Behavior Responses and Reproduction of Mule Deer, *Odocoileus hemionus*, Does Following Experimental Harassment with an All-terrain Vehicle

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Five Mule Deer (*Odocoileus hemionus*) does were caught by helicopter and net gun and were equipped with radio collars. They were habituated to an all-terrain vehicle (ATV) travelling the same truck trail for 12 weeks. Three of the females were then followed by ATV for 9 minutes per day for 15 days between 1 to 24 October, 198, for a total of 135 minutes. The harassed females, but not the other females, shifted feeding into darkness, used cover more frequently, left their home ranges more often, and increased flight distance from the ATV. In the following year the three harassed females collectively raised 1 fawn, having had normal reproduction the year before and the year after. Neither the unmarked females in the study area nor the two radio-collared control females suffered decreases in reproduction during the study. These results confirm expectations and are statistically significant.

Key Words: Mule Deer, *Odocoileus hemionus*, disturbance, harassment, reproduction, Alberta.

Harassment of wildlife has been considered detrimental ever since the late middle ages in Europe, when edicts were issued by local rulers banning entry to forests during calving seasons of Red Deer (*Cervus elaphus*). Despite the lowly regard of nobility for commoners, such prohibitions were still not issued lightly. Economic hardship was imposed on peasants by such bans because they used forests heavily, not only for firewood and seasonal plant foods, but also for forage for their livestock (Stahl 1979: 144–145). The notion that wildlife requires freedom from disturbance is deeply engrained in central European thinking on wildlife management and in Germany it is anchored in law (von Raesfeld and Vorreyer 1978: 154).

Considerable evidence about the detrimental effects of harassment has mainly been accumulated through close observation of husbanded stocks of domestic or semi-domestic herbivores (Klein 1971; Geist 1971, 1978), but also through the study of capture myopathy (Young and Bronkhorst 1971; Wobeser et al. 1976; Lewis et al. 1977; Chalmers and Barrett 1977) or physiological blood values (Franzmann and Thorne 1970; Hyvarinen et al. 1976), through the examination of displacement and reduction in habitat use (Rost and Bailey 1979; Basil and Lonner 1979; Morgantini and Hudson 1979), and displacement in time (Douglas 1971).

Of particular interest are the classical laboratory experiments by the late Howard Liddell and associates of various stressors applied to domestic caprids as reviewed by Moore (1968). The first experimental investigations of systematic harassment of a free-living big game animal were carried out by Batcheler (1968) in New Zealand on Red Deer. He found detrimental impact on body growth, reproduction and habitat selection. MacArthur et al. (1979, 1982) and Geist et al. (1985) concentrated on immediate physiological responses as indicated by heart-rate telemetry in Bighorn Sheep (*Ovis canadensis*).

However, capture by helicopter and net guns, trapping, handling and drugging of free-living Caribou (*Rangifer tarandus*) do not appear to have detrimental effects on individuals, neonatal production or post-natal survival (Hamlin et al. 1982; Valkenburg et al. 1983; Bergerud et al. 1984). Experience in an ongoing study of Caribou confirms these findings (Mahoney, Government of Newfoundland and Labrador, Wildlife Division, personal communication).

These studies of traumatic experiences differ from earlier ones which dealt with chronic disturbance. Also, Caribou, the species studied by Valkenberg et al. (1983) and Bergerud et al. (1984), is a cursorial form, and is expected to have more stamina than saltatorial runners (Gambaryan

1974). Another complexity is that stimuli need not be noxious by their very nature; rather, they become harassing stimuli only within the experience of the animal (Geist 1971, 1978). On the basis of learning theory (Hebb 1966), we expect animals to habituate readily to novel stimuli, except where such stimuli are either very rare, very violent, or where the stimulus pursues or hurts the animal. A stimulus gains "meaning" if the animal is repeatedly confronted by it. We address these points in the following experiment with Mule Deer, (*Odocoileus hemionus*).

Experimental Design and Methods

We subjected Mule Deer first to capture and handling by helicopter and net gun, then habituated them to potentially harassing stimuli (passes by an all-terrain vehicle), and then we selected individuals to be harassed by these stimuli. We expected no effects from trapping, nor any effects from the stimuli to which deer habituated, but we did expect behavioral and reproductive changes in the deer we subjected to experimental harassment.

We chose an unhunted population of Mule Deer on the Suffield Military Reserve in southeastern Alberta. These deer rarely saw vehicles or humans, since the study area was off-limits to military personnel, except military police. The area is formed of stabilized sand dunes, with a vegetation representative of the mixed prairie association of the northern Great Plains (Coupland 1950).

Five adult does were caught in June 1981 with helicopter and net gun and equipped with individually coloured radio collars. For 12 weeks thereafter, deer in the study area were subjected to the experimenter (CY) driving an all-terrain vehicle (Honda three-wheeled motorcycle) along a designated truck trail.

After the deer had become habituated to the ATV, we selected three radio-collared does for harassment. This procedure consisted of the experimenter following each designated doe for 9 minutes with his ATV, causing the deer to run and hide repeatedly. This dosage was considered safe because Mule Deer, as saltatorial runners, cannot be expected to run as long as cursorial reindeer, where running for up to 20 minutes is possible (Gambaryan 1974).

Harassment began on 1 October 1981 and terminated on 24 October. Each doe was pursued 15 times for a total of 135 minutes. Pursuit alternated between the first 2 hours and the last 2 hours of daylight. From 1 to 19 October the does were pursued every second day; from 20 to 24 October they were pursued daily. Although no more pursuits were made after 24 October, the deer were still subjected to the noises made by the experimenter's ATV in his travels through the study area from 25 October to 28 November.

The month of October was chosen for experimental harassment because that was the month during which does are expected to fatten just prior to mating (beginning about 15 November). We expected to impose stress to disrupt normal patterns of feeding and resting, and thereby affect body condition and possibly reproducton.

We recorded the frequency with which collared deer were found in open terrain (away from cover), the flight responses to the appearance of the ATV at a distance of 250 m or less, and the exact map location of each deer. We recorded, for all females in the study area, the presence or absence and number of fawns. We monitored collared deer for eight 24-hour periods following harassment (25 October to 2 November). The position of each deer was located every 2 hours by telemetry, and a record was kept on whether it was stationary or moving. We investigated the reproduction success of collared deer in August of 1981, 1982, and 1983 by locating each doe and checking repeatedly on whether fawns were present or not.

We constructed home ranges for each known deer based on observations from June to October 1981 by joining the outermost geographic sightings of each deer to form a polygon, following Hornocker (1969). We also tested the responses of hunted deer outside the military reserve to the ATV.

We chose to experiment with few individuals but to study them in detail. That is, we chose reliability of individual responses over representativeness. We lumped the results from the three experimental adult does, even though this violates the assumption of independence among samples. We did not consider this violation serious because samples were well spaced in time. We regarded a longitudinal study of individuals which were tested for expected responses to harassment superior to a short statistical study of many individuals of whose individual fate we would remain ignorant. Also, our experience and the published experiences of others have led us to expect marked responses by harassed deer.

The activity data were subjected to chi-square analysis (Zar 1974: 59). For analysis of data on use of open spaces versus cover, and on flight responses, we used Z-statistics for differences between proportions (Zar 1974: 296). To deter-

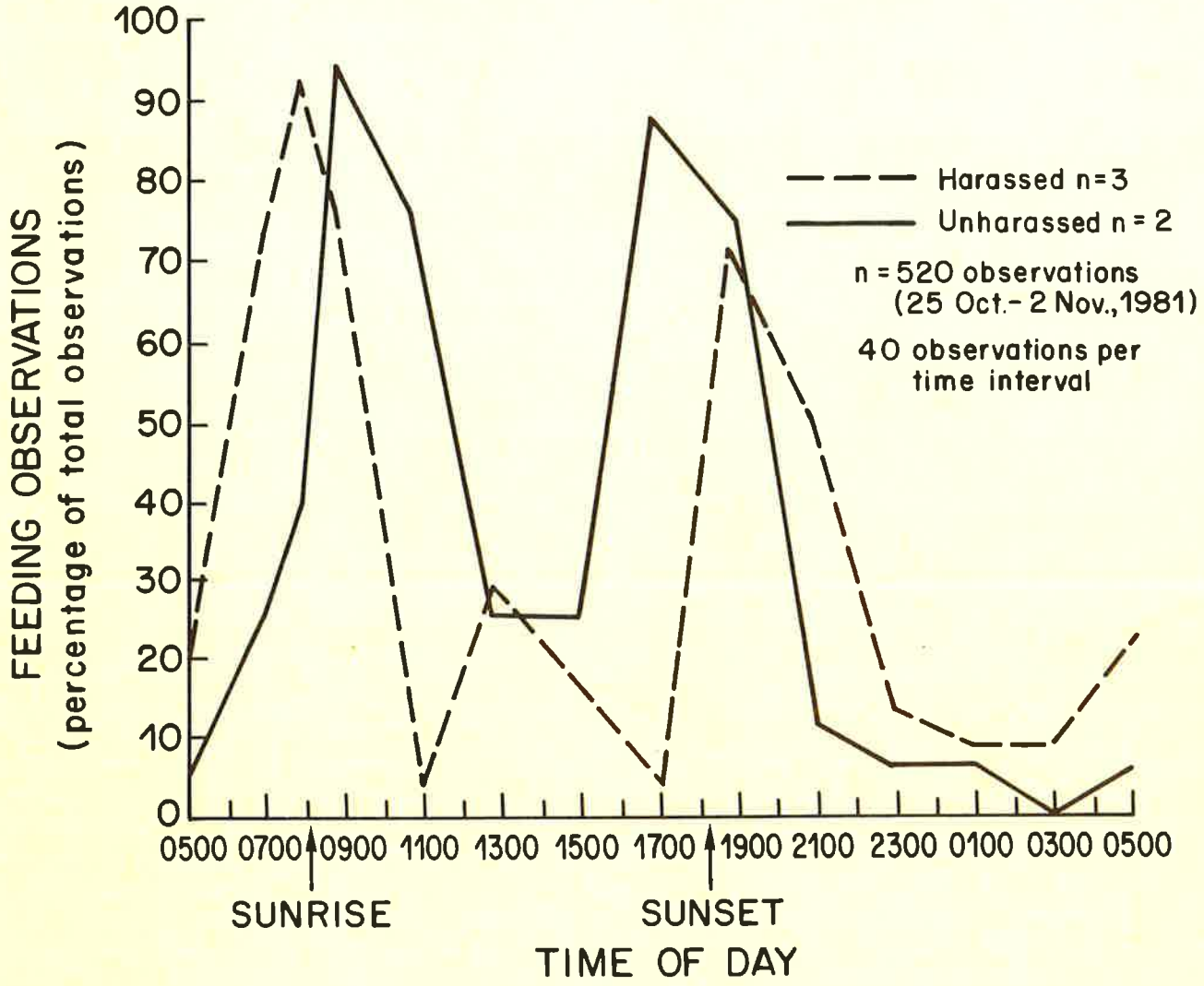

FIGURE 1. Daily feeding patterns of harassed and unharassed does for the period 25 October to 2 November 1981 in Suffield Military Reserve, Alberta.

mine the statistical significance of observed differences in the reproduction of the experimental deer, we employed an empirical probability distribution developed using data on how many unmarked does were observed with zero, one, two or three young.

Results

Daily feeding patterns (Figure 1) of three harassed and two unharassed does between 25 October and 2 November 1981 are based on 520 observations. The harassed does spent more time active during darkness than did unharassed does ($\chi^2 = 104.3$, 6 df, $P < 0.001$). The harassed does spent mornings and evenings, the times of day when the deer were normally harassed, in hiding.

The use of cover by harassed deer increased noticeably. From 1 to 30 September 1981, 220 observations were made of all collared deer; from 25 October to 28 November, 168 observations were made of harassed deer, and 112 observations were made of unharassed deer. The corresponding percentages of these deer found in cover were 12, 33, and 10, respectively, and harassed deer made more use of cover than unharassed deer ($Z = 4.54$, $P < 0.001$). Use of cover by all collared deer before harassment trials, and by unharassed deer following trials, did not differ ($Z = 0.72$, $P > 0.05$). Pre-trial harassed deer made less use of cover than post-trial harassed deer ($Z = 4.19$, $P < 0.001$).

From 15 to 30 June, collared deer fled in 16 of 39 cases when the ATV approached within 250 m. Between 5 and 25 September collared deer fled in only 5 of 47 cases ($Z = 3.81$, $P < 0.001$). After the harassment trials, the collared deer fled in 62 of 77 instances; the unharassed deer fled on 5 of 33 occasions ($Z = 8.25$, $P < 0.001$). Flight responses of unharassed collared does from 25 October to 27 November and of all collared does prior to harassment did not differ ($Z = 0.21$, $P > 0.05$). The

difference in flight responses between collared deer prior to harassment (5–25 September) and harassed collared deer was considerable ($Z = 10.67$, $P < 0.001$).

In testing the flight response of hunted Mule Deer outside the Suffield Military Reserve (1 to 3 December) with the same ATV, 52 of 61 deer fled before the distance was closed to 250 m. This proportion is much the same as that of the harassed, collared does within the reserve, which was 62/77 ($Z = 0.51$, $P > 0.05$).

From 1 to 24 October the three harassed females were encountered outside their home ranges in 15 trials on five, five, and seven occasions, respectively, whereas the two collared, unharassed does were observed within their home ranges. We located each of the three harassed does 28 times from 25 October to 28 November. They were outside their home range five, five, and eight times, respectively, but none of the control females was outside its home range. This difference is highly significant ($\chi^2 = 5.5$, 9 df, $P < 0.001$). Harassed does ran in some instances more than 1.5 km beyond the boundary of their home ranges, a distance equal to the diameter of the home ranges of the females, and in one case a doe stayed away for two days.

In 1981 the three harassed does had four fawns in late summer; in 1982 only one fawn could be attributed to the three does; in 1983 the three does had five fawns. The two unharassed does had three fawns in 1981, one each in 1982, and three in 1983. In 1981 we saw unmarked females with zero, one, two and three fawns on 8, 105, 47 and 3 occasions, respectively (163); in 1982 the numbers were 2, 34, 11, 0 (47) and in 1983 they were 1, 28, 9, 0 (38). There were no differences among categories between years ($\chi^2 = 1.98$, df = 4, $P > 0.05$). The probability of three does producing one young is based on the proportions of unmarked does with zero, one, two and three fawns [P(0 fawn) = 11/248 = 0.0443; P(1 fawn) = 167/248 = 0.6734; P(2 fawns) = 67/248 = 0.2702; P(3 fawns) = 3/248 = 0.0121]. The probability of one fawn being produced by three unharassed does is 3 [P(0) × P(0) × P(1)] = 3 × 0.0443 × 0.0443 × 0.6734 = 0.00396. Thus, the probability of the three harassed does producing only one fawn, given normal circumstances, is 1 in 253 cases.

Discussion

The results of this experiment on harassment follow expectations in every instance; the capture and handling of the deer affected neither the habituation nor the behavior and reproduction of two control females. All deer habituated to the ATV travelling along a predictable route. Even when the ATV departed from the predictable route of travel, the habituated deer continued to ignore it; nor did the behavior of harassed companions and their flight through the study area affect the deer we did not pursue. This implies that deer will habituate to and ignore motorized traffic provided the deer are not pursued. Big game readily accept traffic at very close range, as can be seen in national parks and other areas with no hunting (Geist 1971). Only deer pursued by the ATV responded with noticeable behavioral and reproductive changes.

As expected, the harassed females, but not the other females, shifted feeding into darkness, used cover more frequently, left their home ranges more often, and increased flight distances from the ATV. In the following year the three harassed females collectively raised one fawn, having had normal reproduction the year before and the year after. Neither the unmarked does nor the two control radio-collared females suffered decreases in reproduction during the study.

The reproduction depression we observed in harassed deer was highly unlikely to occur by chance alone, and may well be representative despite the small sample size. The harassed does behaved as expected and were reliable in the behavioral changes they exhibited. We conclude that deer "addressed" by a harassing stimulus suffer significant disruptions in their biology.

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