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To the Graduate Council:

I am submitting herewith a thesis written by Jeanne Crozer Ludlow entitled "A Preliminary Analysis of the Activities of Captive Black Bears (*Ursus americanus*)--Locomotion and Breeding." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Psychology.

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A PRELIMINARY ANALYSIS OF THE ACTIVITIES OF CAPTIVE BLACK BEARS (*Ursus americanus*)--LOCOMOTION AND BREEDING

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee

Jeanne Crozer Ludlow

June 1974

To my families

for their love

1147106

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ABSTRACT

The behavior of the American black bear, *Ursus americanus*, has been poorly documented in the past. This investigation is a preliminary analysis of the diurnal activities of a hand-reared female and a captive wild male black bear, and the successful breeding of another pair of captive black bears.

Two black bears were kept in a semi-naturalistic enclosure at Tremont within the Great Smoky Mountain National Park (GSMNP). Their daily activities were recorded by a scan sampling technique, supplemented by photographic accounts. Detailed systematic records were kept of behaviors classified into categories (locomotor, non-locomotor). The bears' activities were analyzed in terms of the female's oestrous cycle, weather conditions and enclosure conditions. Differences were found in overall activity as a function of the three variables considered, with the greatest effect evidenced when the bears were allowed together: the female's activity level decreased and the male's activity level increased. No more than 20% of the total time observed was spent engaged in non-locomotor activities.

Because the Tremont bears did not breed, another pair of black bears, kept in the Goldrush Junction Amusement Park (outside GSMNP), were observed and filmed during breeding activities. Prior to copulation, the male actively followed the female, sniffing and licking her external genitalia; the female remained passive, but exhibited a tail lift just prior to the mount. Six sequences of copulation were observed, most of which extended 20 minutes or more. The mount resembled that of canids: the male grasps the female with his forelegs, anterior to

her hind legs, but in the inguinal area. Neck biting by the male was observed consistently. Quivering of the male (perhaps related to intromission) occurred while mounted. After mating, the female appeared restless and was more active than the male. During this time, she exhibited quiverings, or muscle spasms, of her hindquarters.

Although both pairs of bears were enclosed in semi-naturalistic facilities, it is suggested that the topography of the behavior patterns observed may not have been altered to any appreciable extent.

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CHAPTER I

INTRODUCTION

The American black bear, *Ursus americanus*, is a well known but little understood Tennessee carnivore. Literature on the black bear is limited, and most early research concerns the ecology and management of this species of Ursid (Murie, 1937; Cottam et al., 1939; Bennett et al., 1943). More recently, reviews of the black bear's behavior include only gross observations and trends in development (Van Wormer, 1966; Bray & Barnes, 1967; Matson, 1967). Only in the last decade have attempts been made to classify behaviors through more systematic and detailed approaches (Hornocker, 1962; Erickson, 1965; Burghardt & Burghardt, 1972; Bacon, 1973). The topic of the present investigation is a preliminary analysis of the diurnal activities of a hand-reared female and a captive wild male black bear; activity will be discussed in terms of time of day, weather patterns, and oestrous cycle; successful breeding of another pair of bears will be described.

History of Research

Since the early 1900's, behavioral scientists and laymen have noted the general characteristics of the black bear. During the thirties and forties these reports outlined the food habits of this species for different areas of the country (Murie, 1937; Cottam et al., 1939; Bennett et al., 1943). Popular accounts of bear sightings and killings were anecdotal and anthropomorphic, lacking evidence and/or repeated observations (Matson, 1967). Dufresne (1965) has written an account of the black, brown and grizzly bears in Alaska, but this (somewhat

anecdotal) account includes few systematic behavioral observations in general, and specifically, very little on *Ursus americanus*. Van Wormer (1966) attempted a more complete review of the black bears' behavior; however, some explanations are general and others inaccurate. Even Matson (1967), who criticizes both hasty conclusions and observations of "semi-domesticated" bears in parks, chose to use reports from hunters in his book on the black bear. Meyer-Holzapfel (1957) surveys the literature on all seven species of bear, but most of this information is related to the European Brown bear (*Ursus arctos*) and its American sub-species. In the past few decades, information has slowly accumulated on the physiology and morphology of *Ursus americanus*, but there are severe deficits in the areas concerning the bears' behavior and adaptability (Walker, 1964).

Breeding. Hornocker (1962) has examined the social and reproductive behavior of the grizzly (*Ursus arctos horribilis*) in Yellowstone National Park. His ecological study was undertaken with the purpose of preserving and managing the remnant populations of these bears. Meyer-Holzapfel (1957) describes the reports on mating foreplay, copulatory behavior, and the raising of cubs, but only in relation to the brown bear. Mundy and Flook (1964) have briefly described mating in black and grizzly bears, but it appears that the details of courtship and mating in bears has been overlooked. Erickson (1965) has discussed in depth the breeding biology of the black bear in Michigan, but he does not describe the reproductive behavior or care of the young. Matson (1967) reports on the observations of parturition and development of cubs, but his data are second hand and non-systematized. The North

Carolina Wildlife Commission (1969-1971) has also compiled data on the biology and management of black bears, observed both in zoos and on game preserves. However, that study was primarily concerned with food availability and the resultant annual breeding numbers. Ewer (1973), in her extensive survey of the literature on carnivores, mentions breeding seasons, but found little information on the development of young Ursids, especially *U. americanus*.

Activity and movements. Descriptions of this Ursid's movement usually include only anatomical characteristics (skeletal structures) and gross behavioral statements (Bray & Bray, 1967). Several authors have noted the black bears' plantigrade movement, or walking on the soles with the heels touching the ground, as in Man (Walker, 1964; Matson, 1967; Meyer-Holzapfel, 1957). Dufresne (1965) accounts for the bears' agility in climbing through his description of this Ursid's curved, semi-retractible claws. In contrast to other members of the family Ursidae, the black bears' footprint shows no claw marks. Hediger (1950), on the basis of his observations, has argued that the ability to climb must be learned individually by each bear. Hediger has also noted (1955) that the bears are continuous feeders. Most authors have agreed that the black bear's wide distribution across North America (Morris, 1965) is due in part to their adaptability; traveling is done to find an adequate food supply (Meyer-Holzapfel, 1957). Beeman (1971) has investigated the seasonal food habits of the black bear in Tennessee and North Carolina, using scat and stomach samples; currently, he is in the process of tracking bears by radio-telemetry to determine their movements and range. Van Wormer's (1966) description of the black

bears' movements is more detailed than most with brief mentions of the gaits and stride. He notes that black bears might have been both diurnal and nocturnal (in activity) before the destruction of forested areas by Man. No literature has been found on the changes in levels of activity with the onset of oestrous.

The misconceptions about the black bear are due in part to their human-like qualities; and folklore, legends, and children's stories perpetuate this fault (Van Wormer, 1966; Matson, 1967). Caras (1964) and Bray and Barnes (1967) note the black bears' "unpredictability," and Andrew (1972) demonstrates the paucity of information on (and lack of understanding of) the Ursid's vocalizations. Until the last decade, the bear was considered a pest and an animal to be hunted (Cowan, 1970; Guse, 1970). Now, however, ecologists and ethologists alike are concerned with the behavior of these bears. Not only are the Ursids a feature attraction at zoos and national parks, but they have also become an interesting study in and of themselves. It is in this light, possibly, that Burghardt and Burghardt (1972) carried out their study of the behavioral development of two female black bear cubs. This research has been extended by Bacon (1973), Pruitt (1974), and Jordan (in preparation). Bacon described the visual capacities and ingestive behaviors; Pruitt, the development of social interactions; and Jordan, the seasonal activities, vocalizations and facial expressions of the black bear.

With the territory available to black bears being constantly restricted by rural development and/or increasing numbers of *Homo sapiens*, there is an ever-present problem of limiting the bears' reproductive capacity (potential natality). To avoid or at least alleviate such a

problem, it becomes necessary to understand as much as possible about the behavior of this species.

Methods for a Semi-Naturalistic Study

Various methods of observation are possible for recording the behavior of animals, each with its own advantages and disadvantages (Hutt & Hutt, 1970; Slater, 1973; Altmann, 1974). In the present study two methods of direct observation were employed: written and photographic accounts. For the former method, a scan sampling technique (Altmann, 1974) was used; activity could then be quantified as the percentage of total time spent engaged in a certain behavior. Filming and videotaping ("indispensible technical aids"--Saayman et al., 1973) were chosen as a secondary means of investigating the bears' behavior. This method was especially useful in the analysis of interactions between the male and female (brief aggressive encounters, mating behaviors) and of complex behaviors of the individual animal (running, investigating objects/other animals).

Limitations of a Semi-Naturalistic Study

This study is a continuation of the research done by Burghardt & Burghardt (1972), Bacon (1973), Pruitt (1974), and Jordan (in preparation). The animals were within an enclosure, but one that resembled their natural habitat to such an extent as was possible. The two major limitations to such a semi-naturalistic study are (1) the presence of humans, and (2) the restricted space.

As for the first issue, wild animals *can* become habituated to the presence of a human (Hediger, 1950), given enough time. Furthermore, it is possible that raising an animal in captivity does not change its

behavior, but only to whom/what the behavior is directed and its frequency (Burghardt, 1973). However, the former argument involves long term animal-human contacts, and the latter statement refers to initiating human interactions early in an animal's life.

The second problem, that of limited ground space, must be accounted for in terms of the species of animal involved. Matson (1967) has noted that the black bear's range may be as large as 20 miles or as small as 4 miles, depending on seasonal preferred vegetable diet. To go one step further then, if adequate food is available, a bear may remain in a "restricted" range. Although the dimensions of the enclosure in this study are by no means similar to even a restricted range for the black bear, a variety of foods was introduced.

Finally, a recurring criticism of semi-naturalistic studies is that generalizations and theoretical statements are made which the research methods do not warrant (Caras, 1964; Matson, 1967). Unfortunately, many wild animals are difficult to observe, or even locate, in their natural environments. And, because of this, assumptions are often made as to an animal's diurnal or nocturnal, and/or solitary or social characteristics (Kruuk, 1972). In such cases, it becomes necessary to pool whatever evidence there is, be it supportive or conflicting, in the hopes that the behavior in question can be described, and perhaps eventually explained and understood.

CHAPTER II

METHODS

Subjects

Four black bears, *Ursus americanus*, were observed for this study. A female, raised by Burghardt and Burghardt (1972) and Bacon (1973), and a wild male captured in the Cades Cove Campground of the Great Smoky Mountains National Park (GSMNP), were kept in the Tremont enclosure; both bears were native Tennessee black bears. The female, Kate, was born in February 1970; the male was estimated to have been born in the early spring of 1964. A male and female, native of Vermont, were acquired from the Gallop Animal Farm (VT.) by the Goldrush Junction Amusement Park (Pigeon Forge, TN.) as cubs; they were also born in the early spring of 1970, and are kept in the Amusement Park area just outside of GSMNP.

The Tremont bears were identified both by their ear tags and size differences (the male was much larger than the female). The Goldrush bears were identified solely by such size differences. All four animals were black in color, except for tan areas around their muzzles (more so for the two females than for the males).

During the late spring (1973), Kate developed a skin infection which became more severe by mid-summer. Dr. D. G. Brown ran a culture of a skin scraping and determined the cause to be a dermaphyton called prichophyton, probably the common mentagrophylea found in many wild animals. The treatment was in two stages:

1. July 23-July 29--four injections (IM) of penicillin (Flocillin); 300,000 units/cc on alternate days.

2. July 30-August 10--Griseofulvin (10 mg/lb) in tablet form Phlorphyramine (an antihistamine) and Prednisclone (a steroid) in capsule form (5 mg of each capsule).

The tablets were crushed and the capsules opened, and both were mixed with Karo syrup on a slice of bread, fed daily. By late August, Kate's pelage was regrown and in excellent condition.

Housing

The enclosure for the Tremont bears is described in detail in Bacon's (1973) study and "represents an example of confinement within a semi-natural habitat" (Bacon, p. 14). Briefly, it was an 18.3 meter square fence bisected by a center fence with 3.05 meter gates at each end. There were entrance gates on each side (1.22 x 1.83 m). Around the top of the fencing there was 1.22 cm sheet metal to contain the subject. Also, to prevent the bears' moving from tree tops to the fence, sheet metal collars, 1.22 meters in height and 1.5 meters above the ground, were placed on the trees near the fencing.

The enclosure for the Goldrush bears was less similar to their natural habitat. It was approximately 25 m x 80 m, with an electric fence surrounding it. A 1.2 meter chain link fence was situated about 2 meters outside of the electric fence. (The purpose of this was more to keep visitors to the bear area out, rather than to keep the bears in.) A shelter was in the south end of the enclosure. This had two separate sheds on each side with a roof attaching the two. The male and female were individually confined during the night. No access was available to these sheds during the day, however the bears could lie between them under the center roof for shade or protection from the

elements. (More exact measurements were not available from the Goldrush personnel and entrance into the bears' enclosure was not possible.) There were no trees in the enclosure, but the West and North side were bordered with forest. A stream (c. one meter wide) traversed the north end of the enclosure from north-northwest to west-northeast.

Maintenance

The maintenance of the Tremont bears was similar to that carried out by Bacon, Pruitt and Jordan. The bears were fed Wayne bite-size dry dog chow twice a day. Feeding times were from 7-9 A.M. and from 4-6 P.M. The female was fed in the two-lid hog feeder on Side 2. The male was fed on the ground by fence 1, Side 1, 2 meters from the end fence. However, on rainy days from July 3-August 8, food for both bears was placed in the feeder on Side 2. (During the first few weeks of the male's captivity, a single-lid hog feeder was placed in Side 1 where he was later fed on the ground. This proved unsatisfactory, and the male pushed it over several times.) A variety of other foods was given to the bears throughout the summer. These included apples, blackberries, raisins, and bread. Water was available to the Tremont bears in three ways:

1. A water tank placed midway along the east fence of Side 1 (Bacon, 1973), allowing for a continuous clean water supply.
2. A water tub (96 x 127 x 40 cm sheet metal) placed in the southwest corner of Side 2 along the west fence.
3. Rain water collected in holes.

Water was changed regularly (approximately every other day for the first two methods). The tub was also used for bathing or wallowing. Shelter

was provided in Side 2 of the enclosure (Bacon, 1973).

The maintenance of the Goldrush bears was handled by Junior Morgan, an employee of the Amusement Park. The bears were fed Purina Calf chow; this was given individually into each side of their shelter. Water was available from the stream, but only during the day when they were free to leave the shelter.

Apparatus

A two-story observation tower/storage shed stood opposite the south side of the enclosure's center fence. Data (in the form of observations and pictures or tape) could be collected from the second floor; here, a clear view of the enclosure was available.

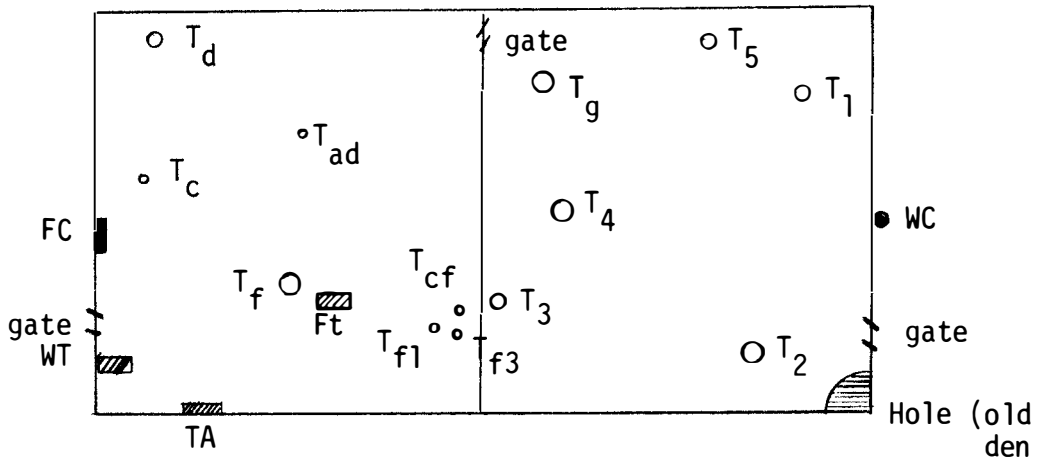
Three different types of photographic equipment were used to film the bears' activity: a Sony-video recorder, model AV3400; a super 8 mm cine camera, Nizo S-80; and a 35 mm still camera, Minolta SRT-100. Various clocks and/or stop-watches were used to time the 40-minute observation periods in 10-second intervals.

Procedures

Using the scan sampling technique, the Tremont bears were observed during 40-minute time periods, at 10-second intervals, on the average of two times per day, from June 11 until August 8, 1973 (covering the time from 7:30 A.M. until 6:30 P.M.). This technique involved recording *current* ongoing activities (states), at specified time intervals. At the start of each interval (for this study, 10 seconds), the animal's activity *at that time* was recorded. In this research, observations were taken at varying times during the day, with no attempt to observe at a regular time every day. The rationale for both the 10-second interval

observations and the varying times observed was two-fold: first, to get a general idea of the bear's overall behavior pattern (without unintended biases), it was necessary to sample the behaviors in a systematic manner--10-second intervals were chosen as the smallest interval in which accurate data could be collected; second, the author's hypothesis was that the bear's behavior may be cyclical--to avoid getting "into a rut," randomized observations were made.

A method for recording data was formulated by the author, using ideas from both Bacon's (1973) and Jordan's (in preparation) research. Basically, this method involves classifying each of the bears' activities. By use of the abbreviations and symbols for such behaviors and their direction, and for the location in the cage, a detailed systematic record can be kept (Figure 1, a and b, and Table I). Occasionally, stick figures were used to show a bear's posture. Unclassified behaviors were written out in full. At the start of each 10-second interval, the bear's activity *at that time* was recorded. The first 10 minutes of the observation period served as a "warm-up" to allow the observer to get the feel for the method, and the "pace" of the bear's activities; the next 30 minutes were considered as the data to be analyzed. Data were collected every day possible despite weather conditions. Both locomotor activities (Table I) and non-locomotor activities were recorded. *Active* locomotions involved walking, running, or pacing; non-active "locomotions" were standing, sitting, or lying. The first four locomotions were easily distinguishable; on occasion, ly and sit were not and a diagram to show position was used. Using the above method, analysis of data collected by independent observers and observing the same bears' activities at the same time showed 85% or more agreement.



Ft - fort (den)
WT - water tub
WC - water container
TA - taste apparatus
FC - food container
T - tree
CF - center fence

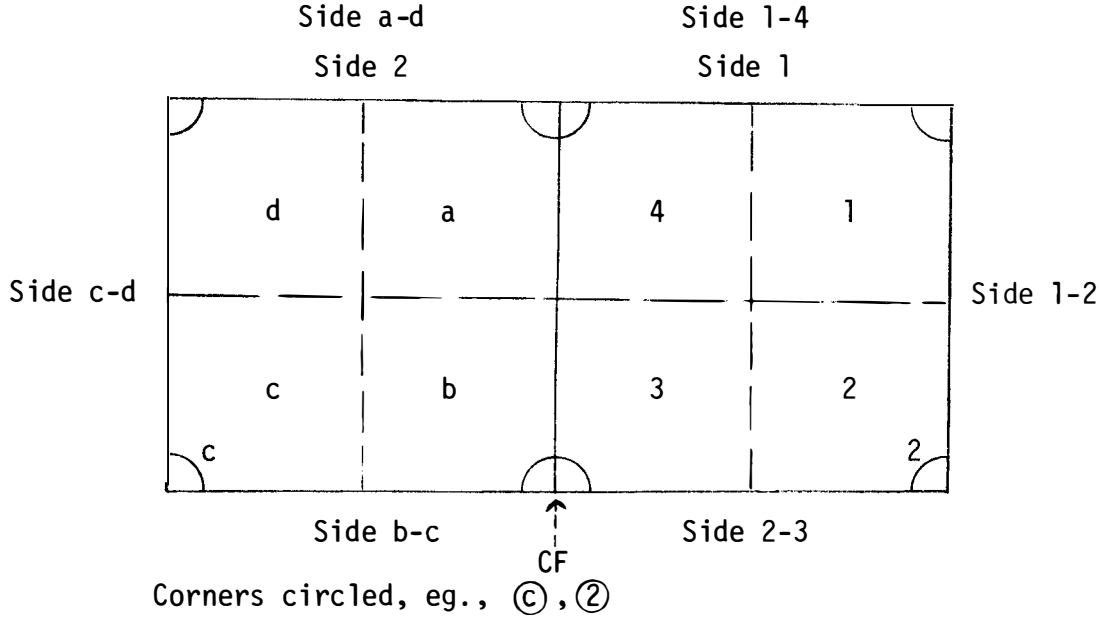


Figure 1. Diagrammatic representation of Tremont enclosure.

TABLE I

ABBREVIATIONS, CLASSIFICATIONS OF BEHAVIORS

Abbreviation	Classification
Ly	Lying (flat or up)
St	Standing (if bipedally, say "on 2")
Sit	Sitting (up or back)
W	Walking
Run	Running
Pa	Pacing (S walked same fence more than once)
Eat	Eating (S ingests matter. See Bacon, 1973)
Bi	Biting (S chews matter but does not ingest)
Scr	Scratching--usually self
Paw	Pawing--usually ground or fence
SC	Sniff Close (nose close to object)
SM	Sniff Mash (nose against object)
SA	Sniff Air (nose and head tilted up)
Drink	Drinking (S puts nose/mouth into water container)
Str	Stretch
Lying:	flat or up; resting or looking around or sniffing; eating; sleeping
Standing:	scratching; looking; SA; SC, SM, . . . fence, ground
Sitting:	scratching; looking; resting; sniffing
Vocalizations:	Voc.: huff, charge, whine (see Jordan, in preparation)
LM	Look at me
→	Movement towards
↷	Reversal of movement (as in pacing)
↑	Climb up (tree, fort, fence, feeder)

In addition to the above observations, daily records were kept including amount of chow fed, temperature, time of day, general weather conditions, and specific situations and behaviors resulting from the observer's arrival.

Both pairs of bears were observed using the video, movie and still cameras. These filmed accounts were used for more detailed descriptions of behaviors observed. The video-recorder was useful in recording lengthy interactions (30 minutes/tape), and in recording any vocalizations that occurred. The movie camera was used primarily for filming the breeding behaviors; although the films were only three minutes long, it was easiest to transport and change films with this camera. In analyzing the data, the 3-minute films were viewed in blocks of 10 frames, to determine frequency of behaviors. The 35 mm camera was used as a supplementary source of information, and provided slides of the behaviors observed with the above two methods.

The Goldrush bears were observed and filmed for only one week during breeding (July 2-July 10). (Due to the oestrous cycle of the Tremont female and the distance between the two study sites, more time could not be spent on research with the breeding pair.) Film analyses of the Goldrush bears' social interactions and mating and the Tremont bears' interactions (usually aggressive) are descriptive; too few of these interactions occurred for there to be an analysis of the sequences of behaviors.

Weather conditions were arbitrarily classified as one of four types:

1. Rain, when there was precipitation for more than half of the observation period.

2. Clear-sunny, when there were no clouds visible.

3. Partly cloudy, when there were clouds visible but the sun was occasionally out (i.e., also called partly sunny).

4. Cloudy, when there was no sun out and clouds covered the sky.

The Tremont female was allowed access to both sides of the enclosure before the male was introduced. On June 11, the captured male was anesthetized by Larry Beeman (Dept. of Wildlife Management, U.T.), and weighed (280 lbs). (The first premolar on the upper right jaw was pulled; by use of a cementum annuli technique, Beeman determined the male to be nine years old.) The male was carried to the enclosure by Ellis Bacon, Larry Beeman, Larry Marcum, Tom Taylor and Paul Breslin, and placed on Side 1. The center fence gate had been closed with Kate in Side 2. The bears were kept separated until July 3, when it was established that Kate was in oestrous.

To determine oestrous, Bacon manually inspected the external genitalia of Kate. Receptivity was defined as enlarged labia, tail lift, and presentation of the female's hindquarters (to Bacon). Kate was inspected on June 4, 6, 7, 16, 23 and July 2 with the following observations by Bacon:

June 4--initial tail duck, but small tail lift as labia were grasped and opened

June 6--tail lift and lordosis as labia were held; almost receptive

June 7--definite tail lift, much olfaction

June 16--labia rather enlarged

June 23--not in heat, external genitalia swollen but no presentation

July 2--tail lift, Kate is in heat

On July 3, the center fence gate was opened (2:45 P.M.) and the bears had access to both sides of the enclosure. The bears were kept together and observed through August 10. The oestrous cycle was completed within two weeks and Bacon reported "no longer receptive" on July 16.

CHAPTER III

RESULTS AND DISCUSSION

Activity

The first task of the present investigation was to investigate the diurnal cyclical behavior of the black bear. At the end of the study, active and non-active locomotions were summed, and observations were grouped into time periods. Means transformed to percentages of total activity, for each time period, for the male and Kate are shown in Figure 2. There is an obvious difference in activity levels between the male and the female; however, six variables could influence either bear's activity. These are (1) sex (between sexes), (2) weather conditions, (3) stage of the oestrous cycle, (4) open or closed center fence gate (i.e., the bears were separated or together), (5) familiarity with the environment (i.e., raised in captivity or in the wild, experience of human contact), and (6) individual differences (within sex). The first five variables will be discussed, but the last one cannot be evaluated in terms of this research.

As noted above, there was a difference in overall activity levels during the day. The null hypothesis of no differences was tested by a dependent t-test for related measures (Siegel, 1956), and the results showed that the male's activity was significantly different from the females ($p=.05$). But, considering the variability and range of activity for each bear (Figure 3, a and b) the information about cycles of activity loses much of its value.

However, since the bears *were* observed simultaneously, conditions 2, 3, and 4 above were identical. Therefore it is possible to compare

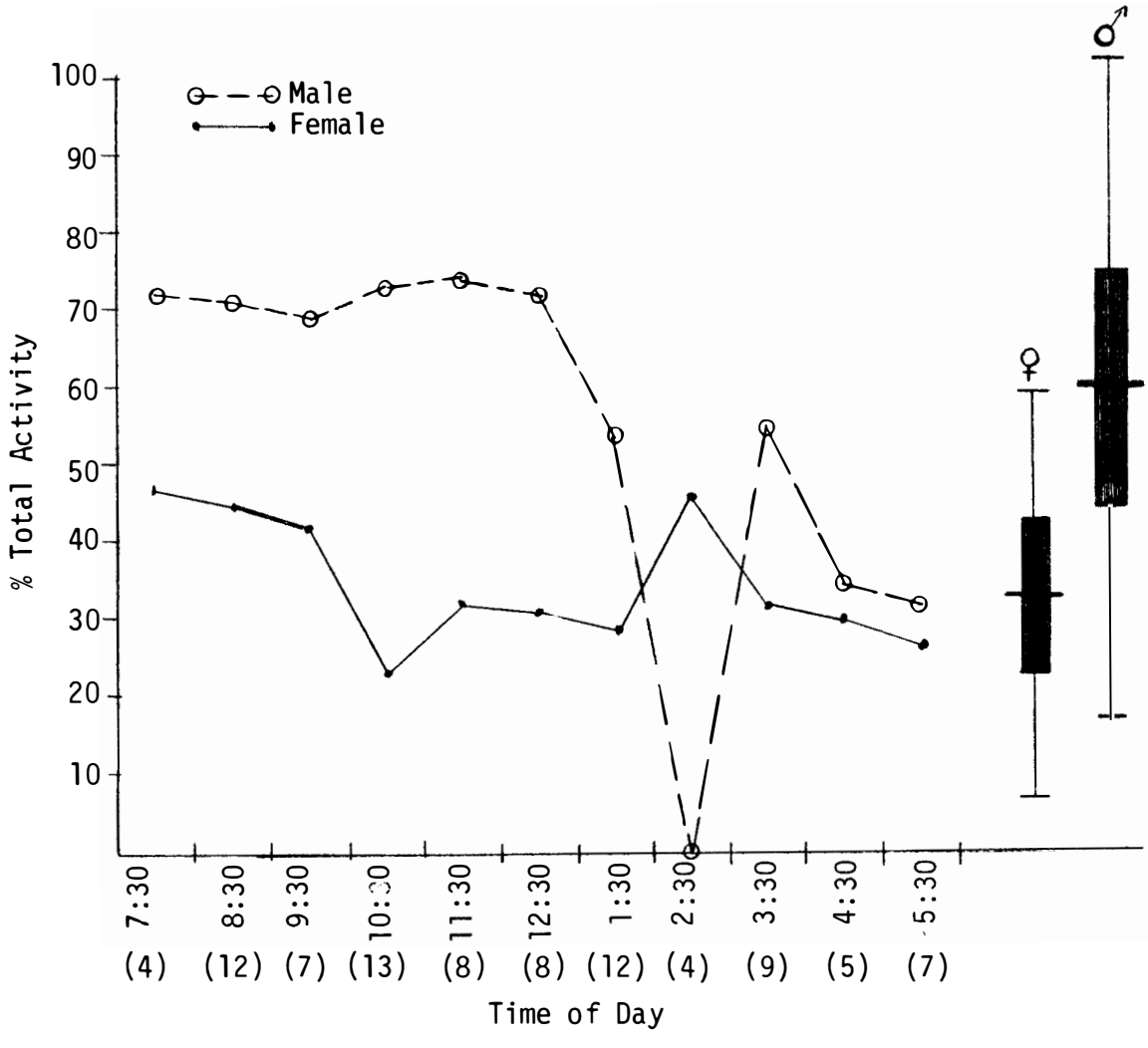


Figure 2. Diurnal cycles of locomotor activities (male and female).

Mean standard deviations (vertical line) and mean standard errors of the means (black bar) for each bear given to right of graph; sample sizes are indicated below time periods in parentheses. 2:30 P.M. fall-off of male's activity discussed in text.

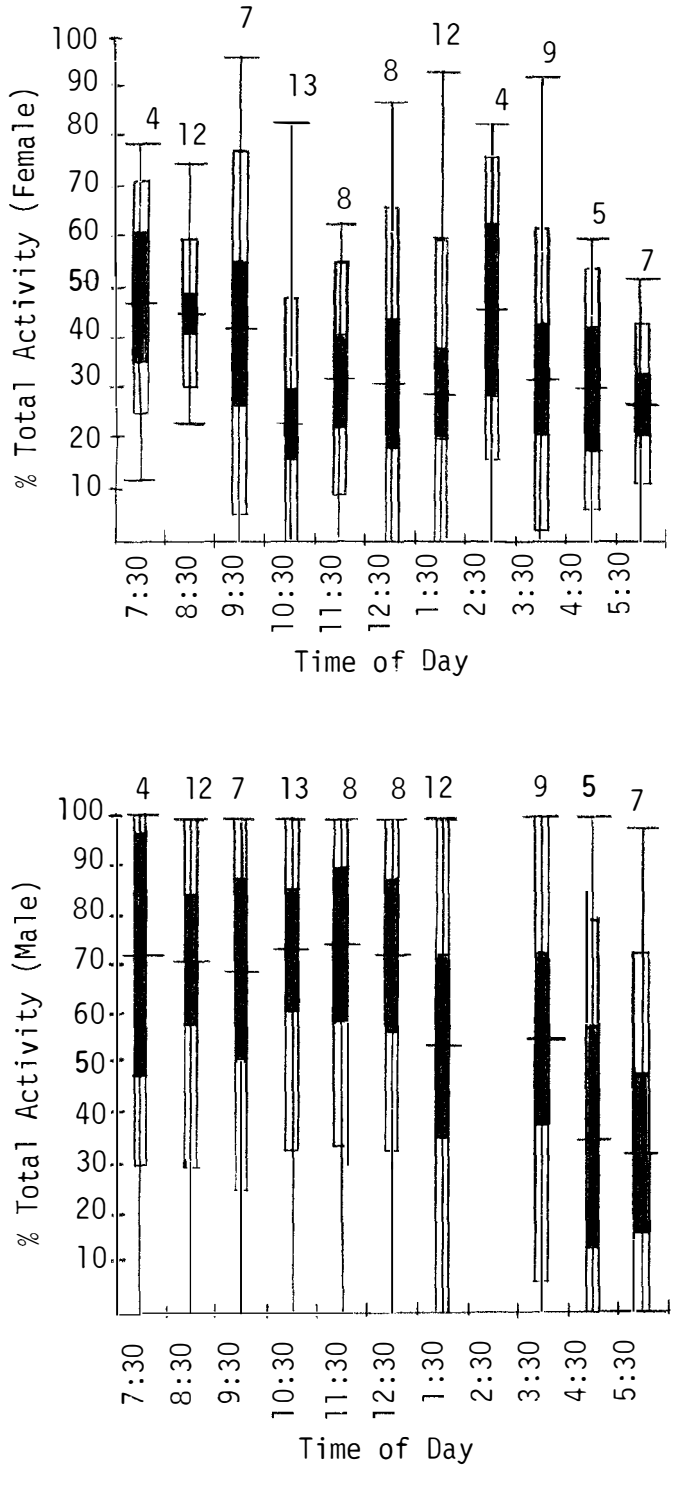


Figure 3. Locomotor activities for female and male.

Mean standard deviations (clear bar), standard error of the means (black bar), range (vertical line), and sample size (above range).

the effects of these variables on the bears' activity. First, though, it is necessary to consider each bear's familiarity with the environment and with humans (variable 5, above). The female, Kate, was raised by humans, and had been in this enclosure for three years. It was assumed that the wild male was raised in the Smokies by conspecifics, and by him both the enclosure and frequent human contact were novelties. Hence, in explaining an activity level such as that for the male at 2:30 P.M., careful review of the records shows that on three of the four observations taken during this time period, the author's presence at the enclosure was immediately followed by the male's inactivity--i.e., the male climbed the sweetgum tree (T_g) and remained there for several hours. As will be discussed later, the male may not have acclimated (at least to the author) until the final part of this study.

Differences in overall activity level in relation to weather conditions, oestrous cycle, and separate-together conditions are shown for the male and female in Figures 4, 5, and 6, respectively. Except for the rain condition, neither bear's activity changes more than 14% for the various weather patterns. Furthermore, when activity in relation to weather is examined in terms of the other two conditions, "trends" of most active and least active are not apparent, and levels of activity never changed more than 20% (Figures 7 and 8). Considering the oestrous cycle, the data were divided into six periods: Pre-oestrous 1, June 18-23; Pre-oestrous 2, June 24-July 1; Oestrous 1, July 3-9; Oestrous 2, July 10-15; Post-oestrous 1, July 16-26; and Post-oestrous 2, July 27-August 2. Data were also included for the last five days of the study, to determine whether or not an increase or decrease in

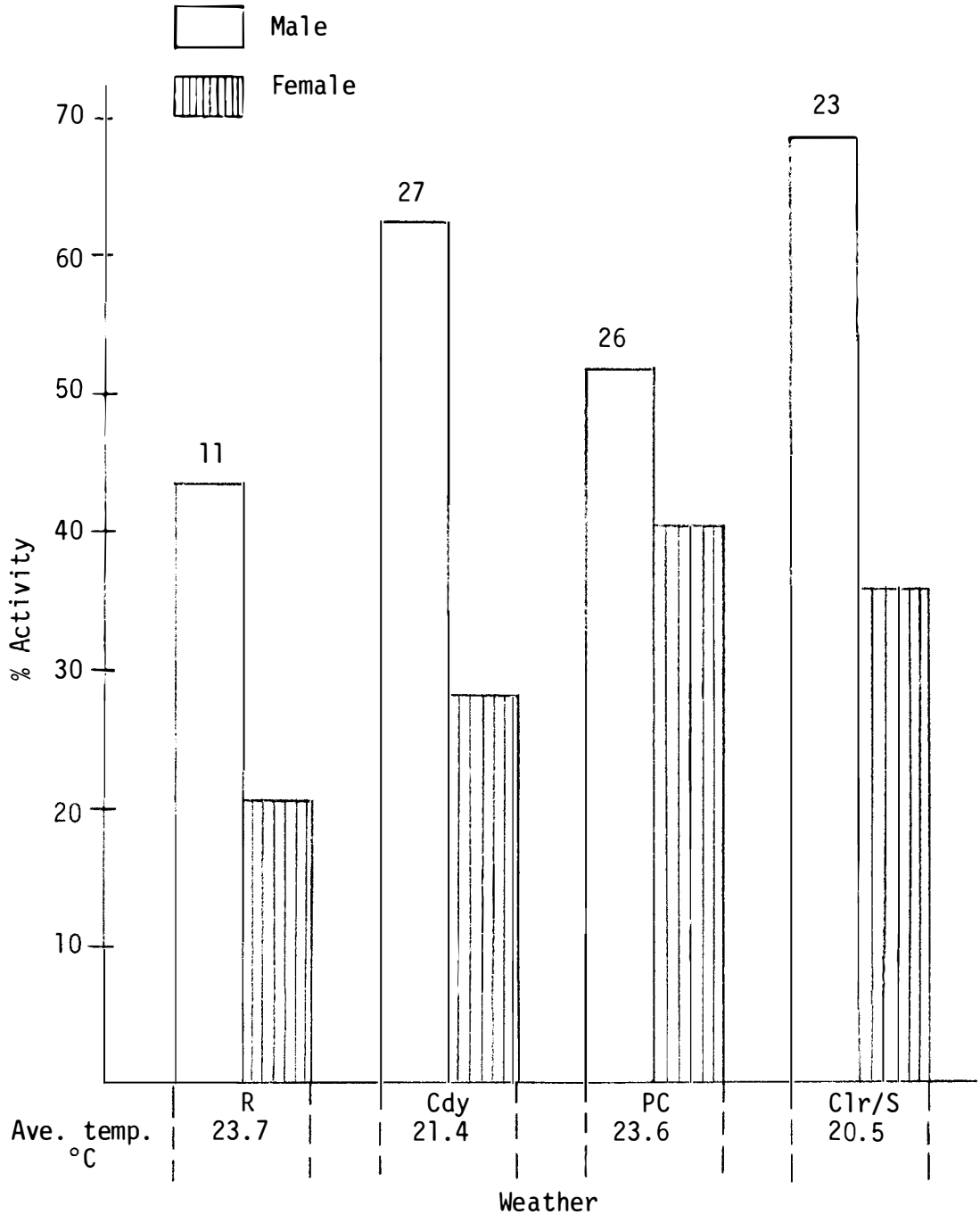


Figure 4. Mean activity levels in relation to weather conditions (male and female).

Numbers above pairs of bars indicate sample sizes (i.e., number of observation periods).

Key:
R - Rain
Cdy - Cloudy
PC - Partly Cloudy
Clr/S - Clear/Sunny

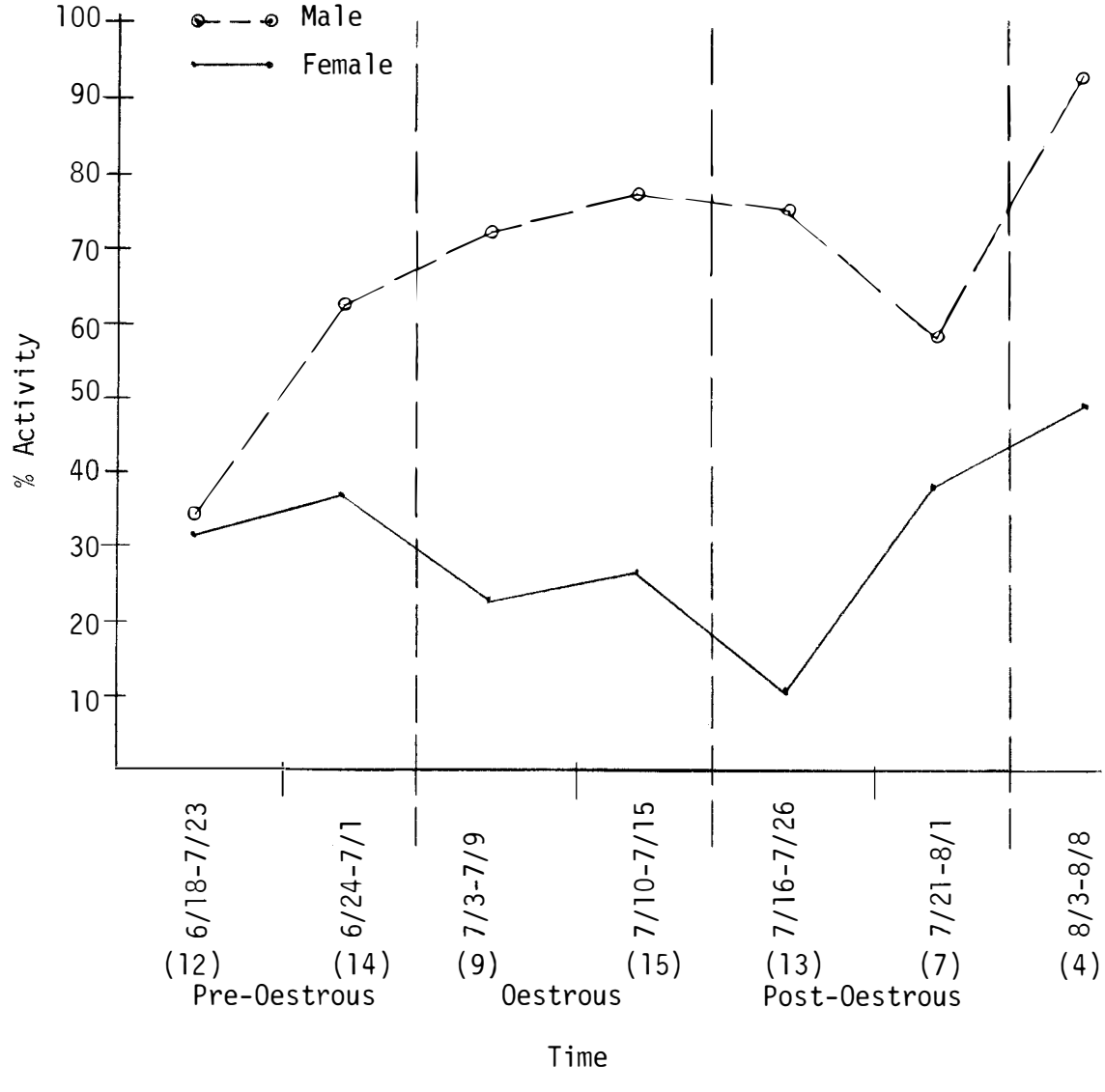


Figure 5. Mean activity levels in relation to oestrous (male and female).

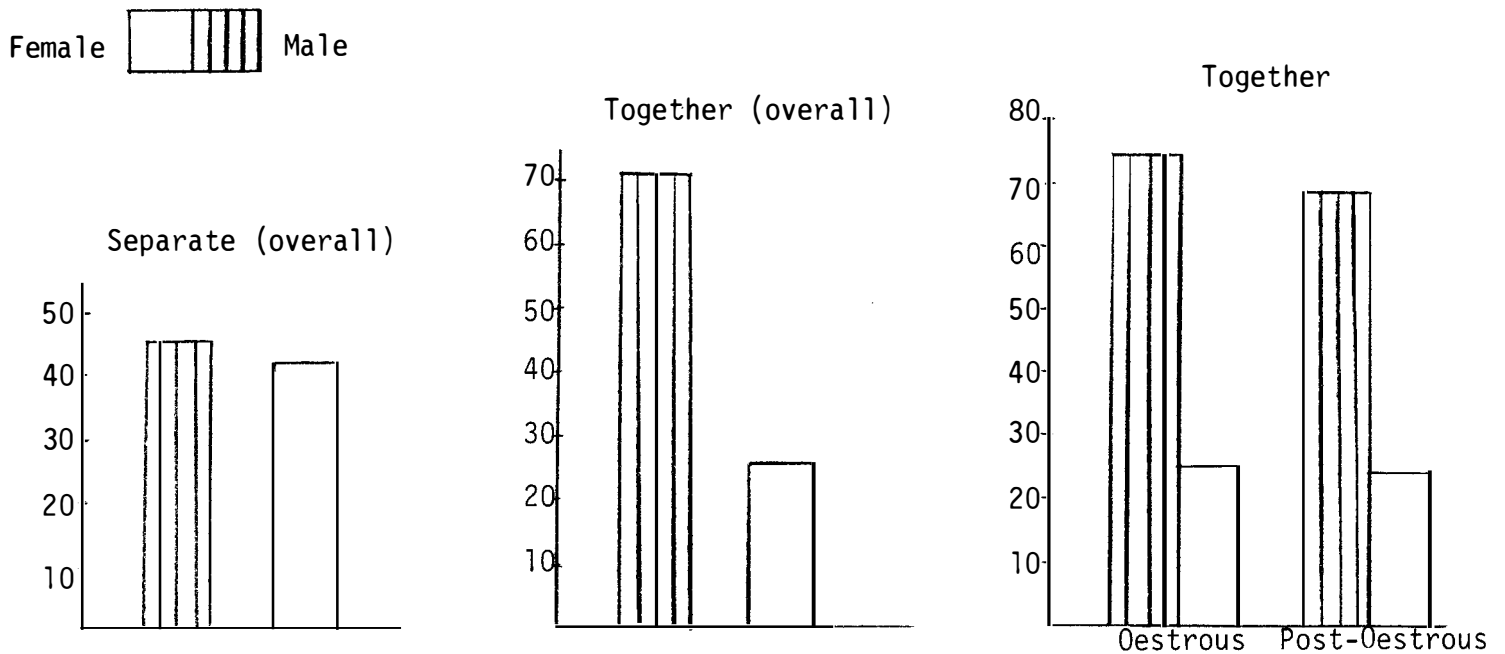


Figure 6. Mean activity levels in relation to enclosure conditions (male and female). Separate--center fence gate closed; together--center fence gate open.

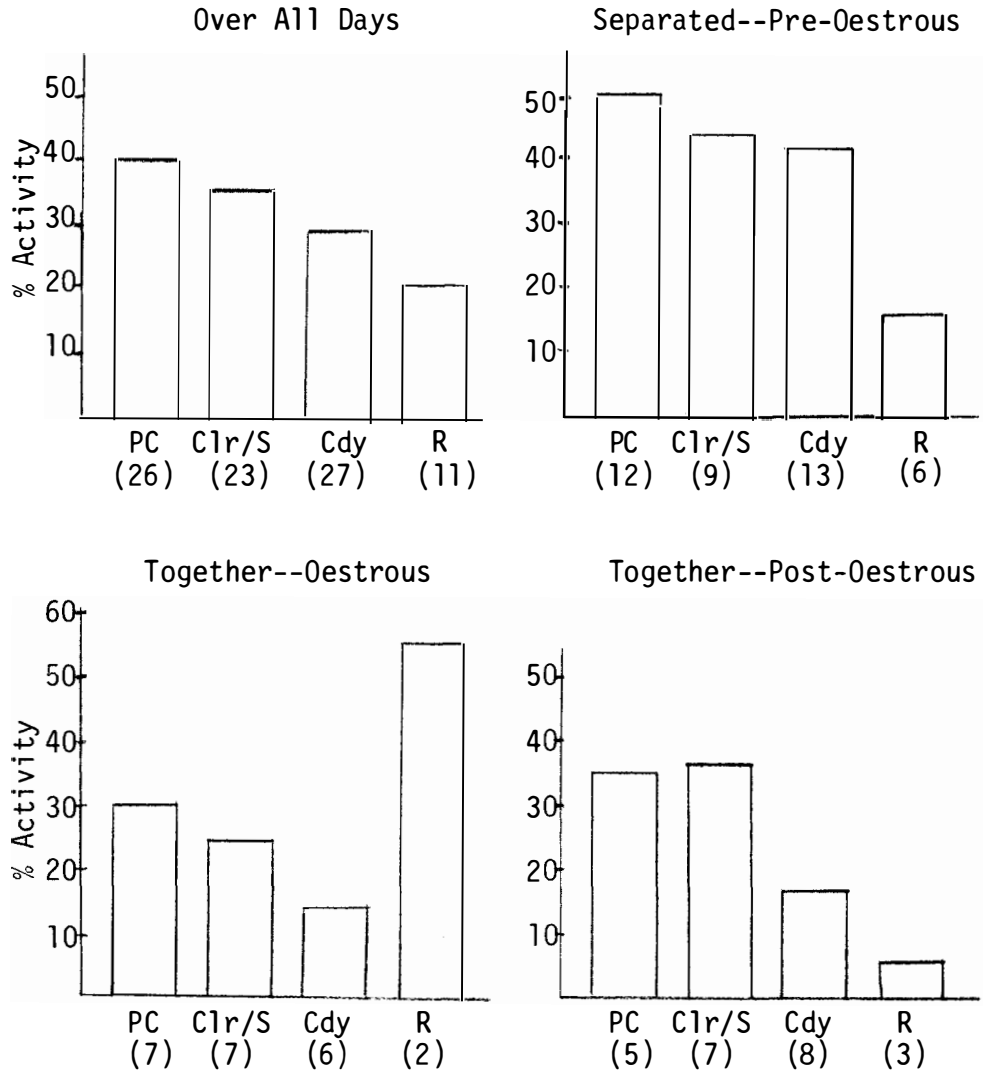


Figure 7. Mean activity levels in relation to weather conditions, considering stage of oestrous cycle (female).

Key:
PC - Partly Cloudy
Clr/S - Clear/Sunny
Cdy - Cloudy
R - Rain

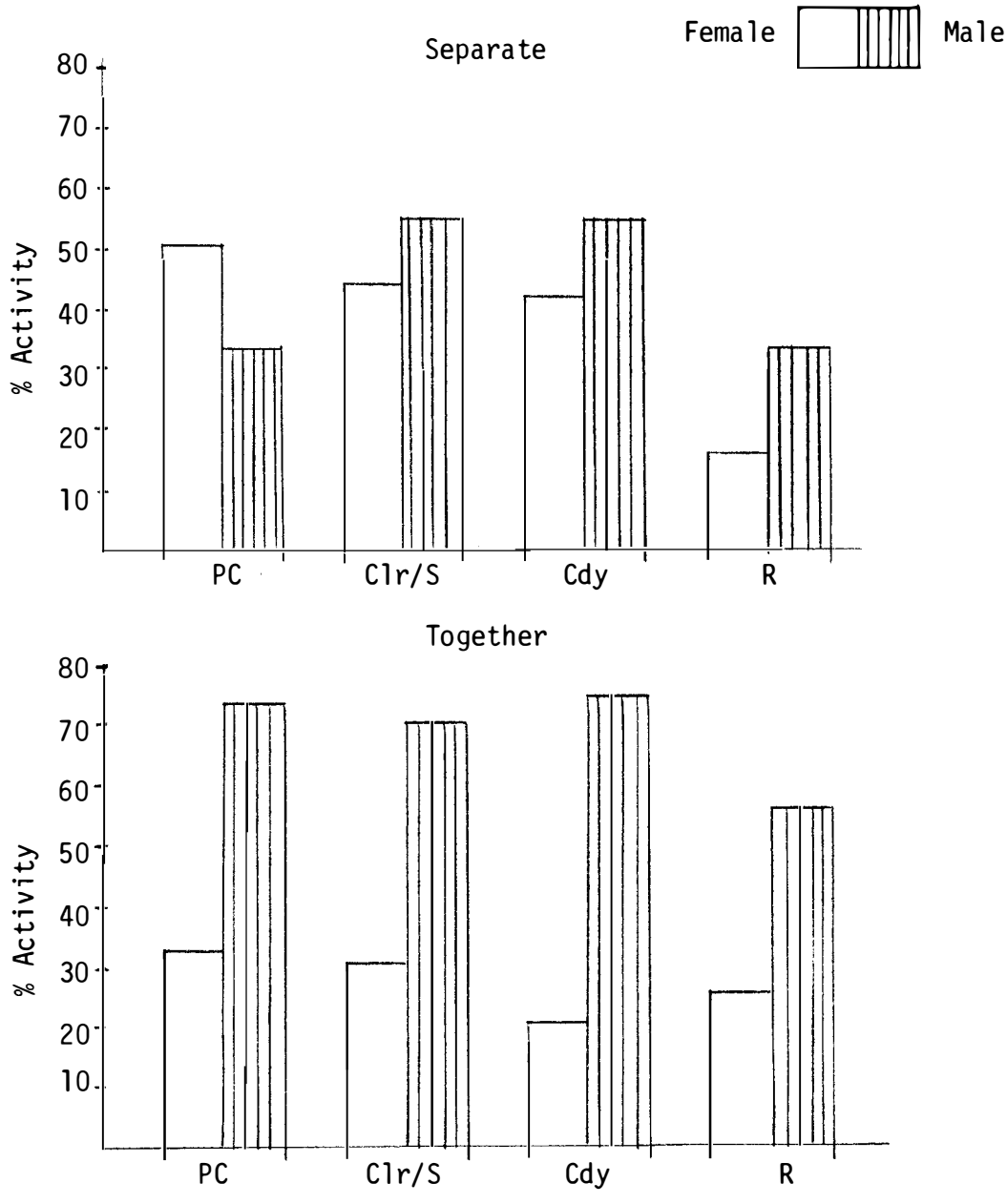


Figure 8. Mean activity levels in relation to weather and enclosure conditions (male and female).

Key:
PC - Partly Cloudy
Clr/S - Clear/Sunny
Cdy - Cloudy
R - Rain

activity as seen in the preceding period was continued. From Figure 5, it appears that the male's activity increased as the female came into oestrous, and then decreased as her oestrous cycle was completed. For the female, it was the reverse, with her activity decreasing with onset of oestrous, and increasing after oestrous. However, these results are confounded by the variable of separate-together. The two bears were kept separated, in different sides of the enclosure, until Kate came into heat, whereupon the center fence gate was opened and the bears could be together. And, looking at Figure 6, which shows the differences in overall activity for the separate-together conditions, it becomes apparent that *this* variable had the greatest effect on the activity of the male and female. Furthermore, looking back at Figure 5, the last entry (i.e., for the observations during August 3-8) indicates that the activity of both bears increased after Post-oestrous 2. In fact, for both the male and female, their activities during this time were greater than at any previous level. As mentioned earlier, this may have been due to acclimation: for the male, in relation to the enclosure and the presence of the female; and for the female, in relation to the presence of the male.

Other, "non-locomotor," activities were also recorded for each bear. The five categories (scr, SC, SA, eat, drink) are not mutually exclusive; that is, the bear could scratch and sniff close, or scratch and eat, at the same time. Nonetheless, rough estimates of the percentage of time engaged in such activities are given in Table 2. The data are separated into six oestrous periods for both the male and female. The female showed more non-locomotor activities than the male, spending about 20% of the time scratching, 20% sniffing close, less than 10%

TABLE II

ACTIVITIES (% TOTAL TIME) DURING PRE-OESTROUS, OESTROUS, AND POST-OESTROUS, MALE AND FEMALE

	Active	Scr	SC	SA	Eat	Drink	f Number of Observations
Female							
Pre-oestrous							
1. 6/18-6/23	30	11.1	24.7	2.2	10.7	1.0	12
2. 6/24-7/1	40	19.1	30.2	4.6	11.4	.4	14
							26
Oestrous							
1. 7/3-7/9	26.6	16.5	24.2	2.0	6.4	1.0	10
2. 7/10-7/15	34.0	20.4	17.9	1.0	.31	1.0	15
							25
Post-oestrous							
1. 7/16-7/26	11.4	23.2	21.9	1.0	.03	.11	13
2. 7/27-8/2	40	21	15.4	1.2	1.0	.22	7
							20
8/3-8/8	51.7	23.7	16.1	.56	1.1	1.5	4
Male							
Pre-oestrous							
1. 6/18-6/23	44.4	.03	.03	.03	.89	2.0	12
2. 6/24-7/1	66.9	.1	.14	.28	1.25	3.5	14
							26
Oestrous							
1. 7/3-7/9	78.6	0	.7	.3	1.2	2.2	10
2. 7/10-7/15	69.6	.4	1.4	.51	1.5	2.9	15
							25
Post-oestrous							
1. 7/16-7/26	81.1	.33	.93	.34	1.1	0	13
2. 7/27-8/2	51.3	1.1	1.4	4.2	.42	0	7
							20
8/3-8/8	93.9	.3	1.1	.8	1.5	1.1	4

eating, and less than 5% drinking and sniffing the air. (For the male, time spent engaged in these activities was less than 5% for every category.) Changes in the levels of these activities in relation to the weather and separate-together conditions are shown in Appendix B and C; time spent engaged in these activities is similar to that represented above.

In conclusion then, it is not possible to separate all of the variables. However, the import of one variable over another, in its effect on activity can be suggested:

1. The male's locomotor activity was greater than the female's in most cases; however, the female's non-locomotor activity was greater than the male's, with most of her time being spent scratching or investigating the enclosure (sniffing close).
2. Weather conditions may affect the movements of the bears, but the bears are not necessarily least active during rain.
3. Bio-cyclical events, such as the female's oestrous cycle, may have altered the activity of both bears (although this was confounded by other variables).
4. The separate-together condition seemed to have the greatest effect on the activity of both bears; when free interactions between the male and female were possible, activity levels changed: the male's activity increased and the female's decreased.

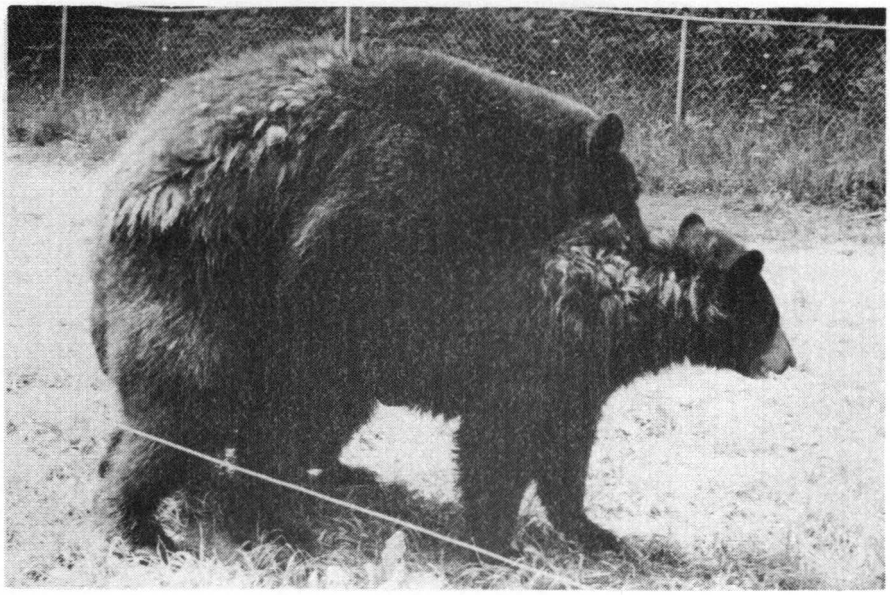
Breeding and Male-Female Interactions

On July 2 and 4, breeding activity was observed and filmed at

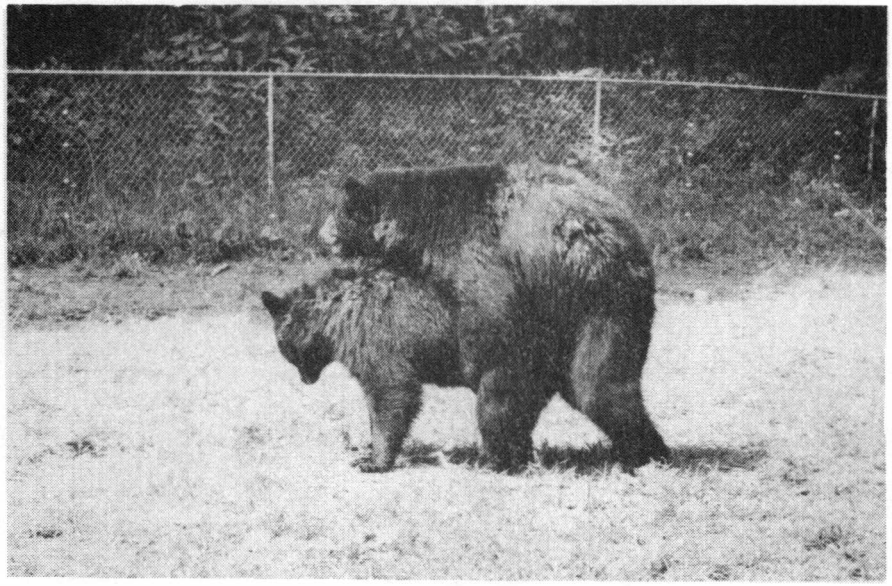
Goldrush Junction, with the assistance of Bob Jordan. Since the reproductive behavior of black bears has not been documented in the past, the terms used in the present report are adapted from studies on other mammals (England et al., 1971; Christie and Bell, 1972; Ewer, 1973).

The Goldrush female was receptive to the male on both July 2 and 4; however, by July 9, male-female interactions of any sort were at a minimum. The following observations of the breeding activity have been made from reviewing films, slides and written records. Once receptive, it appears that the male and female show little courtship behavior prior to copulation. The male approached the female, sniffing the ground by her, and then sniffing and/or licking her head, trunk, and external genitalia. This is usually accompanied by a distinct tail lift by the female. The mount was initiated from an angle with one paw placed mid-way up her back. The male then grasped her stomach with both forepaws and lifted himself up on two legs. The mount was often accompanied by a neck bite, with the male grasping the female just behind the ears, and to one side (Figure 9a). The neck bite was intermittently renewed throughout the copulation. Occasionally the male would bite the female's face. When the male was not neck-biting, his head was either resting on the female's back, pressed against her side, hung down near her side, or held above her back (Figure 9b). The female did not remain stationary for the entire copulation, but moved almost every minute, and walked several yards every few minutes. The female both initiated and returned bites towards the male, biting his ears, head or forepaws. While mounted, she might look around, sniff the ground, eat grass, drink water, or stand still with her head up.

After mounting, the male assumed an arched position with both



(a)



(b)

Figure 9. Goldrush Junction bears in copulatory position.

(a) Neck-bite; (b) Head above back.

forepaws pressed in against the female's pelvic area. His hind legs were usually bent somewhat, although on occasion he would stretch them back and out, or go up "on his toes." Once mounted and positioned to the center of the female's back, he began pelvic thrusts, occasionally varied by circular movements. These continued whether the female was stationary or moving. After several minutes of copulation, the male might remove one forepaw and either hang it down by the female's side, rest it on the ground, or place it on her back. While standing, the female's legs were in a braced position, but her back appeared to be slightly arched. Both bears showed heavy panting during the mating and both stood, at times, with their mouths open. On one occasion, the male stood on only his left hind foot while resting (?) on the female.

Of the seven mounts observed, three were timed and their durations were 3 minutes 10 seconds, 21 1/2 minutes, and 29 minutes. (The shortest duration occurred after the copulation of 21 1/2 minutes.) It is impossible, at present, to determine when intromission and ejaculation occurred. However, during one copulatory sequence the male was mounted on the female and seemed to quiver every 25 to 30 seconds. He "hung" on to the female until the quivering began, then grasped her in the pelvic area and arched his back. (This copulatory period lasted 29 minutes.) The intervals between the quiverings were timed, and the mean duration was 30.2 seconds. This particular behavior was observed only once, and no further mating occurred on this day. Meyer-Holzapfel (1957) reports that it is during this span of time (when the quivering is seen) that the ejaculation of sperm occurs.

Copulation was terminated on all occasions observed by the female

walking and the male "standing down." The male then sat down or lay flat on his side. Several times he walked to the stream and lay in it for up to 10 minutes. The female was more active than the male after mating, walking around the enclosure, sniffing the ground or the male.

On June 4, the female was observed with her hindquarters quivering. This occurred after copulation, while she was walking around the enclosure, standing or lying down. When this occurred while walking, she would stand, with apparent muscle spasms twitching her body from the pelvic area back. After this happened while she was lying down, she would rise and walk a few feet. At times her back legs were extended far outward and back (stiff), and during one post-copulatory sequence her hind legs gave way five times.

Three of the films were analyzed by noting what behavior was occurring at every tenth frame. (See summaries in Appendix A.) The first two films were of copulation. It can be seen that during the earlier parts of mating, the male bit the female more and held his head down by her side more often; in turn, the female stood still more often while mounted. During the later parts of copulation, more frequent behaviors were the following: the male rested one paw on the ground or by the female's side, and he placed one or both paws up on the female's back; the female walked and sniffed or scratched the ground while mounted. The third film is representative of post-copulatory behaviors. There was one attempted mount, during which the female walked most of the time; this ended with the male pulling the female to the ground, with both bears biting each other's head. Thereafter, the male lay flat on the ground and the female appeared restless--lying down and then walking around. It was during this time that the female exhibited quiverings

or muscle spasms of her hindquarters.

The mating of black bears appears to be very similar to that of the brown bears, as described by Meyer-Holzapfel (1957): mating foreplay involves licking the female's face and sex organs; actual mating lasts about 20 to 30 minutes; copulation occurs on several successive days; and when the female is no longer receptive she moves away from the male.

In general, then, the mating behavior of ursids is similar in some ways to the canids (the mount and the pelvic thrusts) and in others to the felids (neck bite). It is suggested that the duration of a successful mount and intromission is about 20 to 30 minutes (the duration of the male's quiverings). Copulation occurs while both animals are standing, and there does not appear to be a copulatory tie (as in canids, where the male and female stand for over 10 minutes in a locked position). However, Meyer-Holzapfel (1957) reports that "the bear has a penis bone which maintains the joining of the pair for a relatively long time and makes the separation difficult" (p. 186). These observations are in accordance with those collected by Mundy and Flook (1964). Muscle spasms of the female's hindquarters may have been due to exhaustion. Vocalizations are few, and only occur in conjunction with neck biting. This is not unusual, because the black bear is basically a solitary animal (Matson, 1967; Ewer, 1973); intraspecific contacts are kept to a minimum except for mating and raising cubs (Dufresne, 1965; Matthews, 1969). Males do not participate in the parental responsibilities, and have been known to show cannabalism towards their own cubs (Hediger, 1950). An extensive array of vocalizations between the male and female would not be adaptive.

The interactions between the Tremont male and female were predominantly aggressive. Only one attempted mount was observed and this was incomplete; the female lowered her hindquarters, pulled down her tail and finally walked away. On several occasions the male approached her, sniffing the air; one time he sniffed her head while she was eating and on another, he sniffed and licked her external genitalia while she was lying flat. However, at no point during the summer was the female receptive to the male. The interactions were more often agonistic. On the first day together, the male slapped and bit the female's head when she blocked passageway through the center fence gate. There were several vocalizations including, for the male: roar, jaw pop, lip smacking; and for the female: whine and jaw pop (Jordan, in preparation). In late July, the female often charged the male with jaw popping, but only while he was walking away from her. Throughout their time together, the female would whine as the male approached her, with very few exceptions. Thus, when a female is non-receptive, vocalizations may be more important in rejecting a male.

CHAPTER IV

CONCLUSION AND SUMMARY

In studying the diurnal activity of black bears the approach taken here was a scan sampling technique of the behaviors of a captive male and female bear. Although differences in their overall activity were evidenced, no cyclical changes were obvious. Weather conditions, the (female's) oestrous cycle and the social situation (with male or separated) affected the various types and amounts of activities observed. Only one other author has attempted to observe black bears for an extended period of time, to determine diurnal and nocturnal activity peaks (Frame, 1967). His method, however, was based on a number of bears (Alaskan black bears) observed feeding on salmon at tidal flats; hence, he was measuring feeding activity, which could be non-locomotor. His results were also influenced by cycles of high and low tides, but no report of weather effects were noted. The peaks in activity found in that study were from 3:00 to 5:00 A.M. and from 4:00 to 8:00 P.M. with a relatively constant, low level of activity between those two time periods. General discussions of the black bear's activity are more common. Erickson (1965) has stated that males are more active than females. Similarly, Van Wormer (1966) lists the male's range as having a 15 mile radius, while that of the female is only a 10 mile radius. Furthermore, whether the black bear is primarily nocturnal or diurnal is still disputed; the author has recorded diurnal movement of bears during the summer in GSMNP: of six bear sightings, five were during the daylight hours--and, except for one female with her cub, all bears were alone.

Seton (1954), however, indicates that the bears prefer twilight and only travel by day or dark nights occasionally.

Activity studies on other mammals have considered even more variables that affect an animal's movement. Cone and Cone (1970) have found that it is easier to increase a rabbit's activity during a peak arousal period than to increase it during a low arousal period. Oldham and Morlock (1970) proved that the amount of activity in rodents is directly related to size of test area, but inversely proportional to time spent in a test area. These studies suggest that it may be difficult to control for extraneous factors influencing an animal's activity, especially for a wild animal such as the black bear for which "arousal" levels and ranges are not conclusively determined.

Breeding activities, as well, are poorly documented. It is known that the female raises the cubs alone (Matson, 1967; Matthews, 1970; Ewer, 1973). During June and early July the male and female come together for a period of about one month, during which time the male follows the "restless" female (Van Wormer, 1966).

Although both areas of the present investigation, locomotion and breeding activities, involved semi-naturalistic facilities, the behavior patterns observed may not have been altered to any appreciable extent. Squire (1971) acknowledges this fact in his reference to Scott (1969):

> It is generally recognized that a given species has a fairly limited repertoire of behavioral responses. Each species has its own peculiar basic patterns of behavior which can be partially repressed or exaggerated but not drastically altered (p. 660).

With this in mind, a summary of the present research can be informative. Confining a wild male with a hand-reared female proved to alter the activity levels of both animals, depending on whether they were

separated or together. Weather patterns, and bio-cyclical events of the female, also affected the activities of the two Tremont bears, but to assign a quantitative value to such effects will require more lengthy (in terms of days) and frequent (in terms of observations per time period) study of the bears' behaviors. In addition, the variables influencing such activity must be kept to a minimum.

Filmed and written accounts of breeding between another pair of captive bears delineated the behaviors and time periods involved. However, the mating observations cannot be generalized to all black bears until more pairs are considered and/or bears are observed breeding in the wilds.

The value of using more than one observational technique lends itself well to such a study in which details of rapid interactions, as well as time of day for such behaviors, can be recorded.

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APPENDICES

APPENDIX A

TABLE III

ANALYSIS OF FILMS #1 AND #2, JULY 2, 1973, 10:15 A.M., ON THE BREEDING ACTIVITIES OF THE GOLDRUSH BEARS

Male						Female			
Mounted	Bite Female	One Paw Down	Head Down	Paw On Female's Back	Quiver	Walk	Stand	Bite Male	Head Low
				Film #1					
361	66	6	43	20	--	124	237	1	43
				Film #2					
359	25	16	20	54	25	147	212	1	56

Activity at every tenth frame is recorded as totals for each film. Films #1 and #2 are continuous sequences.

TABLE IV

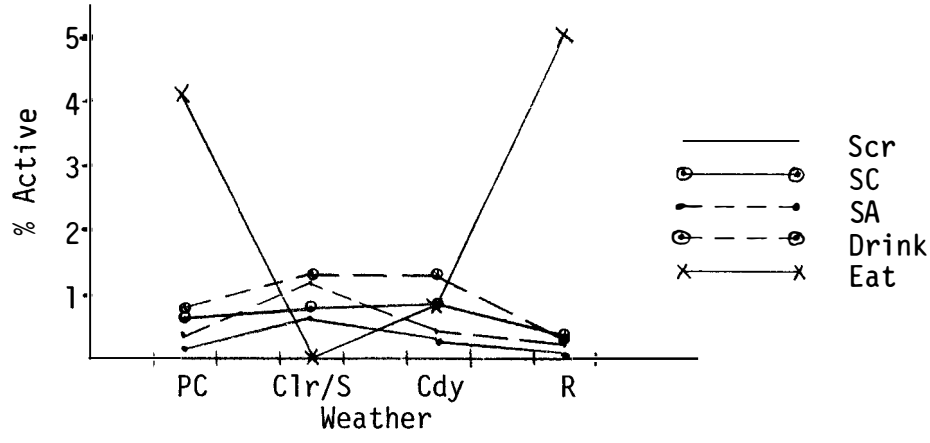
ANALYSIS OF FILM #3, JULY 4, 1973, 10:30 A.M., ON THE BREEDING ACTIVITIES OF THE GOLDRUSH BEARS

Total # of 10th frames viewed	Male				Female										
	Mount	Follow	Bite	Ly	Mounted w	Mounted st	W	St	Ly	Sit	Bite	SC	Tail lift	Quiver	Str
37	16	1	18	2	14	3	9	5	3	1	6	8	2	--	--
33	--	--	--	33	--	--	12	4	3	15	--	13	--	--	--
22	--	--	--	22	--	--	--	--	22	--	--	--	--	22	--
40	--	--	--	40	--	--	--	--	40	--	--	--	--	11	5
27	--	--	--	27	--	--	10	4	12	--	--	1	2	--	--
120	--	--	--	120	--	--	6	74	--	42	--	29	--	4	51

Activity at every tenth frame is recorded as totals for the film; film #3 shown as six sequences. Total frames in film #3 = 3120.

APPENDIX B

Male: Other Activities and Weather



Female: Other Activities

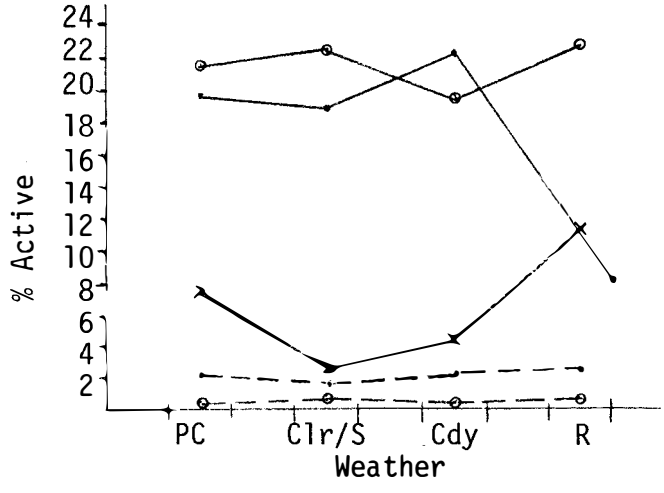


Figure 10. Changes in levels of non-locomotor activities in relation to weather conditions.

Key:

PC - Partly Cloudy
Clr/S - Clear/Sunny
Cdy - Cloudy
R - Rain

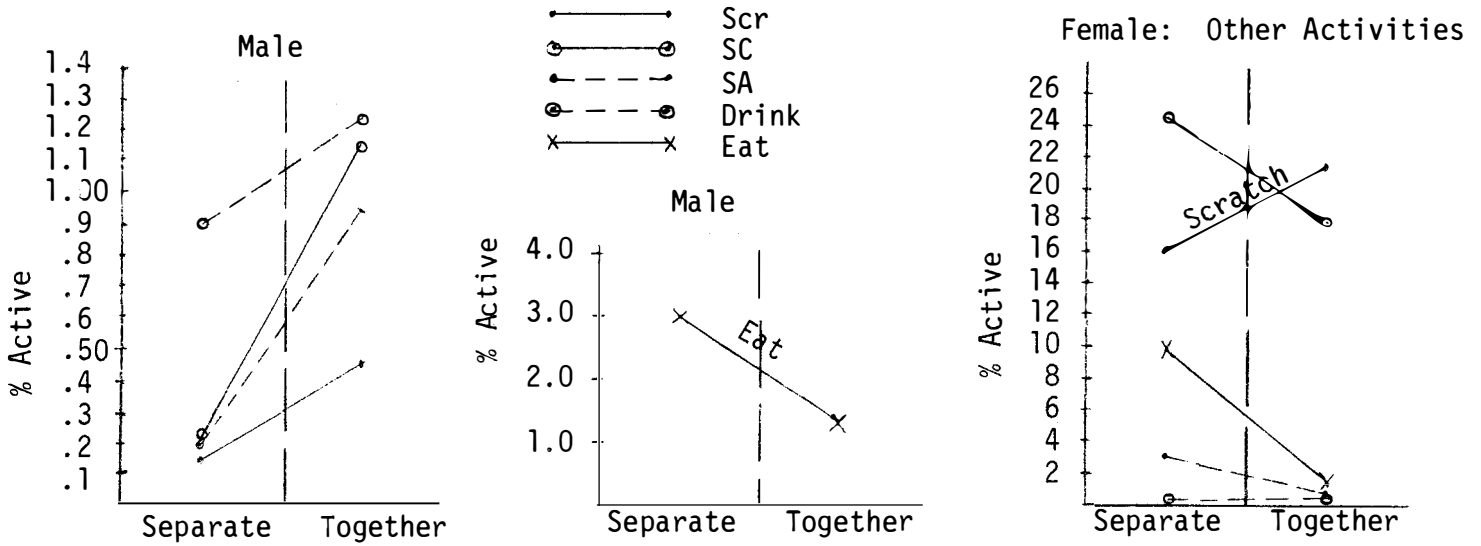


Figure 11. Changes in levels of non-locomotor activities in relation to separate-together conditions.

VITA

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