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EFFECTS OF DISTURBANCE BY SNOWMOBILES ON HEART RATE OF CAPTIVE WHITE-TAILED DEER[1]

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ABSTRACT

Captive white-tailed deer exhibited increased heart rates in response to controlled tests of the effect of disturbance by snowmobiles conducted from December through March. Peak rates averaged 2.5 times pre-stimulus rates when the snowmobile moved tangentially to the deer, and 2.9 times when it circled the deer. There was no evidence of habituation, either in the magnitude of the response or in the time required for the heart rate to return to a pre-stimulus or stabilized level.

Seasonal changes in metabolism and energy-conservation adaptations of white-tailed deer (*Odocoileus virginianus*) in the winter have been observed in field and laboratory studies of deer energetics (Moen, 1976, 1978). Low intensities of snowmobile use in Minnesota resulted in a significant negative correlation between the numbers of deer seen along a 10-kilometer trail and the numbers of snowmobiles registered for travel (Dorrance et al., 1975). These authors also reported an obvious trend toward larger home ranges for the deer during periods of disturbance by snowmobiles. However, Eckstein et al. (1979) did not see differences in home-range size and habitat use with or without such disturbance. Since deer exhibit their lowest heart rates of the year during the winter, with a concomitant reduction in activity and ecological metabolism (Moen, 1978), disturbances by snowmobiles in wintering areas have the potential to increase energy expenditure of the deer, contrary to their long-term energy-conservation adaptations.

In the winter of 1976-77, a study of the heart rate and behavioral responses of captive white-tailed deer to disturbances by snowmobiles was conducted at the Wildlife Ecology Laboratory at Cornell University. Tests were made weekly from December through March to evaluate the

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magnitude of the responses and evidence of habituation to the snowmobile. Changes in heart rate were monitored by telemetry in relation to the position of the snowmobile throughout each run, and changes in behavior were observed visually.

METHODS

Some 10 to 20 deer were being kept in a 2.4-hectare yard at the Laboratory for experimental purposes. Several of these were trained to wear the equipment used to monitor cardiac activity (Moen and Chevalier, 1977). A six-month-old male was monitored through the entire study, and another male fawn was used as a companion to the experimental animal. These deer were confined to 30 × 30-meter telemetry pen of wood-slat snowfence located near the center of the yard (Figure 1). The west side of the yard was marked every 6 meters so the position of the snowmobile in relation to the pen could be observed from the mobile research unit which housed the telemetry receivers and recorders. A large window allowed constant observation of the monitored deer, and they could see the snowmobile and the other deer in the yard at all times during the test runs as their vision was only slightly impaired by the wooden slats in the snowfence.

Tests were conducted one day each week when snow was present (13 of 17 weeks) between December 2 and March 24, starting at 9:00 a.m. They were made on three separate, parallel trails (T_1, T_2 and T_3) that were 40, 20 and 2 meters, respectively, from the telemetry pen when directly opposite it (Figure 1). Beginning at Points A_1 - A_3, runs included passes to the far end of the yard at Points E_1 - E_3, and returns to the starting points. A fourth run began at Point A_3 and circled the pen. Velocities of the snowmobile varied with snow conditions, maximums of 30 to 40 m.p.h. being reached between Points B and C on the initial pass and between D and C on the return. However, although tests were conducted during all 13 weeks, some runs did not yield usable data because static from outside sources (such as a tractor, airplane or radio station) disturbed the operation of recording equipment. The number of runs on each trail that did furnish usable data varied from 9 to 11.

Pre-run heart rates were recorded prior to any preparations for each day's tests when possible. The snowmobile was then brought through the gate and heart rates were again recorded, following which the runs were made. Runs were not started until the heart rate had stabilized or reached the pre-run rate after a response to a previous stimulus or run, and the time required for such recovery was recorded in each case. Measured heart rates were evaluated on a second-to-second basis for each run, and rates were expressed as beats per second.

An average heart rate for each run was calculated, and the highest rate, reached when the snowmobile was closest to the deer (Point C) on the in-

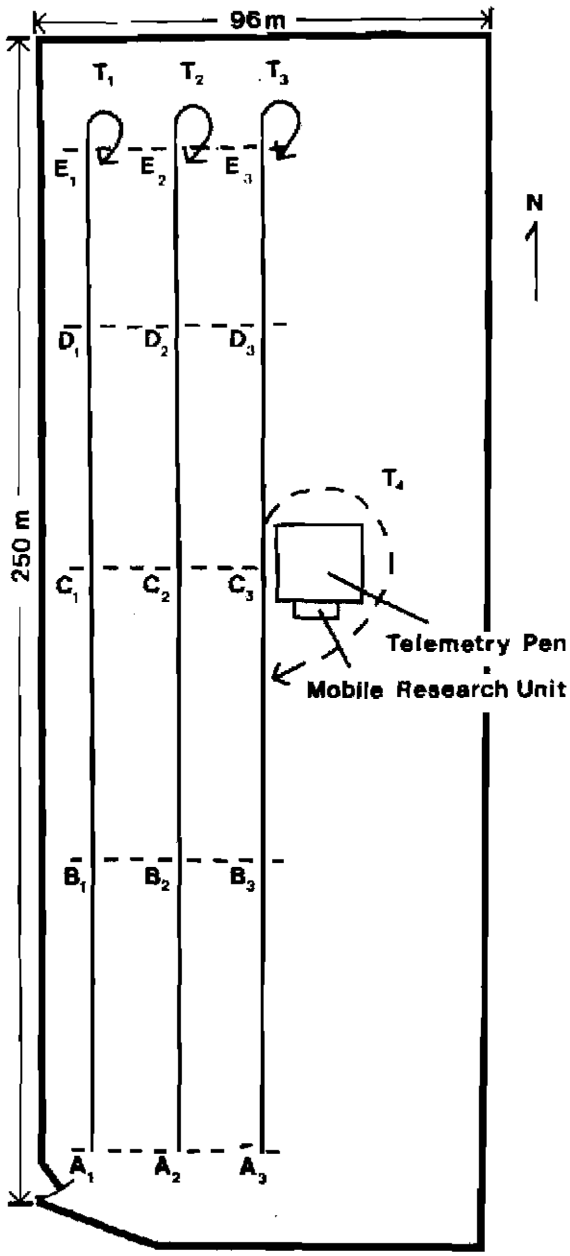

Figure 1. The deer yard showing position of the telemetry pen and the trails used for snowmobile runs as referred to in the text.

itial pass up the trail, as well as the next highest, which generally occurred when the snowmobile was closest to the deer on the return, were determined. The highest and next highest peaks were called the primary peak and secondary peak, respectively. Muscle artifacts made it impossible to read the signal for seven secondary peaks (see Table 1). Each of the two peaks and the average rate for each run were expressed as multiples of the predicted pre-run rate to account for seasonal rhythms in the heart rate (Moen, 1978). The pre-run rates, which it was possible to measure prior to any preparatory activities on only some of the days, were used as a baseline because they did not differ significantly (t = 0.15, d.f. = 15) from those predicted with equations given by Moen (1978) for various activities on the test days.

RESULTS

Heart rates, measured on a second-to-second basis, were dynamic as illustrated in Figure 2 for a 46-second run on Trail 1 and a 30-second post-run period. Changes in activity from walking to standing to running were accompanied by an increase from 115 beats per minute during the pre-run period to 209 b.p.m. (primary peak) in 16 seconds, followed, as the snowmobile moved away from the deer, by a rapid decline to a low of 123 b.p.m. 10 seconds after the peak. A similar pattern occurred as the snowmobile returned; the heart rate reached 180 b.p.m. (secondary peak) when the machine was closest to the deer, declined momentarily to 143 b.p.m.,

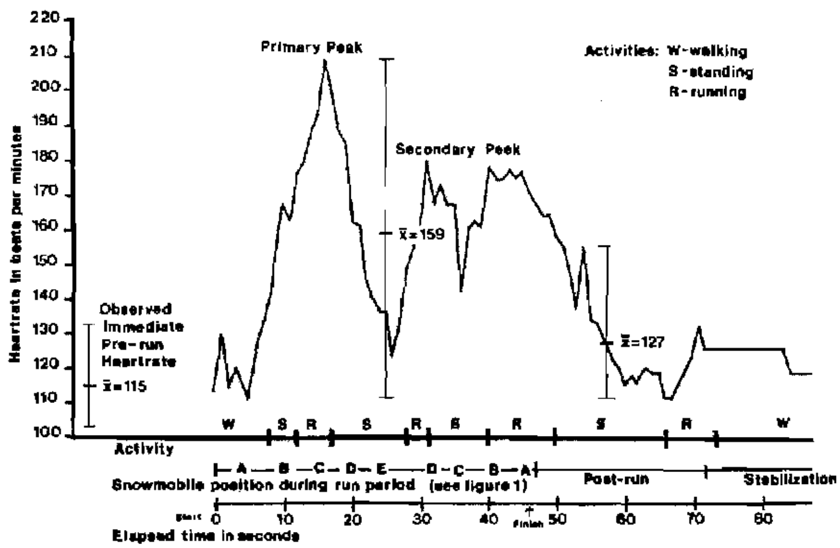

Figure 2. Rapid change in heart rate in relation to position of the snowmobile during one of the test runs.

TABLE 1. AVERAGE VALUES* FOR THE HEART RATE OF THE DEER STUDIED, WITH RESPECT TO THE MAJOR INDICES RECORDED DURING EACH RUN OF THE SNOWMOBILE, FOR EACH TRAIL AND ALL TRAILS COMBINED

Index	Trail 1		Trail 2		Trail 3		All trails combined§
	Number of runs	Average value	Number of runs	Average value	Number of runs	Average value	
Primary peak	12	2.62	12	2.44	12	2.44	2.50
Secondary peak	9	1.78	9	1.57	11	1.80	1.72
Average rate†	. .	1.63	. .	1.55	. .	1.64	1.62

*Figures represent multiples of the predicted pre-run rate in each case, i.e., the rate actually recorded divided by the pre-run rate.

§Does not include Trail 4.

†Average of the averages for the complete individual runs.

then fluctuated around 175 b.p.m. for 6 seconds as the machine returned to the starting point, and stabilized at 118-125 b.p.m. 25 to 30 seconds after the run was over. The pattern of heart rate response shown in Figure 2 was typical of nearly all those recorded during the runs observed.

The average values, in terms of multiples of the predicted pre-run rates, for the primary peaks, secondary peaks and the over-all average rates for the runs recorded on each trail are given in Table 1 together with the average for the three trails combined in each case. For none of the three multiples was there a significant difference between the trails. The data for the three trails combined are shown graphically in Figure 3.

Heart rates were higher when the snowmobile circled the telemetry pen on Trail 4 than when it passed by on the other trails. For the primary peak, the average multiple value was 2.87, significantly higher ($P < 0.01$, t =

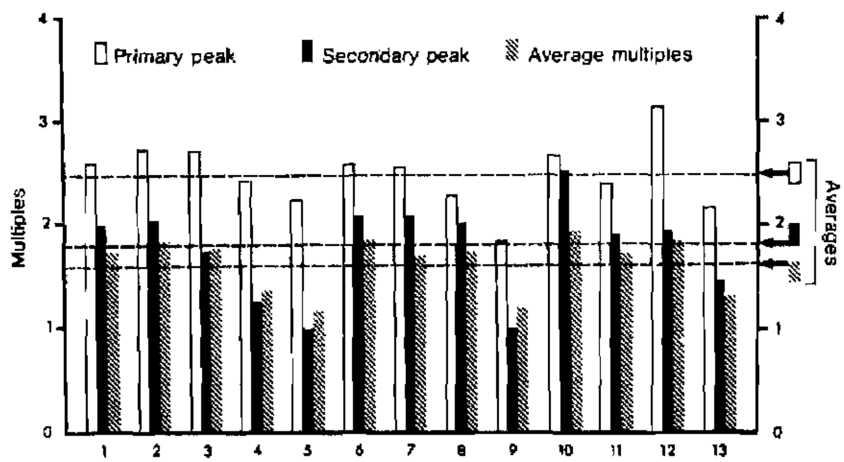

Figure 3. Average values, as multiples of the baseline pre-run heart rates, for the primary peak, secondary peak and average for all runs (combined data for Trails 1, 2 and 3) during each of the 13 test days between December 2 and March 24. Horizontal dash lines represent averages for all tests.

2.98, d.f. = 10) than that (2.50) for Trails 1-3. A secondary peak did not occur when the snowmobile circled the pen and returned to the starting point. The over-all average was 2.05, significantly higher ($P < 0.01$, t = 6.68, d.f. = 11) than that (1.62) for all of the runs on the other trails.

These data demonstrated that the primary and secondary peaks were not different between Trails 1, 2 and 3. Further, the average heart rates for each run on each trail, expressed as multiples of the pre-run rates, were not statistically different. Apparently the snowmobile had as much effect on the deer's heart rate when it passed no closer than 40 meters from the pen (Trail 1) as when it passed within 2 meters (Trail 3). The response was greater, however, when the snowmobile circled the pen than when it simply passed by it.

Changes in the behavior of the deer were not dependable indicators of the effects of disturbance by snowmobiles on their heart rates. The monitored deer remained either bedded or standing on 11 of the 13 test days, but there were increases in the heart rate each time without overt changes in behavior. The rates for the primary peak ranged from 1.50 to 3.21 (mean = 2.27) times the predicted pre-run rates, while those for the secondary peak ranged from 1.01 to 2.14 (mean = 1.71), and the over-all average ranged from 1.14 to 1.79 (mean = 1.51).

Regular exposure of these deer to snowmobile runs raises the possibility of habituation. If habituation occurred, then the multiples for the primary peak, secondary peak and over-all average for each run should have declined as the winter progressed. The slopes of regression lines expressing these multiples over time were statistically zero in all three cases, however; no habituation was evident.

The time necessary for heart rates to stabilize or return to pre-run levels after the machine had stopped varied from a few seconds to over 11½ minutes and averaged 2 minutes. The average time did not decline as more tests were conducted, again indicating that habituation to the snowmobile or controlled test conditions did not occur.

DISCUSSION

Initial heart rate responses to the starting of the snowmobile and responses to its moving by indicated that deer can react to stimuli without changes in their overt behavior. When the snowmobile circled the pen, the deer showed greater heart rate and behavioral responses. Other deer in the yard also showed greater fright responses when the snowmobile approached them directly than when it moved tangentially to their activity area.

It is important to realize that it is not the snowmobile noise *per se* that affects the deer. Chain saw engines emit a similar noise, but deer learn to associate that noise with the felling of trees and new supplies of forage. Eckstein et al. (1979) considered the location and timing of logging operations to be one of the main factors in determining winter home range, activity patterns and habitat use. Chain saws, however, do not move through the woods at 30 or more miles per hour, while snowmobiles appear to be predators with unlimited kinetic energy. Disturbances may be unintentional on the part of the operator but real to the deer when the machines move through their winter range. One important factor to consider in interpreting the results reported by Eckstein et al. (1979), who did not recognize differences in home-range size and habitat use between areas with and without snowmobiling, is that logging operations were going on at the same time the snowmobile tests were conducted. They concluded that "Deer probably became accustomed to the noise of machinery and power-saws, and this decreased their reaction to snowmobiles."

Eckstein et al. (1979) observed that deer within 61 meters of a trail (21 meters farther than in the tests reported here) moved farther away in 11 of 21 encounters but remained where they were in the other 10. In 22 encounters beyond 61 meters, the deer moved away in five instances, remained in nine and moved closer in eight. The movement toward the snowmobile trails from over 61 meters may indicate that the deer associated the noise with logging operations and that curiosity caused them to move closer to possible forage supplies. In Minnesota, free-ranging deer in an area with no logging moved out of their usual winter range to more secluded areas that were free from disturbance by snowmobiles when traffic levels were high on weekends (Dorrance et al., 1975).

The 2-minute average time observed in the present study for a return to pre-stimulus or stable heart rates may not seem long, but, when expressed on a distance basis, snowmobiles travelling 30 m.p.h. could be ½ mile apart and yet go by a deer every 2 minutes. Distances less than ½ mile between machines are not unlikely in areas with heavy snowmobile traffic. Further, operators often travel in groups, and a prolonged stimulus may add to the total response time of the deer. Such responses are certain to cause an increase in the energy expenditure of deer at a time when energy conservation is a more likely biological response (Moen, 1976, 1978).

Increases in heart rate and additional movements caused by encounters with snowmobiles must increase rather than decrease energy expenditures by deer. Such increases have the potential to affect the productivity of individuals and, ultimately, of the population. Management should take into consideration the basic biological characteristics of wildlife species, and it is evident that disturbance by snowmobiles is contrary to long-term energy-conservation adaptations of white-tailed deer.

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