TRAPPING, IMMOBILIZING AND COLOR-MARKING GRIZZLY BEARS

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This investigation was initiated by the Montana Cooperative Wildlife Research Unit[1] to gather information on population dynamics, behavior, and other ecological data concerning the grizzly bear, Ursus horribilis. A number of bear studies have been conducted in recent years. The investigators have encountered common problems in trapping and handling these large mammals; the details varying with the kind of study area and the species of bear involved. Our experiences in adapting live-trapping and immobilizing techniques and developing color-marking methods for grizzly bears in Yellowstone National Park constitute the subject matter of this progress report. We hope it will prove helpful to others pursuing similar lines of investigation. A grizzly bear population has not until now been the subject

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[1] Contribution from the Montana Cooperative Wildlife Research Unit; U.S. Fish and Wildlife Service, Montana State Fish and Game Department, Montana State University, and Wildlife Management Institute cooperating.

of intensive trapping and marking. Therefore a brief discussion of the general status of this large carnivore in the United States and in Yellowstone in particular seems desirable.

Since Lewis and Clark first saw grizzly bears on our western prairies in 1805, their numbers have steadily declined. In the United States (with the exception of Alaska) they now exist only as remnant populations in wilderness areas, national parks, and national forests of the Rocky Mountains.

The grizzly, an endangered species, has disappeared from Texas, Kansas, Arizona, New Mexico, Oregon, Utah, and the Dakotas. In California, where it was once numerous, there has been no record of a grizzly for 38 years (Storer, 1955). Cooney (1956) has reviewed the status of the grizzly in the United States and concludes that the state of Washington may have a few, Colorado possibly 10, Idaho approximately 60, and Wyoming, excluding Yellowstone National Park, not more than 50. Montana lists about 450 exclusive of Glacier National Park. Estimates for Glacier and Yellowstone at that time showed 100 and 125 grizzlies respectively. Rough estimates indicate the number of grizzlies left in the United States, excluding Alaska, may lie between 500 and 1,000. Thus there is need for detailed ecological studies of the grizzly throughout its present range if it is to be preserved and intelligently managed. This has been recognized for some time but formidable obstacles have prevented intensive research.

Obstacles to such a study in western United States have been:

1. Solving the tremendous physical problem of gathering data and supplying an operation over thousands of square miles of wilderness grizzly habitat.
2. Locating a grizzly bear population sufficiently large and localized that data could be obtained on a quantitative basis.
3. Adapting and improving methods of immobilizing wild bears for detailed inspection and measurement.
4. Developing a method or methods of marking grizzlies so individuals and known-age animals could be observed in the field.

After much fruitless searching in Montana for a suitable study site, Yellowstone National Park was investigated and found to have a wild grizzly population sufficiently free of artificiality that fundamental biological data could be obtained and on a quantitative basis. Advantages of the Yellowstone area are that grizzlies are numerous, readily observable, and can be studied both in the vicinity of man and in the back country - a situation that should yield basic ecological data as well as information on the adaptation of this large carnivore to man. The National Park Service indicated interest

in a proposal for research and offered to cooperate in the study. Park records and literature dealing with the fauna of Yellowstone provide a wealth of general information on the grizzly and its history in the Park.

Skinner (1925) notes that as early as 1889 black bears, Ursus americanus, in Yellowstone began to frequent garbage piles but it was not until three or four years later that grizzlies followed their example. On August 2, 1916, he had 29 grizzlies in sight - the most he had ever seen at one time. At about this time he estimated a total of 40 grizzlies in Yellowstone. His descriptions of the grizzlies in those early days indicate the relations of these bears to man and to artificial food in the park have changed little if any in the past 50 to 60 years. Regarding this he says, "Three-fourths of the bears we ordinarily see in the park are near scrap piles, yet it is evident that this is not their principal food, or even any considerable part."

In 60 years of close association with man, the grizzlies in Yellowstone have not basically changed their behavior nor their habits. They have not become "roadside bums" like the black bear. From June through September they frequent the half dozen large garbage dumps chiefly during evening and night. Early in the season the bears are wary and come to the dumps only at night. Soon they get bolder and

some begin arriving in the afternoon. This habit of concentrating where food is available has been characteristic of the grizzly from the time his numbers and behavior were first recorded and there are innumerable references to this in the literature. Storer and Trevis (1955) in citing early writers, quote such phrases as . . . "regiment of bears", . . . "countless troops", . . . "bears are very plentiful", . . . "are often seen in herds," . . . "not unusual to see fifty or sixty within twenty-four hours" . . . "the whole lake and swamp seemed alive with bears." These and numerous similar expressions referred to the California grizzly.

"Many early accounts tell of the grazing habits of grizzlies. The bears congregated locally to forage in wild pastures and made seasonal migrations to such places." (Storer and Trevis, op. cit.). The same authors summed up the gregarious behavior of the California grizzly in these words, "But when grizzlies congregated with their kind to relish some desirable food - clover, acorns, or whale - they ate together peaceably."

Food disposal areas attract bears in Yellowstone, just as the salmon streams of Alaska concentrate the Alaskan brown bear, Ursus middendorfii during the spawning runs. While feeding at these areas some bears are indifferent to man, but most are alert and sufficiently shy to run at the least disturbance. Skinner (1925) states,

"Out in the wilderness that covers so much of the Yellowstone National Park, they (grizzlies) are just as wild, just as cautious, and just as difficult to find as bears anywhere else." This statement is essentially true today.

It seems the grizzlies' habit of concentrating where food is abundant and of seeking it boldly in the vicinity of man is not of modern origin.

With regard to their food, Skinner (op. cit.) says of grizzlies in Yellowstone . . . "grass is eaten as much, if not more, than any other single item, and this is true of the lordly grizzly as well as of the common bear . . . . bears do not depend upon garbage."

Murie (1943 unpublished) studied the food habits of Yellowstone grizzlies and black bears and concluded that vegetation comprises 81 per cent of their food and garbage 6 per cent. He stated, "It was found too, that even at the camp grounds, where bears habitually sought garbage, natural food still constituted 89 per cent, garbage 10 per cent." Our examinations of grizzly bear feces at disposal areas during the summer of 1959 indicated heavy use of natural foods. The situation in Yellowstone where grizzlies concentrate to feed on garbage is not as artificial a condition as first appears.

It is the grizzlies' nature to scavenge and to congregate wherever food is available and we believe these natural traits of

the grizzly are intensified under the conditions prevailing in Yellowstone. We seriously doubt if this will invalidate the basic data we plan to obtain; in fact, the behavior of grizzlies in Yellowstone is so reminiscent of the early accounts of the California grizzly as they came in contact with the settlers (Storer and Trevis, 1955) that we suspect "historic" bear and man relationships have been preserved rather than altered in Yellowstone National Park.

Trapping

Techniques for capturing and handling black bears were developed by Erickson (1957). This work stimulated black bear investigations in New York, Pennsylvania, West Virginia, Virginia, and Montana. It was inevitable that the basic techniques used should be applied to the grizzly bear. We captured grizzlies in culvert traps on trailer frames similar to those used by the U. S. National Park Service for capturing and moving nuisance bears. The basic design with modifications as well as the trapping techniques have been described by Erickson (1957) and Black (1958).

Counts made throughout the summer of 1959 indicated a minimun population of 150 grizzlies for Yellowstone National Park. Most of these bears concentrated in the disposal areas at night, but daily moved considerable distances. Thus sets were made at these feeding areas, along the back roads, and outside camp grounds. Fourteen

grizzlies were captured in two traps during 21 nights of trapping. This constituted a trapping success of 76 per cent or 1 bear for every 1.3 trap nights. Black (1958) captured one black bear for every 3 culvert trap nights in 1956, less in 1957. Troyer (1960) informed us that he was unable to trap the Alaskan brown bear in culvert traps, but was successful in capturing 32 in steel traps in 813 trap nights. Information on trapping success is lacking for 9 grizzlies trapped by park rangers which we marked and released. However, the sex, age, and weight of all trapped bears appear in Table 1. The bears range from yearlings to a 710-pound boar. Lactating sows were taken but no cubs were captured in culvert traps.

Immobilizing and Handling Trapped Grizzlies

All bears handled, whether trapped or shot free-roaming were immobilized by propulsive injection of succinylcholine chloride (Sucostrin) using a syringe dart and gas (CO_2) operated rifle. The automatic projectile type syringe and rifle are described by Crockford et al (1958).

Erickson (1957) produced effective anaesthesia in black bear using one grain of Pentobarbital Sodium for each 5 pounds of body weight. Complete sedation was achieved in approximately 11 minutes. Black (1958) used 60 milligrams of Pentobarbital Sodium per $5\frac{1}{2}$ pounds of body weight to produce anaesthesia. Black (1958)

Table 1

Immobilizing Grizzlies with Succinylcholine Chloride

Bear No.	Weight (pounds)	Sex	Milligrams drug		Number of injections	Pounds of body weight per milligram of drug		Minutes required to take effect initial dose	Minutes immobilized		Minutes until complete recovery	
			Initial dose	Total all doses		Initial dose	Total all doses		Initial dose	All doses	Initial dose	All doses
1*	200	M	50	120	2	4.0	1.7	0.2	11	36	15	108
2	300	M	90	210	3	3.3	1.4	3.5	7	41	10	90
3	150	F	70		1	2.1		3.0	31		70	
4	240	M	70	120	2	3.4	2.0	5.0	7	31		42
5*	110	F	40	80	2	2.8	1.4	5.0	12	32	15	50
6	45	F	7	17	2	6.4	2.6	6.0		14		19
7	300	F	140		1	2.1		1.0	20		180	
8*	260	F	90		1	2.9		1.0	18		50	
9*	160	F	56		1	2.9		3.0	19		45	
10*	140	F	46		1	3.0		3.0	16		27	
11	120	F	34	212	5	3.5	0.6	3.5		12		35
12*	620	M	207		1	3.0		8.0	23		41	
13	645	M	215		1	3.0		4.0	Died			
14	520	M	150		1	3.5		1.0	6		7	
15*	150	F	50		1	3.0		4.0	16		25	
16*	300	F	100		1	3.0		4.0	18		27	
17*	435	F	145		1	3.0		5.0	15		25	
18*	380	F	127		1	3.0		3.0	19		41	
19*	235	M	78		1	3.0		2.0	17		23	
20*	280	M	100		1	2.8		4.0	17		34	
21	300	F	90	300	3	3.3	1.0			38		180
22*	260	M	86		1	3.0		6.0	12		25	
22*			85		1	3.0		3.5	21		41	
23	370	F	100		1	3.7		3.5	40		60	
23			80		1	4.6		2.0	Died			
24	70	M	14	34	2	5.0	2.1	2.0	Died			
25	50	?	12		1	4.0		3.0	4		4	
25*			15		1	3.3		2.5	20		30	
26*	90	M	20		1	4.5		5.0	10		17	
27*	505	M	150		1	3.4		3.0	24		40	
28*	500	M	125		1	4.0		3.0	16		25	
29	92	F	20	30	2	4.6	3.1	7.0		10		10
29			25	42	4	3.7	2.2	2.0		5		25
30	710	M	170		1	4.2		8.0	23		93	

* Satisfactory immobilizations - data analyzed in Tables 2, 3, and 4.

accomplished complete relaxation with intramuscular injection of succinylcholine chloride with doses averaging approximately 1 milligram for every 3.7 pounds of body weight.

During the summer of 1959 this rapid muscle relaxant was used successfully on black bear in Montana by Jonkel and Hawley (1960), on the Alaskan brown bear by Troyer (1960) on Kodiak Island, and by the authors on grizzly bear in Yellowstone.

After capturing a grizzly, we pulled bear and trailer onto portable scales recording the weight of trap, trailer, and bear. This was generally repeated three times or until constant weights (within 10 pounds) were recorded. The weight of the bear was then obtained by subtracting the known weight of trap and trailer from the recorded weight. Cubs were weighed on spring scales.

Dosages of Sucostrin were prepared on a basis of body weight. On large bears, crude adjustments in dosages were made to allow for estimated body fats. The grizzly was then maneuvered into position with a probe and shot in the side of the neck with a syringe dart. Injection was intramuscular with a few exceptions where the dart may have penetrated a blood vessel.

After the bear collapsed, probing of the jaw accurately indicated the degree of immobilization. Normally the jaws relaxed first followed by the forearms and finally the hind legs. The intercostal

muscles and the diaphragm are last affected; respiration becomes depressed but with proper dosage breathing is quiet and regular. Normally, first symptoms were a fluttering of the eyelids. As the drug took effect the bear's head would lower until the muzzle rested on the chest, then the bear might sit on its haunches or roll directly to its side. With proper dosage, complete relaxation would occur within minutes. At first the door of the trap was raised with trepidation but as we gained confidence in the drug the procedure of hauling a large grizzly out of the culvert became routine.

Ear tags were placed on the upper leading edge of each ear as close to the base of the ear as possible. It was necessary to slit the tough hide in order to insert the tag. Color markers were put in the lower edge of both ears; a tattoo was placed under the forearm where the hair is thin and measurements and other data recorded. All bears were kept under observation until sufficiently recovered to move off. Of the grizzlies immobilized, some evidenced definite aggressive behavior when muscular control returned, others were aggressive only when pressed by the observers, and the majority were relatively submissive.

Immobilizing and Handling Free-Roaming Grizzlies

To shoot a free-roaming grizzly it was necessary to approach within 50 feet as the dart gun was unreliable at greater distances.

Of 7 bears obtained in this manner, 5 were shot from a vehicle and 2 (a yearling and a cub) were shot by stalking in the open.

The general procedure was to estimate the bear's weight, prepare 3 darts with dosages of succinylcholine chloride ranging above and below the indicated dosage. The bear was then approached as close as possible and shot in the neck. The supplemental darts were used if the initial dose was unsatisfactory.

Each bear shot in this manner presented a different situation and little in the way of standardized procedure evolved. A 370-pound sow with two cubs wheeled and fled when the dart struck her. She collapsed in a stream and had to be hauled out while still not completely immobilized.

Cubs were captured at night by shooting them at the sides of their mothers. A flashlight was used to spot the cubs and the marksman was covered with a rifle. Behavior of the sows varied widely but in no case did one charge, and all but one deserted their downed cubs when the car motor was raced or a rifle discharged. One sow, however, returned before we could get to the cub and she did not leave until the cub could walk away. Captured cubs were held overnight in a holding cage and released the next day after being immobilized a second time for tagging and marking.

Evaluation of Succinylcholine Chloride

Succinylcholine chloride is not an anaesthetic but a short acting skeletal muscle relaxant that blocks nervous transmission at the myoneural junction. It is sold under various trade names (Sucostrin, Anectine) and chemically is diacetylcholine. It replaces acetylcholine (the chemical compound that activates skeletal muscles) and blocks nervous transmission at the myoneural junction. Muscular paralysis persists until the diacetylcholine is hydrolyzed by cholinesterase in the blood and normal nerve transmission at the myoneural junction is again resumed. The amount of cholinesterase varies widely in blood and different organs of different species (Grollman and Slaughter, 1947). This probably accounts for its selective action on certain parts of the body.

The muscles of the eyelids are first to be affected when succinylcholine chloride is given to conscious human patients. Thereafter the muscles of the jaws, arms, legs, and abdomen are affected in the order given. Paralysis of the upper intercostal muscles then occurs and respiration becomes depressed. The diaphragm is last to be affected.

Intramuscular injections of high potency solutions were used to produce complete relaxation. Ten minutes were sufficient to allow the animal to be removed from the trap, tattooed, measured, ear tagged,

and color marked for future individual recognition. Whenever a drug is administered intramuscularly it is difficult to control its absorption. This difficulty probably accounted for some unexpected reactions to the drug but individual susceptibility as well as other factors undoubtedly were also important. Literature supplied with the drug stated "The optimum intravenous dose for such purposes" (short duration) "will vary among individuals, usually ranging from 10 to 40 milligrams." A similar variation may be expected among individual grizzlies.

We experimented with dosages of succinylcholine chloride on the first half dozen grizzlies captured and arrived at a working dosage of approximately 1 milligram of Sucostrin per 3 pounds of body weight administered in a single dose. This rule-of-thumb dosage was used on all bears with modifications discussed later. No attempt was made to cage a grizzly and determine minimum, average, and lethal doses as it appeared there was considerable individual susceptibility to the drug as well as the probability that susceptibility might be altered by confinement.

Multiple Doses

There is need for more precise information on dosages, to avoid mortality and reduce stress in treated animals, as well as to increase the safety of the bear handlers. With this in mind we have

analyzed our data and experiences during a summer's work and present our findings for the benefit of other workers, recognizing that our conclusions are tentative.

Multiple doses were administered at first in an attempt to arrive at an effective single dose injection and whenever a bear failed to immobilize completely. A bear was considered immobilized only during the time it was prostrate and unable to bite. This served as a criterion for computing time interval immobilized (Tables 1 and 2). Recovery time (Tables 1 and 3) includes time interval immobilized plus the time required to regain sufficient muscular control to leave the area. Ten of 30 bears or 30 per cent required multiple doses. The average initial dose was 1 milligram of Sucostrin per 3.6 pounds of body weight with an average second dose of 1:4.5. The maximum initial dose that failed to achieve immobilization was 1 milligram per 3.3 pounds of body weight; the minimum 1:6.4.

Table 2

Relation of Dosage to Bear Weight and Immobilization Time
(Single Dose Selected Data from Table 1)

Time immobilized (minutes)	10-15	16-20	21-25
Average dose (pounds of body weight per milligram)	3.5	3.1	3.1
Average bear weight (pounds)	219	246	462
Number of bears	5	10	3

Table 3

Relation of Dosage to Bear Weight and Recovery Time
(Single dose selected data from Table 1)

Recovery time (minutes)	15-24	25-39	40-60
Average dose (pounds of body weight per milligram)	3.6	3.1	3.0
Average bear weight (pounds)	159	264	364
Number of bears	4	8	6

Since succinylcholine chloride is hydrolized by cholinesterase, the time interval between injections is important in determining second or additional doses. Our experience and data are as yet too limited to suggest desirable multiple doses in terms of milligrams of drug per pounds of body weight, but we can offer some helpful observations.

Forty per cent of the animals requiring multiple doses were not immobilized with an initial dose. These bears upon receiving a second dose were either still not immobilized or if so, only for a brief period of time. On the other hand all bears immobilized to some extent with an initial dose were subsequently satisfactorily kept in that state or re-immobilized by a second dose.

Thus, indicated procedure for administering multiple doses is:

1. Where immobilization occurs with the initial dose but is of brief duration, administer a light second dose as soon as there are

signs of returning muscle coordination.

2. Where immobilization does not occur with the initial dose, wait a minimum of 45 minutes, preferably longer, then administer a more potent second dose.

Whenever the initial dose failed and additional doses were given without a considerable time lapse, the recovery time was greatly prolonged. A heavy second dose (equal or greater than the initial dose) administered prematurely can be lethal.

The procedure recommended for administering multiple doses is far from perfected and exceptions are to be expected. The complexity of administering multiple doses to either trapped or free-roaming bears is illustrated by the following examples.

Bear 11, Table 1, received five injections within a period of approximately three hours. The initial dose was 34 milligrams or 1 milligram per 3.5 pounds of body weight and did not immobilize; seven minutes later 25 milligrams were administered with no apparent effect. About two hours later a 42 milligram injection failed to immobilize. This was followed 24 minutes later with a 50 milligram injection which caused partial paralysis but failed to immobilize. A final dose of 60 milligrams, 39 minutes after last injection, caused immobilization in three minutes. The total dose received was 211 milligrams or 1 milligram per 0.6 pounds of body weight.

A cub and litter mate to Bear 29 (Table 1) was estimated to weigh between 100 and 120 pounds. On two successive nights this cub was shot a total of five times in attempts to immobilize it. The first night, while feeding at its mother's side, the cub received an initial dose of 25 milligrams in the neck at a distance of 30 feet. It staggered but did not fall. A second dose of 15 milligrams similarly delivered, 15 minutes later, had no noticeable effect as did also a third dose of 20 milligrams approximately 10 minutes later. The second night, dosages of 33 and 22 milligrams were injected in the neck from approximately 30 feet. The first dose caused the cub to arch its neck and lie down momentarily; the second dose had no apparent effect. The sow became aroused and dangerous and no further attempts were made to capture her cub.

Single Doses

Single dose injections proved more satisfactory than multiple doses. However, not all single dose injections were satisfactory nor successful (Table 1). The basic data for computing a dosage was body weight, but it early became evident that other factors such as age, sex, physical condition, injection site, amount of body fat and perhaps the age of the drug itself might be affecting the drug action. An analysis of this type data showed no correlation between sex and drug action or between age of drug and its action. The succinylcholine

chloride was kept under refrigeration to prevent deterioration and none was opened and used for longer than 23 days. Comparison of the action of fresh solution and dosages prepared from bottles carried about and used for as long as 19 and 23 days showed no evidence of loss of potency with age.

Selected data from 17 bears (18 dosages) in which satisfactory immobilization occurred are presented in Table 2. An immobilization was considered satisfactory and selected for presentation in Table 2 if the time immobilized lay between 10 and 25 minutes and the recovery time one hour or less.

We can infer from the data of Tables 2 and 3 that an average dose of 1 milligram of Sucostrin per 3.5 to 3.6 pounds of body weight gave minimum immobilization and recovery times. An average dose of 1 to 3.1 yielded optimum results on medium-sized bears ranging in average weight between 246 and 264 pounds but resulted in prolonged immobilization and recovery in the larger bears (average weight 462 and 364).

If we consider an average immobilization time of 16 to 20 minutes and recovery time of 25 to 39 minutes to be optimum (Tables 2 and 3), then in general we tended to underdose small bears, administered optimum doses to medium-sized bears and overdosed the large bears. Data show that the larger bears were probably more sensitive to succinylcholine chloride than medium-sized bears.

There is a basic correlation between dosage and body weight of bears that appears to be modified by other factors. Age and amount of body fat were suspected as being important. We do not yet have sufficient data to determine the degree of susceptibility of cubs and other young bears. However, if we can consider weight as a function of age (Tables 2 and 3) then the inference is that older bears require less drug per pound of body weight to immobilize them satisfactorily than young bears. This is further supported by data on multiple doses. The average weight of all bears requiring 2 or more doses was 170 pounds and those failing to immobilize with the initial dose averaged 139 pounds.

We had no way of accurately estimating amount of body fat, but it was evident from field observation that the bear population in general did not begin to put on fat rapidly until about the first of August. By grouping data on 18 bears (receiving what we considered optimum drug doses) by time of year (Table 4) we find that bears immobilized between June 29 and July 31 required 1 milligram per 3.0 pounds of body weight whereas bears immobilized between August 1 and August 28 required an average dose of 1:3.4. It appears that the smaller average doses required late in the season were due to the fact that body fat was included as weight in dosage determination. Erickson (1957) found in using Halatal that "estimates of body fats should not be included as weight in dosage determination." We tentatively concur with this statement in regard to succinylcholine chloride.

Table 4

Relation of Dosage to Time of Year

Time Period	6/29 - 7/31		8/4 - 8/28	
	Total	Average	Total	Average
Milligrams of drug administered	989	90	581	83
Number of bears	11		7	
Bear weight	2,990	272	1,945	278
Minutes immobilized	184	16.7	120	17.1
Minutes to recovery	334	30.4	212	30.3
Dosage pounds of body weight per milligram		3.0		3.4

In summarizing our data on single dose injection we recommend the following rule-of-thumb procedure until more information is available: For all grizzlies under 360 pounds administer 1 milligram of Sucostrin per 3 pounds of body weight. The fat weight should be subtracted from the total weight to give the weight for dosage determination. Except in the case of retrapped bears, fat weight will have to be an estimate. In time, data on fat accumulation during the summer months will be obtained and this information should lead to more accurate estimates. For bears over 360 pounds administer somewhere between 1:3 and 1:4 compensating for body fat. Very old bears may be quite susceptibile and the dose should be conservative.

Color Marking

Color marking permits field recognition and observation of individuals and age classes. To be useful markers should be both

visible and durable; the ideal marker would last the lifetime of the animal marked. We were doubtful that grizzlies with their predisposition to fight and chew one another would long retain conventional color markers. We therefore proceeded on the theory that a number of markers had a better chance of retention than only one. Accordingly we slit the lower leading edge of each ear and inserted plasticized polyvinyl chloride tape (Craighead and Stockstad, submitted for publication). In addition, the tough hide on the back of the neck was punctured and tape threaded through and secured with rivets. Eight basic colors were used and this gave 64 combinations for individual identification when identical markers were used for each ear of every individual marked. Each marker consisted of an ear loop and a tail of different color. Both ends of the ear loop close over the tail strip and are secured with brass rivets. The neck marker was experimental and used to designate original site of capture.

Visibility of markers was excellent in daylight and good at close range at night with flashlights. Reflective tape can be attached over the basic color combinations for nocturnal observation.

Of 27 grizzlies color marked and released, 13 were observed and identified. One was sighted 27 times, the average being 12 observations per bear. Fourteen other marked bears were not seen but most of these were marked and released with no attempt made to obtain sight records.

Retention of the markers surpassed our expectations. Prior to hibernation one bear had lost its neck marker and the tail of the left ear marker but the right ear marker was still intact. Two other bears lost an ear marker or part of one.

A small male, shot outside the park boundaries in October, still had both ear markers and neck marker in excellent condition 84 days after marking. We believe most of the marked bears went into hibernation with their color markers intact. Elk marked in a similar manner with vinyl tape (Craighead and Stockstad, op. cit.) still had color markers when shot 20 and 21 months later.

The value of color marking grizzlies is evident. During the summer we obtained 160 specific observations yielding information on range, population composition, and behavior. During the same period of time only two grizzlies were retrapped.

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Literature Cited

Black, H. C.

1958. Black bear research in New York. N. A. Wildl. Conf. Trans. 23:443-461

Cooney, Robert F.

1956. Wilderness monarch. Montana Wildlife VI:14-17.

Craighead, J. J. and D. S. Stockstad.

(Unpublished). Color marker for big game.

Crockford, A. J., Frank A. Hayes, James H. Jenkins, and Seldon D. Feurt.

1957. Nicotine salicylate for capturing deer. J. Wildl. Mgmt. 21:213-220.

Erickson, A. W.

1957. Techniques for live-trapping and handling black bears. N. A. Wildl. Conf. Trans. 22:520-543.

Grollman and Slaughter

1947. Pharmacology and therapeutics. 868 pp. Lea and Febiger, Philadelphia, Pa.

Jonkel, Charles and Vern Hawley

1960. Personal communication.

Murie, O. J.

1954. Progress report of the Yellowstone bear study. Unpublished.

Skinner, M. P.

1925. Bears in the Yellowstone. 158 pp. A. C. McClurg & Co., Chicago.

Storer, T. I. and L. P. Trevis, Jr.

1955. California grizzly. 335 pp. Univ. of Calif. Press, Berkeley, Calif.

Troyer, Will

1960. Personal communication.

Summary

An intensive long-term study of the grizzly bear, Ursus horribilis, was initiated in Yellowstone National Park during the summer of 1959.

Thirty grizzlies were captured and 27 ear tagged, color marked, and released for future observation. Twenty-three bears were captured in mobile culvert traps and 7 were shot free-roaming with propulsive syringe darts using a gas-operated rifle. All bears handled, whether trapped or shot free-roaming, were immobilized by propulsive injection of succinylcholine chloride, a rapid muscle relaxant. Of the grizzlies immobilized, some evidenced definite aggressive behavior when muscular control returned, others were aggressive only when pressed, and the majority were relatively submissive.

Cubs were captured at night by "shooting" them at the sides of their mothers. Behavior of the sows varied but in no case did they charge.

Both multiple and single dose injections of succinylcholine chloride were administered. Thirty per cent of the grizzlies treated required multiple doses; the average initial dose being 1 milligram of drug per 3.6 pounds of body weight with an average second dose of 1:4.5.

Single dose injections proved more satisfactory than multiple doses. A satisfactory dose immobilized a grizzly for 10 to 25 minutes with complete recovery time of one hour or less. There was a basic correlation between dosage and body weight of bears that appeared to be modified by such factors as age, amount of body fat and injection site. In general, single doses of 1 milligram of drug per 3.5 pounds of body weight gave minimum immobilization and recovery times. Doses of 1 milligram of drug to 3 pounds of body weight yielded optimum results on medium-sized bears, but resulted in prolonged immobilization and recovery in the larger bears. The larger bears were more sensitive to succinylcholine chloride than either the small or the medium-sized ones. The build-up of body fat throughout the summer also seemed to have an effect on dosage.

Grizzlies were individually color marked by slitting the base of each ear and inserting polyvinyl chloride tape. Each marker consisted

of an ear loop and a tail of a different color, secured with rivets. Both visibility and retention were excellent and most marked bears probably went into hibernation with their color markers intact. One hundred and sixty observations were made of color-marked bears yielding information on range, population composition and behavior. During the same time only two bears were retrapped. A yet more durable color marker was made from polyethylene diamond braided rope and will in the future be used experimentally for ear markers.

The largest bear trapped weighed 710 pounds. The greatest distance traveled exceeded 50 air miles over the rugged Absaroka Range in Wyoming.