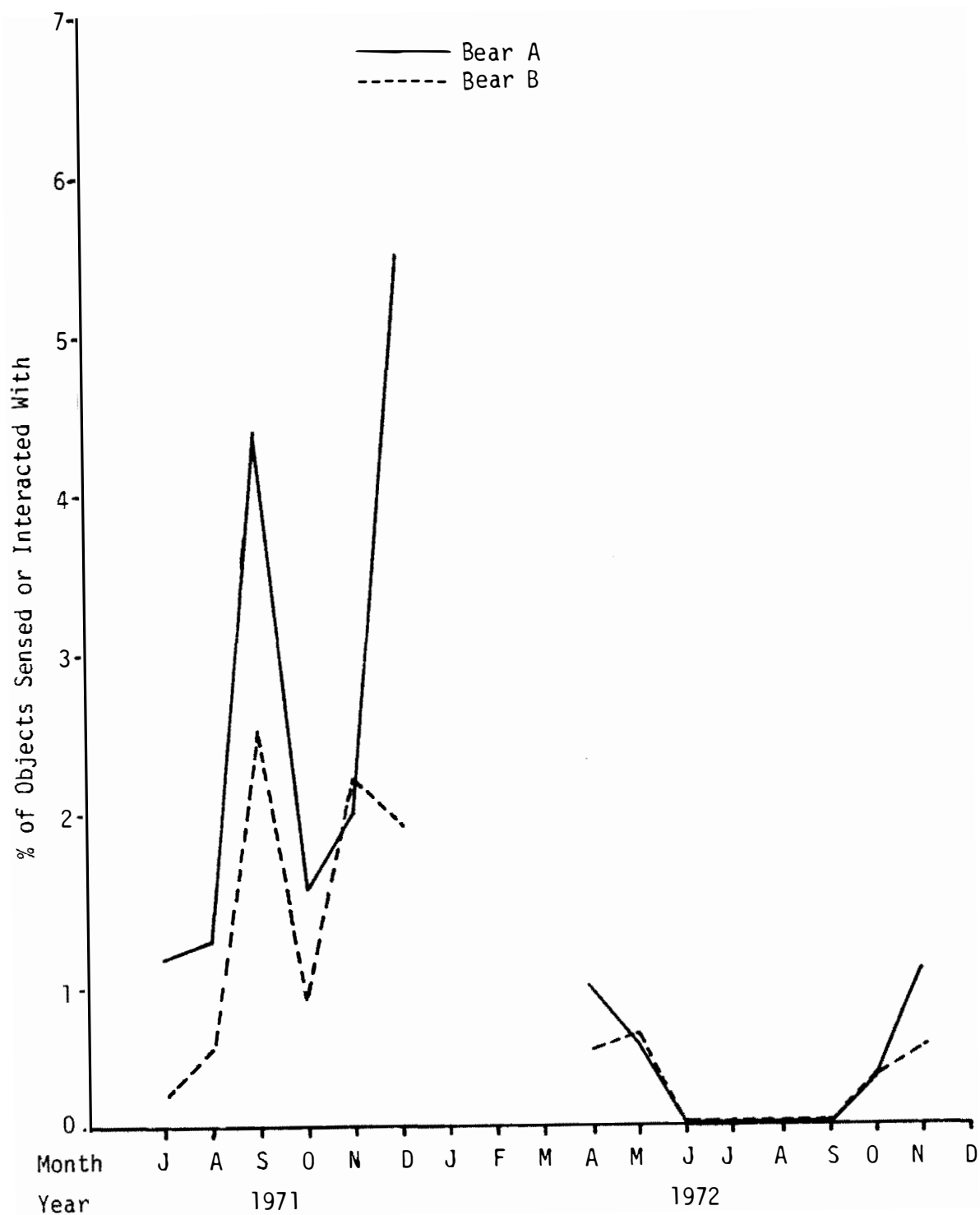


Figure 3.9. Goldrush bears' rates of attending to the Standing observer (D24) per month in 1971 and 1972.

TABLE 3.6

FREQUENCY AND PERCENT OF CLASS C BEHAVIORS (FUNCTIONS...) DIRECTED
AT THE OBSERVER (D24) BY BLACK BEARS AT
GOLDRUSH

Name of Category	Freq. Bear A (♂)	Percent	Freq. Bear B (♀)	Percent
Looking	73	64.00	49	77.78
Sniffing and looking	12	10.62	5	7.94
Sniffing	6	5.31	4	6.35
Pacing	8	7.08	0	0.00
Alerting	4	3.54	3	2.65
Other	11	9.45	4	6.28

TABLE 3.7

FREQUENCY AND PERCENT OF CLASS C BEHAVIORS (FUNCTIONS...) DIRECTED
AT THE OBSERVER (D24) BY BLACK BEARS AT TREMONT

Name of Category	Freq. Bear C (♀)	Percent	Freq. Bear D (♀)	Percent
Looking	176	85.44	115	64.61
Threatening	4	1.94	37	20.79
Sniffing and looking	12	5.83	7	3.93
Pacing	1	0.49	6	3.37
Pawing object	1	0.49	3	1.69
Other	12	5.81	10	5.61

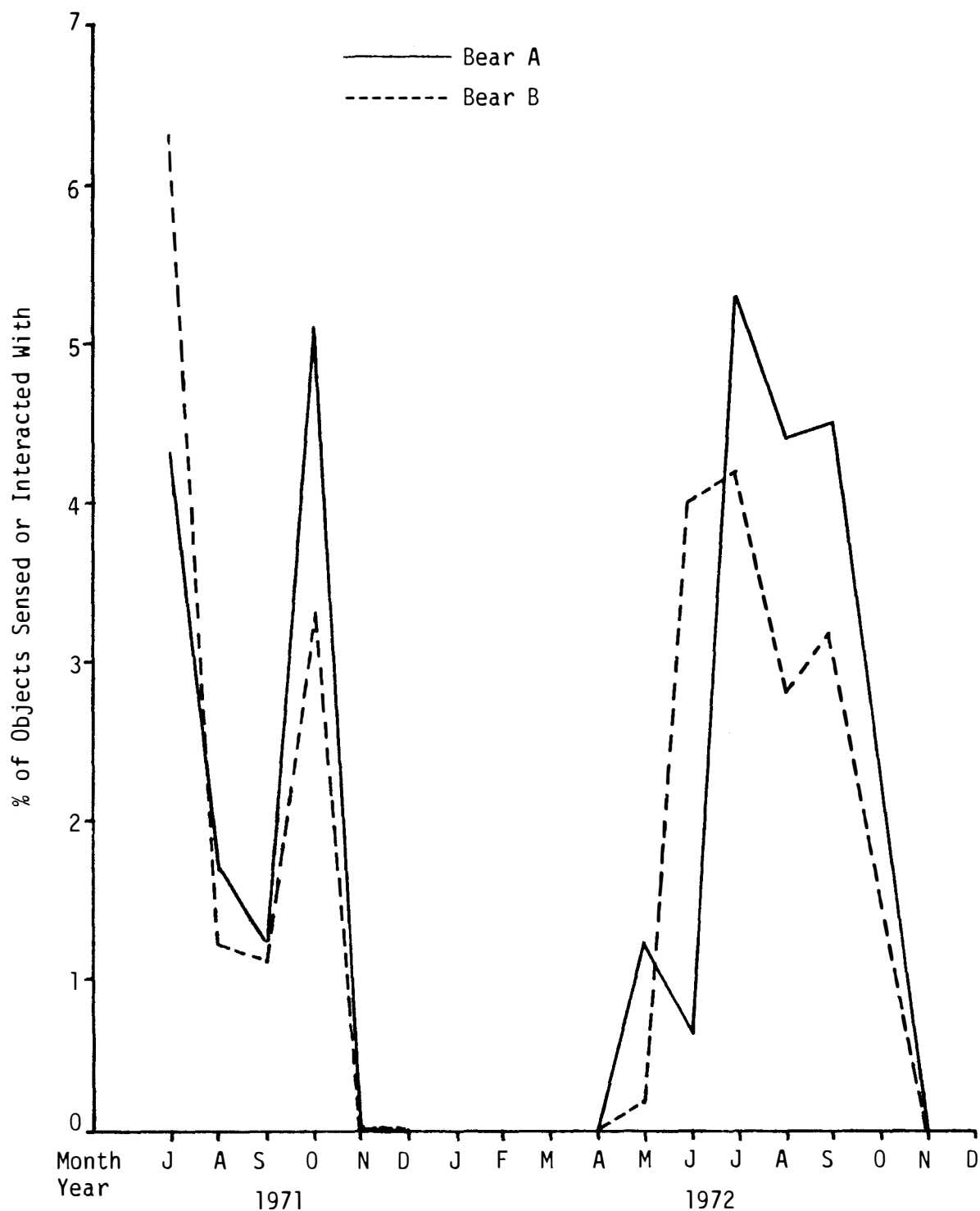


Figure 3.10. Goldrush bears' rates of attending to People other than the observer (D25) per month in 1971 and 1972.

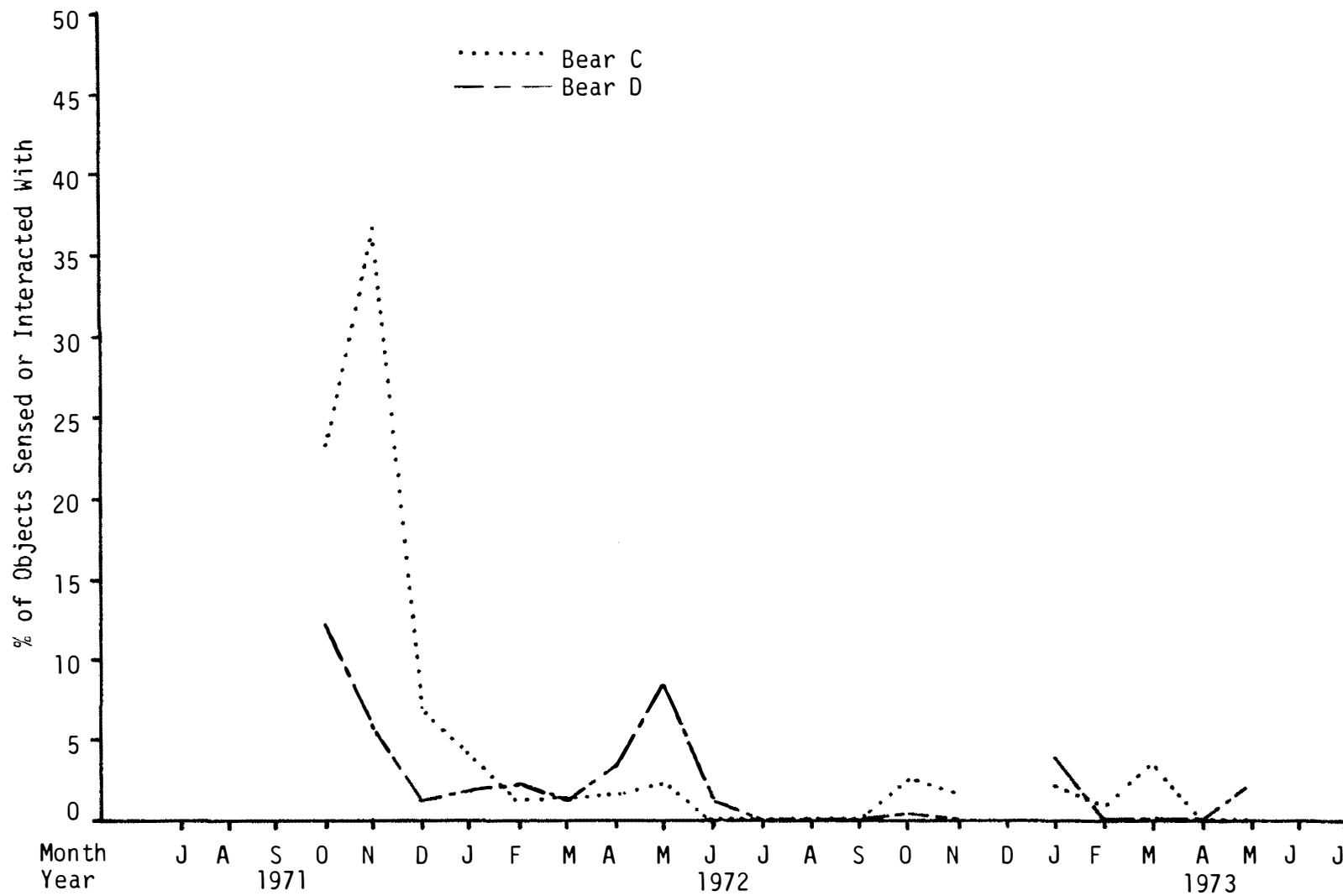


Figure 3.11. Tremont bears' rates of attending to the Standing observer (D24) per month in 1971, 1972, and 1973. (Note change in scale.)

The second explanation is more likely, for a variety of reasons. For example, Resting (F60), a behavior that was usually interpreted as sleeping (sleeping is a physiological state that cannot readily be determined by behavioral observation and therefore was not used as a category), and postures which were identified primarily as resting, namely Lateral lying (P8) or Lying in a tree (P28), increased during sessions. Resting (which includes sleeping) is unlikely to occur if an animal feels threatened or disturbed. On the other hand behaviors which are likely indicators of arousal or alarm decreased during sessions. Examples are Sniffing objects (F6), Looking (F11), Huffing (S3), a threat sound, and Biting other (F49) (Table 3.5, page 45).

Another indication of habituation to the observer's presence was a gradual return to the performance of behaviors that were occurring when the observer first arrived but before the bears responded to his presence. The observer could determine the bears' first overt response to his presence because they suddenly became alert (Figure 3.12) or at least looked toward the observer and frequently ran or walked quickly to another place in the enclosure--either farther away from the approaching observer or to the base of a tree (Figure 3.12). If the bears approached a tree they either Stood quadrupedally (P3) at the base of it looking toward the observer, Stood bipedally touching the tree with the front paw (P1), Stood bipedally without touching any object with the front paw (P2), or, when especially alarmed, they climbed the tree. Height climbed was an indication of degree of alarm. On two occasions when dogs were brought to the enclosure, the bears climbed very high, a reflection of their extreme antipathy for dogs. The cubs spent most



Figure 3.12. Bear C alerting (F12) at Tremont. (When alerting the bear's muzzle is typically pointed down and the face and ears are pointed towards the stimulus.)

of their time resting in trees when people were present at the enclosure especially during the first two or three months after introduction. A similar use of trees was noted in wild bears in the present study and by Herrero (unpublished manuscript).

At any point in the occurrence of these sequences of behavior the bears could apparently recognize the observer and immediately "relaxed." Kauffman (1962) has described a similar pattern of alert response to alarming stimuli followed by relaxation in coatis (Nasua narica), another semiarboreal species of Carnivora. Often the bears approached the observer or continued behaving as they had before noticing the the observer's presence. Since the observer was often able to see for a moment what the bears were doing before becoming alert, it was possible to compare behaviors subsequent to recognition to those preceding it. Usually the behavior had returned to its "undisturbed" state before the observation session was completed. If, for example, the behavior occurring before the bears recognized the presence of the observer was resting, the bears gradually returned to resting. Or, if they had been foraging or playing, they returned to these activities.

Among Class A behaviors (Postures and Locomotions) at Tremont two behaviors which indicate resting (and sleeping) increased: Lateral lying (P8) and Lying in a tree (P28). Another resting behavior, Ventral lying (P7), did not change significantly. This, unlike other resting postures, was also assumed frequently when eating or exploring and manipulating objects.

Standing quadripedally (P3), Sitting erect or semierect (P4), and Sitting with forelimbs touching the ground (P5), all of which may

indicate moderate arousal, decreased significantly (linear regression "r" test, $P < .001$) during sessions at Tremont. The rate of decrease for these postures is similar to that for Activity Level 2 under which heading they fall (Table 3.5, page 45).

Behaviors in Class A (Postures and Locomotions) that predominated in response to the observer are described below, while behaviors in Class C and Class B that occurred in response to the observer are shown in Tables 3.6 (page 54), 3.7 (page 54), 3.8 and 3.9, and are discussed below. Standing quadrupedally (P3) was the most common posture for both bears at Goldrush when attending to the observer, while Lying in a tree (P28) was most common for Bear C and Sitting down (P5) was most common for Bear D.

Vocalizations (Tables 3.8 and 3.9) were rarely directed towards the observer (or towards each other) at Goldrush, but at Tremont Bear D threat-vocalized and Bear C, the only bear who occasionally grunted at high rates, grunted more while oriented towards the observer than towards any other discernible object in the environment (Table 3.10). Grunting may function as an alarm and/or "contact" vocalization between mother and cubs (personal observation) but its purpose when oriented towards the observer was not immediately apparent. It did not occur in the behavioral or situational context of threat. Perhaps she was actually attempting to vocally "contact" the observer.

All four bears looked (F11) at the observer more often than they directed other Class C behaviors to him (Tables 3.6 and 3.7, pages 54). The combined category, Sniffing and looking (F10) at the observer, ranked second in frequency of occurrence for three of the bears, while threatening

TABLE 3.8

FREQUENCY AND PERCENT OF CLASS B BEHAVIORS (SOUNDS) DIRECTED
TOWARDS THE OBSERVER (F24) BY BLACK BEARS AT GOLDRUSH

Name of Sound	Freq. Bear A (♂)	Percent	Freq. Bear B (♀)	Percent
Panting	5	83.33	0	0.00
Slapping	1	16.67	1	50.00
Huffing	0	0.00	1	50.00
Total	6	100.00	2	100.00

TABLE 3.9

FREQUENCY AND PERCENT OF CLASS B BEHAVIORS (SOUNDS) DIRECTED
TOWARDS THE OBSERVER (F24) BY BLACK BEARS AT TREMONT

Name of Sound	Freq. Bear C (♀)	Percent	Freq. Bear D (♀)	Percent
Grunting	41	87.23	1	3.13
Panting	4	8.51	18	56.25
Slapping	1	2.13	3	9.38
Snorting	0	0.00	3	9.38
Huffing	1	0.00	1	3.13
Moaning	1	2.13	0	0.00
Slap/huff	0	0.00	1	3.13
Slap/huff-jaw-pop	0	0.00	1	3.13
Slap/pant	0	0.00	1	3.13
Sigh	0	0.00	1	3.13
Huff-jaw-pop	0	0.00	1	3.13
Bellow	0	0.00	1	3.13
Total	48	100.00	32	100.00

TABLE 3.10
OBJECTS FACED BY BEAR C AT TREMONT WHILE PERFORMING
THE GRUNTING (S7) VOCALIZATION

Name of object	Freq.	Percent
Observer	41	32.3
Unknown	29	22.8
Ground	15	11.8
Other bear	14	11.0
Tree	8	6.3
Fence	4	3.1
Chest	3	2.4
Other	13	10.3

the observer ranked second for Bear D. Sniffing the observer ranked third for three of the bears. The bears at Tremont directed two to four times as much of their behavior toward the observer as did those at Goldrush.

Bear D frequently threatened the observer, although this is not clear from the systematic observation data, since the threats usually ceased before observations were begun. Bear D averaged one threat towards the observer in every 2-1/2 systematic observation sessions. This nearly always consisted of offensive threat, which included elements such as standing bipedally, slapping the fence, huffing, panting, and jaw-popping (Jordan, 1976). Threatening behavior by these bears towards humans has been discussed by Jordan (1976) and Pruitt (1974).

There was, in summary, evidence of reactivity to the observer at both Goldrush and Tremont. At Tremont the response to the observer was evident from the decay within sessions of certain responses that indicated moderate to high arousal and the increase within sessions of some behaviors that indicated low arousal. This indicated repeated habituation to the observer during each session. There was also evidence of an habituation effect from session to session during the two years of observation. The combination of recovery of response from session to session followed in each case by decay of response, and an overall decrease in rate of response across sessions fits the classic description of habituation (Heiligenberg, 1977). The relative lack of habituation at Goldrush may be attributed to the much lower level of stimulation from outside the enclosure at Tremont than at Goldrush. Therefore the relative amount of stimulation from the observer was much greater at Tremont.

CHAPTER 4

SOCIAL INVESTIGATION AND BODY CONTACT BEHAVIOR

I. INTRODUCTION

Studies of diverse mammalian species, including lions (Panthera leo) (Schaller, 1972), horses (Equus caballus) (Hafez, Williams, and Wierzbowski, 1969), pigs (Sus scrofa) (Hafez and Signoret, 1969), and chimpanzees (Pan troglodytes) (Van Lawick-Goodall, 1971) have shown that social sniffing, licking, and body contact can function in three possibly overlapping ways: (1) maintaining group cohesion and friendly relations, (2) social grooming, and/or (3) seeking tactual, olfactory, and gustatory stimulation from a conspecific. A goal of the present study was to determine which of these were characteristic of black bears.

II. RESULTS

In systematic observations sniffing another bear (F46) occurred at low rates for all four bears (<1 percent) during all months of the year (Table 4.1). It ranked seventeenth out of 45 behavior categories for Bears A and B combined and thirteenth out of 48 for Bears C and D combined (Appendix A--Class C behaviors). Licking another bear (F47) occurred even less frequently (Table 4.2 and 4.3). It was ranked last of all Class C behaviors at Goldrush and was ranked thirty-sixth out of 45 at Tremont (Appendix A). In two years of systematic observations at Goldrush, the male was observed licking the female only once. He was, however, observed licking the female during nonsystematic observations on several occasions, primarily during the mating season of 1973. The

Table 4.1

THE BEARS' RATES OF SNIFFING OTHER BEAR (F46) PER MONTH IN 1971, 1972, AND 1973
AT GOLDRUSH AND TREMONT

Month	Bear A (♂)			Bear B (♀)			Bear C (♀)			Bear D (♀)		
	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total
(1971)												
7	0.0	0	477	0.0	0	479	-	-	-	-	-	-
8	0.1	1	899	0.5	4	888	-	-	-	-	-	-
9	0.6	4	721	0.1	1	723	-	-	-	-	-	-
10	0.7	6	851	0.2	2	844	1.1	2	185	0.0	0	186
11	1.0	6	598	0.8	5	600	0.8	2	254	0.4	1	252
12	0.8	5	599	1.0	6	591	0.3	1	377	0.8	3	376
Total	0.5	22	4145	0.4	18	4125	0.6	5	816	0.5	4	814
(1972)												
1	-	-	-	-	-	-	1.2	7	594	0.7	4	592
2	-	-	-	-	-	-	0.5	2	443	0.4	2	480
3	-	-	-	-	-	-	0.0	0	360	0.6	2	358
4	0.4	1	239	0.0	0	239	0.0	0	349	0.0	0	361
5	0.4	3	718	0.3	2	714	0.4	2	465	0.0	0	480
6	0.5	3	591	0.3	2	585	1.0	6	594	0.2	1	595
7	1.5	11	715	0.1	1	710	0.3	2	699	1.0	7	686
8	1.1	8	717	0.7	5	711	0.0	0	698	0.4	3	715
9	1.2	9	740	0.3	2	738	0.0	0	731	0.0	0	731
10	0.5	2	369	0.3	1	367	0.5	3	622	0.0	0	622
11	0.0	0	240	0.4	1	240	0.0	0	240	0.0	0	240
12	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.8	37	4526	0.3	14	4514	0.4	22	5795	0.3	19	5860

Table 4.1 (Continued)

Month	Bear A (♂)			Bear B (♀)			Bear C (♀)			Bear D (♀)		
	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total
(1973)												
1	-	-	-	-	-	-	0.8	1	119	0.0	0	120
2	-	-	-	-	-	-	0.0	0	120	0.0	0	119
3	2.5	6	238	0.8	2	238	5.9	9	153	0.0	0	163
4	-	-	-	-	-	-	3.3	7	215	0.9	2	217
5	-	-	-	-	-	-	6.3	16	256	3.1	8	258
6	-	-	-	-	-	-	-	-	-	-	-	-
7	0.0	0	66	0.0	0	65	-	-	-	-	-	-
Total	2.0	6	304	0.7	2	303	3.8	33	863	1.1	10	877

TABLE 4.2
 FREQUENCY AND PERCENTAGE OF SOCIALLY-LICKED BODY PARTS
 AT GOLDRUSH

Name of body part	Freq. Bear A (♂)	Percent	Freq. Bear B (♀)	Percent
Other-bear ^a	1	100.00	--	--
Total	1	100.00	--	--

^aUndifferentiated.

TABLE 4.3
 FREQUENCY AND PERCENTAGE OF SOCIALLY-LICKED BODY PARTS
 AT TREMONT

Name of body part	Freq. Bear C (♀)	Percent	Freq. Bear D (♀)	Percent
Other-bear ^a	1	16.67	2	40.00
Ear	0	0.00	3	60.00
Muzzle	2	33.33	0	0.00
Eye	1	16.67	0	0.00
Head (general)	1	16.67	0	0.00
Neck	1	16.67	0	0.00
Total	6	100.00	5	100.00

^aUndifferentiated.

female was never observed licking the male during systematic observations. Similarly, Bear C and Bear D licked each other and the cubs only 6 and 5 times respectively. Actually licking may have occurred somewhat more often during systematic observations than the data indicate since it can occur very rapidly and may be obscured by other parts of the body, thereby making observation difficult. Some social licking may have been mistakenly recorded as social sniffing. Even considering this, the rate observed is low.

In order to best interpret Table 4.4 and 4.5 in which Sniffing other (F46) is related to body part sniffed, it is necessary to subtract the undifferentiated Other-bear (D29) category from the total. (In the Other-bear (D29) category the bear was the object of the behavior but the particular body part was not determined.) This permits a comparison of the rates of sniffing of particular body parts. Also, if particular parts of the body are grouped into body regions, comparison is easier. Therefore, the neck and the parts of the head were added together as were rump/tail-perianal/genital parts. These data are summarized in Table 4.6. The male at Goldrush sniffed the head/neck region of his partner 12 times and the perianal/genital-rump/tail region 19 times. The total for the two regions is 31 out of a total of 38 for all body parts (excluding Other-bear (D29)). The female at Goldrush was only observed sniffing the head/neck and perianal/genital-rump/tail regions of the male twice each out of a total of 9 (excluding Other-bear (D29)). With the Other-bear (D29) category included, the male sniffed the female twice as often as she sniffed him (63:32; $\chi^2=10.12$, $P<.01$).

TABLE 4.4
FREQUENCY OF SOCIALLY-SNIFFED BODY PARTS
AT GOLDRUSH

Name of body part	Freq. Bear A (♂)	Freq. Bear B (♀)
Other-bear ^a	25	23
Rump/tail	17	1
Head	4	0
Shoulders	4	0
Nose	2	2
Muzzle	3	0
Back	2	1
Perianal/genital	2	1
Ears	2	0
Front paw	1	1
Rear paw	0	2
Neck	1	0
Rear leg	0	1
Total	63	32

^aUndifferentiated.

TABLE 4.5
FREQUENCY OF SOCIALLY-SNIFFED BODY PARTS
AT TREMONT

Name of body-part	Freq. Bear C (♀)	Freq. Bear D (♀)
Other-bear ^a	24	10
Muzzle	9	8
Head	11	3
Ears	2	4
Back	4	0
Rump/tail	3	1
Flank	0	2
Front leg	0	2
Nose	1	0
Perianal/genital	1	0
Rear paw	1	0
Neck	1	0
Total	57	30

^aUndifferentiated.

TABLE 4.6
FREQUENCY OF COLLAPSED CATEGORIES OF SOCIALLY-SNIFFED BODY PARTS
AT GOLDRUSH AND TREMONT

Name of body parts sniffed	GOLDRUSH				TREMONT			
	Freq. Bear A (♂)	Freq. Bear B (♀)	χ^2	χ^2 (P)	Freq. Bear C (♀)	Freq. Bear D (♀)	χ^2	χ^2 (P)
Head/neck	12	2	7.14	<.01	24	15	2.08	n.s.
Perianal/genital- rump/tail	19	2	13.98	<.001	4	1	1.80	n.s.
Total	31	4	20.83	<.001	28	16	3.27	n.s.

At Tremont the females' sniffing rates of their partners' rump/tail-perianal/genital region were also much less than the male's at Goldrush. With the Other-bear category (D29) included the total Sniffing other (F46) rates differ nearly as much as they did at Goldrush (Bear C=57; Bear D=30; $X^2=8.38$, $P<.01$). The rates of sniffing of the head/neck were 24 for Bear C and 15 for Bear D and for the rump/tail-perianal/genital region, 4 and 1.

Thus the male's rates of sniffing the combined perianal/genital-rump/tail regions of his partner were several times higher than the rates of the three females. He sniffed the female at relatively high rates during July, August, and September of 1972 as indicated in Table 4.1, page 65. The male at Goldrush also sniffed the female at relatively higher rates during the mating season of 1973, according to nonsystematic observation (Ludlow, 1974; personal observation).

Perhaps related to the low rates of social investigatory behavior are the low rates of sniffing bear feces and urine by all four bears as shown in Appendix F showing Sniffing (nonbear) objects (F6) by objects sniffed. However, there are methodological shortcomings in observing urine-sniffing that make interpretation difficult. It is likely that the bears sniffed each others' urine more often than the data would indicate since the observer could not know where urine had been deposited unless a bear had been seen depositing it shortly before it was sniffed or unless the area sniffed was plainly darkened by urine. On the other hand feces could usually be seen for days unless it was removed or washed down by heavy rain. Therefore the systematic data for sniffing feces reflect the rate that actually occurred more accurately than the systematic data for sniffing urine.

III. DISCUSSION

Licking (F47) was the only behavior which might be classified as social grooming. The forepaws were never used for social grooming despite the fact that the forepaws are dextrous in obtaining food (Bacon, 1973), in play (Pruitt, 1974; Henry and Herrero, 1974), in manipulating objects (Bacon, in press), and in autogrooming (Chapter 5).

Except for the bond between mating adults and between a sow and her cubs, maintaining relationships through social grooming (i.e., licking) is not necessary for the solitary adult black bear. Not surprisingly, these are the relationships in which social licking occurs.

While social grooming between adults in the wild may occur, it has not been reported except for the brief period of mating. It is apparently unnecessary for the maintenance of healthy skin and fur. Perhaps black bears possess some resistance to ectoparasites. Pelton (personal communication) has noted that most of the bears that he examined were relatively free of ectoparasites compared to other species examined, although bears are attacked by several species of ectoparasites, including eight arthropod species, mites, and fleas (Rogers and Rogers, 1976). In any case they have a well-developed repertoire of flexible autogrooming behavior which allows them to scratch, lick, bite, or rub any part of the body easily (Chapter 5).

Social grooming may have been performed by the subadults at Tremont only when they were permitted contact with wild-caught cubs who were introduced into their enclosure. On their first encounter, the subadults sniffed and licked the cubs frequently. This also

occurred subsequently after periods of separation. Much less frequently, the cubs licked the subadults. Their relationship resembled that of a mother bear with cubs.

In contrast there was a very low rate of social licking between the subadults or adults recorded in 146 hours of systematic observations: one instance by Bear A, none by B, six by C, and five by D. Social licking between subadult or adult captive black bears only occurred at high rates during the mating season when the male licked the genitals of the female (Ludlow, 1974; personal observation). Licking in this context probably should not be considered as "social" grooming; the male may lick to induce the female's sexual readiness or simply because the taste and odor of her secretions are attractive. The rates for social sniffing were also low: less than 1 percent of all observations for each bear.

To quote Schaller on lions (1972; page 85):

Head-rubbing and social licking are common peaceful tactile gestures. These two patterns, more than any other, help to promote group cohesion.

Ewer (1968; page 187) writes that "amongst mammals the commonest form of friendly behavior is social grooming." In the present study the bears were never observed rubbing against each other, although they sometimes leaned against or rested in contact with each other (personal observation). However, in a previous study Pruitt (1974) observed rubbing by these same bears at Tremont as well as other contact behaviors. The subadults at Tremont avoided physical contact with the author when he was inside the enclosure with them. Attempts by the author to touch or scratch the areas of the bears' bodies that typically elicit an

approach response in domestic dogs and cats, behind the ears, under the neck and chin, on the chest, back, and rump, for example, instead elicited withdrawal of the part touched and raising the head while threatening to bite in the manner typical of play behavior. Ellis Bacon, their caretaker, with whom they had the most direct contact, said that they did not like to be touched (personal communication).

Most observations of black bear behavior in the wild support the notion that adults avoid social contact except during the mating period and when aggregating at concentrated sources of food. Eagar (personal communication) has noted an exception that, however, does not necessarily invalidate the general observation. She observed a pair of males, judged to be adults, engaged in play behavior. Their physical appearances were nearly indistinguishable and they were suspected to be littermates, perhaps accounting for this unusual expression of friendly behavior between adult males. This observation at least establishes that black bears demonstrate a greater variety of behaviors in social relationships than was previously suspected. However, the low rates of physical contact in the present study as the bears grew older support the more traditional view that adult black bears avoid physical contact and proximity, even if littermates.

Pheromones and Glands Producing Pheromones

Fox (1971), referring to canids, has noted that parts of the body socially sniffed or licked are often sources of pheromones (or other odorous substances) which alter behavior in other animals. The subjects in the present study sniffed and licked each other at low rates. The only part of the body sniffed or licked appreciably was the head (except for genital-sniffing of the female by the male primarily during the mating

season). This raises several questions: (1) Do black bears have any glands which produce pheromones?; (2) Were our bears too young to produce pheromones?; and (3) Had they habituated to each other's odors because of the conditions of captivity? Sniffing and licking of a female's genital area by a male might be solely in response to the odor of her urine and vaginal secretions, which may contain pheromones derived from the breakdown products of sex hormones. In many mammalian species, sex pheromones alert the male to the state of the female's sexual readiness (Estes, 1972).

In contrast with most other species of Carnivora, black bears possess small anal glands (Pocock, 1921; Ewer, 1973). This may have been reflected in the behavior of the bears. If their anal glands actively produced pheromones, far higher rates of social sniffing and licking this area should have occurred.

Perhaps there are pheromone-producing glands in the head and neck region of black bears since, in the present study, parts of the head were socially sniffed more than other parts of the body by all but the male, although this phenomenon might also be accounted for by odors of food from the mouth and clinging to the lips and muzzle. However, Pocock, who conducted the most thorough studies of the external parts of the black bear (1914, 1918, 1921), expressed the opinion that they possess no specialized cutaneous scent glands. Ewer (1973) argued that there may be scent-producing glands in the neck of brown bears, since that is a part of the body that is frequently

rubbed. Further, the present research may suggest the presence of glands in the forepaws. This is discussed in more detail in Chapter 5.

Earlier investigators may have overlooked external glands because they examined bears of inappropriate age or sex or because they examined them during a period of the year when the glands were inactive. For example, glands of sexually mature and sexually active females which produce sex pheromones or pheromones related to territoriality might only be active during the mating period. Glands which are inactive might be nearly undetectable. Further anatomical study is needed.

Frequency of Social Investigation by Age

Black bears appear to have lower rates of social investigation than species that typically seek social contact as adults. The social canids, including dogs and wolves, for example, spend considerable time sniffing parts of each others bodies (Fox, 1971). Most of the attention is directed towards the head and perianal/genital regions. Certain specific pheromone-producing skin glands are investigated very intensively, the anal glands, for example. In this study only the male sniffed the perianal/genital region of his partner more than rarely. The male's highest rates for these behaviors occurred during the mating periods of 1972 and 1973. Perhaps the interest at that time was due to the presence of sex pheromones derived from breakdown products of hormones in urine and vaginal secretions rather than the secretions of anal or other skin glands.

As subadults and adults the bears licked each other infrequently. Again this is unlike the conspicuous and frequent social licking of

the social canids (Fox, 1971). Teeth and paws were never used for social grooming. Social licking may have had a grooming function but even this might be interpreted as something other than grooming (see below).

Pruitt (1974), observing the same two female bears (at Tremont) that were observed in this study, recorded higher frequencies of social investigatory behavior and physical contact. She terminated her observations at approximately the same time that the present observations began (October 1971, when the bears were 21 months old). She occasionally observed sniffing and licking of the mouth and muzzle region, which she called "greeting" behavior. It was most likely to occur when the bears were allowed together after being separated. This appeared very infrequently in the present study. The differences in rates of social investigation, contact behavior, and "grooming" may be a consequence, in part, of maturation.

Sniffing, Licking, and Touching the Cubs

When first permitted physical contact with cubs in October of 1972 and subsequently when reunited with the cubs after periods of separation, the Tremont subadult (3-year-old) females, especially Bear C, sniffed and licked the cubs at high rates (Figure 4.1) (e.g., when the cubs climbed down from a tree after a long rest). These rates declined as a function of time during each period spent together. With the cubs present, contact, "greeting," social investigation, vocalizations, and play behavior between the two subadults increased as well, while agonistic behavior between them decreased. During the cold weather



Figure 4.1. Bear C sniffing and/or licking newly-introduced cubs. (Cubs typically "freeze" while being sniffed and licked. The cub being sniffed in the upper photograph has raised its tail.)

of 1972 and 1973 the two subadults and three cubs were frequently observed sleeping together in the small shed at night (personal observation). Before the introduction of the cubs the two subadults were not observed sleeping together.

The decline in social sniffing and licking rates of the cubs by the subadults as a function of time together may have been due to habituation to chemosensory stimulation from the cubs rather than completing the task of grooming them. Before the cubs were introduced, sniffing and licking behavior between subadults occurred at low rates. On occasion the two subadults were separated by closing the midfence of the enclosure, although they were still able to see and smell each other. When again permitted free access to the entire enclosure and to each other, they spent very little time in social sniffing or licking or in bodily contact. However, they did spend considerable time sniffing the ground and other parts of the enclosure from which they had been separated. Perhaps they were obtaining indirect olfactory stimulation from each other short of social investigation (i.e., Sniffing other (F46) and Licking other (F47)).

Sniffing Trails of Conspecifics

Rogers (1977) observed bears sniffing paths travelled and objects rubbed by other bears. This may be the primary method used by wild black bears in their natural habitat to determine whether other bears are in the vicinity, when they passed, and possibly even individual identity, gender, sexual receptivity, dominance, health, and emotional state (Rogers, 1977).

Bacon (1973) describes the posture of black bears walking in search of food (i.e., "foraging"). It consists of walking with the

neck angled downward, nose perhaps one to three inches from the surface of the ground. He distinguishes this from walking, not in search of food, during which the neck and head are held higher. Using this method they can quickly "scan" odors on and under the ground as they walk, thereby detecting food and also, quite likely, trails of odor deposited by the front and hind paws of conspecifics.

Summary

Social sniffing and licking can serve three possibly overlapping functions: (1) maintaining group cohesion, (2) social grooming, and/or (3) seeking tactual, olfactory, and gustatory stimulation.

The first and second hypotheses may help to explain social sniffing and licking between courting adults and between mother and cubs.

However, the third hypothesis is the simplest and most parsimonious and is best supported by the evidence. Even if social licking does perform the first two functions, the correct antecedent to the behavior may be the third.

CHAPTER 5

AUTOGROOMING AND MARKING BY RUBBING

I. INTRODUCTION

Autogrooming and marking by rubbing are discussed together in this chapter, since they can be related in at least two ways. First, it is hypothesized that animals may sniff and lick body parts that produce pheromones more than parts that produce none. Pheromones are deposited in marking by rubbing. Second, rubbing can function in autogrooming, marking, or both simultaneously, although the forms and/or contexts of rubbing as autogrooming and marking would probably differ.

Autogrooming can serve other functions which are mentioned briefly here. It can acquire a social signaling function. According to Eibl-Eibesfeldt (1970), ritualized grooming behaviors in many mammals and birds appease conspecifics. Finally, autogrooming may be a displacement behavior that occurs when an animal experiences strongly conflicting motivational states (Tinbergen, 1969, original, 1950).

Autogrooming in Bears

The present study is apparently only the second in which autogrooming behavior has been studied quantitatively in any bear species. Frame (1974) briefly noted that black bears spent less than 1 percent of the time scratching during days of salmon fishing on an Alaskan stream. However, Tschanz et al. (1970) studied rubbing quantitatively in relation to possible marking functions in European brown bears as did Rogers (1977) in black bears.

In bears, behaviors that are commonly called autogrooming can serve several functions. Care of the skin and fur is the most obvious and can occur in response to various external stimuli, including foreign matter, parasites, insect bites and stings, skin infections and wounds, and fur that is being shed (Krott and Krott, 1963; Rogers, 1977).

Autogrooming in Nonbear Species

Grooming has been related directly to skin irritations in horses and squirrels (Hafez, Williams, and Wierzbowski, 1969; Ferron, 1976). Often the rate of autogrooming is closely correlated with the emergence of certain ectoparasitic insects after winter inactivity or pupation. There is a particular kind of grooming common to many Carnivora in which the incisors are rapidly and repeatedly opened and closed while touching the fur and skin which is popularly known as "fleaing" (Ewer, 1963; Fox, 1974). The apparent function is to kill fleas or other ectoparasites.

In addition grooming can occur when there is no apparent external stimulus. Ewer (1967) observed that her African giant rats (Cricetomys gambianus) groomed routinely after resting and eating even when they were already completely clean and free of parasites. Ewer believed that grooming was endogenously motivated in this case and therefore required no external stimulus.

Much of the ethological research on grooming has been done on rodents (Bolles, 1960; Ewer, 1967; Ferron, 1976), although Ewer has also done studies on comfort behavior including grooming in a viverrid

(Suricata suricatta) (1963) and a marsupial (Sminthopsis crassicaudata) (1968).

According to Hafez and Signoret (1969), studies of pigs, a "contact" species (i.e., seeking physical contact) (Hediger, 1964), have shown that certain techniques of autogrooming reach much of the surface of the body but the remaining parts are reached only through allogrooming, namely the top of the neck and the belly. Horses also allogroom body parts which are inaccessible to autogrooming (Hafez, Williams, and Wierzbowski, 1969).

It follows that autogrooming is of even more importance to animals that are typically solitary as adults than to those that are socially oriented. Solitary animals cannot depend on conspecifics to groom them (Chapter 4) so they must have other means to groom those parts of the body that are difficult to reach with their own paws, tongue, and teeth.

Some animals in captivity groom more often than their wild counterparts. One reason proposed here is that they are unable to leave the scene of insect or disease infestation and therefore become progressively infected. Secondly, many aspects of behavior usually performed by the animal in the wild cannot be performed in captivity; consequently, behaviors, such as grooming, which are not hindered by the conditions of captivity, occur at higher rates. The author observed chimpanzees in a very restrictive zoo setting allo- and autogrooming at very high rates. Unfortunately, data confirming a lower rate in the wild than in captivity were not available.

Rubbing that functions in skin care would be expected to occur at higher rates in captive as compared to wild animals. However,

rubbing that serves as marking would be expected to occur at lower rates. The marking animal would presumably habituate both its own and its cagemates' scents, unless a new animal was introduced or the olfactory environment was altered in some other way.

Marking by Rubbing

Rubbing can serve a skin care function but it is also a marking behavior in many species. This distinguishes rubbing from scratching with a paw which cannot serve to deposit scent directly. Rubbing as marking is characterized by stereotyped postures and motions in diverse species (Morris and Morris, 1966; Verberne and deBoer, 1976). When the scent-producing glands are in areas of the animal's body that are exposed with difficulty, the postures or motions employed to deposit the scent often seem peculiar.

Another indication of the specialized ability of a species to mark by rubbing is obvious discontinuities in the types of skin and fur (Fox, 1971). Often the fur is thinner over scent glands or of a different color than that of surrounding fur. It may be revealing, then, that black bear fur is typically of only one color or shade, usually black, although the muzzle, the inside of the pinnae, and spots of hair above the eyes, are usually brown. Occasionally, one sees a spot or blaze of white hair on the chest. The fur of black bears is thick on all parts of the body except the muzzle and possibly the lower belly.

Krott and Krott (1963), speaking of their experiences in raising European brown bear cubs, claimed that bears were "socially neutral"

animals and that their rubbing behavior did not serve a marking function. Instead they related rubbing to shedding fur. Perhaps their bears were too young to mark by rubbing. Observers of black bear behavior since that time (e.g., Henry and Herrero, 1974; Pruitt, 1974; Jordan, 1976) have offered evidence that black bears have a well-developed repertoire of social behaviors. Further, Meyer-Holzapfel (1957) interpreted rubbing by bears as marking. In a later paper in which Meyer-Holzapfel participated (Tschanz, et al., 1970) the authors could not determine whether their bears "marked" intentionally but demonstrated that the behavior of other bears was altered by sniffing surfaces that had been rubbed.

For many years there has been debate over the significance of "bear trees," trees that are repeatedly rubbed, bitten, and clawed by black bears in the wild. Rogers (1977; pages 98-99) has listed the following possible explanations for this behavior:

(1) sharpening of claws, (2) testing of strength of claws, (3) scratching insect bites, (4) removal of fur during molt, (4) play, (6) causing sap to run for later feeding, (7) marking of boundaries, and (8) social communication.

He observed (page 95) that

Mature males marked significantly more often (during 16 of 92 observations) than did mature females (during 3 of 553 observations) or subadults (during none of 478 observations).

Furthermore he found that mature males marked significantly more often during the mating period than during the rest of the year. Rogers (page 99) concluded that

The first six of these [explanations] fail to account for the sex- and age-related differences in frequency that were observed. Marking also did not appear to be a boundary marking activity because it rarely was done by territorial females and it was not concentrated near the edges of ranges of males.

Therefore, the only explanation that is consistently supported by Roger's observations is social communication. He hypothesized that marking could reduce the number of damaging agonistic encounters where bears aggregated, as well as communicate other socially useful information.

II. RESULTS

The data below were taken from the systematic observations unless otherwise indicated. It is presented in the following order: Sniffing self (F35), Licking self (F39), Scratching with the hind paw (F36), Pawing self (F37 and F38), Biting self (F40), Rubbing rump, etc., up and down (F42), Rubbing rump, etc., from side to side (F43), and Rubbing flank, etc. (F44). Tables for the first five behaviors, not including rubbing categories, list the parts of the body that were autogroomed. Tables for two of the rubbing categories (F43 and F44) list the objects rubbed.

Sniffing Self (F35)

Sniffing self (F35) was rare, but the part of the body autosniffed most frequently by all four bears was the Front paw (D48) (Tables 5.1 and 5.2). The Rump/tail (D40) and Front leg (D46) were ranked second for Bears A and B respectively and the Front leg was ranked second for both Bear C and Bear D. Sniffing the Rump/tail (D40) ranked second for the male and third for the female but the female never sniffed her Perianal/genital region (D42) and the male sniffed himself in this area only once. Bear D never sniffed the rump/tail area and Bear C did only once. Bear C never sniffed her perianal/genital region (D42) and D did only twice (photograph in Figure 5.1).

TABLE 5.1
 FREQUENCY OF BODY PARTS AUTOSNIFFED (F35) BY BLACK BEARS
 AT GOLDRUSH

Name of body part	Freq. Bear A (♂)	Freq. Bear B (♀)
Front paw	4	13
Front leg	2	7
Rump/tail	3	4
Rear paw	0	4
Back	0	3
Self	1	2
Rear leg	1	1
Flank	1	0
Perianal/genital area	1	0
Total	13	34

TABLE 5.2
 FREQUENCY OF BODY PARTS AUTOSNIFFED (F35) BY BLACK BEARS
 AT TREMONT

Name of body part	Freq. Bear C (♀)	Freq. Bear D (♀)
Front paw	13	19
Front leg	11	6
Belly	0	6
Rear paw	0	5
Rear leg	3	1
Flank	0	4
Back	1	1
Self	1	1
Perianal/genital area	0	2
Rump/tail	1	0
Total	30	45



Figure 5.1. Bear D at Tremont sniffing and/or licking herself.
(The bears were capable of considerable flexion of
the spine.)

The female at Goldrush sniffed herself significantly more often than did the male (34:13; $\chi^2=9.38$, $P<.01$) and Bear D at Tremont sniffed herself more than did Bear C (45:30; $\chi^2=3.00$, $P<.10$). Most of the total difference at Goldrush was attributable to the female sniffing her Front paw (D48) more often than did the male (13:4, $\chi^2=4.76$, $p<.05$).

Licking Self (F39)

The pattern for body parts licked (Tables 5.3 and 5.4) resembles closely the pattern for sniffing. For all four bears the Front paw (D48) was ranked first and Front leg (D46), second. For the two bears at Goldrush Chest (D44) was ranked third.

The Rump/tail (D40) area is not listed in the rankings for any of the four bears. The perianal/genital area was never licked by Bears A, B, or D and only once by Bear C.

The female at Goldrush licked herself significantly more often than the male (47:20; $\chi^2=10.88$, $P<.001$), with most of the difference attributable to a difference in the licking rates of the Front leg (D46) (11:2, $\chi^2=6.23$, $P<.05$). There was no significant difference between the bears at Tremont (43:34; $\chi^2=1.05$, P n.s.), although Bear C licked her Front paw (D48) significantly more often than Bear D (28:12; $\chi^2=6.05$, $P<.05$).

Licking the muzzle (F80) was not included in Tables 5.3 and 5.4 or classified as autogrooming since this behavior had multiple functions. However, it was noted as a category in Class C and the totals for it are listed in Appendix A.

TABLE 5.3
 FREQUENCY OF BODY PARTS AUTOLICKED (F39) BY BLACK BEARS
 AT GOLDRUSH

Name of body part	Freq. Bear A (♂)	Freq. Bear B (♀)
Front paw	17	24
Front leg	2	11
Chest	1	5
Rear leg	0	4
Rear paw	0	3
Total	20	47

TABLE 5.4
 FREQUENCY OF BODY PARTS AUTOLICKED (F39) BY BLACK BEARS
 AT TREMONT

Name of body part	Freq. Bear C (♀)	Freq. Bear D (♀)
Front paw	28	12
Front leg	6	8
Nose	4	0
Flank	0	4
Rear leg	0	4
Belly	2	2
Chest	1	2
Rear paw	1	2
Perianal/genital area	1	0
Total	43	34

Scratching With the Hind Paw (F36)

For three of the bears the Neck (D36) was the part of the body most frequently scratched using the hind paw (Tables 5.5 and 5.6). The Front leg (D46) and Flank (D39) jointly were ranked first for Bear B. The Shoulder (D32) and Flank (D39) were ranked second for Bear C and Bear D respectively. Examples of Scratching with the hind paw (F36) are shown in Figure 5.2.

Pawing Self (F37 and F38 combined)¹

The female at Goldrush pawed (F37 and F38) her Perianal/genital area (D42) most frequently but the male was never observed doing it (Tables 5.7 and 5.8). Whether the female's pawing of this area was masturbatory or related to skin irritation is unknown. The male did not paw any one part of his body more than three times. Both bears at Tremont pawed (F37 and F38) their Rear legs (D45) most frequently. At Tremont pawing the Perianal/genital area (D42) was ranked third for Bear C but this was never done by Bear D. The Rump/tail was never pawed by Bear C or D. Examples of this method of grooming are shown in Figure 5.3.

Biting Self (F40)

All four bears bit the Rear leg (D45) most frequently (Tables 5.9 and 5.10). This was also the part of the body pawed (F37 and F38) most frequently at Tremont as previously noted (Tables 5.7 and 5.8). The rump was

¹Scratching self with the front paw (F37) and Pawing self (F38) were combined because a clear operational distinction between them could not be made. Hereafter, both Scratching self with the front paw (F37) and Pawing self (F38) will be referred to as Pawing self (F37 and F38 combined).

TABLE 5.5
 FREQUENCY OF BODY PARTS AUTOSCRATCHED WITH HIND PAW
 (F36) BY BLACK BEARS AT GOLDRUSH

Name of body part	Freq. Bear A (♂)	Freq. Bear B (♀)
Front leg	5	4
Neck	6	2
Belly	5	1
Flank	1	4
Self	1	3
Head	3	0
Total	21	14

TABLE 5.6
 FREQUENCY OF BODY PARTS AUTOSCRATCHED WITH HIND PAW
 (F36) BY BLACK BEARS AT TREMONT

Name of body part	Freq. Bear C (♀)	Freq. Bear D (♀)
Neck	25	23
Flank	7	18
Shoulder	9	10
Front leg	7	8
Head	5	0
Chest	3	0
Ears	2	0
Back	1	0
Belly	1	0
Muzzle	0	1
Total	60	60



Figure 5.2. Bear C and a cub at Tremont scratching with the hind paw (F36).

TABLE 5.7

FREQUENCY OF BODY PARTS AUTOPAWED WITH FRONT PAW (F37 and F38
COMBINED) BY BLACK BEARS AT GOLDRUSH

Name of body part	Freq. Bear A (♂)	Freq. Bear B (♀)
Front paw	3	3
Perianal/genital area	0	5
Head	3	1
Front leg	2	2
Muzzle	2	1
Belly	3	0
Rear leg	2	1
Ears	0	2
Rear paw	2	0
Chest	1	0
Nose	0	1
Rump	1	0
Total	19	16

TABLE 5.8

FREQUENCY OF BODY PARTS AUTOPAWED WITH FRONT PAW (F37 AND
F38 COMBINED) BY BLACK BEARS AT TREMONT

Name of body part	Freq. Bear C (♀)	Freq. Bear D (♀)
Rear leg	13	9
Front leg	12	1
Rear paw	9	2
Perianal/genital area	11	0
Front paw	2	8
Belly	3	4
Muzzle	4	1
Flank	0	2
Head	1	0
Chest	1	0
Total	56	27



Figure 5.3. Bear C at Tremont Pawing herself (F37 and F38).

TABLE 5.9
FREQUENCY OF BODY PARTS AUTOBITTEN (F40) BY BLACK BEARS
AT GOLDRUSH

Name of body part	Freq. Bear A (♂)	Freq. Bear B (♀)
Rear leg	9	5
Back	4	5
Chest	5	0
Rump	4	0
Flank	2	1
Front leg	1	2
Front paw	1	2
Belly	0	1
Rear paw	0	1
Total	26	17

TABLE 5.10
FREQUENCY OF BODY PARTS AUTOBITTEN (F40) BY BLACK BEARS
AT TREMONT

Name of body part	Freq. Bear C (♀)	Freq. Bear D (♀)
Rear leg	5	10
Front leg	2	5
Front paw	2	5
Back	1	6
Belly	0	7
Flank	1	2
Chest	0	3
Rear paw	1	1
Rump	0	1
Perianal/genital area	0	1
Total	12	41

bitten four times by the male but not at all by the female at Goldrush. The genitals were never bitten by either of them. At Tremont neither the rump nor the perianal/genital region were bitten by Bear C and Bear D bit each area only once.

Bear D bit herself more frequently than Bear C (41:12; $\chi^2=15.87$, $P<.001$). There was no significant difference between the bears at Goldrush.

Rubbing Rump, etc., Up and Down (F42)

The frequencies for Rubbing rump, etc., up and down (F42) were so low that tables for this behavior were not included (Total instances: Bear A=0; Bear B=2; Bear C=6; and Bear D=0).

Rubbing Rump, etc., From Side to Side (F43)

In this and the section which follows the object rubbed is described rather than the part of the body rubbed since the definition of the category includes the body part(s) rubbed.

The object most frequently rubbed (F43) by the male at Goldrush was the Den (D71) (Table 5.11). The female was observed rubbing her rump, etc., from side to side (F43) only once. The object was a post of the shed. Bear D at Tremont rubbed the Fence (D69) most frequently, while Bear C rubbed trees and the fence most frequently (Table 5.12). Trees (D6) were second-ranked for Bear D.

Bear C rubbed (F43) more frequently than Bear D (12:4; $\chi^2=4.0$, $P<.10$). The male rubbed (F43) much more frequently than did the female (17:1; $\chi^2=14.22$, $P<.001$). Examples of this method (i.e., F43) are shown in Figure 5.4.

TABLE 5.11

FREQUENCY OF OBJECTS RUBBED FROM SIDE TO SIDE WITH RUMP, ETC.,
(F43) BY BLACK BEARS AT GOLDRUSH

Name of object	Freq. Bear A (♂)	Freq. Bear B (♀)
Den	7	0
Fence	3	0
Post	2	1
Shed	2	0
Tree	1	0
See-saw	1	0
Food box	1	0
Total	17	1

TABLE 5.12

FREQUENCY OF OBJECTS RUBBED FROM SIDE TO SIDE WITH RUMP, ETC.,
(F43) BY BLACK BEARS AT TREMONT

Name of object	Freq. Bear C (♀)	Freq. Bear D (♀)
Fence	5	3
Tree	5	1
Shed	1	0
Water trough	1	0
Total	12	4



Figure 5.4. Bear C at Tremont Rubbing her rump, etc., from side to side (F43). (In both examples the head is raised vertically in order to rub its dorsal surface.)

Rubbing Flank, etc. (F44)

At Goldrush the male rubbed his flank, etc., against the posts supporting the shed most frequently (Table 5.13). In the one instance of rubbing by the female, she rubbed the post. At Tremont Bears C and D each rubbed (F44) the Fence (D69) most frequently (Table 5.14). Trees (D6) and the Testing apparatus (D80) were second-ranked for Bear C and Bear D respectively at Tremont. An example of Rubbing the flank, etc. on a tree is shown in Figure 5.5.

Combined Rubbing Methods

Generally, the bears at Tremont rubbed objects more frequently than did the Goldrush bears (percentages of combined rubbing categories out of all Class C behaviors: Bear A=0.46 percent; Bear B=0.07 percent; Bear C=0.80 percent; Bear D=0.66 percent). Tables 5.15 and 5.16 show the ranked objects for all categories of rubbing (F42, F43, and F44) combined. The shed posts (D84) are ranked highest at Goldrush for both bears. At Tremont the fence (D69) ranked first for both bears.

Comparison of Body Parts Groomed Employing the Various Methods of Grooming

Table 5.17 shows that each mode of grooming tends to reach certain parts of the body more than others. Sniffing and licking reach the front paw and front leg primarily; scratching with the hind paw reaches the neck, flank, front leg, and shoulders; pawing with the front paw reaches the head, the perianal/genital area, the rear leg, the front paw and leg, and a greater variety of body parts than other methods; and biting reaches the front and rear legs, the front paw, and the lower back. The dorsal parts of the body, including the rump,

TABLE 5.13

FREQUENCY OF OBJECTS RUBBED WITH FLANK, SHOULDERS, NECK, AND
HEAD (F44) BY BLACK BEARS AT GOLDRUSH

Name of object	Freq. Bear A (♂)	Freq. Bear B (♀)
Post	8	1
See-saw	2	0
Den	1	0
Shed	1	0
Total	12	1

Table 5.14

FREQUENCY OF OBJECTS RUBBED WITH FLANK, SHOULDERS, NECK, AND
HEAD (F44) BY BLACK BEARS AT TREMONT

Name of object	Freq. Bear C (♀)	Freq. Bear D (♀)
Fence	18	14
Testing apparatus	3	10
Tree	6	4
Shed	0	7
Attached limbs	4	0
Stone	2	0
Log	0	1
Total	33	36



Figure 5.5. Bear C at Tremont Rubbing her flank (F44).

TABLE 5.15

FREQUENCY OF OBJECTS RUBBED USING ALL METHODS (F42, F43, AND F44
COMBINED) BY BLACK BEARS AT GOLDRUSH

Name of object	Freq. Bear A (♂)	Freq. Bear B (♀)
Post	10	4
Den	8	0
Fence	3	0
Shed	3	0
See-saw	3	0
Tree	1	0
Food-box	1	0
Total	29	4

TABLE 5.16

FREQUENCY OF OBJECTS RUBBED USING ALL METHODS (F42, F43, AND F44
COMBINED) BY BLACK BEARS AT TREMONT

Name of object	Freq. Bear C (♀)	Freq. Bear D (♀)
Fence	24	17
Tree	11	5
Testing apparatus	3	10
Shed	4	7
Attached limbs	4	0
Stone	2	0
Water trough	1	0
Log	0	1
Total	49	40

TABLE 5.17

BODY PARTS GROOMED (CLASS D: OBJECTS) BY BLACK BEARS EMPLOYING ALL METHODS OF AUTOGROOMING EXCEPT RUBBING
(CLASS C: FUNCTIONS . . .) AT GOLDRUSH AND TREMONT

Body Part Groomed	Autogrooming Method																								
	Sniffing self (F35)					Licking self (F39)					Scratching self (F36)					Pawing self (F37, F38)					Biting self (F40)				
	Identification of Bear					Identification of Bear					Identification of Bear					Identification of Bear					Identification of Bear				
	A	B	C	D	Tot.	A	B	C	D	Tot.	A	B	C	D	Tot.	A	B	C	D	Tot.	A	B	C	D	Tot.
Self (D29)	1	2	1	1	5	0	0	0	0	0	1	3	0	0	4	0	0	0	0	0	0	0	0	0	0
Head (D30, D31, D32, D33, D34, D35)	0	0	0	0	0	0	0	4	0	4	3	0	7	1	11	5	5	5	1	16	0	0	0	0	0
Neck (D36)	0	0	0	0	0	0	0	0	0	0	6	2	25	23	56	0	0	0	0	0	0	0	0	0	0
Shoulders (D37)	0	0	0	0	0	0	0	0	0	0	0	0	9	10	19	0	0	0	0	0	0	0	0	0	0
Back (D38)	0	3	1	1	5	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	4	5	1	6	16
Flank (D39)	1	0	0	4	5	0	0	0	4	4	1	4	7	18	30	0	0	0	2	2	2	1	1	2	6
Rump/tail (D40)	3	4	1	0	8	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	4	0	0	1	5
Perianal/genital (D42)	1	0	0	2	3	0	0	1	0	1	0	0	0	0	0	0	5	11	0	16	0	0	0	1	1
Belly (D43)	0	0	0	6	6	0	0	2	2	4	5	1	1	0	7	3	0	3	4	10	0	1	0	7	8
Chest (D44)	0	0	0	0	0	1	5	1	2	9	0	0	3	0	3	1	0	1	0	2	5	0	0	3	8
Rear leg (D45)	1	1	3	1	6	0	4	0	4	8	0	0	0	0	0	2	1	13	9	25	9	5	5	10	29
Front leg (D46)	2	7	11	6	26	2	11	6	8	27	5	4	7	8	24	2	2	12	1	17	1	2	2	5	10
Rear paw (D47)	0	4	0	5	9	0	3	1	2	6	0	0	0	0	0	2	0	9	2	13	0	1	1	1	3
Front paw (D48)	4	13	13	19	49	17	24	28	12	81	0	0	0	0	0	3	3	2	8	16	1	2	2	5	10

back, neck, and top of the head, are not readily reached by any of these methods but rubbing the rump, etc., using either of the techniques described (F42 and F43) does scratch these areas. Therefore it appears that rubbing complements other autogrooming methods.

Comparison of Body Parts Sniffed in Social Investigation and Autogrooming

In general, different parts of the body are sniffed in social investigation and autogrooming as shown in Table 5.18. Auto- and allolicking were not compared since social licking occurred at such low rates. Other methods of autogrooming (i.e., scratching self with the front and hind paws, biting self, and rubbing self) were not comparable to allogrooming methods since these had no allogrooming equivalent. In Table 5.18 some parts of the body (i.e., parts of the head) were not listed since they could not be reached by autolicking. The undifferentiated category, Self (D29), was also eliminated from comparison.

Comparison of Autogrooming Methods by Quarters of the Year

The rates of combined categories of grooming occurring in three-month periods during 1971, 1972, and 1973 are compared in Figure 5.6 (sniffing/licking and biting) and Figure 5.7 (scratching and rubbing). For each individual the rates of rubbing and scratching roughly parallel each other with the rates for rubbing below those for scratching generally. Bear B's rates of rubbing are so low that a comparison in her case is not meaningful. For all four bears the rate during the fourth quarter of 1972 was lower than during the preceding two quarters

TABLE 5.18
A COMPARISON OF RATES OF SOCIAL SNIFFING AND AUTOSNIFFING OF BODY PARTS
AT GOLDRUSH AND TREMONT

Part Body Sniffed	Bear A (♂)				Bear B (♀)				Bear C (♀)				Bear D (♀)			
	Auto-groom.		Social Invest.		Auto-groom.		Social Invest.		Auto-groom.		Social Invest.		Auto-groom.		Social Invest.	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Perianal/genital-rump/tail	4	33.33	19	86.36	4	12.50	2	28.57	1	3.45	4	44.44	2	4.55	1	20.00
Back	0	0.00	2	9.09	3	9.38	1	14.29	1	3.45	4	44.44	1	2.27	0	0.00
Belly	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	13.64	0	0.00
Front paw	4	33.33	1	4.55	13	40.63	1	14.29	13	44.83	0	0.00	19	43.18	0	0.00
Front leg	2	16.67	0	0.00	7	21.88	0	0.00	11	37.93	0	0.00	6	13.63	2	40.00
Rear paw	0	0.00	0	0.00	4	12.50	2	28.57	0	0.00	1	11.11	5	11.36	0	0.00
Rear leg	1	8.33	0	0.00	1	3.13	1	14.29	3	10.34	0	0.00	1	2.27	0	0.00
Flank	1	8.33	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	9.09	2	40.00
Total	12	100.00	22	100.00	32	100.00	7	100.00	29	100.00	9	100.00	44	100.00	5	100.00

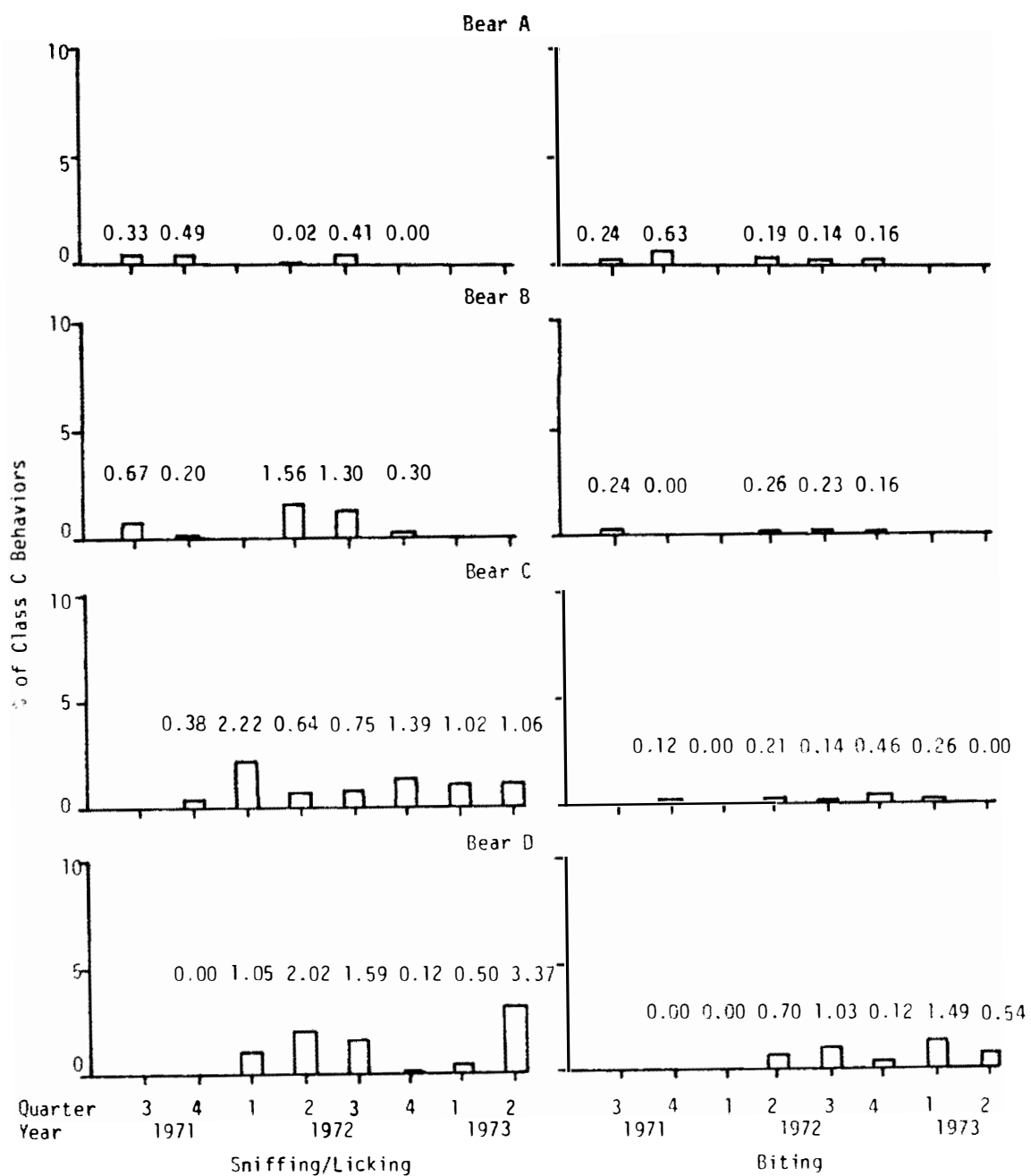


Figure 5.6. Bears' rates of sniffing/licking and biting by quarters of the year in 1971, 1972, and 1973 at Goldrush and Tremont.

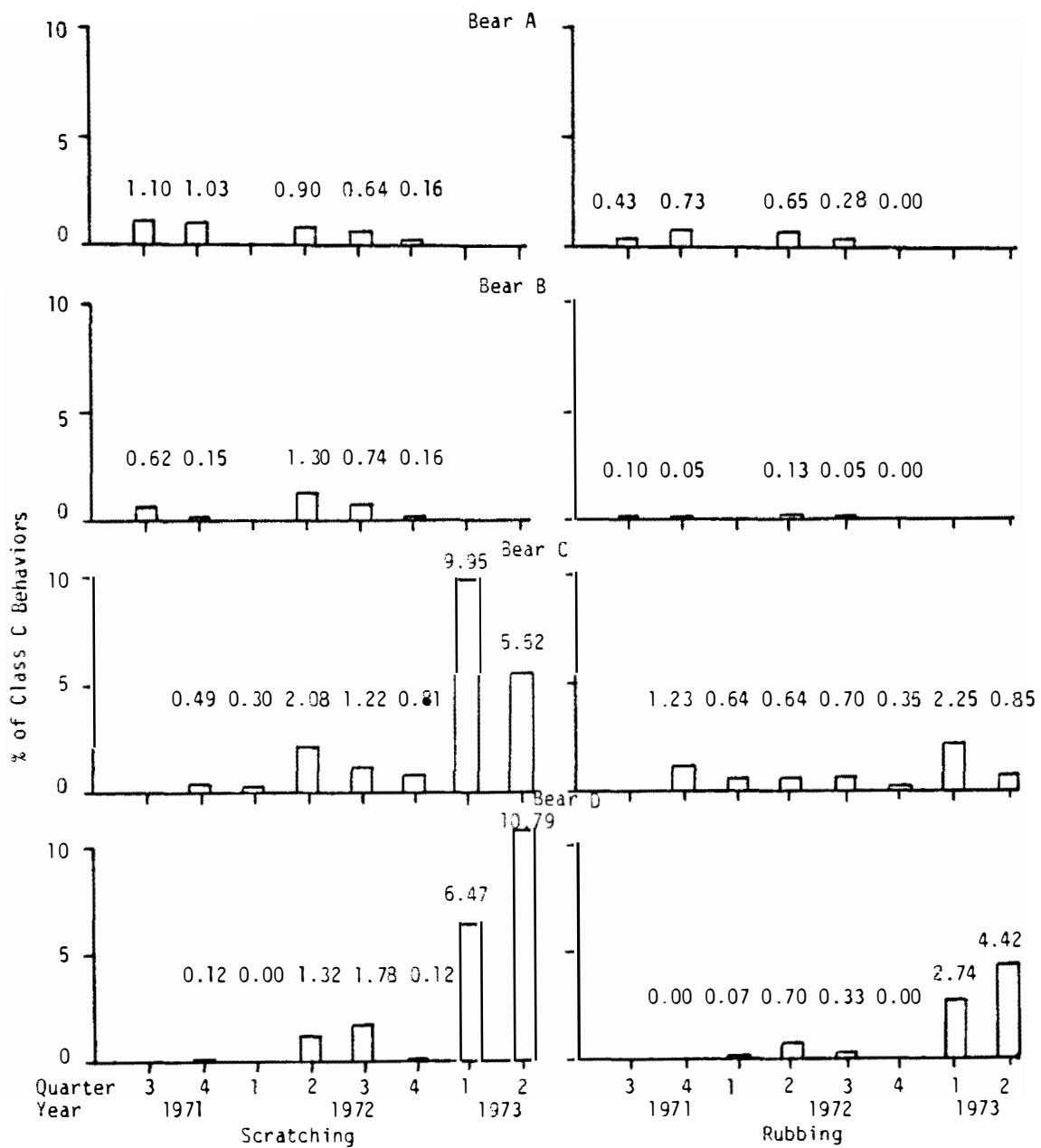


Figure 5.7. Bears' rates of scratching and rubbing by quarters of the year in 1971, 1972, and 1973 at Goldrush and Tremont.

and in the case of the Tremont bears far lower than in the following two quarters.

III. DISCUSSION

Sniffing Self (F36) and Licking Self (F40)

Although Sniffing self (F36) in itself does not perform a grooming function, it is being included here for two reasons: (1) it is almost always a part of sequences of self-licking behavior (F40); (2) postures during sniffing, body parts sniffed, and seasonal patterns of sniffing are similar to those for self-licking.

Two patterns of the data on self-sniffing and self-licking of body parts are striking: (1) the comparatively high rates of self-sniffing and self-licking the front paws and front legs; and (2) the comparatively low rates of self-sniffing and self-licking the perianal/genital region. (Self-sniffing and self-licking will be referred to as sniffing and licking in the remainder of the chapter.)

Sniffing and licking the front paws and front legs. There are several possible reasons for the relatively high rates of sniffing and licking the front paws and front legs:

- (1) These body parts are most easily reached by the snout;
- (2) These body parts may produce a pheromone or other odor that the bears find attractive;
- (3) Material from the environment adheres to the front paws and legs more than to other parts of the body and the bears explore and remove this material by sniffing and licking;

- (4) Particles and traces of food acquired during foraging and eating adhere to the front paws and legs and the bears locate and remove food particles by sniffing and licking these areas.

Positive evidence is presented for each hypothesis. Negative evidence is presented for some of the hypotheses. None of the hypotheses are incompatible with the others.

The accessibility hypothesis. During Sniffing self (P35) the forepaws and front legs were accessible in all postures assumed by the bears including the Sitting down (P5) posture, which was ranked first for Bears B and D and the Ventral lying (P7) posture, which was ranked first for Bears A and C. Considering bear anatomy it would have been difficult in fact for them to sniff or lick anything other than the forepaws and front legs in the Ventral lying position.

The gland hypothesis. Some evidence supports and some calls into question the hypothesis that there are pheromone-producing glands in the forepaws. The contradictory evidence is somewhat more convincing.

A behavior which was called Stiff-legged walking (F29) in the present study was performed by all four of the captive bears (Appendix A). A fifth wild free-roaming bear at Spence Field in the Park was observed walking stiffly after an aggressive encounter with another bear. One captive bear in particular (Bear C) performed this behavior many times, although this is not reflected in the systematic observations. She did this most notably when the cubs, who had been confined in small carrying cages smelling strongly of urine, were first brought to the

enclosure. Unfortunately, no systematic observations were made at that time, although film and videotape records exist.

The behavior consisted of sliding the front paws, knees locked, along the substrate, producing a noticeable skid mark (Figure 5.8). Simultaneously, urine often trickled down the hind legs. A pheromone secreted from glands in the forepaws and urine dripping from the hind legs and hind paws could be deposited on the substrate during "stiff-legged walking" and possibly while walking normally as well. This would provide a mechanism for avoidance of social contact by adult bears.

Some species of Carnivora have glands on the foot that may secrete pheromones according to Ewer (1973, pages 91 and 92):

Sweat glands are present on the interdigital membrane of the paws in a number of species and these may also have some function setting scent. In the Canidae little glandular pockets are also present in the dorsal surface of the membranes near the bases of the digits.

Two facts weigh against the hypothesis above. The most compelling is that there is no anatomical evidence for such glands at present. Secondly, our captive bears might have been expected to have expressed more interest in the forepaws during social sniffing and licking behavior if such glands were actively functioning (Chapter 4 and Table 5.18).

The adhesion hypothesis. Because of the unique role of the forepaws, front legs, and mouth in manipulating objects, a greater variety of materials adhere to these parts during normal activities than to other parts of the body. If self-produced odors and tastes are neutrally "attractive" or "unattractive" and if bears are attracted to novel odors and tastes then one would expect them to sniff and lick their own forepaws and front legs (and muzzle and lips, of course) more than other areas.



Figure 5.8. Bear C at Tremont Walking stiffly while urinating (F29).

Exploration and removal of substances from the body surface through sniffing and licking accomplishes at least two purposes:

- (1) the animal is rid of a substance that might be harmful to health or decrease the ability to survive in any way;
- (2) the animal's ability to survive is increased by seeking stimulation from the environment, concerning, for example, food, predators, rivals, and sexual partners.

Removal of substances cannot be the sole or even primary function of licking in black bears. If it were, then all parts of the body would be licked thoroughly on occasion, especially after eating and resting. However, the bears were never observed licking the body systematically as would domestic cats. Also, their saliva which is very thick and sticky (personal observation) may not be well suited for grooming. Therefore the second alternative immediately above, seeking stimulation from the environment, is a more likely explanation of licking.

The food residue hypothesis. The arguments supporting the fourth hypothesis are an extension of those for the third hypothesis. The paws of bears play an important role in foraging for and eating food (Bacon, 1973) and this may account for higher rates for sniffing and licking these rather than other parts of the body. The plantigrade forepaws of Ursids and Procyonids are more important for this purpose than the forepaws of digitigrade Carnivora owing to the necessity of rigidity in the forepaws of digitigrades in order to locomote on the tips of the digits (as in Canids, Felids, Hyaenids, Mustellids, and Viverrids). In general, this adaptation, by extending the length of

the limbs, permits digitigrades to run more quickly than plantigrades, but their paws are relatively less dextrous in obtaining food and manipulating objects.

Bears also use the paws to avoid ingesting a great deal of nonfood material when feeding. They do this by dropping food that is mixed with nonfood from the mouth (e.g., crushed nut shells and nut meat) onto the top of the forepaw and then using the tongue to selectively touch and draw in those pieces which are food (Bacon, 1973). In this context sniffing and licking the forepaws is necessary to ingest the pieces of food. Sequential analysis of the collapsed data for the four bears revealed, however, that licking occurred at lower rates during and after sequences of eating than it did overall ($\chi^2=6.17$, $P<.05$). This was probably an artifact of the scoring system since eating was more likely to be scored than licking unless licking was clearly separated in time from eating. Since the bears usually did not eat food mixed with nonfood (e.g., nuts and nut shells) they normally had no need to differentiate food from nonfood by sniffing and licking the front paws and front legs. However, the informal observation notes reveal that they did sniff and lick the paws when eating food of this type. What the sequential analysis reveals most clearly is that they did not engage in autogrooming for an extended period after eating. Of the four hypotheses offered to explain the preference for sniffing and licking the forepaws and front legs, all are plausible, though the fourth hypothesis (i.e., sniffing and licking food) appears most likely based on informal observation.

Sniffing and Licking the Perianal/Genital-Rump/Tail Region.

The bears sniffed and licked their own perianal/genital and rump/tail regions infrequently, especially considering the females' mode of urination in which some of the urine trickles down and dries on the fur of the hind legs (Herrero, unpublished manuscript; Burghardt and Burghardt, 1972). They might be expected to sniff or lick the urine if it contained pheromones or to groom the fur to remove the urine. Most members of Order Carnivora have large functional anal glands (Ewer, 1973). Other pheromone-producing glands (e.g., inguinal glands) are associated with this region of the body in some species of Carnivora. Universally in mammals, the excreted urine contains metabolites of hormones. These metabolites serve as pheromones in many species, especially during the mating season (Estes, 1972). Pheromones which do not serve a sexual function may also be contained in the urine and feces. The low rates of self-sniffing and self-licking the perianal/genital region by the bears in this study do not necessarily mean that American black bears as a species do not secrete pheromones from this region. Our bears may have been atypical for several reasons that will be elaborated later in this chapter.

There was a greater difference in rates of self-sniffing between the male and female at Goldrush than between the females at Tremont. At Goldrush the female sniffed herself much more frequently than the male sniffed himself. She sniffed her front paws often but was infrequently observed sniffing her perianal/genital-rump/tail area (Table 5.18, p. 107). By contrast the male at Goldrush sniffed his partner's perianal/genital-rump/tail area much more frequently (Table 5.18) and her front paws only once. If females produced pheromones in the urine during the mating

season these data would be an indication that parts of the body which produce pheromones can be attractive to conspecifics without being attractive to the producer itself. Of the four bears only Bear C was observed licking her own perianal/genital-rump/tail area in systematic observations and she did so on only one occasion. There may be a relationship between the parts of a bear's own body that it sniffs and licks frequently and the capacity of glands in that part of the body to produce pheromones. However, body parts that are sniffed and licked during social investigation are better indicators of a source of pheromones than parts autogroomed by sniffing and licking since by definition pheromones perform a social function (Chapter 4).

Scratching (F36, F37, and F38), Biting (F40), Licking (F39), and Rubbing Self (F42, F43, and F44)

The data on scratching, biting, licking, and rubbing were compared to demonstrate:

- (1) that the front paws, hind paws, tongue, and teeth are each used to groom distinct parts of the body and that rubbing involves those parts of the body not readily reached with paws, tongue, and teeth (Table 5.17) and
- (2) that scratching, biting, licking, and rubbing do not have identical functions.

These data suggest that the teeth, tongue, front paws, and hind paws easily reach certain parts of the body for grooming, but the dorsal surfaces of the rump, back, neck, shoulders, and head are not easily reached. Instead these parts are groomed primarily by rubbing against objects.

Ewer (1968) has discussed social grooming in species that live in social groups as adults. For them the parts of the body socially groomed most often and that elicit the greatest expressions of pleasure when groomed (e.g., in domestic dogs behind the ears, on the chest, under the chin) are those which are hardest for the animal to reach itself. The adult bear living alone without the benefit of social grooming (Chapter 4) must be able to relieve skin irritation on all parts of its own body by scratching, licking, biting, and rubbing. It is assumed that scratching behavior primarily serves a function of relief of skin irritation, although it may occur in other contexts, such as displacement behavior.

Displacement behavior occurs during bouts of aggression (or courtship or whatever) when hypothetically there may be strong but conflicting motivations existing simultaneously in an individual (e.g., flight and fight motivations during aggression), neither of which is dominant, leaving a behavior with less motivation to occur (e.g., grooming behavior) (Tinbergen, 1969, original 1950; Hinde, 1970).

Rubbing against objects undoubtedly relieves skin irritation but it is also a suspected marking behavior (Meyer-Holzapfel, 1957; Rogers, 1977). If rubbing serves a function other than relief of skin irritation then there are likely to be dissimilar variations from quarter to quarter in the rates of scratching and rubbing behavior. Variations do occur but the trends appear to be basically the same (Figure 5.7, p. 109), especially at Tremont.

Black bears are known to suffer from various ectoparasites and skin diseases (Rogers and Rogers, 1976). The bears at Tremont suffered

from mange and fungal infections. The approximate periods of infection are known (Bacon, 1973; Ludlow, 1974). In the first quarter of 1973, rates of scratching and rubbing increased considerably as the bears became progressively infected. Similarly in the second quarter of 1973, the rates of scratching and rubbing decreased for Bear C as she overcame the infection, while Bear D's rate increased as she was still suffering from it.

Depending on whether rubbing functions in marking or relief of skin irritation, the behaviors which immediately precede and follow it may differ. Rogers (1977) observed wild black bears marking by biting and clawing trees immediately before and after rubbing. Meyer-Holzapfel (1957) observed brown bears urinating on trees in association with other possible marking behaviors. The bears in the present study were not observed to bite, claw, or urinate on trees in association with rubbing or at any other time. Perhaps rubbing unassociated with biting and clawing trees is more likely to function in relief of skin irritation than is rubbing associated with these behaviors.

The informal observations more than the systematic data supported the hypothesis that these bears rubbed in order to mark objects. The Tremont bears frequently sniffed and rubbed objects in their enclosures that were touched by humans including the fence, where it was touched most frequently by the observer, and the testing apparatus which was also frequently touched. The rate of rubbing at Tremont was higher than at Goldrush (Tables 5.19 and 5.20). Perhaps this difference is related to humans touching and walking within the enclosure much more at Tremont than at Goldrush, although an equally plausible

TABLE 5.19

FREQUENCIES OF COMBINED CATEGORIES OF AUTOGROOMING
BY BLACK BEARS AT GOLDRUSH

Names of autogrooming categories	Code Number	Freq. Bear A (♂)	Percent	Freq. Bear B (♀)	Percent
Autosniffing and autolicking	F35, F39	80	0.31	75	0.84
Autoscratching and autobiting	F36, F37, F38, and F40.	74	0.82	56	0.63
Autorubbing	F42, F43, F44	41	0.46	6	0.07
Total		143	1.59	137	1.53

TABLE 5.20

FREQUENCIES OF COMBINED CATEGORIES OF AUTOGROOMING
BY BLACK BEARS AT TREMONT

Names of autogrooming categories	Code Number	Freq. Bear C (?)	Percent	Freq. Bear D (?)	Percent
Autosniffing and autolicking	F35, F39	80	1.07	97	1.28
Autoscratching and autobiting	F36, F37, F38 and F40	136	1.82	136	1.80
Autorubbing	F42, F43, F44	60	0.80	50	0.66
Total		276	3.69	283	3.75

explanation is that there were more objects of a greater area available to rub. The fence at Tremont offered the largest vertical surface available at either enclosure, so it is not surprising that this was rubbed most. However, since some objects that were rubbed often did not offer much area (e.g., the testing apparatus), the rate of rubbing various objects could not have been due solely to availability.

Undoubtedly black bears transfer odor-bearing substances, some of them self-produced, during rubbing. The nature of these substances and their significance to conspecifics, if any, was not investigated in this study. Skin oils must be transferred, but perspiration is not a possibility since bears do not perspire.

Thiessen and Rice (1976) have mentioned several correlates between marking behavior and characteristics of an individual animal. As they state the case, marking is: (1) more likely to be performed by males than females, (2) more likely to be performed by postpubertal animals, (3) dependent on seasonal development, (4) associated with dominance, (5) associated with aggressive behavior, and (6) associated with sexual behavior.

The Gender Hypothesis. According to the first principle outlined above the three females should have been less likely to mark than the male although the most recent field observations indicate that females are probably more territorial than males (Rogers, 1977) and might therefore be expected to mark more than males. It is noteworthy that the two females at

Tremont rubbed at higher rates than the male at Goldrush, although he rubbed significantly more often than his female cagemate. Possibly related to this was the fact that within pairs the two bears who rubbed the least, sniffed objects typically rubbed by their mates more often than did their mates. This is reflected in the data which follows. The male rubbed posts more than the female at Goldrush (10:4; $\chi^2=2.57$, P n.s.) but the female sniffed posts more than the male (18:5; $\chi^2=7.35$, $P<.01$). Bear C rubbed the fence more than D (24:17; $\chi^2=1.20$, P n.s.) but D sniffed the fence more than C (341:232; $\chi^2=20.73$, $P<.001$). Similarly C rubbed trees more than D (11:4; $\chi^2=3.27$, n.s.) but D sniffed trees more often (69:38; $\chi^2=8.98$, $P<.01$).

Sniffing objects was related to rubbing in another way. Sequential analysis revealed that Bear C, who rubbed at higher rates than did the other three bears, sniffed objects before rubbing significantly more often than predicted by her overall rates of sniffing during all observations (14:5; $\chi^2=4.26$, $P<.05$).

The Age Hypothesis. Rates of rubbing of the Tremont bears increased as they got older (especially in Spring 1973) taking into account seasonal variability. This may have been due either to increasing incidence of skin infections, to sexual maturity with concomitant marking by rubbing, or both. The simplest and factually best supported explanation is that rates of rubbing were closely related to incidence of skin infection (Table 5.18, page 107 and Figure 5.7, page 109).

The Seasonal Hypothesis. There was a seasonal development of rubbing behavior with the highest levels during the second and third

quarters of 1972 and the lowest during the first and fourth quarters (Figure 5.6, page 108). The second and third quarters would have included the periods of most intense sexual activity but they also included the months when insects were most bothersome and when fur was shed. The three explanations (i.e., sex-related marking vs. insect infestation vs. fur-shedding) for rubbing could not be separated in terms of effect. The year 1973 is not useful for comparison to 1972 because observations were only made during two quarters of the year and the bears were known to be suffering from irritating skin infections at that time.

The Dominance Hypothesis. Bear A, the male, was usually dominant over Bear B, the female. Although a pattern of dominance was not nearly as clear at Tremont, Bear C appeared to be dominant more frequently than Bear D. Both Bear A and Bear C rubbed more frequently than their cagemates. Perhaps these facts are related. Refer also to discussion of the gender hypothesis above.

The Aggression Hypothesis. Other circumstantial evidence supports the notion of rubbing as marking behavior. The male at Goldrush repeatedly rubbed the door of the den that enclosed a strange new male at Goldrush. The two males threatened each other frequently both prior to and following rubbing instances. Rubbing as displacement behavior is an alternative explanation for rubbing in this context.

The Sexual Hypothesis. The females at Tremont rubbed their genitals on objects such as rocks and walked over and bent down

saplings horizontally between their legs during the mating seasons of 1972 and 1973. This could be a mark that acts as a sexual attractant and does not necessarily indicate territorial marking. Such behavior is probably sexually stimulating as well. The two explanations are not mutually exclusive. In fact they complement each other well. The females' rubbing during the mating season is distinct from rubbing during the rest of the year in form, objects rubbed, and body parts rubbed. Rubbing by the male possibly associated with mating could not be distinguished from other possibly nonsexual rubbing that occurred during the same season.

Rubbing as a Possible Generalized Marking Behavior

There were no obvious stereotyped postures or motions during rubbing that might indicate a highly-evolved marking behavior. On the other hand it might be argued that behaviors occurring in stereotyped form in adults often occur in fragments, or out of sequence, or in response to inappropriate stimuli in immature animals. The bears at Goldrush were sexually mature in 1972 in the sense that they showed copulatory behaviors (it was not possible to determine whether intromission and ejaculation occurred) during the mating season, but they were not successful in conceiving young until the mating season of 1973. (The female bore cubs in January 1974.) The question of the precise onset of their sexual maturity is therefore debatable, but it came sometime during the mating seasons of 1972 or 1973. To extend this argument further, specific small areas of skin and fur (i.e., localized glands) were not consistently applied to objects within

the enclosure as one would expect if the bears possessed localized pheromone-producing glands. The entire dorsal surface of the body including the top of the head was usually applied to objects when rubbing with the rump, etc., from side to side (F43) (Figure 5.4, page 100). The bears also rubbed the entire side of the body (F44) against broad surfaces. The bears were never seen backing up to and touching an object, tail raised, in the manner of a panda marking with its anal gland (Morris and Morris, 1966). The rubbing behavior of the bears seemed to be a generalized, perhaps primitive, response in that it might be from this sort of behavior pattern that more specialized or stereotyped marking behaviors develop phylogenetically and ontogenetically. However, the bears at Goldrush and Tremont may have exhibited fragments of stereotyped marking behavior without the observer being aware of the pattern. Complementing this notion is Ewer's suggestion (1968) that mammals may mark an object bearing an unfamiliar odor in order to reduce the anxiety which follows sniffing such odors. Mixing the unfamiliar odor with one's own familiar body odor, both on the object marked and on the body itself, renders the unfamiliar odor less fearful. This is a generalized function which may be the evolutionary origin of many kinds of marking behavior. No specialized pheromone-producing glands would be necessary for such behavior to occur.

Rogers (1977) has written that he observed no marking (interpreted as rubbing primarily) of "bear trees" in the wild by subadults (0 of 478 observations) and only observed 3 of 553 instances performed by mature females. The male was observed marking in 16 of 92 observations, a significant difference in comparison with females and subadults.

He felt that the sex and age differences could only be explained if the behavior functioned in social communication. The present research supports social communication as a possible explanation. However, since rubbing in the present study was performed by subadults and adults, females and males, all at fairly high rates at times, and since it was closely associated with periods of skin infection and provided a means of autogrooming by scratching areas of the body not readily scratched by other means, it was also interpreted as an important form of autogrooming to relieve skin irritation.

CHAPTER 6

CONCLUSIONS

Activity Levels and Reactivity to the Presence of Humans

Categories of postures and locomotions were divided into four activity levels based on the estimated energy required by each behavior. When the categories of posture and locomotions within each activity level were rank-ordered by frequency of occurrence for pairs of bears at Goldrush and Tremont, the rank-order correlations within pairs at each location were very high. The rank orders comparing the paired bears at the two locations were somewhat less similar. Since one pair consisted of a male and female and the other of two females, location was judged a more important variable related to rank order than were gender or individual differences.

Activity levels as well as individual categories of behavior were used as a measure of the bears' reactivity to human presence. Pooling the 146 hours of observations, the rates of certain behaviors for 2-minute divisions within hourly observations increased or decreased significantly from beginning to end of observations as measured by the linear regression analysis correlation coefficient and slope.

Rate changes were much greater at Tremont than at Goldrush. At Tremont the rates of resting or "relaxed" behaviors, that is, various lying down postures, increased from beginning to end of observations, while more energy-demanding behaviors, such as walking and standing quadrupedally, decreased. At Goldrush there was no clear pattern of change which applied to both the male and female. This may have been related to the distance separating observer and bears, which was greater

at Goldrush than at Tremont. Also there was much more stimulation from sources other than the observer at Goldrush. Although the bears at Tremont appeared to be considerably disturbed by the observer initially, habituation was rapid within sessions.

At Goldrush the bears attended much more to tourists than to the observer during the tourist season. With tourists absent, they frequently attended to the observer. Knowledge of the effects of human intrusion on the bears should be useful in evaluating results of and developing methodology for observations of black bears.

Social Investigation and Body Contact Behavior

Pruitt (1974; page 114) concluded that the two females at Tremont regularly acknowledged one another's presence in the enclosure by rubbing against each other and through greetings after brief separations. Additionally, they slept in close proximity often with their bodies touching. In short, they did not avoid bodily contact, and at times appeared to actively seek such contact.

Observation of the identical bears in the present study began at about the time Pruitt's observations ended. This study finds low rates for such behaviors. Social sniffing and licking (i.e., social investigation) occurred at low rates at both Goldrush and Tremont. They were never observed rubbing against each other although they occasionally leaned against each other. The bears at Tremont rarely rested in contact with each other until cubs were introduced into their enclosure in the Fall of 1972. Thereafter all bears frequently slept together at night. The introduction of the cubs signalled an increase in play and a decrease in agonistic behavior between the two females. At Goldrush social interactions between the male and female also decreased with increasing age but less so than at Tremont.

Sniffing and licking of the cubs at Tremont (especially by one of the subadult females) occurred at high rates as soon as the subadult females and cubs were permitted contact. These behaviors recurred after periods of separation. This may have been less a measure of social grooming than of seeking chemical stimulation from the cubs.

The two females at Tremont socially sniffed and licked the head/neck area most frequently. In contrast the male at Goldrush sniffed his female partner's perianal/genital-rump/tail area most frequently. The male's rate for such behavior was higher during the mating season of 1972 when both members of the pair were 2 1/2 and during 1973 when both were 3 1/2. The female at Goldrush infrequently sniffed her partner's head/neck and perianal/genital-rump/tail area and was never observed licking him. The low rates of social sniffing and licking may have been due to the inactivity of pheromone-producing skin glands in these bears or their inactivity or absence in black bears generally.

Autogrooming and Marking

The four bears possessed a varied repertoire of autogrooming behaviors that is attributed to their postural flexibility and the dexterity of the plantigrade forepaw. The behaviors included scratching with the front and hind paws, licking, biting, and rubbing against objects. The forepaw and front leg were respectively sniffed and licked first and second most frequently. The bears performed these behaviors while eating food but not notably afterwards. The perianal/genital-rump/tail area was sniffed and licked very infrequently. Autogrooming to clean fur was apparently not very important.

Some parts of the body were not readily reached by licking,

biting, or scratching with the front or hind paw. These were the dorsal surfaces of the rump, back, shoulders, neck, and head, which were reached most readily by rubbing against objects. Quarterly rates of scratching with front and hind paws and rubbing against objects closely paralleled each other, especially at Tremont when the bears were known to have irritating skin infections. The bears used rubbing as a major part of their repertoire of autogrooming to relieve skin irritation and perhaps to shed fur.

Marking is another function of rubbing that has been proposed frequently. The present nonquantitative and quantitative observations give limited support to this hypothesis. The bears at Tremont frequently rubbed objects that had just been touched by people, such as the fence and testing apparatus. The function of this behavior may have been to mark the objects or, more simply, to transform an unfamiliar odor into a more familiar one, thus rendering it less fearful. The male at Goldrush rubbed objects significantly more often than the female but she sniffed the same objects significantly more often than he did. The same reverse in the pattern of rubbing and sniffing responses occurred at Tremont as well. Rubbing postures and motions and accompanying behaviors did not appear to be stereotyped and no particular part of the body was consistently applied to objects, which may indicate that the bears did not possess active localized pheromone-producing skin glands. This complements observations of social investigatory behavior.

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APPENDICES

APPENDIX A

TABLE A.1

FREQUENCIES OF CLASS A (POSTURES AND LOCOMOTIONS) BEHAVIORS--
GOLDRUSH

Behavior Name	Freq. Bear A (♂)	Freq. Bear B (♀)	χ^2	$\chi^2(P)$
Ventral lying	2492	2289	8.62	<.01
Standing quadrupedally	1965	2235	17.35	<.001
Walking	2501	1627	185.04	<.001
Lateral lying	544	838	62.11	<.001
Sitting down	696	697	---	n.s.
Sitting or lying in tree	200	532	150.58	<.001
Walking toward	192	131	11.52	<.001
Dorsal lying	56	200	81.00	<.001
Sitting up	80	98	---	n.s.
Standing in tree	78	93	---	n.s.
Standing bipedally (P1)	95	66	5.22	<.05
Standing bipedally (P2)	79	57	---	n.s.
Walking away	26	32	---	n.s.
Climbing down tree	25	26	---	n.s.
Running when walking	6	40	25.13	<.001
Running toward	18	20	---	n.s.
Climbing up tree	28	41	11.61	<.001
Running away	11	22	5.45	<.05
Running	9	8	---	n.s.
Jumping	6	4	---	n.s.
Walking stiffly	7	1	4.50	<.05
Rolling over	0	3	---	n.s.
Backing up	1	2	---	n.s.
Total	9115	9112		

TABLE A.2

FREQUENCIES OF CLASS A (POSTURES AND LOCOMOTIONS) BEHAVIORS--
TREMONT

Behavior Name	Freq. Bear C (♀)	Freq. Bear D (♀)	χ^2	$\chi^2(P)$
Walking	1368	1896	85.61	<.001
Lateral lying	1872	1251	123.48	<.001
Standing quadrupedally	1352	1551	13.64	<.001
Ventral lying	1064	868	19.88	<.001
Sitting down	612	909	57.99	<.001
Lying in a tree	602	462	54.94	<.001
Sitting up	210	65	76.46	<.001
Standing bipedally (P1)	81	116	6.22	<.05
Dorsal lying	90	99	---	n.s.
Walking toward	45	61	---	n.s.
Standing in tree	28	29	---	n.s.
Running then walking	15	28	3.93	<.05
Climbing down tree	18	16	---	n.s.
Climbing up tree	37	29	---	n.s.
Walking away	8	14	---	n.s.
Running toward	6	16	---	n.s.
Standing bipedally (P2)	7	9	---	n.s.
Running	2	8	---	n.s.
Running away	1	3	---	n.s.
Walking stiffly	0	1	---	n.s.
Total	7418	7431		

TABLE A.3
 FREQUENCIES OF CLASS C (FUNCTIONS. . .) BEHAVIORS--
 GOLDRUSH

Behavior Name	Freq. Bear A (♂)	Freq. Bear B (♀)	χ^2	$\chi^2(P)$
Looking	1693	1583	7.95	<.01
Sniffing objects	1318	1635	34.03	<.001
Pacing	1843	975	267.36	<.001
Eating	1199	1521	38.12	<.001
Resting	1074	1480	64.54	<.001
Threatening to bite	334	368	---	<.001
Unclassified	177	179	---	n.s.
Biting other	170	76	35.92	<.001
Pawing and sniffing object	97	134	5.93	<.05
Pawing object	91	138	9.65	<.01
Other stereotyped behavior	96	125	---	n.s.
Scanning visually	94	78	---	n.s.
Sniffing and looking	105	56	14.91	<.001
Biting object	100	43	22.72	<.001
Pawing and biting object	52	66	---	n.s.
Drinking	56	43	---	n.s.
Sniffing other	64	33	9.91	<.01
Alerting	58	38	4.17	<.05
Licking self	20	48	11.53	<.001
Bathing	29	35	---	n.s.
Pawing other	38	24	---	n.s.
Biting and sniffing object	44	10	21.41	<.001
Normal urination	26	22	---	n.s.
Licking object	3	45	36.75	<.001
Scratching self with hind paw	26	18	---	n.s.
Biting self	26	17	---	n.s.
Pawing and sniffing soil	15	25	---	n.s.
Looking and licking muzzle	17	20	---	n.s.
Sniffing self	8	27	10.31	<.01
Eating and looking	7	23	8.53	<.01
Rubbing rump, etc., from side to side	25	1	22.15	<.001
Resting without head support	1	21	18.18	<.001
Sniffing and licking object	6	15	---	n.s.
Touching other	15	6	---	n.s.
Pawing self	20	16	---	n.s.
Yawning	9	10	---	n.s.
Threatening	7	11	---	n.s.
Rubbing flank, etc.	15	3	8.00	<.01
Defecating	3	12	5.40	<.05
Begging	10	5	---	n.s.
Mounting and thrusting	12	1	9.31	<.01
Mounting	10	0	10.00	<.01

TABLE A.3 (continued)

Behavior Name	Freq. Bear A (♂)	Freq. Bear B (♀)	χ^2	$\chi^2(P)$
Surprise or startle response	4	3	---	n.s.
Walking stiffly	5	1	---	n.s.
Shaking	3	2	---	n.s.
Turning object over	4	1	---	n.s.
Dribble-urinating	3	1	---	n.s.
Biting and licking object	1	2	---	n.s.
Stretching	3	0	---	n.s.
Rubbing rump, etc., up and down	0	2	---	n.s.
Slapping	0	1	---	n.s.
Licking other	1	0	---	n.s.
Total	9037	8999		

TABLE A.4
 FREQUENCIES OF CLASS C (FUNCTIONS. . .) BEHAVIORS--
 TREMONT

Behavior Name	Freq. Bear C (#)	Freq. Bear D (#)	χ^2	$\chi^2(P)$
Resting	2423	1767	102.71	<.001
Looking	1632	1685	---	n.s.
Sniffing object	938	1373	81.88	<.001
Pacing	725	840	8.45	<.01
Eating	372	368	---	n.s.
Pawing and sniffing object	103	286	86.09	<.001
Scanning visually	150	154	---	n.s.
Pawing object	142	251	127.67	<.001
Scratching self with hind paw	66	65	---	n.s.
Threatening to bite	63	62	---	n.s.
Pawing and sniffing	36	68	9.85	<.01
Biting object	70	32	14.16	<.001
Sniffing other	60	32	8.52	<.01
Licking self	47	39	---	n.s.
Unclassified	33	50	---	n.s.
Rubbing flank, etc.	38	40	---	n.s.
Sniffing self	29	48	4.69	<.05
Sniffing and licking object	44	31	---	n.s.
Threatening	12	53	25.86	<.001
Biting other	31	33	---	n.s.
Biting self	12	44	18.29	<.001
Scratching self with front paw	35	14	9.00	<.01
Pawing other	27	16	---	n.s.
Drinking	12	25	4.57	<.05
Pawing self	23	13	---	n.s.
Looking and licking muzzle	20	12	---	n.s.
Alerting	17	14	---	n.s.
Normal urination	15	15	---	n.s.
Rubbing rump, etc., from side to side	17	8	---	n.s.
Biting and sniffing object	8	17	---	n.s.
Sniffing and looking	14	9	---	n.s.
Defecating	13	9	---	n.s.
Pawing and biting object	14	6	---	n.s.
Yawning	14	6	---	n.s.
Licking object	8	4	---	n.s.
Licking other bear	6	5	---	n.s.
Resting without head support	5	2	---	n.s.
Shaking	1	5	---	n.s.
Rubbing rump, etc., up and down	6	0	---	n.s.

TABLE A.4 (continued)

Behavior Name	Freq. Bear C (♀)	Freq. Bear D (♀)	χ^2	$\chi^2(P)$
Sucking	0	5	---	n.s.
Touching other	3	2	---	n.s.
Dribble urinating	1	3	---	n.s.
Turning object over	1	3	---	n.s.
Bathing	2	2	---	n.s.
Mounting and thrusting	3	0	---	n.s.
Surprise or startle response	3	0	---	n.s.
Walking stiffly	1	2	---	n.s.
Biting and licking object	2	0	---	n.s.
Total	7296	7370		

APPENDIX B

TABLE B.1

BEHAVIOR CODE NUMBERS AND EQUIVALENT STICK FIGURE OR LETTER/SYLLABLE
ABBREVIATION USED IN RECORDING OBSERVATIONS:
CLASS A: POSTURES AND LOCOMOTIONS

Behavior Code #	Stick Figure or Letter/Syllable	Behavior Code #	Stick Figure or Letter/Syllable
P1		P21	tow. quickly
P2		P22	away slowly
P3		P23	away quickly
P4		P24	↑ t.
P5		P25	↑ t. slowly
P6		P26	↑ t. quickly
P7		P27	↓ t.
P8		P28	int.
P11		P29	↑ or ↓ int.
P12		P32	→
P13		P33	
P18		P34	
P19		P35	
P20	tow. slowly		

BEHAVIOR CODE NUMBERS AND EQUIVALENT STICK FIGURE OR LETTER/SYLLABLE
ABBREVIATION USED IN RECORDING OBSERVATIONS:
CLASS C: FUNCTIONS

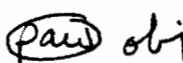

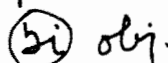

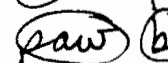
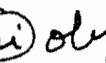

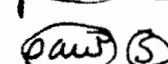


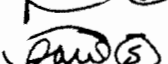




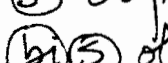




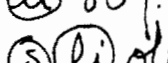





























Behavior Code #	Stick Figure or Letter/Syllable	Behavior Code #	Stick Figure or Letter/Syllable
F1	 obj.	F30	
F2	 obj.	F32	
F3	  obj.	F35	 self
F4	  obj.	F36	 self w/ hind
F5	  soil	F37	 self w/ front
F6	 obj.	F38	 self
F7	  obj.	F39	 self
F8	 obj.	F40	 self
F9	  obj.	F42	
F10	 	F43	 rump
F11		F44	 flank
F12		F46	 other
F15		F47	 other
F16		F48	 other
F17	 	F49	 other
F18	  obj.	F50	touching other
F25		F51	
F26		F52	other stereo.
F27		F54	  or 
F28	drizzle 	F57	
F29	 stiff	F60	 w/ support

Table B.2 (continued)

Behavior Code #	Stick Figure or Letter/Syllable	Behavior Code #	Stick Figure or Letter/Syllable
F61	(Re) w/out support	F78	(shake)
F63	(stretch)	F80	(L) (li)
F65	surprise resp.	F81	(scan)
F67	disgust resp.	F82	(turn obj. over)
F70	(yawn)	F84	(suck)
F74	(bath)		

APPENDIX C

SAMPLE PAGE OF TIME-SAMPLING RECORDING SYSTEM

[illegible]

APPENDIX D

STRUCTURAL ANALYSIS OF SOUNDS USING SONOGRAMS

The original tape-recordings that are represented by sonograms here were made on three tape-recorders: (1) a Wallensak, Model 1500; (2) a Tandberg, Model 11; and (3) a Uher, Model 4400 Report Stereo I.C. Some of the tapes had to be copied in order to be usable on the Voice-print sound analyzer, described later, which can only handle tapes with only one track.

In addition to these methods, moments visually represented on videotape could be matched with sounds on the tape produced by the bears at the same moment. Thus, videotape was very useful for analyzing the context of bear sounds. The black and white videotapes were recorded on a Sony, Model AW4300, using 20 and 30 minute Sony and Ampex tapes.

Tape-recordings were sequentially analyzed by transcribing tape and by sonogram analysis. Sonograms were printed on the Voice Identification, Inc. (VII) analyzer (Series 700) that is owned by the Speech and Hearing Department of the University of Tennessee, Knoxville. This prints pictures of sound with the coordinates of time on the abscissa axis and frequency on the ordinate axis.

Irrelevant background noise was whited out on some sonograms to give them more clarity. The darkness of the representation of the vocalization was enhanced by xeroxing the original. Virtually none of the details were lost by xeroxing due to the the very high quality of copies produced by the Xerox 3100 Model.

The range of frequencies of the vocalizations was determined by making a sonogram extending up to 8000 Hz (the upper limit of the Voice Identification, Inc. analyzer). Then the sonogram was expanded, keeping the base line lower limit of zero, but magnifying vertically the recorded frequencies so that those that were uppermost were just below the upper limit of the sonogram. In other words, the sonogram was manipulated within the same vertical space to expand, for example, from 0-8000 Hz to 0-4000 Hz or 0-1000 Hz or anything in fact between 0-0 Hz and 0-8000 Hz. Unlike the ordinate, the abscissa or time axis cannot be manipulated on this analyzer.

The total length of time measured by a sonogram analyzer is about 2.4 seconds. Of this I excerpted a little less than 1.3 seconds of image that I thought best-illustrated the vocalizations that are represented.

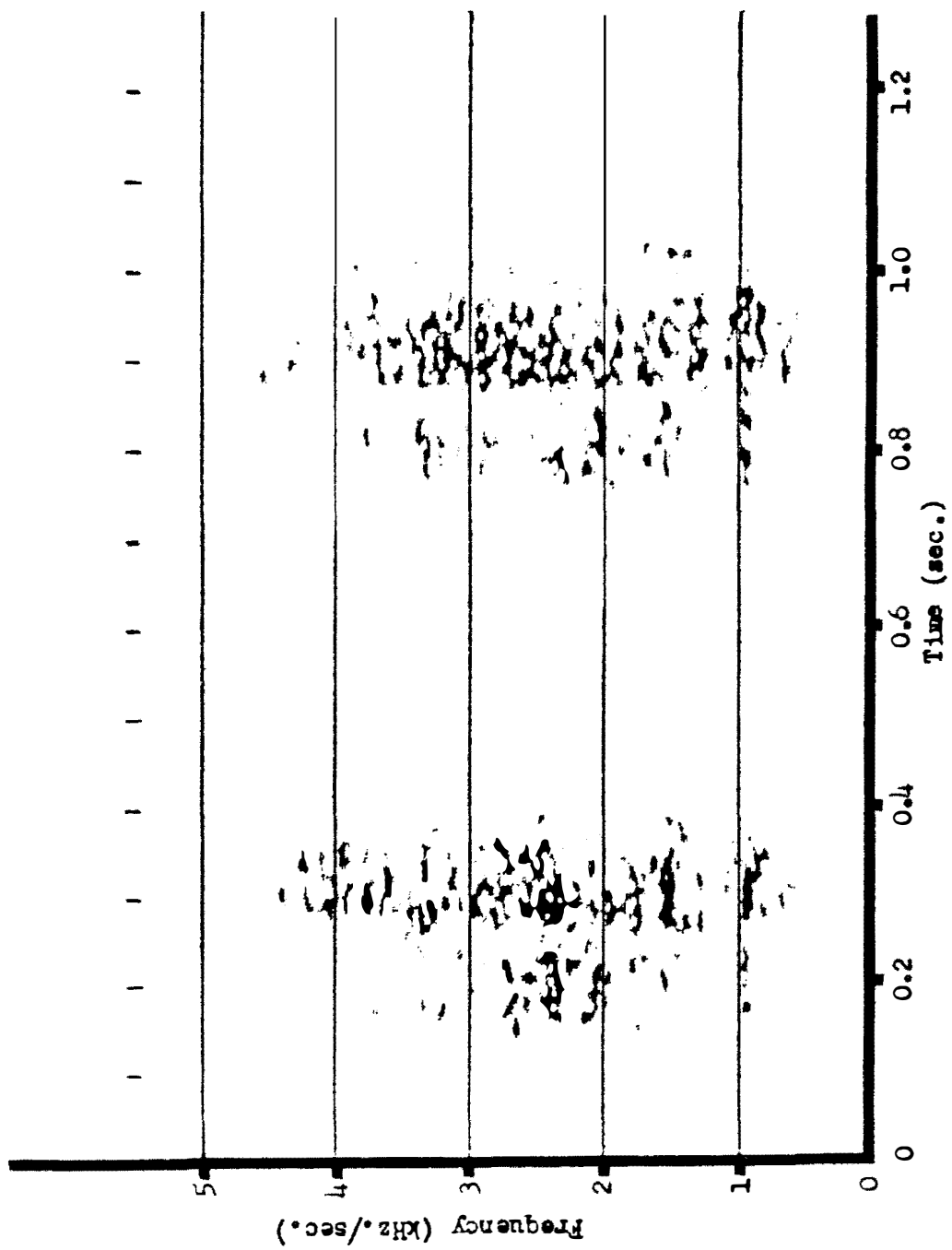


Figure D.1. In-out huffing produced by a nine-month-old cub.

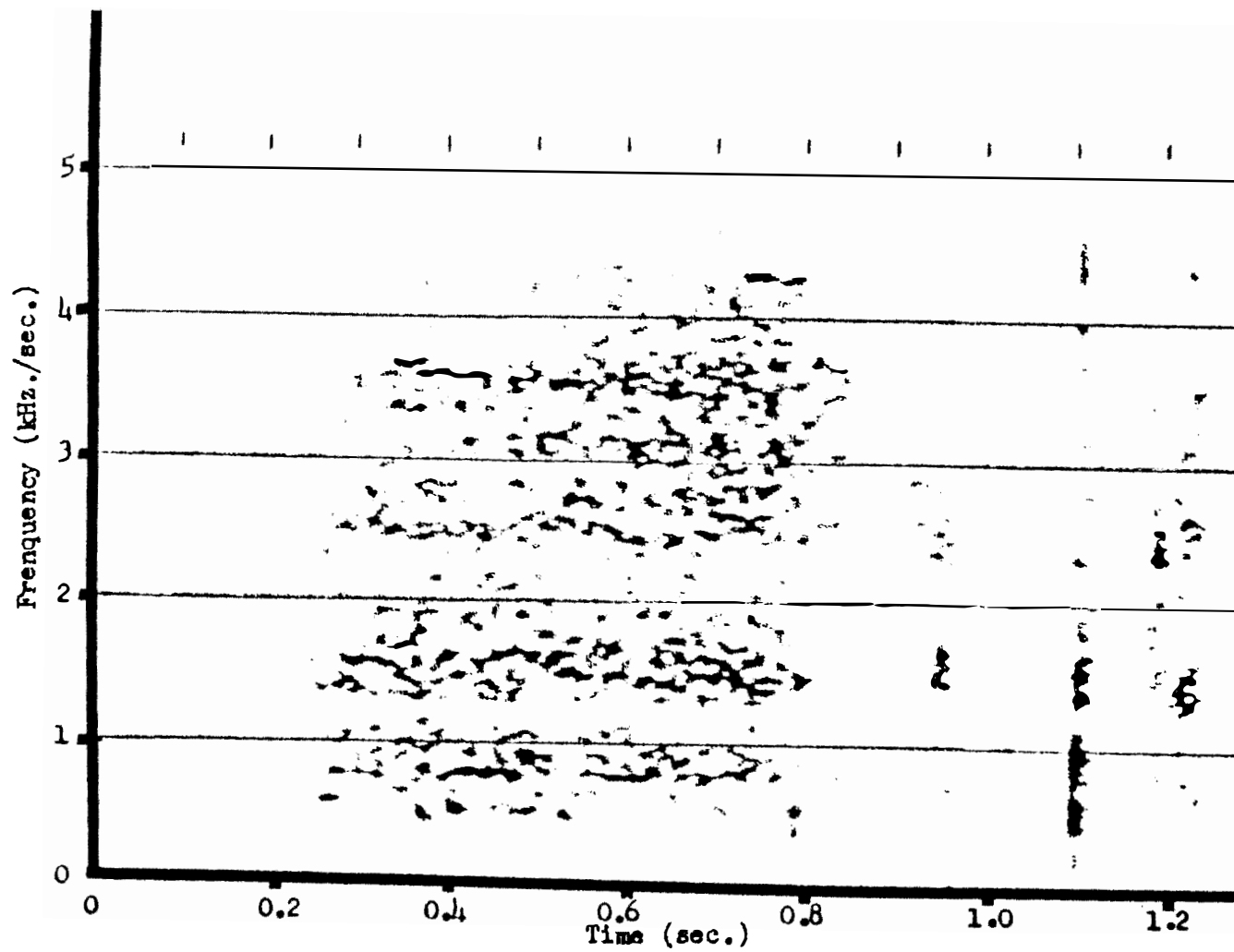


Figure D.2. A huff and jaw-pop produced by a subadult.



Figure D.3. Bellowing produced by a subadult male.

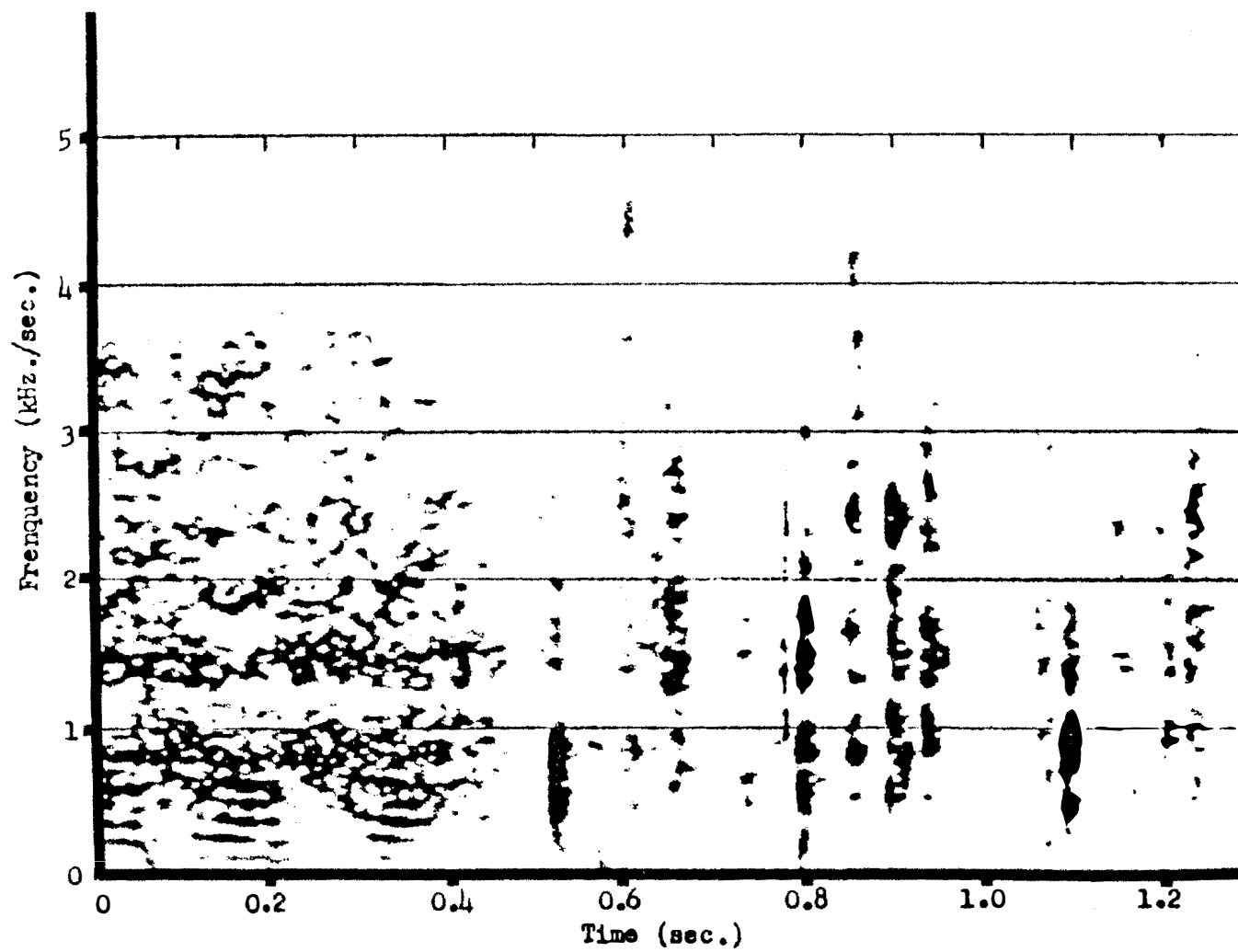


Figure D.4. Bellowing then jaw-popping produced by a subadult female.

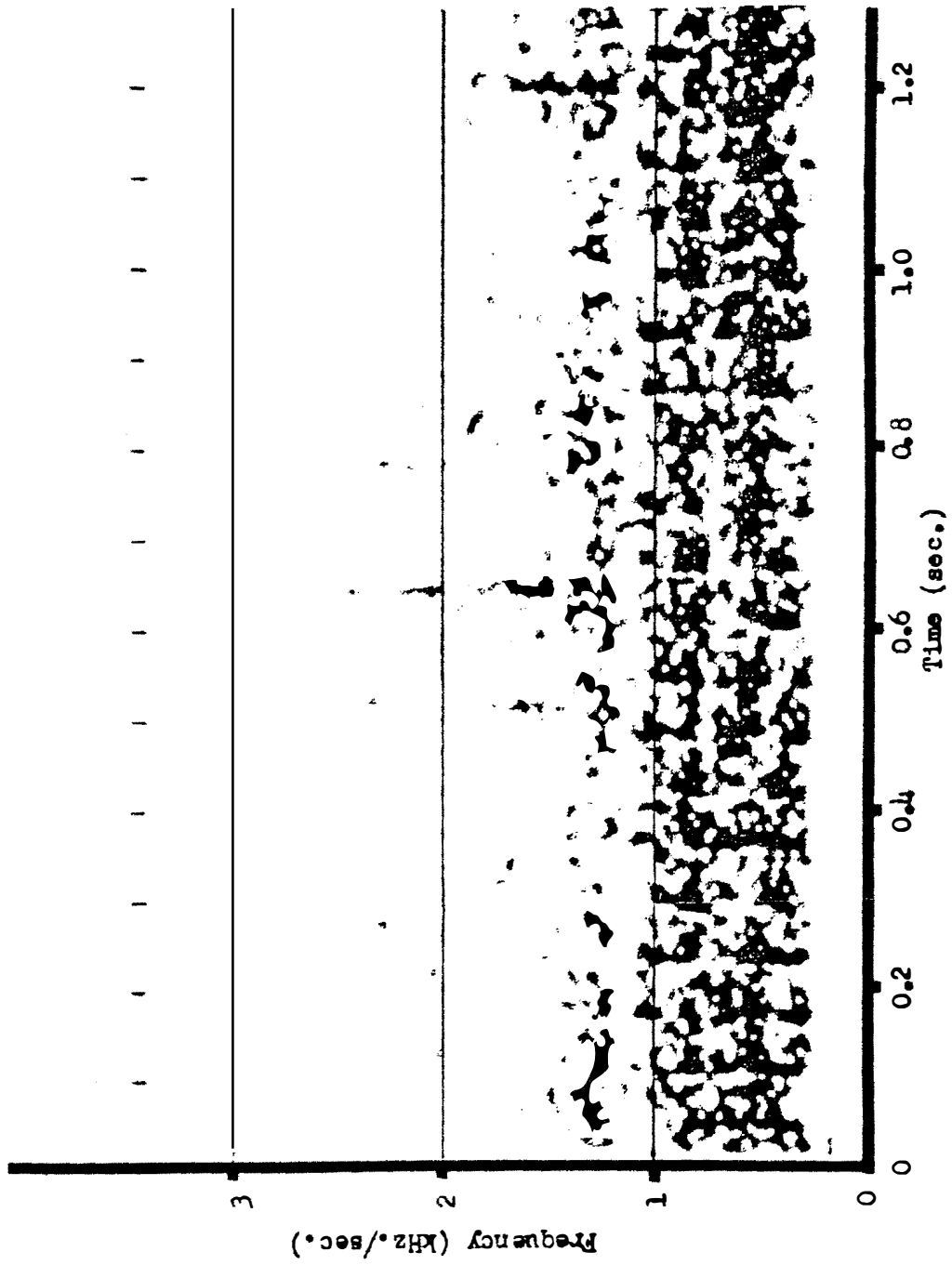


Figure D.5. Purring produced by a two-month-old cub.

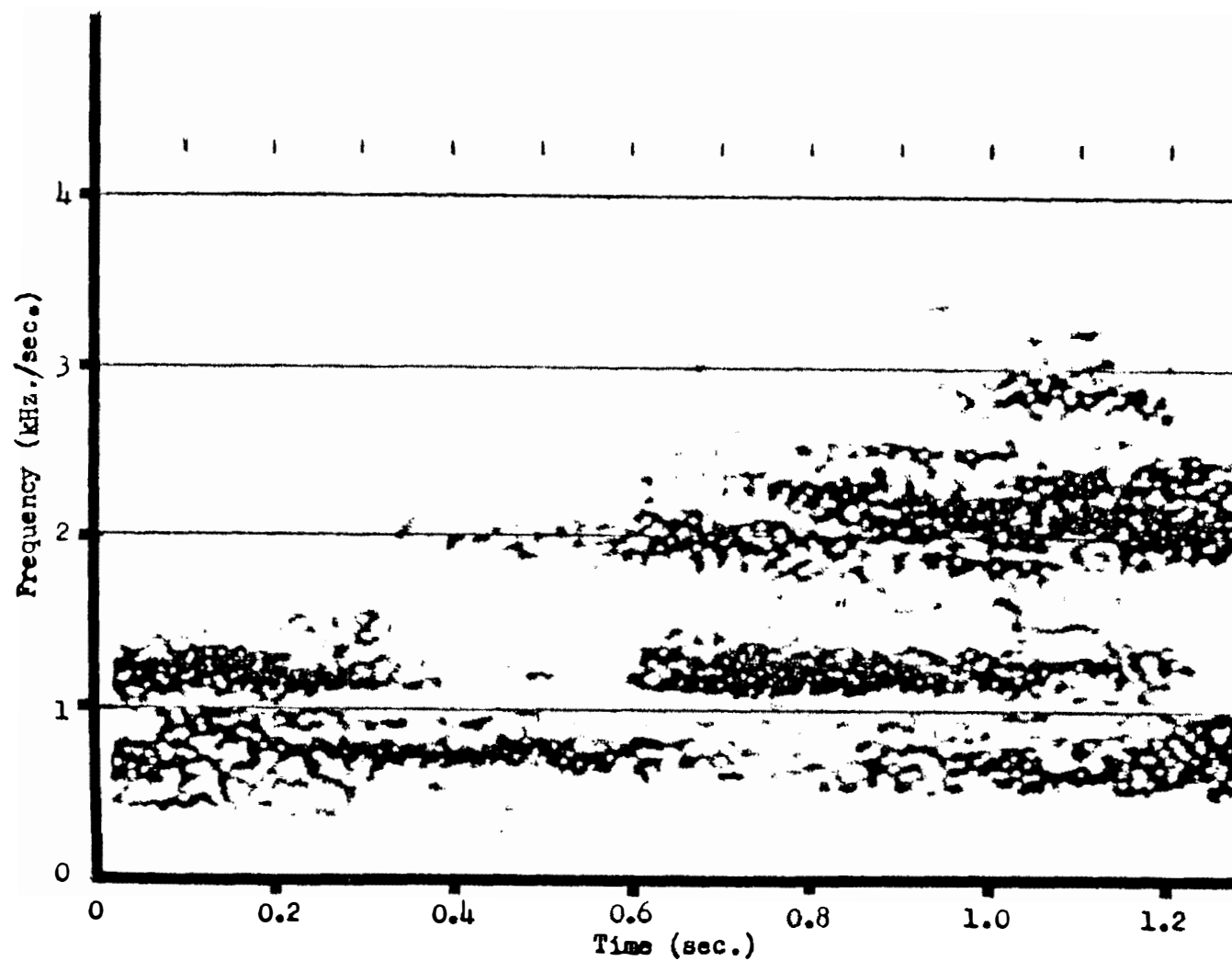


Figure D.6. Screech produced by a two-month-old cub.

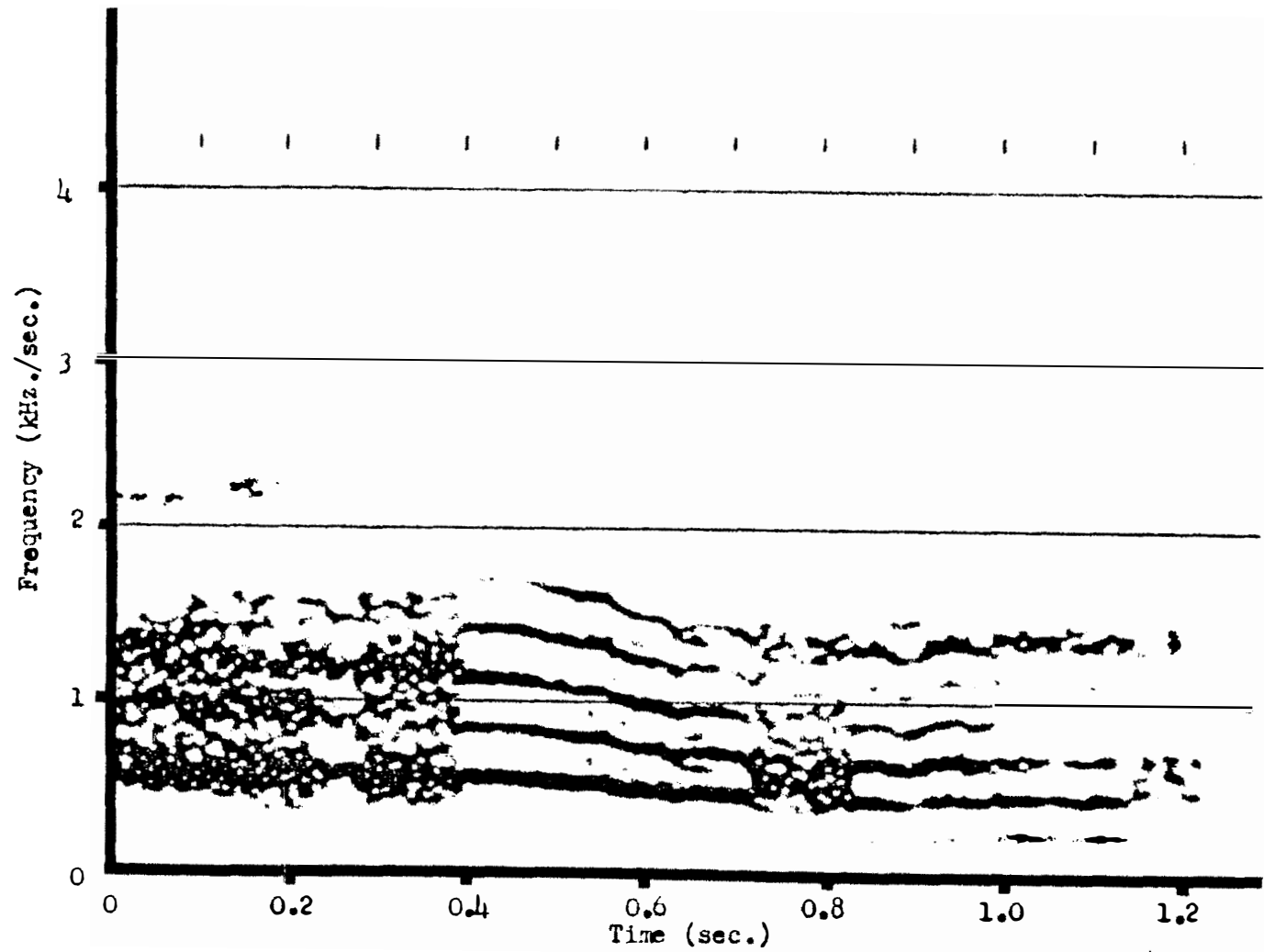


Figure D.7. A screech grading into a moan produced by a two-month-old cub.

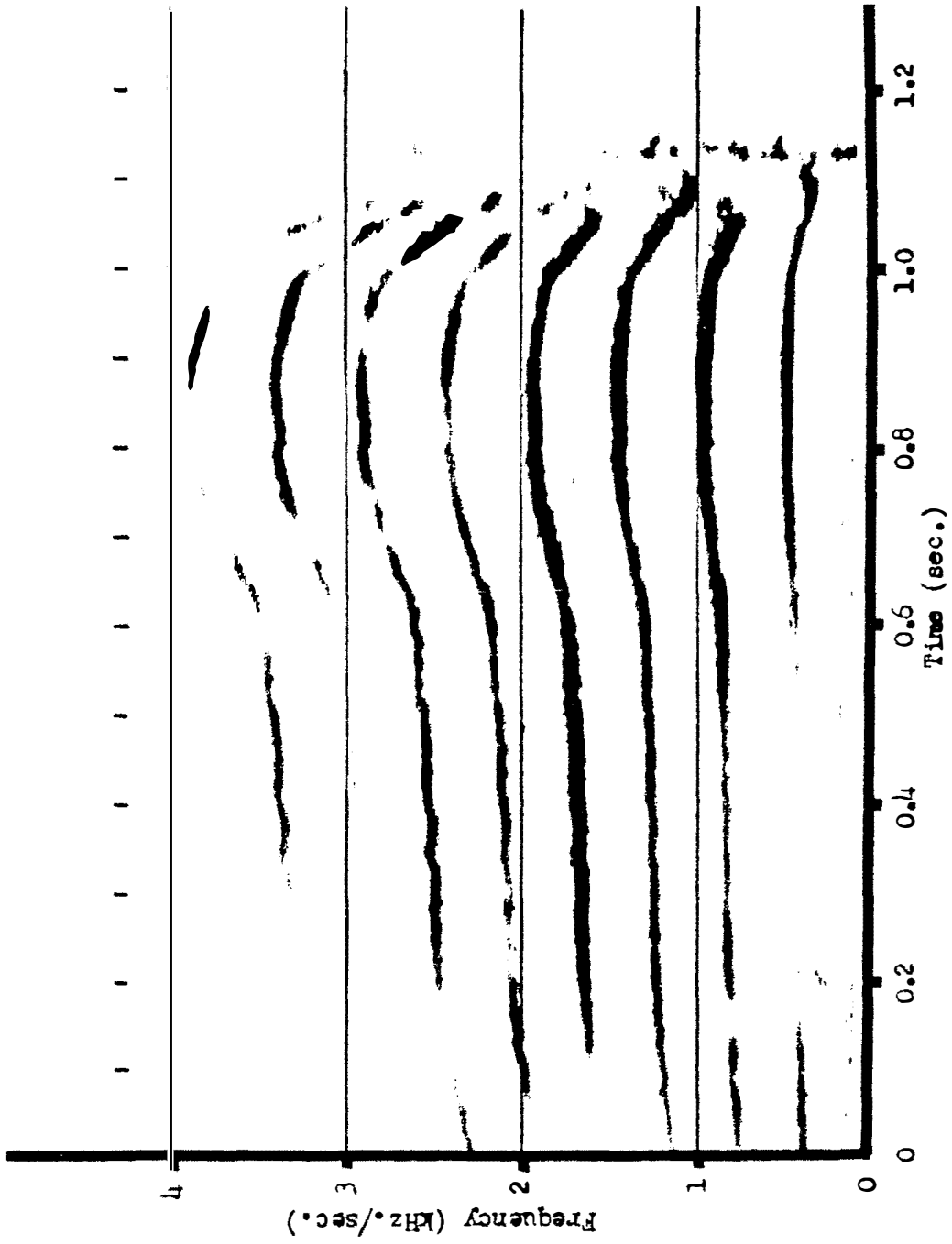


Figure D.8. A moan produced by a nine-month-old cub (A).

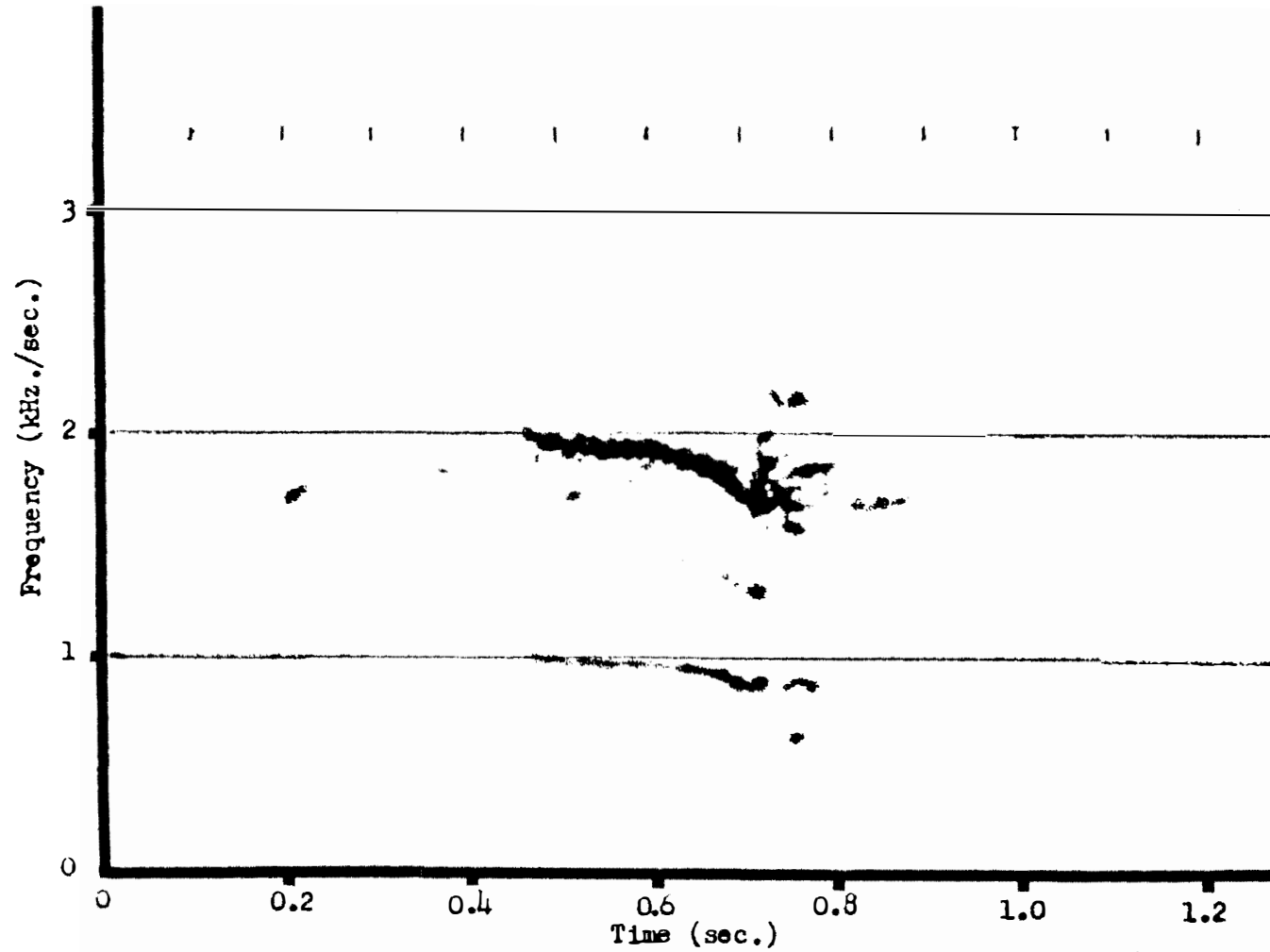


Figure D.9. A moan produced by a nine-month old cub (B).

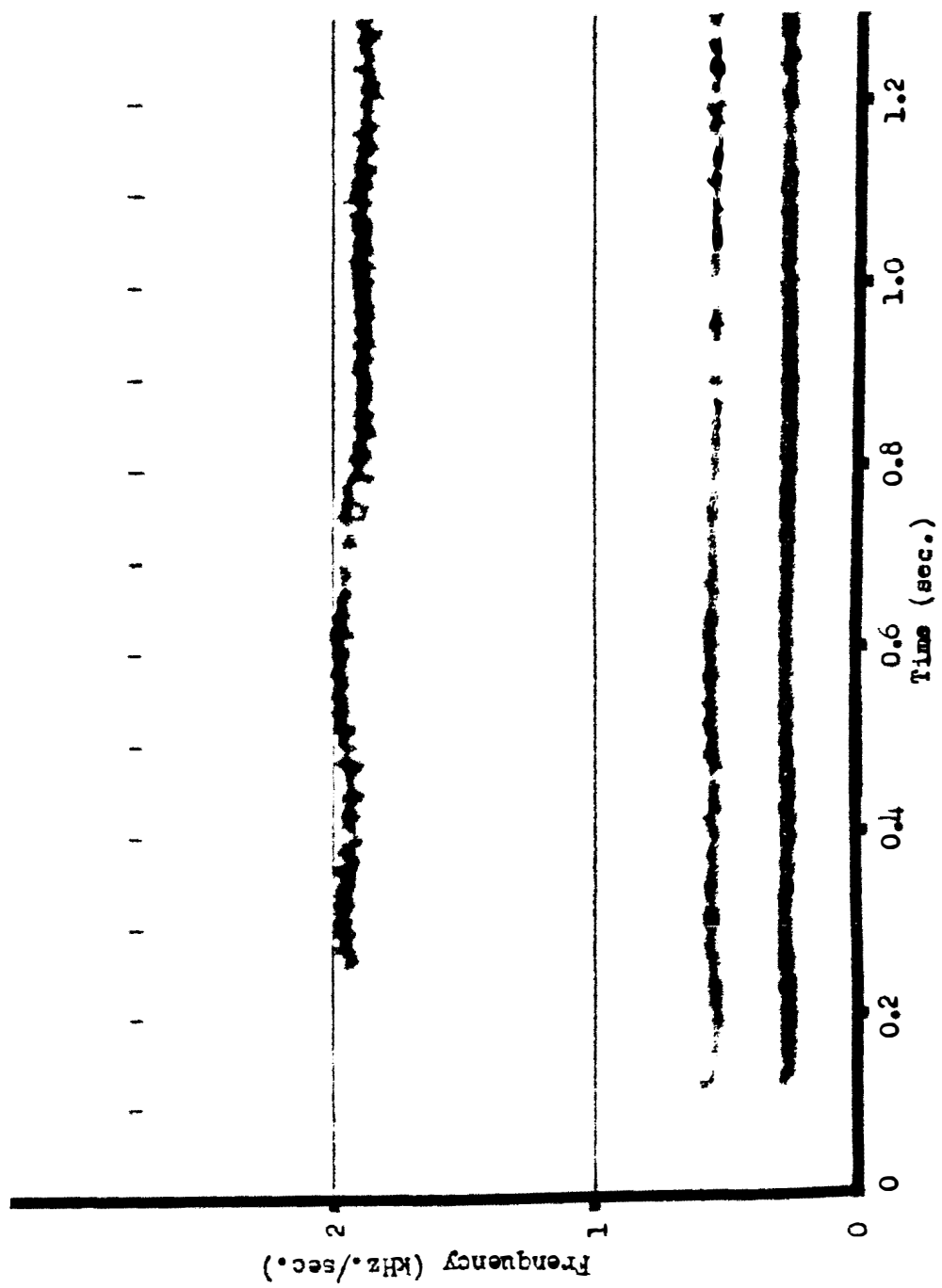


Figure D.10. Long low moan produced by a subadult male.

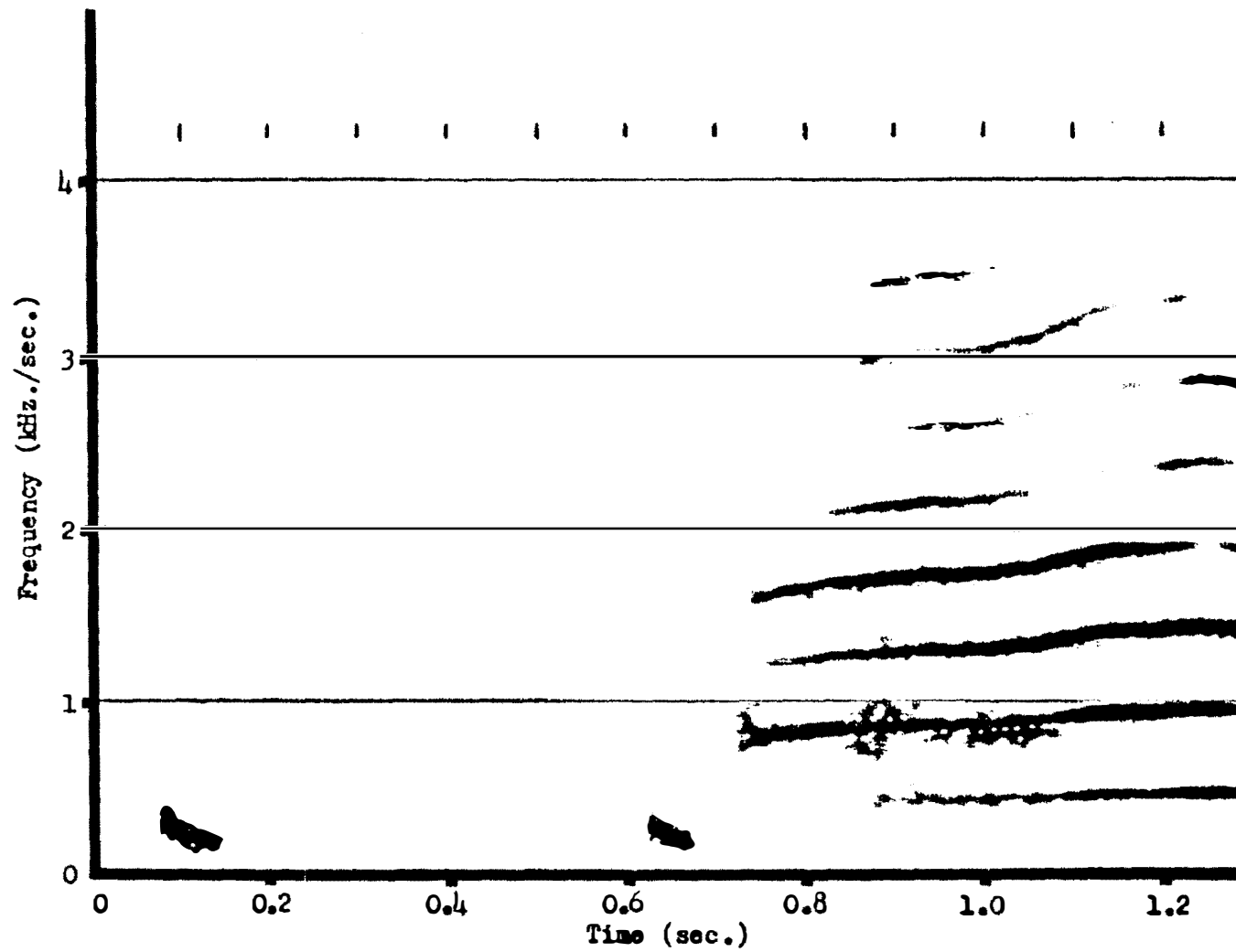


Figure D.11. Grunting produced by a subadult female and moaning by a nine-month-old cub.

APPENDIX E

8MM MOVIE FILM ANALYSIS

The super-8mm films were made with a Braun-Nizo, Model S-80, and a Minolta, Autopak-8 D6. The film types used were black and white (Kodak Tri-X (A.S.A.: 160) and 4-X (A.S.A.: 400)) and color, Kodak Kodachrome 40 (A.S.A.: 25), Ektachrome G (A.S.A.: 160), and 3-M (A.S.A.: 45).

Super-8mm films of a few selected behaviors were sequentially analyzed frame by frame and, more simply, by trying to note patterns by viewing the same sequences of behavior repeatedly. Sometimes selected frames from sequences of behavior that were particularly illustrative were photographed with a 35mm camera using a Fujica Macrocinecopier. Some of these photographs have been used to illustrate the dissertation.

APPENDIX F

TABLE F.1

SNIFFING OBJECT (F6) BY OBJECT SNIFFED AT GOLDRUSH

Object Name	Object Code #	Bear A Freq.	Rank Order	Bear B Freq.	Rank Order
Ground	D1	658	(1)	836	(1)
Unknown	D98	133	(3)	213	(2)
Air	D90	172	(2)	108	(4)
Den	D71	107	(4)	156	(3)
Grass	D2	76	(5)	93	(5)
Fence	D69	52	(6)	24	(7.5)
Shed	D72	21	(8)	27	(6)
Under fence	D86	23	(7)	14	(12)
Boards	D17	5	(14.5)	24	(7.5)
Water	D65	5	(14.5)	21	(10)
Other vegetable	D64	2	(25)	22	(9)
Post	D84	5	(14.5)	18	(11)
Hole	D85	4	(18.5)	12	(13)
See-saw	D74	5	(14.5)	11	(14)
Tree	D6	7	(9.5)	9	(15)
Observer	D24	6	(11)	4	(21)
Dead leaves	D18	7	(9.5)	2	(26.5)
Attached limbs	D9	4	(18.5)	5	(18.5)
Unattached					
Sticks	D15	5	(14.5)	3	(24)
Chow	D58	1	(30)	7	(16)
Straw	D14	0	(35)	6	(17)
Bear feces	D93	5	(14.5)	0	(34.5)
Paper or cloth	D78	0	(35)	5	(18.5)
Feed box	D83	1	(30)	4	(21)
Bear urine	D94	2	(25)	3	(24)
Tire	D73	0	(35)	4	(21)
Other nonorganic	D82	2	(25)	2	(26.5)
Other toy	D76	0	(35)	3	(24)
Flower	D4	3	(21)	0	(34.5)
Root	D11	3	(21)	0	(34.5)
Stone	D67	3	(21)	0	(34.5)
Other herbs	D3	2	(25)	0	(34.5)
Other human	D25	2	(25)	0	(34.5)
Shrub	D5	0	(35)	1	(28.5)
Fence door	D70	0	(35)	1	(28.5)
Pot	D75	1	(30)	0	(34.5)
Nuts	D63	1	(30)	0	(34.5)
Other food	D66	1	(30)	0	(34.5)
Total		1324		1638	

TABLE F.2
 SNIFFING OBJECT (F6) BY OBJECT SNIFFED AT TREMONT

Object Name	Object Code #	Bear C		Bear D	
		Freq.	Rank Order	Freq.	Rank Order
Ground	D1	403	(1)	589	(1)
Fence	D69	232	(2)	341	(2)
Unknown	D98	98	(3)	113	(3)
Air	D90	64	(4)	63	(5)
Tree	D6	38	(5)	69	(4)
Den	D71	27	(6)	53	(6)
Fence door	D70	26	(7)	44	(7)
Boards and logs	D17	4	(15.5)	24	(8)
Attached limbs	D9	11	(9.5)	13	(9)
Observer	D24	12	(8)	7	(13.5)
Food box	D83	11	(9.5)	8	(12)
Stone	D67	7	(13.5)	11	(10)
Straw	D14	10	(11)	6	(15)
Grass	D2	7	(13.5)	9	(11)
Hole	D85	8	(12)	3	(17.5)
Apparatus	D80	3	(17.5)	7	(13.5)
Shed or shelter	D72	3	(17.5)	4	(16)
Post	D84	2	(19.5)	3	(17.5)
Water tank	D81	4	(15.5)	0	(31)
Pot	D75	2	(19.5)	1	(26.5)
Bear feces	D93	1	(23)	2	(20)
Dead leaves	D18	0	(29)	2	(20)
Under fence	D86	0	(29)	2	(20)
Bear urine	D94	1	(23)	1	(26.5)
Human urine	D96	1	(23)	1	(26.5)
Sawdust	D16	0	(29)	1	(26.5)
Other humans	D27	0	(29)	1	(26.5)
Insects	D55	0	(29)	1	(26.5)
Raisins	D60	0	(29)	1	(26.5)
Nuts	D63	0	(29)	1	(26.5)
Other herbs	D3	1	(23)	0	(31)
Water trough	D87	1	(23)	0	(31)
Total		951		1381	

APPENDIX G

TABLE G.1

RESPONSE TO PEOPLE OTHER THAN THE OBSERVER (D25)
AS A FUNCTION OF MONTH AT GOLDRUSH

Month 1971	Bear A			Bear B		
	Percent	Freq.	Total	Percent	Freq.	Total
7	4.3	20	468	6.3	28	444
8	1.7	13	752	1.2	9	779
9	1.2	7	571	1.1	6	568
10	5.1	27	530	3.3	14	428
11	0.0	0	508	0.0	0	503
12	0.0	0	524	0.0	0	528
Total	2.0	67	3353	1.8	57	3250
<u>1972</u>						
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	0.0	0	223	0.0	0	222
5	1.2	7	598	0.2	1	620
6	0.6	3	512	4.0	19	480
7	5.3	32	607	4.2	25	595
8	4.4	27	616	2.8	18	632
9	4.5	25	553	3.2	20	622
10	2.6	8	302	1.4	4	287
11	0.0	0	203	0.0	0	210
12	-	-	-	-	-	-
Total	2.7	102	3830	2.3	87	3859
<u>1973</u>						
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	0.0	0	162	0.0	0	133
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	0.0	0	52	0.0	0	49
Total	0.0	0	214	0.0	0	182
Grand Total	2.28	169	7397	1.96	144	7291

TABLE G.2
ALERTING (F12) AS FUNCTION OF MONTH

Month	Goldrush						Tremont					
	Bear A			Bear B			Bear C			Bear D		
	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total
(1971)												
7	1.0	5	477	1.5	7	479	-	-	-	-	-	-
8	0.3	3	899	0.0	0	888	-	-	-	-	-	-
9	2.6	19	721	1.5	11	723	-	-	-	-	-	-
10	1.1	9	851	0.2	2	844	0.5	1	185	2.7	5	186
11	2.2	13	598	1.8	11	600	0.8	2	254	1.2	3	252
12	0.3	2	599	0.0	0	591	0.0	0	377	0.0	0	376
Total	1.2	51	4145	0.8	31	4125	0.4	3	816	1.0	8	814
(1972)												
1	-	-	-	-	-	-	0.0	0	594	0.0	0	592
2	-	-	-	-	-	-	0.0	0	443	0.0	0	480
3	-	-	-	-	-	-	0.0	0	360	0.0	0	358
4	0.0	0	239	0.0	0	239	0.0	0	349	0.0	0	361
5	0.1	1	718	0.3	2	714	0.0	0	465	0.0	0	480
6	0.0	1	591	0.2	1	585	0.0	0	594	0.0	0	595
7	0.3	2	715	0.1	1	710	0.1	1	699	0.0	0	686
8	0.0	0	717	0.0	0	711	0.9	6	698	0.7	5	715
9	0.1	1	740	0.3	2	738	0.3	2	731	0.0	0	731
10	0.0	0	369	0.0	0	367	0.3	2	622	0.0	0	622
11	1.3	3	240	0.4	1	240	0.0	0	240	0.0	0	240
12	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.2	7	4526	0.2	7	4514	0.2	11	5795	0.1	5	5860

Table G.2 (continued)

Month	Goldrush						Tremont					
	Bear A			Bear B			Bear C			Bear D		
	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total
(1973)												
1	-	-	-	-	-	-	0.0	0	119	0.8	1	120
2	-	-	-	-	-	-	0.0	0	120	0.0	0	119
3	0.0	0	238	0.0	0	238	0.0	0	153	0.0	0	163
4	-	-	-	-	-	-	0.9	2	215	0.0	0	217
5	-	-	-	-	-	-	0.4	1	256	0.0	0	258
6	-	-	-	-	-	-	-	-	-	-	-	-
7	0.0	0	66	0.0	0	65	-	-	-	-	-	-
Total	0.0	0	304	0.0	0	303	0.3	3	863	0.1	1	877
Grand Total	0.64	58	8975	0.42	38	8942	0.23	17	7474	0.19	14	7551

TABLE G.3
RESPONSE TO OBSERVER (D24) AS A FUNCTION OF MONTH

Month	Goldrush						Tremont					
	Bear A			Bear B			Bear C			Bear D		
	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total
(1971)												
7	1.1	5	468	0.2	1	444	-	-	-	-	-	-
8	1.2	9	752	0.5	4	779	-	-	-	-	-	-
9	4.4	25	571	2.5	14	568	-	-	-	-	-	-
10	1.5	8	530	0.7	3	428	23.2	26	112	12.2	15	123
11	2.0	10	508	2.2	11	503	36.7	55	150	5.6	8	144
12	5.5	29	524	1.9	10	528	7.0	16	229	1.1	3	275
Total	2.6	86	3353	1.3	43	3250	19.8	97	491	4.8	26	542
(1972)												
1	-	-	-	-	-	-	4.3	21	485	1.8	9	493
2	-	-	-	-	-	-	1.1	4	354	2.1	7	332
3	-	-	-	-	-	-	1.4	4	276	1.1	3	266
4	0.9	2	223	0.5	1	222	1.6	5	320	3.1	10	326
5	0.5	3	598	0.6	4	620	2.4	9	369	8.3	28	337
6	0.0	0	512	0.0	0	480	0.0	0	550	1.2	6	521
7	0.0	0	607	0.0	0	595	0.0	0	568	0.0	0	539
8	0.0	0	616	0.0	0	632	0.0	0	598	0.0	0	559
9	0.0	0	553	0.0	0	622	0.0	0	677	0.0	0	597
10	0.3	1	302	0.3	1	287	2.3	12	515	0.4	2	539
11	1.0	2	203	0.5	1	210	1.7	4	235	0.0	0	221
12	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.2	9	3830	0.2	8	3859	1.2	59	4947	1.4	65	4730

Table G.3 (Continued)

Month	Goldrush						Tremont					
	Bear A			Bear B			Bear C			Bear D		
	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total	Percent	Freq.	Total
(1973)												
1	-	-	-	-	-	-	2.1	2	96	3.9	3	77
2	-	-	-	-	-	-	1.0	1	100	0.0	0	89
3	0.0	0	162	0.0	0	133	3.2	3	94	0.0	0	123
4	-	-	-	-	-	-	0.0	0	140	0.0	0	162
5	-	-	-	-	-	-	0.0	0	167	2.0	3	152
6	-	-	-	-	-	-	-	-	-	-	-	-
7	0.0	0	52	0.0	0	49	-	-	-	-	-	-
Total	0.0	0	214	0.0	0	182	1.0	6	597	1.0	6	603
Grand Total	1.28	95	7397	0.69	51	7291	2.68	162	6035	1.65	97	5875

VITA

Robert Herbert Jordan was born in Bryn Mawr, Pennsylvania, on August 11, 1944. He attended elementary school in Narberth, Pennsylvania and was graduated from Lower Merion Senior High School in Ardmore, Pennsylvania, in 1962. In September 1962, he entered the University of Southern Mississippi in Hattiesburg, transferring in the following year to the University of Tennessee, Knoxville campus. In June 1966, he received the degree of Bachelor of Science in Psychology from the University of Tennessee.

As a Peace Corps Volunteer in Tanzania from July 1966 to October 1968, he taught agriculture, science, English, music, and history to fifth, sixth, and seventh grade students. This was immediately followed by seven months of formal language study and travel in Europe.

He entered Graduate School at the University of Tennessee in September 1969, and began study toward the Doctor of Philosophy degree with a major in Psychology.