TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCE

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Abstract

Telemetry from confined and free-roaming elk (Cervus canadensis) carrying implanted transmitters and neck collar repeaters showed immediate and readily discernable responses in heart rate due to activity and human disturbances. Close-range gunshots and humans on foot consistently produced more reaction than moving automobiles, motorbikes, and low flying aircraft.

Harassment of big game animals is becoming a larger problem as human use of our native ranges increases. An animal's response to harassment can either be considered "active," resulting in immediate flight, or "passive" when the animal is only alerted. Earlier studies by Ward et al. (1973) and Ward (1976) used ordinary tracking telemetry to detect "active" responses. The heart rate monitoring system use in more recent studies allows the collection of both "active" and "passive" responses. Either response may be detrimental to the well-being of the animal because of increased energy consumption (Horejsi 1976).

The heart rate telemetry system proved to be a practical field method to obtain qualitative and quantitative data on the effect of human disturbance on behavior of wild elk. The equipment has been modified for use with other big game and domestic animals. The technique provides substantial advantages over previous techniques; elements are not attached to the skin of the animals, and animals do not have to move long distances or be seen to determine response.

During the summer of 1975 and fall and winter of 1976, a telemetry technique was tested on two adult cows and a yearling male elk in the field on Pole Mountain just east of Laramie, Wyoming and three adult cows at the Sybille Wildlife Unit maintained by the Wyoming Game and Fish Department, to evaluate elk reaction to human disturbances by monitoring their heart rate and activity. According to Thompson et al. (1968), monitoring heart rate can provide "...a sensitive instaneous and easily recorded index to fright-induced behavior in the natural environment." In addition, Gessman (1973), Holter et al. (1976), Kautz (1978), and Moen (1978) have shown a good correlation between heart rate and metobolic rate in many homeotherms. Gessman (1973) concluded that "...heart rate is potentially the only practical method..." for estimating the metabolism of a completely unrestrained animal.

Some rapid heart rates are caused by factors such as playing and breeding. Since there doesn't appear to be a way to differentiate between these natural events and man-made disturbances from heart rate recordings, the human disturbances were introduced or observed to be taking place while the heart rate was being recorded. The problems of measuring stress by heart rate monitoring are complex and will require more study to be fully understood.

STUDY AREA

The Pole Mountain portion of the Medicine Bow National Forest in southcentral Wyoming is mostly rolling ridges with scattered escarpments and occasional patches of dense timber.

Elk have been hunted on an either-sex permit basis since 1969. Approximately 50 elk inhabitated the area (about 88 sections) during 1975, a reduction from a 1971 estimate of 150 animals. During the summer, elk concentrate in and near conifer or aspen timber. Elk behavior has been studied on this area since 1971 (Ward et al. 1973, Weeks et al. 1972; and Ward et al. 1976).

The area is a popular recreational area for activities including viewing, picnicking, camping, fishing, hunting, hiking and trail-biking. Forest Service records show that during the summer of 1975 approximately 436,000 people visited the main recreation centers, resulting in more than 100,000 visitor use days (one person for 12 hours). These totals did not include use at more remote areas.

Cattle grazing is permitted during the summer, but timber harvesting is not allowed.

METHODS

A heart-rate and activity-monitoring telemetry system (Cupal et al. 1976, Weeks et al. 1977) was installed on the test elk. The system consisted of an implanted heart-pulse transmitter, a repeater neck collar for long-range transmission of heart-rate information and a data recording system (Cupal 1977) at the receiver. With this system, analog recordings of heart rate and received signal strength were obtained. Because of the anisothropic radiation properties of the neck collar antenna, the received signal strength was modulated by animal motion. Activity could be determined from the resulting patterns.

Five types of activity were categorized from watching elk at Sybille: rest and ruminating, feeding, walking, alerted but still, and alerted and moving. Recordings for resting, feeding, and walking are shown in Figure 1. A discontinuous heart rate pattern resulted when an elk lowered its head to graze. The repeater slid down the neck of the animal, and the implant signal was lost due to excessive separation of the repeater from the collar.

With the use of the heart rate-activity telemetry system, we were able to determine the relative reaction of elk to different disturbances under field conditions. The reactions of the test elk to five specific test situations will be discussed, namely: gunshots and people, trail bike, traffic, airplanes, and cattle and mule deer.

The elk at Sybille were held in small fenced pastures and provided supplemental feed. They were accustomed to having people and vehicles near and were observed mainly to obtain ground truth information on heart rate changes caused by being observed. The first 2 cows, instrumented in February and March 1975 were monitored only a few days. One system had power problems, and the other came out from under the skin because of poor sutures. The third cow provided heart rate signals from May 26 to September 22, 1976.

The yearling bull (1) on Pole Mountain was captured and instrumented on May 27, 1975. Heart rate data were obtained from this elk until July 23 (2 months), at which time the transmitter failed. The lead wires from the sternal electrodes probably broke as a result of rapid body growth. The tracking signal continued to operate until the elk was shot by a hunter on November 20, 1976. This elk was seen 33 times with an average of 4 other elk and as many as 18. He was observed alone seven times.

Cow 6, trapped and instrumented on August 15, 1975, had a calf that stayed with her constantly until she was shot on the opening day of elk season, October 28 (2.5 months). This elk was observed 13 times with an average of 4 other elk and as many as 12. She and her calf were seen alone on four occasions. The heart rate transmitter was operating the day she was killed.

Cow 8, trapped and instrumented on October 5, 1976, was not seen with a calf the first winter, but had a calf in early June 1977. Heart rate data were obtained from this animal until February 6, 1977 (4 months) and the tracking signal continued to operate until March 1978. This elk was observed 27 times throughout the 17 months with an average of 10 other elk and was seen with 26 on October 1, 1977. She was seen alone on three occasions.

The animals were located using Telonics TR-1 receivers (Telonics, Mesa, Arizona) and Yagi antennas.[3] Observers made visual sightings and continuous recordings from prominent rock outcrops near test animals. The recorder was checked periodcially to insure radio contact with the animals by moving the recorder when the elk moved, which was a problem with the free-ranging elk.

Observers disturbed the instrumented elk on Pole Mountain 344 times, most during daylight rest periods, because the heart rate showed a more consistent pattern and the response to the disturbance could be better documented. The elk were found in aspen or conifer cover during this time. Usually a two-man team performed each test; one attended the recorder and observed, while the second harassed the elk.

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[3]Trade and company names are used for the benefit of the reader; their use does not imply endorsement or preferential treatment.

Prior to each test, the location and activity of the test animals were determined by triangulation and listening to the heart rate. Communication was maintained using transceivers. Each disturbance event was documented by recording the time, location, and method of harassment. In some cases, the event was later repeated and sound levels were measured at the animals' bed site with a sound level meter (General Radio, type 1556-B)[3] to quantify the noise level of the disturbing event.

RESULTS

The overall active time (moving and feeding) was close to 50% of observed time as reported from other areas (Craighead et al. 1973, Stehn 1973). The daily activity patterns (Table 1) were similar to those reported by Stehn (1973) for hunted populations but distinctly different from those reported by Craighead et al. (1973) and Altmann (1952) for elk in National Parks. Altmann's elk rested for extended periods, especially at night. Our data and earlier work (Ward et al. 1973) show relatively short, alternating active and rest periods throughout a 24-hour period. Feeding activity peaked at dawn and dusk, followed by ruminating and resting periods. Elk moved and fed even on very dark nights.

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Average heart rate of all cows varied from 44 to 68 beats per minute (bpm) and ranged from 26 to 130. The spike's heart rate averaged 76 bpm and ranged from 51 to more than 140, which is about 10 bpm higher than that of the cows monitored at Sybille during the summer. The heart rates of juveniles of many other species are faster than those of adults (Altmann and Dittmer 1964).

The mean values shown in Table 1 are similar to those reported by Holter et al (1975) for white-tailed deer (Odocoileus virginianus) under housed conditions. The standard deviations reported here are much greater, apparently because these elk are free ranging.

Heart rate in elk is directly related to air temperatures. During the warmer weather of fall, 60° F (16° C) with 10 mph wind (16.1 km/hr) the average heart rate for Cow 8 while resting in shade was 45 bpm. On January 9, 1977 at -18° F (-28° C) with a 25 mph (40.2 km/hr) wind blowing, her heart rate while resting was 31 bpm. Rates for Cow 6 were about the same, going from 57 bpm at 60° F (16° C) in August to 31 bpm at 30° F (-1° C) in October. The spike did not show a significant reduction due to lower temperatures because of the early spring mild weather in June and his fast body growth at this time.

Two cows at Sybille showed resting heart rates of 33 and 31 during February and March when ambient temperatures were in the low 30° F (-1° C) range. The heart rate of the other, monitored at Sybille during the warmer weather, was observed to be much higher. The seasonal variation in mean heart rate for white tailed deer is reported by Holter et al. (1975) and Moen (1978).

Based on our data, it would appear the resting heart rate is faster to help elk stay cool in warm weather. Elk have very few sweat glands and have to cool themselves by respiration and circulation. This relatively inefficient cooling method is also the reason elk stay in the trees for shade or thermal cover on hot sunny days. In cold weather, the key to survival is conservation of heat and energy. The insulating coat of hollow hair, along with low respiration and slow heart rate, help elk conserve heat. The need for energy conservation is probably why elk are reluctant to move away from wind-protected areas or to travel long distances, particularly at a fast pace.

The actual heart rate-signal strength recordings during field tests are shown in Figures 2 and 3. In all cases, the instrumented elk and their associates were bedded in aspen prior to the harassment.

On one occasion a human on foot approached the instrumented cow and her 11 associates. The human discharged a 22-caliber pistol at the times indicated in the top trace of Figure 2. The elk apparently did not hear the first gunshot (460 m) but became alerted at the second gunshot (150 m) and possibly stood up. At this time, the human was not visible to the elk. The heart rate increased dramatically from 45 to 120 bpm within a few seconds. Finally, at the third gunshot, the elk sighted the intruder and fled, traveling 500 meters before resting. The heart rate pattern was not recorded during flight because skeletal muscle action masked the heart impulse.

Cow 6 and at least three other associates were harassed by a human riding a 100 cc trail bike past and within view of the animals at approximately 50 meters. The signal strength record (middle trace) indicates the test elk remained lying during the entire event. The heart rate peak was not as high nor as long as the response from the gunshot, suggesting the elk were less disturbed by this form of human activity. The sound level at the elk bed sites was measured later under similar conditions. The maximum sound level of the trail bike was 53 dBA, while wind noise in the aspen peaked at 58 dBA.

In a similar test, the trail bike was ridden four times within 170 meters past the spike and at least three other associates (1 bull and 2 cows) on July 3, 1975. The elk remained lying down in aspen, with no heart rate response. Finally, the elk were approached directly upwind with the motorbike. The spike got up and moved from the aspen when the motorbike was 15 meters away. The elk moved over a gentle ridge into more aspen, and the spike's heart rate returned to normal resting rate within 4 minutes. Noise levels at the bed site were 65 to 70 dBA when the trail bike was 15 meters away. Background noise from the wind in the aspen was 50 dBA. The trail bike noise was not recorded above the background until the bike was within about 50 meters of the bed sites. The trail bike and rider were not visible to humans standing at the elk bed site until they were within about 25 meters.

Cow 8 and 11 associates were located resting in mixed aspen and conifer cover on December 16, 1976. The trail bike was ridden past the elk, within 150 meters, four times. Three times there was a significant increase in her heart rate, but she did not move. Sound levels were not taken. Possibly, the motorbike and rider were visible to some of the elk. The rider, however, did not see the elk until he came out on a ridge approximately 400 meters across the canyon.

Cow 6's response to automobile traffic is demonstrated in the bottom trace. She and her associates (unknown number, but her calf, another cow, and a spike were seen with her a few days previously) were bedded in aspens and willows within 400 meters of a high-speed hard-surfaced road, and about the same distance from a dirt road. Also, a dirt trail led to within approximately 100 meters of the beds. The instrumented cow did not show a reaction to traffic on either the hard-surfaced or dirt road. The elk reacted only when a vehicle stopped at the end of the dirt trail. Even then they did not leave the timber patch, but moved about while the vehicle was close. The elk were never visible to the driver. The cow's heart rate returned to resting levels 30 minutes after the vehicle left.

In controlled tests with the 182 Cessna airplane, the two cow elk (bedded in conifers) showed no reaction to the airplane passing overhead at 150-meters elevations. Cow 6 responded only with a slight muscle artifact at 30 meters. Sonic booms, however, had a definite effect on these elk. The elk may relate this sound to close range gunshots.

Resting elk heart rate response to feeding and resting cattle and to five mule deer moving through conifers toward Cow 8 during the hunting season is shown in Figure 3. For more than 2 hours cattle rested and grazed to within 100 meters in view of five elk resting in timber. The elk showed no response. The observer was 800 meters away hidden behind rocks. Later the elk's heart rate increased very rapidly at about 11:15 a.m. Two minutes later, five mule deer came into view. Apparently the elk detected the deer about the same time that the observer saw them. The heart rate came back down, but was unstable for five minutes until the deer were out in a small park feeding within 100 meters of the elk. In another case, this same cow showed heart rate response to another elk that was not visible, but was heard moving through timber. Similar events happened with the other two wild elk on Pole Mountain and the elk at Sybille. These particular episodes are important, not only to demonstrate the reaction of elk to other ungulates, but in pointing out that heart rate can be increased by stimulus other than that which is human oriented.

CONCLUSIONS

The telemetry system proved to be a practical field method to obtain qualitative and quantitative data on the effects of human disturbance on behavior of wild elk. The equipment has been modified for use with other big game and domestic animals. The technique provides substantial advantages over previous techniques: elements are not attached to the skin of the animal, and animals do not have to move long distances or be seen to determine response.

Altmann (1952) claims elk have become extremely fearful of man, and are sensitive to potentially dangerous situations due to many years of conditioning through annual hunting seasons. This general behavior has been noted in telemetry studies of elk in relation to multiple use of National Forest lands in southcentral Wyoming (Ward et al. 1973, Ward 1976). Earlier observations and conventional telemetry tracking relied upon elk movement to determine the active (alerted) response. The heart rate system allows recording both active and passive responses. The active reaction can be evaluated on the basis of how long and how far an animal moves; the passive reaction to a disturbance is recognizable but difficult to assess.

The heart rate and movement reactions of the instrumented elk to human disturbances are summarized in Table 2. The three animals' reactions to various stimuli were combined since their reactions appeared to be comparable.

Events such as humans on foot and gunshots produced a high percentage of positive heart rate reactions, particularly if the disturbances were within 300 meters of the elk. These encounters likewise resulted in a high percentage of flight reactions. Possibly the elk's reactions are related to their past experience with hunters. An audible car horn or a stopped vehicle caused more reaction than moving traffic, either trail bike or automobile. High-speed traffic, airplanes, and distant noise from human and natural sources produced very few heart rate reactions. Altmann (1952) noted similar behavior for elk in Jackson Hole.

When elk did detect human disturbances, their first reaction was usually increased alertness accompanied by an increase in heart rate.

When a definite hazard was sensed and identified, they ran. As Table 2 shows, the alert reaction occurred at distances as far as 400 meters for major disturbances such as gunshots, humans seen on foot, and car horns. The distances which produced flight were considerably less. These data indicate the "range of disturbance" caused by humans is considerably greater than previous reports using "flight distance" techniques (Altmann 1952, 1958). In the Jackson Hole area the "object-flight-distance" in elk on free range was about 60 to 85 yards (55 to 78 m) with the wind and about 30 to 45 yards (27 to 41 m) against the wind. The range of disturbance found on Pole Mountain is comparable, however, to the "buffer zone" (distance from humans that hunted elk prefer to maintain) of 800 meters for people walking and 400 meters for moving traffice reported by Ward et al. (1973), Ward (1976) and Ward et al. (1976).

The problems associated with determining the welfare of elk in relation to increased heart rate are complex particularly when we know heart rate increases can come from stimuli within the natural environment as well as from human harassment. Response of elk can vary from a minor heart rate increase to flight, accompanied by a very high heart rate, increased respiration, and fright. Elk can run for considerable distances on some open terrain. Since heart rate is strongly correlated with metabolic rate (Kautz 1978, Gessaman 1973, Holter et al. 1975, Moen 1978) heart rate increases accompanying rapid flight indicate the use of large amounts of energy. Frequent high energy use could adversly affect animals, particularly in late winter when food is scarce and animals are not in good condition, or during the warm summer when heart rates are already higher because of temperature and the cows are nursing and bulls are growing antlers.

If the behavior of the three monitored elk and their 40 to 50 associates on Pole Mountain is typical of hunted elk throughout the West, some management implications are apparent. Although elk in other locations and having different experiences may not respond in the same ways.

Elk react most strongly to sonic booms, gunshots, people on foot, and stopped occupied vehicles. They show less concern for airplanes, steady traffic on Interstate highways, and abandoned vehicles.

In areas where elk are not able to hide or obtain security cover of trees or brush, the distances of effective response should be expected to be greater than in forested areas, particularly on open, alpine areas in early summer, or the foothills and high meadow winter ranges, and open prairie. This could have a major effect upon location of hiking trails in the high alpine areas, including wilderness areas, on elk summer range and on human activities, such as cross country sking and snow-mobiling, on elk winter ranges. Campgrounds and centers of human activities where there are people walking around should be located over 800 meters (.5 mile) from elk use areas. Roads should be hidden in the trees and routed around well used elk feeding sites.

Elk are very adaptable. Even the hunted herds of Jackson Hole become quite accustomed to people and vehicles when fed from a feed truck or a horse-drawn sleigh. Non-hunted elk in National Parks have become tame to the point of being dangerous to the park visitors. There are examples of elk survival throughout many habitats and weather conditions. The elk in each area have behavior patterns that fit the conditions. In order to maintain healthy herds, at least on the Pole Mountain area, we must provide the security required to keep them on the area.

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Table 2. Heart rate and activity response of two cows and a spike elk to disturba

(Positive if heart rate increased two standard deviations.)

Disturbances	Distance to elk (m)	Times occurred	Positive heart reaction	Times elk moved awa
Sonic boom	kms	4	3 75%	1 25
Gunshots	30 to 450	8	7 90%	4 50
	>500	9	1	
Human walking	20 to 100	10	10 100%	9 90
	100 to 300	11	9 90%	5 50
	>300	10	4 40%	2 20
Human and dog	150	2	2	2
Dog only	150	1	1	
Trail bike	15 to 50	4	4 100%	1 25
	50 to 150	5	3 60%	
	150 to 200	4	1 25%	
	>400	8	3 40%	
Auto (car horn)	35 to 800	17	9	2
Auto (stopped)	35 to 100	5	2	2
	150 to 250	7	7	2
	400 to 500	21	7	1
	>500	20	5	1
Auto (moving)	75 to 250	28	16	5
	>300	57	7	
Traffic on roads and highway	365	44	1	
Airplane	30 to 200	60	9	

Figure Legends

Figure 1. Signal strength and heart rate patterns for cow elk.

Figure 2. Activity and heart rate of adult cow elk in relation to controlled human diturbance.

Figure 3. Activity and heart rate of adult cow elk in relation to cattle and mule deer.

NO. 6 ELK
HEART-RATE, SIGNAL STRENGTH PATTERNS
DURING HUMAN DISTURBANCE

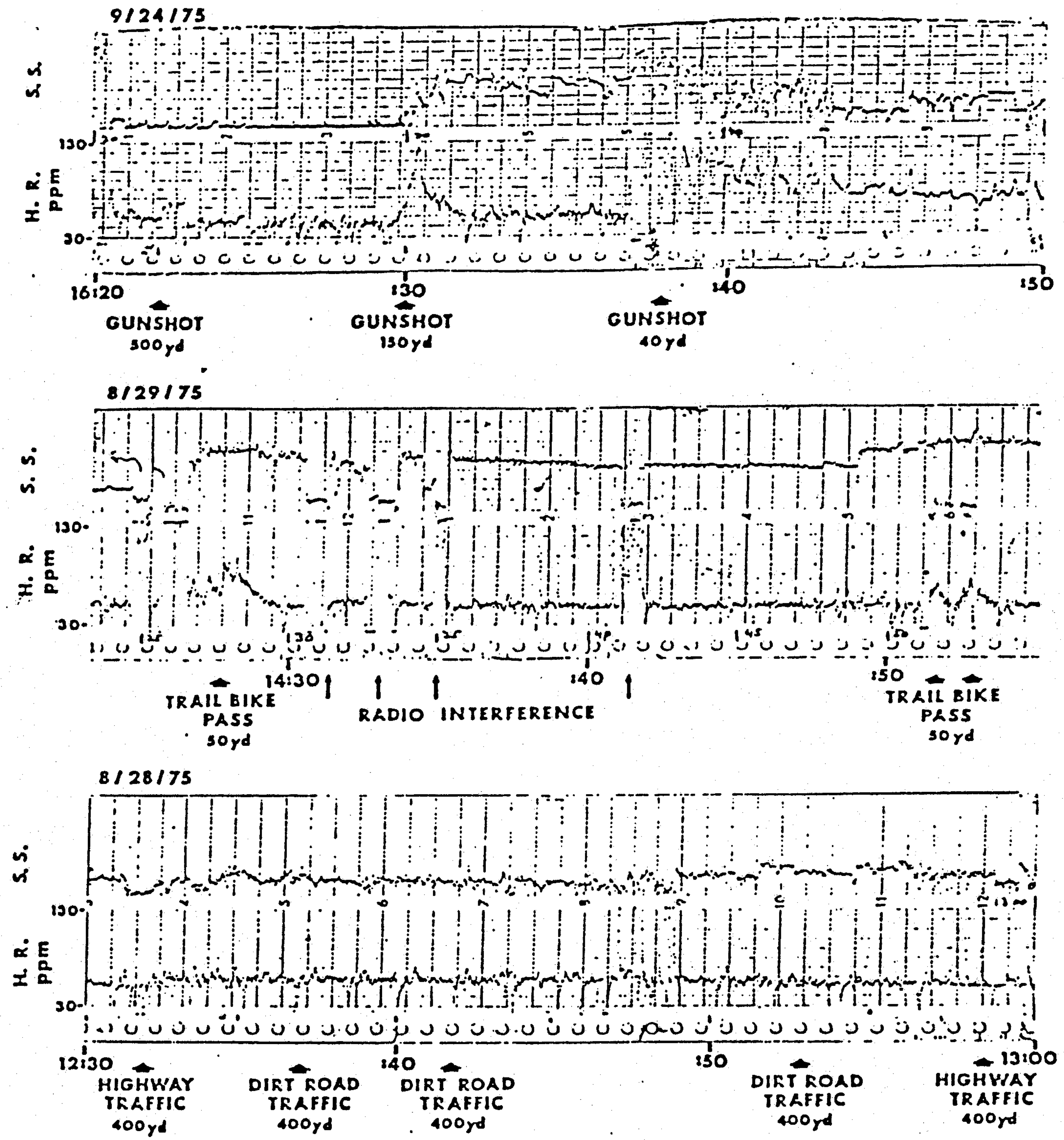

Figure 2. Activity and heart rate of adult cow elk in relation to controlled human disturbance.

COW ELK NO.8 POLE MOUNTAIN 11/7/76

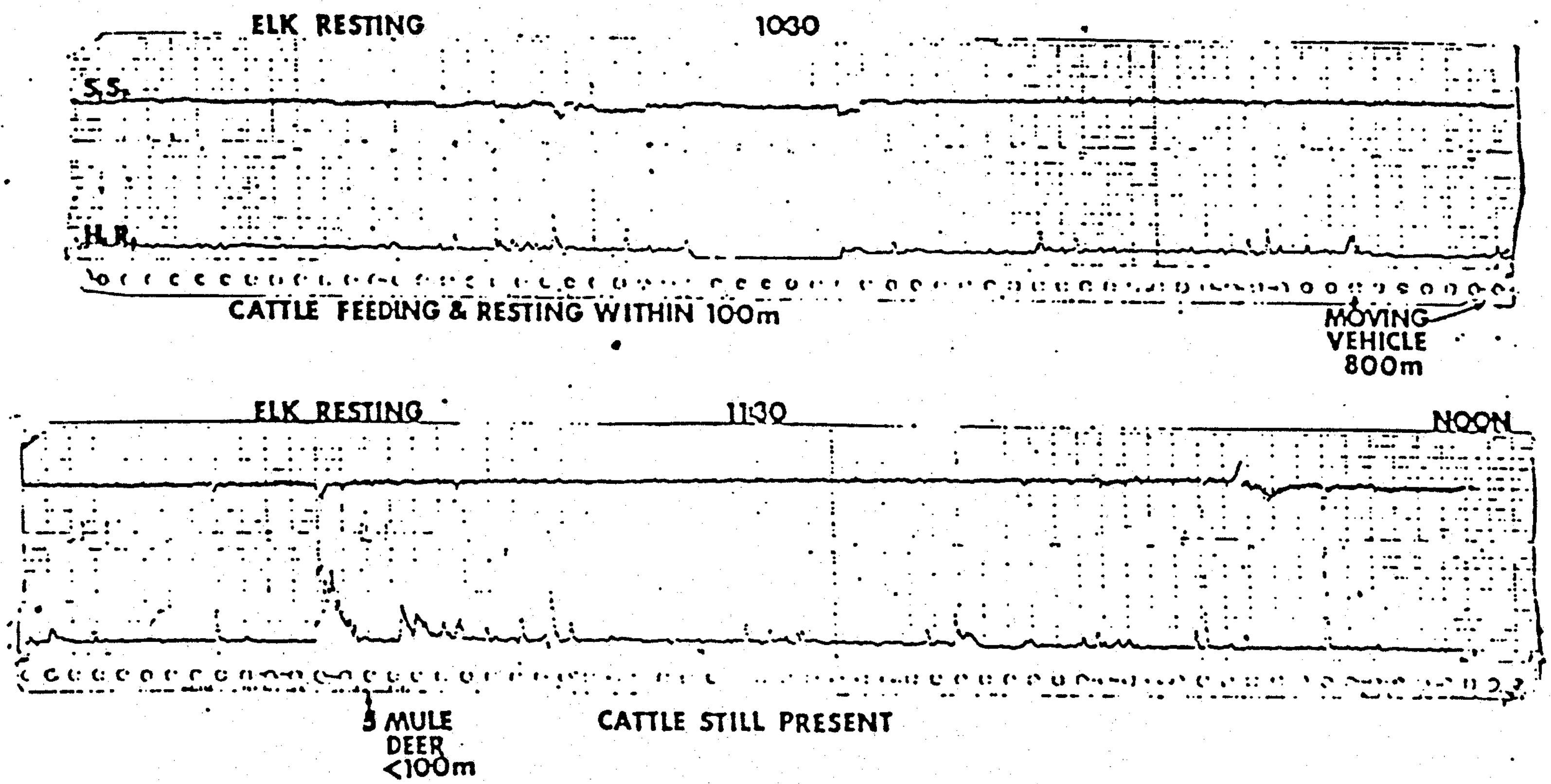

Figure 3. Activity and heart rate of adult cow elk in relation to cattle and mule deer.

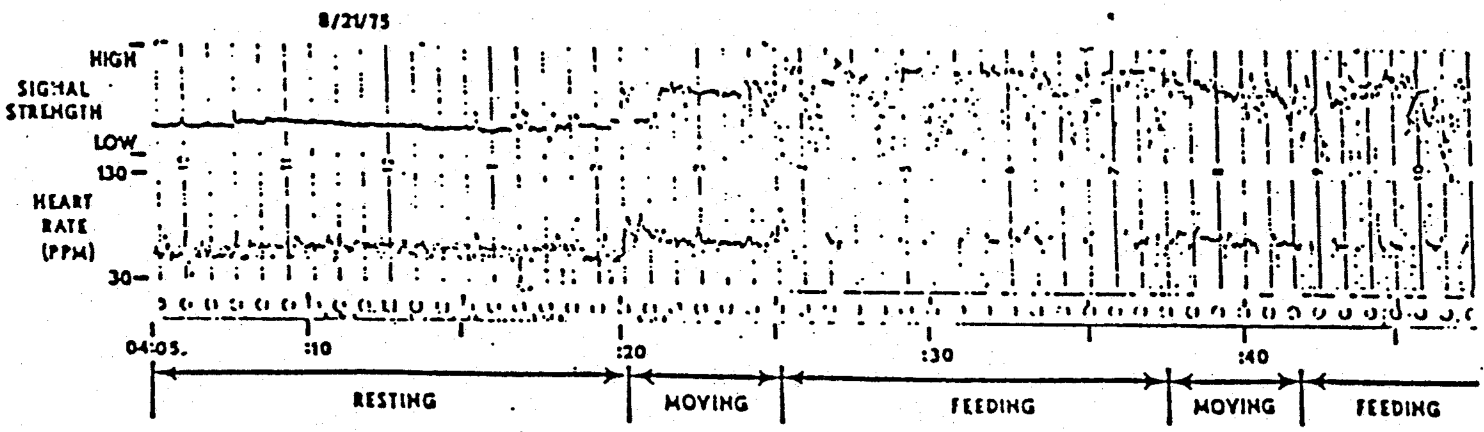

Figure 1. Signal strength and heart rate patterns for cow elk.

Table 1.--The heart rate and activity for six telemetered elk at Pole Mountain and Sybille

Elk	Place	Time of year	Hours documented	Percentage of time spent			Heart rate		
				Resting	Feeding	Moving	Resting	Feeding	Moving
Yearling	Pole Mtn.	Summer	154	56	21	23	68.3 ± 7.9[1]	84.3 ± 9.9	86.2 ± 11.0
Cow 6	Pole Mtn.	Fall	310	48	40	12	46.8 ± 8.8	60.3 ± 9.2	64.4 ± 11.3
Cow 8	Pole Mtn.	Fall-Winter	80	49	45	6	32.2 ± 2.5	48.7 ± 8.8	54.6 ± 6.2
Cow 1	Sybille	February	4	-	-	-	33.4 ± 2.0	51.7 ± 10.3	-
Cow 2	Sybille	March	3	-	-	-	33.4 ± 1.3	63.7 ± 3.8	62.8 ± 8.3
Cow 3	Sybille	Summer	112	49	43	8	58.1 ± 3.9	70.2 ± 3.0	77.0 ± 6.0

[1]Standard deviation.