BREEDING BIOLOGY AND ECOLOGY OF THE BLACK BEAR IN MICHIGAN

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ABSTRACT

BREEDING BIOLOGY AND ECOLOGY OF THE BLACK BEAR IN MICHIGAN

by Albert Wendell Erickson

This paper reports on little-known aspects of the physiology, life history, and ecology of the North American black bear (*Ursus americanus* Pallas) from studies conducted in Michigan from 1957 through 1959.

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The breeding biology of the black bear was described following gross and histological examinations of the testes and epididymides of 54 males, and the ovaries and uterii of 36 females, including some specimens from animals of known age and partial breeding history.

The results of this study classify the female as seasonally constant estrus with ovulation induced following mating. Breeding in Michigan occurs between mid-June and mid-July. Gestation lasts approximately

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seven months, but active embryonic growth is limited to the latter half of pregnancy. Presumably, this is due to delayed implantation since the corpus luteum is formed shortly after breeding. Placentation is zonary. Puberty for both sexes is attained at approximately 3.5 years.

Histological studies demonstrate that the testes undergo extensive retrogression following the breeding season. Sperm production ceases within two months following female receptivity. Testicular awakening, approximately two months before the next onset of estrus, is marked by differentiation of the cell types into Sertoli cells and spermatogonia. Leydig cell activity precedes and exceeds the period of active sperm production.

Histological studies show that the ovary of the unbred adult and immature bear is composed largely of fatty connective tissue during the denning period. With approach of estrus this tissue is replaced with cells resembling active luteal cells. Follicles develop but before reaching mature size are replaced by this endocrine-type tissue.

Cells forming the corpora lutea of ovulation

resemble those of the pre-estrus luteal-like tissue but appear more highly functional. Discrete corpora lutea can be recognized in the ovary until mid-September. The ovary then undergoes a general luteinization until it is composed largely of functional luteal tissue, primarily of para-luteal origin.

Close to whelping the ovary shows marked vascularity and the cells show a decline in endocrine activity. Follicular growth is apparent in lactating bears, but few follicles reach the tertiary stage of development. As in unbred adult and immature bears, the developing follicles are replaced by the invasion of tissue from the general ovary substance. This intense replacement of the developing follicles presumably prevents follicle maturation in the lactating animal. The maintenance of this function appears associated with the act of nursing since removal of the cubs results in follicle maturation and ovulation following breeding.

Following the breeding season, the ovary of the lactating bear declines in activity and resembles that of unbred animals.

<u>Seasonal Variations in Hematology and Physiology</u>

During 1956 and 1957, four bears were held captive and periodically anesthetized and various physical and hematological values determined. The bears were dormant in winter quarters from approximately 25 December to 17 April.

Mean hibernal weight loss was 20 percent of the prehibernal weight. During torpor, body temperatures were 3 or 4 degrees below the 98.6° F. temperature norm for active periods. The only marked hematological changes noted seasonally occurred during early torpor. At that time a substantial increase in circulating erythrocytes was noted, with corresponding increases for hemoglobin, packed cell volumes and total protein. Other blood constituents were variable between specimens.

Live-trapping and Handling Techniques

Techniques were described as developed in Michigan for live-trapping, handling and marking bears.

Bears were captured in box traps constructed of 8-foot sections of 36-inch steel culvert, and in No. 4-1/2 steel-spring wolf traps. Most successful baits were large pieces of fresh meat.

Bears captured in box traps were initially anesthetized with ether after the trap had been rendered airtight. They were continued under sedation with

ether administered via an ether cone, or by an intraperitoneal injection of Pentobarbital Sodium. The latter rendered bears helpless in about 11 minutes.

Bears captured in steel traps were handled by placing a chain loop at the end of a 6-foot section of pipe over the animal's head and twisting it snug. The bear's head was then controlled by one man while another secured its legs with ropes. Ether was then administered via the ether cone or Pentobarbital Sodium was administered intraperitoneally. Metal ear tags were found reliable as markers for bears.

Population Structure, Movements, and Mortality of Tagged Bears

The population dynamics and movements of tagged bears were analyzed from a 5-year live-trapping study, during which 159 bears were handled 182 times. Bears were classified by age as cubs, yearlings, and older animals, and by wildness as "wild", "dump", and "nuisance" bears. Dump and nuisance bears were found to be primarily adult males.

A minimum population of 117 bears was estimated on a 400-square-mile study area as determined from marked-unmarked ratios. Recoveries of marked bears

indicated a minimum annual mortality of 19 percent. Legal hunting accounted for 84 percent of known mortalities. Kills of bears as nuisances and bounty trapping for predators were identified as important causes of death. Garbage dumps were implicated as sources of troublesome bears. Methods were recommended for alleviating nuisance bear difficulties and relieving losses to predator trapping.

Normal movements of marked bears averaged less than five miles. The maximum recorded movement was 19.4 miles. Adult males traveled more widely than adult females; dispersal of young was limited. Transplanted bears mostly re-established in new areas; however, two homed 96 and 64 miles, respectively, to near points of original capture.

The Age of Self-sufficiency

The self-sufficiency of 23 cub bears ranging from 5 to 8 months of age was tested. On the mainland, 20 test cubs were released at points remote from their mothers, and 12 control cubs were released with their mothers. Three test cubs were released on Lake Michigan islands devoid of bears.

One-third of the cubs released on the mainland were recovered and two cubs released on islands survived the winter. Cubs released alone survived as well as cubs with their dams. These studies demonstrated black bear cubs to be self-sufficient as young as 5-1/2 months.

Kill Statistics

Kill data of bears in Michigan for 1955 through 1957 were analyzed from a questionnaire survey of hunters. Data were obtained from 1,129 bear kills. Sixty-nine percent of all kills occurred in the Upper Peninsula and 31 percent in northern Lower Peninsula. Harvests were apportioned 70 percent November 15-30, 18 percent October 1-November 5, and 12 percent September 1-15. In September and November seasons one-fourth of all kills occurred on opening days, and half in the first three days of hunting. Harvests were spread uniformily throughout October seasons.

Mean annual kill densities were calculated as one bear per 21 square miles in the Upper Peninsula and one per 34 square miles in the northern Lower Peninsula. Most Lower Peninsula kills occurred in the northeast lakeside counties. Kills in the Upper Peninsula paralleled hunting effort indicating that kills there were below sustained yield levels. Annual hunter

success was calculated as one bear per 148 hunters in the Upper Peninsula and one per 677 hunters in the northern Lower Peninsula. Most kills were made incidental to other hunting.

Sex ratios reported by hunters were found biased toward males. The degree of bias was directly proportional to time elapsed between kills and reports of kills. Kills confirmed to sex were 52 percent females.

The mean litter size in 176 reports was 2.05 cubs. Sows-with-cubs and cubs comprised 11 and 18 percent of the kills, respectively. In family groups from which bears were reported killed, mortality was 70 percent among mothers and 55 percent among cubs; 32 percent of the groups were annihilated.

Thirty-seven percent of the bears killed November 15-30 were in dens. Bears in and out of dens were equally vulnerable to hunters. Females and cubs denned on an average about two weeks earlier than adult males. First denning was in mid-October. Preferred denning sites were holes beneath logs or fallen trees, or in hillsides. Females lined a higher proportion of dens with leaves, grass or ferns than did males.

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This study was made possible through the co-operation of the Game Division of the Michigan Department of Conservation and the Department of Fisheries and Wildlife of Michigan State University.

The author is deeply indebted to the many persons who rendered assistance to the study. I am particularily grateful to the late Dr. S. C. Whitlock, then Assistant Chief, Game Division, Michigan Department of Conservation, and to Mr. D. F. Switzenberg, retired Biologist-in-Charge, of the Cusino Wildlife Experiment Station, Michigan Department of Conservation, Shingleton, Michigan. Their vision and assistance made the investigations possible and contributed immeasurably to their fulfillment. Particular thanks are due also to Mr. R. A. MacMullan, Assistant Chief, Game Division, Michigan Department of Conservation, for lending every assistance in making available aid or monies for carrying out the project, and for the time he devoted to the counsel of project activities.

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INTRODUCTION

The black bear (Ursus americanus Pallus) of North America is perhaps more widely recognized than any other big game animal on the continent. Yet, though highly prized as a trophy and not infrequently hunted as an undesirable, relatively little has been learned of the biology, ecology or population status of the species. Management of the black bear has, therefore, been generally less precise than may otherwise have been desirable. None-the-less the species has shown remarkable adaptive ability and still occupies most of its former range, in marked contrast to the virtual extinction of the grizzly bear (Ursus horribilis Ord) from its former range in the southern 48 United States.

The goal of this study was to disclose further data on the general life history, reproduction, ecology and management of the black bear which might assist in the formulation of policies for management of the species.

THE BREEDING BIOLOGY OF THE BLACK BEAR

There are very limited data available on the breeding biology of black bears. With the exception of six references cited, I am not aware of any extensive study on reproduction for this species. It is generally recognized that in North America black bears mate in June or early July, and that implantation probably occurs in November (Hamlett, 1935; Asdell, 1946). The young are born in an immature state in late January or early February (Baker, 1904, 1912; Gerstell, 1939). The number of young born ranges from one to four but is usually two or three.

Implantation sites have not been observed in female bears until five months following the recognized breeding season (Hamlett, 1935; Gerstell, 1939). Whether this represents delayed ovulation following mating, delayed implantation following conception at the time of mating, or early implantation following mating with very limited early embryonic growth has not been resolved. The duration of gestation in

black bears is generally agreed to be about seven months (Baker, 1912; Brown, 1936 and Rausch, 1961). Whelping occurs primarily in late January or early February. It is also generally recognized that female bears breed in alternate years. Presumably the female with suckling young does not accept the male during the breeding season, approximately five months following the birth of cubs. It has been reported, however, that captive lactating females may conceive in consecutive years if separated from the young before the end of May (Baker, 1912). It is not known whether the female maintains corpora lutea of lactation, as in some domestic species; or whether ovulation is spontaneous at the time of the breeding season or induced upon acceptance of the male. Cowan and Guiguet (1956) state that females do not ovulate while nursing. The unwillingness of lactating females to accept a male during the breeding season may be due to the suckling stimulus of the young. There are no data available as to the length of time a female is receptive to a male, or as to whether the initial acceptance of a male terminates estrus.

The age of sexual puberty in male black bears has not been established. However, records for female captives show that first breeding occurs at approximately 3-1/2 years (Baker, 1912; Rausch, 1961 and Seton, 1929). The limited observations reported on reproduction in female black bears allow postulation of three types of reproductive activity: (1) seasonally polyestrous, as in white-tailed deer (*Odocoileus virginianus*) and the domestic ewe, during the fall; (2) constant estrous activity, as in domestic cats and rabbits, and more specifically seasonally constant estrous and limited to the late spring; and (3) monestrous cycle with spontaneous ovulation and acceptance of a male once a year during late spring.

There are limited data on reproductive activity in male bears. Only one report (Rausch, 1961) was concerned with gross and microscopic observations on the testes. It has not been established whether libido or spermatogenic activity of males extends throughout the year, or whether they are limited to the brief period of female receptivity in the late spring.

The purpose of the present study was to make gross and histological examinations of reproductive organs of male and female Michigan black bears and to classify the reproductive activity for this species in relation to that reported for other mammals.

Methods and Procedures

The testes of 55 male bears and the reproductive tracts and ovaries of 36 female bears were collected between August 1, 1955 and September 20, 1958. Among females, 11 were captive animals of known recent breeding history, 10 of these were of known age.

Of 25 wild female specimens collected 9 were wild-trapped. A partial breeding history could be accurately estimated from the trapped bears, on the basis of accompanying young, or the presence or absence of milk in the mammary glands (Erickson, 1957). Seven of the males were of known age. Wild specimens were obtained in the field from hunters, the salvage of bears killed as nuisances, or through sacrifice of wild, captured animals.

It was assumed in these studies that whelping in all cases occured close to February 1, and that the ages of bears could be based on this common birth date.

It is recognized that there are variations from this norm, but existing reports (Baker, 1912; Gerstell, 1939; Rausch, 1961; and others) would not support more than one month variability in this time of birth.

Of six cubs of the year, all were taken during fall hunting seasons. They were at or near peak first-year weight. Cubs classified as in their second year were obtained shortly before, during and after the normal breeding season. Those taken earlier in the year were not at peak weight for second-year animals but, nevertheless, were much heavier than cubs of the year. Estimates of age for male bears 3-years or older were based on examination of dentures, skulls, and bacula of known age specimens. Skulls and bacula of know-age males increased in size with advancing age (Table 1). The age criteria established for males are believed reasonably accurate. Among females, however, skull measurements for known-age specimens showed considerable variation and no consistent relationship to age. Consequently age criteria for wild female bears were not sufficient to permit close classification. The classification of immature or mature was based upon breeding activity of captive bears or on the absence or evidence of mature gonadal activity in wild bears.

Specimen collections were for the most part fortuitous, and it was not possible to obtain reproductive specimens for all seasons and reproductive states. Winter collections were particularly difficult, since wild bears in Michigan are normally in dens from mid-November to mid-April.

Male reproductive tracts were removed, the testis dissected free of the tunica vaginalis and the epididymis left in contact with the testis. The testes were then weighed and fixed in 10 percent formalin. Histological sections were prepared from the areas of the head, body, and tail of the epididymis together with their underlying portion of the testis.

Examinations of female reproductive tracts concerned first the gross aspects, followed by detailed histological examination of the ovaries and, in six instances, the preparation of sections of one uterine cornu. Examination of the fresh uterus was accomplished by an incision along the junction of the broad ligament, after which a search was made for blastocysts, implanted embryos and for evidence of previous pregnancies. Gross

ovarian examination was accomplished by sagittal sectioning of fixed organs at 2 1/2 mm. intervals with a hand microtome. A record of ovarian inclusions was made and half of each ovary was prepared for histological examination. These sections were fixed in 10 percent formaldyhyde solution.

Some specimens remained in the formaldyhyde fixative as long as four years. This procedure and the fact that some tissues were not obtained immediately after death, resulted in considerable difficulty in their recovery for histological processing. Regardless of possible artifacts induced by decomposition or prolonged storage of the tissues in fixatives, the specimens to be examined microscopically were cleared, dehydrated, embedded in parrafin, sectioned from 6 to 10 micra, and stained with hematoxylin and eosin.

The thesis developed on the reproductive activity of the bear is based upon specimens properly fixed and preserved and for which the histological slides were suitable for the preparation of photomicrographs. The number of bears from which properly prepared slides were available did not in any case represent a small portion of those collected. Over half of the slides

prepared were in a condition that allowed estimation of cell types and cellular activity of each testicular, epididymal or ovarian component discussed.

The data available for male black bear specimens are listed in Table 1. Included for each specimen, if available, is the collection date, body weight, the length and width of the skull, the length and weight of the bacula, an age estimate based initially on skull measurements, the right and left testicular weight with an average, and the histological classification of the testis and epididymis where available. Seminiferous tubules were classed in three categories (Table 1): (1) solid, tube-like structure with no lumen and no spermatogenesis, (2) tubules open, with a well-developed lumen and active spermatogenesis, and finally (3) spermatic epithelium showing signs of regressing from a functional state. The second and third classifications depended upon whether all stages of spermatogenesis were evident, and whether spermatids were present at the luminal border of the seminiferous tubule with or without the production of abnormal cell forms. Leydig cells were classified as (1) active, with the nuclei round and the cytoplasm ample with

evidence of secretory vacuoles; or (2) inactive, showing pre-seasonal or post-seasonal activity. Epididymides were classified as with or without active secretory products, and whether or not spermatazoa were present in the lumina.

Female black bear specimens were tabulated in three groups: (1) immature, (2) mature open (non-pregnant) or bred, or (3) lactating or post-lactating (Table 2). The classification of "immature" was based upon comparison of body weights, skull measurements, the condition of the uterui, ovarian weights, and ovarian histology with the three immature captive bears of known age. The classifications of "mature open" or "mature bred" were based on histological evidence of lack of ovulation or early or late functional corpora lutea in bears collected following the breeding season on a comparison with known open or bred bears or, if collected preseasonally, whether the ovary described the condition typical of early lactating female bears. The classification of "lactating or post-lactating" was based upon a comparison of ovarian function of bears known to be in lactation or post-lactation; the only distinction between the

lactating and post-lactating bear was that ovarian function declines in a recognizable manner during the weaning period.

Reproduction In Male Black Bears

<u>Body Weight and Age</u>. In lieu of reliable methods for estimating the actual age of male bears obtained in the wilds, one is apt to encounter considerable error when using body weight alone as the criterion of age. The general consideration of body weights suggests, however, that most male bears under 130 pounds, regardless of the season of the year, are sexually immature (Table 1). This generalization does not, on the other hand, imply that bears over 130 pounds are sexually mature. It is apparent from the composite results obtained in this study (Table 1 and beyond) that male bears are not sexually mature during the second year of life, and only rarely, if ever, during the third year. The weights of such bears ranged from 53 to 129 pounds. In fact, the maximum weight of an immature bear could well reach 130 or 140 pounds, since in this study bears in their second

and third year were not obtained in the late fall fattening period.

Under Michigan conditions, however, black bears attain heaviest body weights in the late fall, just prior to denning, and the lightest body weights in late winter and early spring shortly after emerging from dens (Erickson and Youatt, 1961). The season of the year specimens are obtained must be considered, therefore, before any relationship of age and body weight can be established. In general, the heaviest bears encountered in this study were the oldest, and the lightest were younger bears. A graded-weight increase with age was apparent (Table 1): August specimens No. 875 (91 pounds), No. 687 (129 pounds), No. 866 (140 pounds), No. 512 (252 pounds), No. 810 (280 pounds), and No. 1043 (305 pounds). Due to the considerable variation within any one age group of bears, however, these data indicate that the ages of bears cannot be reliably estimated on the basis of body weight alone.

<u>Estimates Of Age By Skull And Bacula Measurements</u>. The length and width of male bear skulls, and the length of the bacula, from known-age specimens, show consistent increases with age (Table 1). There is no evidence

that maximal skull or baculum size is attained by the seventh year, since no plateau was noted in the 7-year-old specimens studied and the maximum measurements obtained were for a 24-year-old specimen[1]. Although variations were found in bear skulls and bacula within given year classes, there was no overlapping in measurements in the limited number of known-age specimens (Table 1, specimens Nos. 5991 and 5996, 0.8-year siblings; Nos. 5479 and 805, 1-1/2 years; No. 810, 6-1/2 years; Nos. 804 and 806, 7-1/2 years; and No. 807, 24 years). These data and the manner in which skull and bacula measurements fall into groupings (Table 1) demonstrate that skulls and bacula sizes provide indices of age in male bears. It may be generalized that male bears with skull length and width summation measurements less than 385 mm., or bacula length measurements less than 120 mm., are sexually immature. The ease with which the bear's baculum can be extruded from the penis sheath is also related to age. Cub bacula could not be extruded; yearling-bear bacula could be partially

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[1]Specimens of known-age were not available between these ages.

extruded; and the bacula of bears in the third year could be totally extruded only by force. The bacula of older specimens were easily extruded during all seasons.

Testicular Weights. There was no apparent consistent difference in the left and right testicular weight in the black bear (Table 1). The lightest testicular weights were found in the youngest specimens and the heaviest in older specimens. The heaviest testicle weight recorded was 77 grams.

There were seasonal variations in the testicular weights of bears, even in immature specimens. The testicular weights in any one age group were greatest close to the breeding season--late May until mid-July. Testicular weights in mature bears at this time of the year were at least twice as heavy as in the fall during testicular regression, and probably several times heavier than at the beginning of the year before any signs of testicular development. The data demonstrate that testicular regression is extensive in mature bears and involves atrophy to weights encountered in some immature bears at the height of the breeding season (Table 1, compare fall adults Nos. 531, 534, and 548 with immatures Nos. 667 and 830.) Although the testes of immature bears do not produce spermatazoa, a seasonal weight change occurs, although not to the extent encountered in mature males. The maximum weights of immature bear testes were noted at the height of the breeding season. There is an inverse relationship of testicular weight to body weight. That is, maximal testicular weights occur at minimal or medial body weights, and minimal testicular weights are associated with the maximal yearly body weights, namely, in late fall.

A consideration of testicular weight and sexual maturity indicates that testicular weights above 25 grams during the breeding season would be from mature bears and testicular weights below 12 grams during the non-breeding season would be from immature bears.

<u>Histological Changes In The Testes And Epididymides</u>. There is only limited information in the literature on the morphology and histology of the black bear testis. The mature bear testis is confined in a well-developed coat of dense connective tissue, the tunica

albuginea, which projects into the posterior portion of the gland as the mediastinum testis. This is continuous with finer strands of connective tissue, the septula testis, which extends radially into the body of the testis encompassing the individual lobuli testis, the germinative and endocrine portions of the gland. The coiled seminiferous tubules contained within the lobuli testis are continuous, with short, straight tubi recti which convey the sperm from the apex of the lobule to a series of irregular epithelial-lined spaces, the rete testis.

It was often observed in these studies that all of the seminiferous tubules did not contribute to an equal extent in spermatozoa production. In some mature bears, during the height of the breeding season, some seminiferous tubules had not developed beyond the solid cord state whereas others in the same testis were fully developed and functional. In other lobuli completely developed seminiferous tubules could be found adjacent to others which, although describing most stages of spermatagenesis, were not producing spermatids.

The transition of cell types within the collecting tubules is consistent with that described for other mammals. This is also true as regards the brush border and central cell flagellum within the ductus efferens, as well as the cell types, stereocilia and secretions described for the epididymis of mammals in general.

The seminiferous tubules in the immature bear appear as solid cords of syncytial cells showing little specialization of cell types (Figure 1). There is some degree of testicular activity in 1-1/2 and 2-1/2-year-old bears approaching the breeding season, although not to the stage of spermatozoa production. The first sign of testicular activity in the immature bear is the appearance of the interstitial or Leydig cells within the previously undifferentiated layer of fibroblasts occupying the intra-seminiferous cord area. It was also noted that although the immature bear does not display differentiation of cells within the seminiferous cords at the height of the breeding season, there is, nevertheless, a development of well-defined functional Leydig cells at this time. This increase in the number and functional appearance of the Leydig cells indicates that immature bears 1 or 2-years old enjoy some degree of endocrine secretion during the limited breeding season. This increase in endocrine activity in the immature bear testis is accompanied by a well-developed epididymis and in a tendency for male cubs 6-months old and older to masturbate during and following the breeding season. Although sexual behavior patterns were noted in immature bears, there is no evidence that the male bear becomes sexually mature before 3-years old. The increase in Leydig cell activity noticed previous to, during, and just subsequent to the active breeding season in the immature bear declines by early fall and the intra-tubular areas are replaced by connective tissue (Figure 1).

The seminiferous tubules of the mature and immature bear during the non-breeding season appear as solid cords of undifferentiated cells (Figure 1). There are no marked differences in testicular histology in 1 1/2-year-old, 2 1/2-year-old, and mature bears during this period. By April, however, the seminiferous tubules in the mature bear testis

are considerably enlarged (Figure 2). The seminiferous tubules at this time occupy a greater portion of the testis. Moderate cellular differentiation in the tubules is confined to a clear distinction between spermatogonia and Sertoli cells with no evidence of spermatogenesis. The lumina of the tubules are evident at this time. The enlargement of the seminiferous tubules in the mature bear precedes any evidence of active Leydig cell function (Figure 3), although small Leydig cells are apparent in the intra-tubular areas. The appearance of spermatogenesis in the enlarged seminiferous tubule precedes the establishment of a definite lumen and occurs at about the same time as the appearance of active Leydig cells. The definite establishment of seminiferous tubule lumina appears to be correlated with an increase in Leydig cell activity (Figures 4 and 5). The Leydig cells, at the height of the breeding season (Figure 6), appear highly active and occupy a greater portion of the intra-tubular spaces; that is, the supporting connective tissue constitutes a minor portion of the tissue present in these areas. There is a clear distinction

between Sertoli and spermatogonia cells at this time (Figure 6). The gonadal activity of the male, including spermatogenesis, precedes and exceeds the period of acceptance by the female. Active Leydig cell development and spermatogenesis, with the presence of spermatozoa in the head, body, and tail of the epididymides were noted in specimens collected from late May and the first of June (Table 1, bears 776 and 804) to the middle or the end of July (specimens 839 and 861).

The first sign of seminiferous tubule atrophy is the appearance of a considerable number of small round cells and cytoplasmic droplets in the tubule lumina. By mid-September, aspermia is apparent and round nucleated cells constitute the sole production or extrusion of the seminiferous tubules, although spermatoza may still be recognized in the head, body, and the tail of the epididymis (Figures 7 and 8). Leydig cell activity is apparent for at least a month subsequent to the decline of the seminiferous tubules. Leydig cell activity declines by mid-September (Figure 9). The nuclei and cytoplasm of the Leydig cells appears more dense with little evidence of secretory activity. Testicular regression continues and although the pattern or extent of regression differs among bears, by October 1 the diameter of the seminiferous tubules is markedly decreased and the interstitial tissue is sparse (Figures 10, 11 and 12). By mid-October, testicular degeneration is nearly complete and by the end of October the testis is a structure composed of a considerable amount of fatty tissue and loose, fibrous, connective tissue (Figure 13). The process of degeneration continues until the mass of the testis is primarily composed of intratubular, loose fatty connective tissue. The seminiferous tubules at this time appear as degenerate cords of cells (Figure 14), the cords themselves occupying a minimal portion of the testicle mass. Testicular weights at this time were the lowest found in the mature bear throughout the year.

From the limited number of specimens, it was not possible to determine the exact duration of the atrophic testicular condition. It would seem, however, that the condition prevails well into the denning period. Testicular recrudescence, however,

is advanced before emergence from winter denning (Figure 2 and 3). The debut of testicular activity is marked by an increase in the size of the seminiferous tubules without any obvious development of tubuli lumina.

The epididymis of the male bear is as described for other mammalian species. Spermatozoa were not observed in the epididymis before the first of June. High secretory activity in the epididymis was noted in the highly developed pseudo-stratified sterio-ciliated cells (Figures 15 and 16). The epithelium of the epididymis changes from the high, stratified, sterio-ciliated cells in the head and body to a more cuboidal type cell in the tail. The first sign of cellular degeneration in the epididymis follows the atrophy of the seminiferous tubule by several weeks. The degeneration of the epididymis was first noted in the highly secretory head. By September 1, the epididymal cell height is decreased, and the sterio-ciliation becomes less evident and the secretions of these cells are limited (Figure 17). A heavy, fibrous, connective tissue layer invades the area previously occupied by the smooth musculature just surrounding that of the epididymal tubule.

Degeneration of the epididymis continues (Figures 18 and 19), the increase in fibrous tissues surrounding the tubule becoming marked and the cellular components lining the lumen becoming indistinct and disorganized. This process continues until the epididymis, in late fall, appears as an atrophied, non-secretory tubule, considerably smaller in diameter than in the normal functional state and surrounded by a heavy wall of connective tissue (Figure 20). At this time, grossly, the epididymis is only a thin layer of tissue lying against the outside of the testis.

A few specimens of bear vasa deferentia were available. The most anterior portion of the vasa deferentia is not unlike that of the posterior portion of the tail of the epididymis except for the lack of a heavy musculature. The epithelium appears as low cuboidal and apparently the cells are ciliated. Spermatozoa were noted in the vasa deferentia during and subsequent to the breeding season. This suggests that the major fate of unejaculated sperm is expulsion rather than resorption.

It was of interest that the mature spermatozoa of the black bear did not closely resemble those described for most domestic mammalian species. The head appears cylindrically rod-shaped rather than oval, and terminates into the tail region without obvious transition into the commonly described neck piece and body. These spermatozoa are not unlike those reported for birds and amphibians.

Reproduction In Female Black Bears

Gross Description Of The Ovaries And Reproductive Tract.

The reproductive tract of the female bear is typically bicornate, each uterine cornu in the unbred adult being approximately 180 mm. long. The body of the uterus is short, averaging 30-40 mm. in length, and opens posteriorly into a single cervix which protrudes into the anterior portion of the vagina. The short, highly convuluted oviducts lie in close apposition to the ovary, and both are entirely embedded in a complete ovarian bursa (periovarial sac) which is closely joined with the distal end of the cornu. The fimbria of the ostium are abundant with a small portion protruding into the peritoneal cavity through a small slit in the periovarial sac. Explanation for this anomaly is wanting. In the rat and mouse (Alden, 1942; Winsatt and Waldo, 1945) as well as in a number of carnivores (Kellogg, 1941), a narrow slit in the periovarian space is reported to allow interchange of fluid with the peritoneal cavity.

No embryos were recovered from the reproductive tracts of known bred bears or from any of the specimens collected in the wild. Implantation, however, is apparently of the zonary type as shown from old implantation sites (Figures 71, 72, and 73). As judged from specimens exhibiting placental scars of known history (see Table 2, specimen Nos. 801, 823 and 854), the darker bands in the fresh tissue shown in Figure 72, represent three implantation sites persisting for five months following parturition; the lighter, less discrete circular area is considered to represent an implantation site from an earlier pregnancy, presumably 2 1/2 years previous (see beyond).

The placement of placental scars suggested that implantations occur most frequently about a

third of the distance from both the bifurcation of the uterus and the distal ends of the cornu. Bear 857 (Figure 72) is an exception. Multiple implantations were characteristically divided between both horns. This observation and the further finding that multiple ovulations usually were predominantly confined to one ovary (see below) suggests that transmigration of ova from one cornu to the other commonly occurs in the bear.

There were no differences in the size or coloration of the most recent placental scars. It was assumed that they represented the number of fetuses carried to term (see beyond)[2]. That the number of young carried to term can be determined during the following lactation and post-lactation period by the presence of recent placental scars, provides a means of measuring reproductive success in bears (breeding rates and breeding success, section beyond). Several wild bears observed (Table 2, bears 854 and 710) had raised fewer cubs than the

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[2]In columns 12 and 13 of Table 2, an entry of 2 + 1 indicates that two recent placental scars and one additional placental scar from an earlier pregnancy were observed in the uterus.

number of recent placental scars indicated were born. In other instances the number of cubs raised equalled the number of recent placental scars in the uterus (Table 2, bears 801 and 823). In no instance did litter size exceed the number of recent placental scars.

The ovaries of the black bear varied markedly in size and configuration depending upon the animal's age and reproductive state. Ovaries of sexually mature bears are often deeply fissured and their surfaces become progressively rugose with advancing age. In general, the average weight of the ovary in an immature bear, was about half that in a mature specimen (Table 2, Column 11). The heaviest ovarian weights (maximum 6.4 grams) were obtained from lactating animals. The general uniformity of ovarian weight in lactating animals, in contrast to that in the open or pregnant mature animal or immature animal, can be explained by the uniform ovarian tissue to be found in a lactating animal (see beyond).

<u>Histology of the Ovary</u>. The histology of the black bear ovary, while generally consistent with

that of other mammals, varies substantially in certain respects. The surface of the ovary is covered by a single layer of germinal epithelium resting on a thick dense connective tissue coat, the tunica albuginea, which encompasses the ovary and projects into the base of the gland as the hilus. Extending radially from the hilus and into the ovary are buttresses of connective tissue and blood vessels. In the mature bear ovary this gives the impression that the ovary is more or less radially divided. Follicles in various stages of development are distributed beneath the tunica albuginea and within the loose connective tissue of the cone-like radial units.

There are no marked microscopic differences in the ovarian structures of the open mature and immature female bear during the late non-breeding season, that is, from December to February. Follicles in the ovary do not develop past the primary follicle stage during this time. The majority of the ovary is comprised of fatty connective tissue (Figures 21 and 22), a very poor organization of

cells, and only a few cells are similar to those of the normal ovarian substance of the active gland.

The first sign of ovarian activity in the anestrous bear is replacement of the loose, fatty, connective tissue of the general ovarian substance with large, round, nucleated cells containing ample cytoplasm. These cells resemble an active cell of luteal origin (Figure 23). The repair of the general ovarian substance during March and April, precedes the state of follicular development. During April and May follicular development progressively increases, in both mature and immature female bears. The developing follicles, however, do not reach mature size, although an antrum may be found. The substance of the follicle is actively replaced by an endocrine type cell, apparently originating from the theca interna (Figure 24), and the ovum consistently appears trapped in the center of the degenerate secondary and tertiary follicles. The cells replacing degenerate follicles do not in any sense appear as the interstitial tissue described in other animals, but appear as active luteal-type cells (Figures 25 and 26).

The germinal epithelium of the ovary is very apparent during the pre-breeding season and appears as a single layer of cells encompassing the ovary (Figure 27). Many follicles apparently develop to the tertiary stage during the pre-breeding season and remain here for a considerable length of time before degeneration proceeds. Degeneration of the tertiary follicles is preceded by a loosening of the granulosa layers and is accompanied by considerable disorganization of the theca interna and externa (Figure 28). Another consistent characteristic of follicular degeneration is a modification of the nuclear membrane from that found in the primary (Figure 29) and secondary follicles to a heavy thickened nuclear membrane (Figure 30) found in the early degenerate tertiary follicle. Prior to the breeding season the healthy, active cells described as replacing the degenerate tertiary follicles (Figure 25, and Figure 26) are not maintained, the cytoplasm becoming dark and compact, the nuclei shrunken (Figures 31, 32), and the cells reverting to elongate, connective tissue-like cells.

In a mature animal close to the breeding season, in late May and early June, several follicles attain mature size (8 to 12 mm. in diameter). In bears not in contact with the male and not bred, the large, mature follicles are replaced by a luteal type tissue of apparent theca interna origin. In all cases, however, the ova are still observed trapped in the centers of the non-ovulatory degenerate follicles. The fate of degenerate mature follicles is apparently not different from that described for secondary and tertiary follicles. (Figures 25, and 26, and Figures 31, and 32.)

The cells forming the corpora lutea following ovulation appear to be of thecal origin, and the invasion of the follicle is similar to the replacement of degenerate secondary and tertiary follicles during the pre-breeding season. The appearance of the invading thecal cells following ovulation, however, is quite different (Figure 33). The nuclei of the post-ovulatory corpora lutea cells are well rounded, the cytoplasm is ample with secretory vacuoles, and the cells develop to a highly functional state (Figure 37). This is in sharp contrast to the

low activity state of post-ovulatory corpora lutea cells found in the armadillo (Dasypus novemcinctus), a species for which delayed implantation has been demonstrated (Hamlett, 1935). In the armadillo high secretory activity is not demonstrable until the initation of active embryonic development approximately 3-1/2 months after ovulation. Assuming delayed implantation in the black bear, these differences suggest basic variations of the phenomenon between species.

The typical definitive corpus contains a large lumen. The earliest date a corpus luteum was noted was on July 20, and practically all adult specimens without young and accessible to males exhibited functional corpora lutea after this date. Since all mature ovaries collected before this data did not contain corpora lutea, it seems evident that breeding is limited to a short period in late June and early July. Diameters of functional corpora lutea ranged from 8 to 15 mm.

Shortly after ovulation the general ovarian substance undergoes changes evidently of an endocrine nature. Intra-follicular areas become more dense

(Figure 34) and a greater portion of the non-follicular cells assume an endocrine-type appearance (Figure 35). By fall, 3 months after breeding, the general ovarian substance (Figure 38) appears as healthy luteal tissue, although it does not assume the height of activity seen in the still discrete corpora lutea (Figures 36 and 37; and Figure 39). There is apparently a general luteinizing influence on the ovary at this time, and the cells that replace degenerate follicles (Figure 31) appear to become more active (Figures 40 and 41), and to assume the appearance of active luteal tissue.

Follicular development still continues in the ovary in the presence of functional corpora lutea but not to the tertiary follicular stage. Follicles of various sizes present in the ovary at the time of ovulation are readily replaced (Figure 42) by encroaching general ovarian substance until the only follicular activity seen is degenerating secondary follicles (Figure 43), and nest cells that appear inactive (Figure 44). As pregnancy progresses, the general ovarian substance appears to be largely replaced by active luteal tissue (compare Figure 34 and 45) and the vascularity of the corpora lutea is greatly increased (Figure 46). This increase in vascularity extends to the general ovarian substance. The corpora lutea of pregnancy apparently maintain their function throughout term and the area of the original ovulation and luteinization can be discerned until close to term (Table 2, bear 931). There is very little difference in the histological appearance of cells occupying the place of the original luteinization (Figures 47 and 48) and those induced adjacent to the corpora lutea in para-luteal tissue (Figures 49 and 50). The ovary at this time is essentially a solid luteal body.

Multiple ovulations seem for the most part to be confined to one ovary, indicating that in most cases one ovary is more active than the other during the breeding season (Table 2). However in four cases functional corpora lutea were found on each ovary, showing that ovulation activity is not necessarily limited to one ovary. In specimens showing unilateral ovulation, the formation of accessory corpora lutea was regularly noted (Figure 51). Follicles in the ovary not containing a functional corpus luteum were replaced by luteal-type activity, presumably maintained as long as the corpus luteum was functional (Table 2, bear 931).

A decline in luteal tissue activity occurred in bear ovaries close to the first of the year or close to the time of whelping. The nuclei of the corpora lutea cells became more dense, the cytoplasm more darkly staining (Figure 52), progressing to pyknotic-type nuclei and irregularly described cells (Figure 53). At this time the corpus luteum showed marked vascularity. The cells of the general ovarian substance, although still apparently of endocrine nature, were smaller, more compact, and less active (Figures 54 and 55). The fibroblast type cells appeared prominent in the general ovarian substance. The endocrine type cells of the general ovarian substance assumed a wheel cell appearance (Figure 56) not unlike the wheel cell formation of interstitial tissue in the hypophysectomized rat.

Well-defined corpora lutea of pregnancy are not discernible on the ovary following parturition (Table 2, bear 801) and the ovary takes the form of what might be described as an ovary of lactation. Although discrete corpora lutea of lactation are not present, the cells of the ovarian mass appear as a basic distinct endocrine-type cell. Shortly after whelping and previous to the next breeding season (June and July), the ovary of lactating bears contains primary and secondary follicles similar to those noted in the non-pregnant mature and immature bear. However, although follicular growth is apparent in lactating bears very few follicles reach the tertiary stage of development (Figure 57). Developing follicles are replaced by the invasion of tissue from the general ovarian substance. These endocrine-type cells, however, do not become inactive as in non-pregnant bears prior to the breeding season, but describe a state of functional activity (Figures 58 and 59). This pattern was consistently observed in lactating females. The follicles developing are replaced by and blend into the general ovarian substance, the two original tissues being indiscernible from each other. There is very little difference in appearance between cells derived from degenerate follicles (Figures 60 and 61) and the original general ovarian substance (Figure 62). The follicles developing in the ovary of the lactating bear prior to the normal breeding season have well-developed granulosa layers (Figure 63), but do not exhibit a well-defined theca interna and externa. The intense replacement of the developing follicles by luteal-type tissue apparently prevents ovulation since follicles do not develop to pre-ovulatory size in lactating animals during the breeding season. The maintenance of this function is apparently associated with the act of nursing, since the removal of the young just prior to the breeding season results in full follicular development and ovulation following breeding, (Baker, 1912). Subsequent to the normal breeding season the ovary of lactation declines in activity. The general ovarian substance becomes less dense (Figure 64), cell outlines less distinct, the cells smaller, and the nuclei pyknotic. There is less tendency for the replacement of developing follicles with active luteal-type tissue (Figure 65) and the cells that previously invaded the atropic follicles appear inactive (Figure 66, as compared to Figure 57). The decline in ovarian function becomes more pronounced in the early fall (Figures 67 and 68), after which the ovary regresses to a state not dissimilar to that previously described for non-pregnant mature female bears during anestrus (Figure 21).

Ovulation Rate, Conception Rate And Litter Size

The persistence of both corpora lutea during pregnancy and placental scars, following pregnancy, as described earlier, provided means by which ovulation and conception rates might be estimated in the black bear. While the phenomenon of general luteinization of the ovary in the bred bear, and especially the formation of accessory corpora lutea and para-corpora lutea, were possible sources of error in the use of corpora lutea as an index of ovulation rate, the histological studies indicated

that errors of this nature were unlikely. Accessory and para-corpora lutea were not only smaller when compared to true corpora lutea, but they typically retained trapped ova and did not display the large open lumen found in all true corpora lutea.

The utilization of the persistence of placental scars from one pregnancy to the next as an index of productivity presented a more serious problem. Uteri exhibiting placental scars of different size and coloration were encountered in four instances (Table 2). In these cases a judgement was made as to whether the faded scars represented previous pregnancies, abortions, resorptions or differential fading of like-age scars. The latter three possibilities appeared improbable. The comparable size and configuration of faded scars, when compared to bright scars (Figures 71 and 72), argued against their being scars resulting from abortion or resorption. Differential fading of placental scars also seemed unlikely, since, except for faded scars all scars for individual tracts were indistinguishable from one another, including member placentations in the four tracts with faded scars. A different origin for the faded scars (presumably previous pregnancies) seems probable. Within a few days following formalin fixation they bleached and became indiscernible in contrast to only a slight bleaching for the scars believed to be younger. Further evidence suggesting that faded scars represented previous pregnancies is that their inclusion in total placental scar counts raised the average count for uteri exhibiting scars to 4.5 scars per tract. This was appreciably above the 2.7 average count obtained for tracts with scars of only like character (Table 2). It is obvious that the live productivity data would not support the conclusion that an average of 4.5 cubs are carried to term.

Corpora lutea counts were obtained from 12 ovary pairs with a 2.42 mean ovulation incidence (Table 2). Seven ovary pairs contained two ovulations each and four showed three each. Two single ovaries, each from a different specimen, showed one and two corpora lutea, respectively. The mean ovulatory rate obtained for the 11 complete ovary pairs is somewhat less than 2.85 mean placental scar count obtained from 13 tracts exhibiting recent scars (Table 2). Placentation scar counts were distributed as follows: 8 tracts had 3 scars each, 2 tracts had 4 scars each, 2 tracts had 2 scars each, and 1 tract had a single scar.

It is apparent from these corpora lutea and recent placental scar data that the estimated conception rate exceeded the histologically confirmed ovulation rate. Other than by chance, this condition could only result poly-embryonically if it is assumed that bright scars represented sibling fetuses carried to term. This possibility appears unlikely and more probably these data were too few to permit a valid hypothesis. It seems obvious though, that primary productivity in the black bear is indicated as quite high, averaging well in excess of two cubs per litter.

Table 3 summarizes the litter sizes of family groups of bears observed by the writer in Michigan, and an additional group of observations recorded subsequent to the Michigan observations for the black bear in Alaska. About a third of the Alaska data were reported by co-workers. The observations in both areas were for the summer months June through September and applied to cubs mostly 5 to 8 months old. The mean litter size for 43 observations was 2.05 cubs, the 20 Michigan records averaging 2.15 cubs per litter, the 23 Alaska records 1.96. These values closely agree with the 2.05 mean litter size established for 176 litters included among kill reports of bears by Michigan hunters (Erickson, 1964). Other workers (Schorger, 1949; Spencer, 1955; and Baker, 1912) have reported mean litter sizes slightly larger than those recorded in this study. However, the manner in which the data reported by Schorger and Spencer were obtained may have resulted in some bias due to the possibility that large litters were more frequently reported to them. The litters reported by Baker were captives at birth and had not been subjected to 4 to 9 months of post-partum mortality as had our litters and the others discussed here. The 28 litters included in Baker's report, averaging 2.43 cubs per litter, provide the only extensive compilation of early post-parturient litter data available. This value is precisely the same as the ovulation rate indicated above and together with the high conception rate indicated by placental scars suggests both relatively low ova loss and low intra-uterine mortality of embryos and fetuses.

TABLE 3. Litter size in the black bear

Location	Number of litters	Size of litter 1	2	3	Mean litter
Michigan	20	3	11	6	2.15
Alaska	23	7	10	6	1.96
	43	10	21	12	2.05

Litter size frequency data obtained in both this study and for the other reports cited classify litter size frequencies approximately as follows: Single cubs--7-15 percent, twin cubs--40-50 percent, triplet cubs--30-40 percent, and quadruplets--5-10 percent.

Discussion

Although criteria for precise estimation of age of black bears have not been fully described, it appears that the shape of the skull and the bacula are reliable criteria of age of males. Skull measurements are apparently not a good index of age of female bears, for although the smallest skulls were found in the youngest females and the largest skulls in the oldest females, there was no direct relationship between length and width of the skull, and age.

Body weight, per se, as a criterion of age of black bears, does not appear to be valid for either sex. There is considerable variation in body weight from the time a bear comes out of its den in April and May, through the period of scanty food supply in early spring, and the ample provisions of late spring and summer. Considerable variation is also shown by like-age specimens at the same season. For these reasons it is not feasible to estimate the ages of male or female black bears on the basis of body weight alone.

There is no evidence that either the length or width of the skull or the baculum terminate growth before the seventh year of life in the male black bear, although the rates of growth markedly decrease as the animal ages. Skull measurements and the length of the baculum therefore appear to be accurate criteria of age in the male bear and

apparently are not dependent, in any one year's time, upon the state of nutrition.

This study demonstrates that black bear testes undergo almost complete degeneration in the late fall and winter months. Sperm production in mature bears ceases 1 to 1 1/2 months after the period of receptivity in the female. The testes remain in a resting state until 1 to 2 months before the next onset of estrus in the females.

Histological studies indicate that sexual maturity is not attained by immature male bears before the third or fourth year and that most male bears are still immature at the height of the breeding season during the third year of life. Although spermatogenic activity is absent in immature male bears, these animals nevertheless achieve some degree of androgen production. Leydig cell activity and development of the epididymides are apparent in bears 2 to 3 years old, and masturbation has been observed at even younger ages. Leydig cell activity of mature male bears precedes and exceeds the period of active sperm production. The epididymis of mature male bears is developed by the first of May

in Michigan and may retain functional characteristics as late as mid-August.

Sperm production on the other hand, although exceeding in time the length of female receptivity, was only observed from mid-May until mid-July. The spermatogenic epithelium of the seminiferous tubules degenerates to a thin cellular cord by late fall and the testis appears to be composed of fatty type connective tissue with little evidence of either seminiferous tubule or Leydig cell activity. The awakening of gonadal activity in the spring is marked by the enlargement of solid seminiferous tubules with a common basic cell type. The differentiation of the cell types into Sertoli cells and spermatogonia, with some degree of spermatogenesis precedes the opening of the seminiferous tubule just prior to the breeding season.

It would appear, therefore, that the black bear testis undergoes extensive testicular atrophy during the fall, and that during the winter denning period the extent of atrophy is more marked than described for most mammalian species. It is of interest that testicular recrudesence begins prior

to emergence from the den.

The results of these studies classify the female black bear as being seasonally constant estrus with ovulation induced following mating. Therefore, breeding activity in the bear is comparable to that found in the ferret (Marshall, 1904), the domestic cat (Eckstein and Zuckerman, 1956) the American mole (Conaway, 1959), the mink (Hansson, 1947) and the European weasel (Deansley, 1944). The height of breeding activity for Michigan bears is between late June and mid-July. The duration of heat was not established. One record (Table 2, bear 893) where the zoo keeper observed a female bear bred several times on June 22 and 23 but not thereafter indicates post-breeding heat to be of short duration. An anestrus period ensues in adult non-bred bears following the breeding season and the ovary regresses to a non-functional structure by late fall. The ovary at this time is primarily composed of fatty tissue and remains in this state until approximately February of the following year. These studies did not clarify whether female black bears have

a delayed implantation, or whether the blastocyst implants shortly after conception but does not show marked embryonic development for several months.

The possibility of delayed ovulation may be eliminated, however, on the basis of early corpus luteum formation following breeding. Reproductive tracts examined grossly and histologically from several bears known bred during the breeding season, as late as 3 or 4 months after breeding, failed to show any evidence of the fertilized zygote or any gross changes indicating an implantation site. This would indicate, considering that whelping occurs shortly after January 1, that the major growth of the bear embryo and fetus occurs within a 2-month period sometime after October.

Corpora lutea appear to be maintained until term, after which time the ovary of the lactating animal assumes a uniform functional state; that is, an endocrine-type tissue apparently derived from the general ovarian substance. Although some degree of follicular growth occurs in the lactating animal prior to the breeding season, follicles do not reach the mature state. Follicules are rapidly replaced

by the endocrine-type tissue of the general ovarian substance. Lactating bears do not go into estrus and accept males during the normal breeding season, since follicles undergo transformation to luteal-type tissue. One instance occurred, however, where a lactating female trapped July 29, 1956 (Table 2, bear 854), and withheld 2 days from her three cubs and then released, gave birth again the following year, that is, in consecutive years. This indicated that she had come in estrus, presumably due to interrupted lactation, had conceived and delivered cubs the following year. Removal of cubs from captive females before the breeding season also results in breeding during consecutive years.

These observations suggest that the lactation anestrus of the bear is similar to that in swine where corpora lutea of lactation are not formed. The ovary assumes a uniform functional condition and either an endocrine activity of the ovary or the act of lactation itself prevents follicular maturation and the expression of estrus. Litters may be removed from swine, and the sow will then come in estrus, ovulate, and can conceive, and

their young can occasionally be placed back on them while they are pregnant. The luteal-type tissue of lactating female bears remains very active until July and August, following the breeding season, at which time the tissue regresses. By October the ovary assumes a condition not dissimilar to that of the mature non-bred bear during the denning period. Although the wild specimens examined indicated that weaning was virtually complete by September there was no difficulty, histologically, in determining whether a bear killed during the fall hunting season had lactated earlier in the year.

It is possible, therefore, upon histological examination of the ovaries at any time of the year, to determine whether a female is (1) immature, (2) sexually mature and open or lactating prior to the breeding season, or (3) bred, open or lactating subsequent to the breeding season. These studies demonstrate that the gross examination of female bear ovaries and of the placental scars in the uteri can give accurate indices on the ovulation and conception rate of female bears at various ages of life and also on the proportion of bears

whelped that are raised successfully. The limited specimens available indicated a 2.4 ovulation rate. If this approximates the normal rate, the high conception rate indicated from placental scar counts and early post-partum litter data suggests relatively low ova loss and in-utero embryo or fetal loss. In any event, the relatively extensive late post-partum litter data indicates the average litter at weaning exceeds two cubs.

Although the specimens available for this study, with the exception of the 17 bears of known age in captivity, were from field sources, the hypothesis is advanced as to the type of reproductive cycle in female black bears and as to the onset and decline in male gonadal activity. The serious limitations, particularly the unavailability of animals during the denning period and shortly after birth, could hardly be avoided. It is felt, nevertheless, that the hypotheses are properly supported by the histological evidence presented in these studies.

Summary

The breeding biology of the black bear was described following gross and histological examinations of the testes and epididymides of 55 male bears and the ovaries and uteri of 36 female bears. Eighteen specimens were of known age. Among females partial breeding history was known for 11 captives and 9 live-trapped animals. Specimen collections were collected between August 1, 1955 and September 20, 1958.

The female black bear has seasonally constant estrus with ovulation induced following mating. Breeding activity in Michigan occurs between mid-June and mid-July.

Gestation lasts approximately seven months. However, active embryonic growth is limited to the latter half of pregnancy. Presumably this is due to delayed implantation since the corpus luteum is formed shortly after breeding. Placentation is zonary. A mean ovulation rate of 2.4 ova per breeding is indicated from limited data. Puberty for both sexes is attained at an age of approximately

3.5 years.

Histological studies demonstrate that the testes of the male bear undergo extensive degeneration following the breeding season. Sperm production in the mature bear ceases one to two months after the period of female receptivity, and the testes remain in a resting state until one to two months before the next onset of estrus in the female. Testicular awakening is marked by differentiation of the cell types into Sertoli cells and spermatogonia. This procedes the opening of the seminiferous tubules just prior to the breeding season. Leydig cell activity precedes and exceeds the period of active sperm production.

Histological studies of the ovary show no marked microscopic differences in the ovarian structure of adults that have not been bred and in immature bears during the denning period. The mass of the ovary is composed largely of fatty connective tissue. With the approach of the breeding season the loose fatty connective tissue is replaced with tissue comprised of cells resembling active luteal cells. Follicles develop but before reaching mature

size are replaced by this endocrine-type tissue. It is very likely that this tissue is comparable to the "thecal glands" described in other species as replacing degenerate follicles.

The cells forming the corpora lutea of ovulation resemble the pre-breeding season luteal-like tissue and appear to be highly functional. The discrete corpora lutea can be recognized in the ovary until mid-September. The ovary then undergoes a general luteinization until it is largely composed of functional luteal tissue. It appears that the general luteinization is formed of para-luteal tissue rather than from the thecal gland tissue previously described.

A decline in luteal tissue activity is noted close to whelping. The ovary shows marked vascularity and the cells show a decrease in endocrine activity. Follicular growth is apparent in lactating bears, but few follicles reach the tertiary stage of development. As in adults that have not been bred and in immature bears, the developing follicles are replaced by the invasion of tissue from the general ovary substance. This

intense replacement of the developing follicles presumably prevents ovulation in lactating animals during the breeding season. The maintenance of this function is apparently associated with the act of nursing since removal of the cubs results in follicle maturation, and ovulation following breeding.

Following the breeding season, the ovary of the lactating bear declines in activity and resembles that of animals that have not bred.

TABLE 1. Reproduction in male black bears

Specimen number	Date collected	Body[a] weight (lbs.)	Skull measurements (mm.)[b] Length	Width	Total	Bacula Length (mm.)	Weight (grams)	Age (years) Known	Est.[c]
Cubs:									
1048	8-25-58	62							0.6
518	9- 4-55	61				78	1.4		0.6
1055	9- 9-58	56							0.6
524	9-21-55	73	196	117	313	79	1.3		0.7
1286	10- 1-55	64				72	1.2		0.7
5991	11-17-56	58 dr.		105		61	1.2	0.8	
5996	11-17-56	64 dr.	186	105	291	71	1.4	0.8	
Yearlings:									
641	6- 1-56	53				88	2.0		1.3
805	6-14-57	121	222	129	351	112	2.4	1.4	
828	6-26-57	113				109	2.6		1.4
830	6-27-57	67	232	121	353	108	2.6		1.4
5479	7-15-57	74	227	129	356	96	1.9	1.5	
863	8- 9-57	76	224	121	345	93	2.6		1.6
875	8-25-57	91	220	117	337	87	2.0		1.6
692	9- 2-56	84				89	1.5		1.6
878	9- 2-57	113	229	128	357	103	2.8		1.6
Two-year olds:									
983	5-14-58	82							2.3
667	6-27-56	105	245	131	376	121	3.1		2.4
858	7-26-57	121	238	127	365	112	3.5		2.5
687	8-31-56	129	249	133	382	108	2.7		2.6
1049	9- 2-58	127							2.6
515	9- 3-55	120				119	3.8		2.6

TABLE 1-Continued on page 58

TABLE 1. Continued

Testes weights (grams)			Histological evaluation			
Left	Right	Average	Semi-niferous tubules(d)	Sperma-togenesis(e)(f)	Leydig cell activity(g)	Epididymis(h)
4.7	4.7	4.7				
3.9	4.1	4.0	S	I	A-	D
2.2	2.2	2.2	S	I	I	A
3.4	3.8	3.6	S	I	I	A
3.9	4.2	4.0	S	I	I	A
5.8	6.3	6.0	S	I	A +	At
9.3	10.0	9.6	S	I	I	
9.3	7.8	8.5				
10.9	10.4	10.6	S	I	A +	
5.2	5.1	5.1	S	I	A-	At
5.6	5.8	5.7	S	I	A-	At
4.7	4.8	4.7	S	I	I	At
6.4	6.1	6.2	S	I	I	At
12.5		12.5	S	I	A +	At
26.8	30.0	28.4	S	I	A +	R
7.3	7.2	7.2	S	I	A-	At
6.6	6.8	6.7	S	I	A-	At
10.2	10.2	10.2				
21.0		21.0	O	M-	A-	D

TABLE 1. Continued - Reproduction in male black bears

Specimen number	Date collected	Body weight (lbs.)[a]	Skull measurements (mm.)[b] Length	Width	Total	Bacula Length (mm.)	Bacula Weight (grams)	Age (years) Known	Est.[c]
Three-year olds:									
827	6-25-57	160	263	142	405	122	5.0		3.4
1021	6-27-58	118							3.4
673	6-28-56	145				135	5.5		3.4
840	7-12-57	123	304	172	476	117	2.6		3.5
845	7-16-57	125	255	145	400	127	4.0		3.5
686	8- 3-56	129				129	6.4		3.6
511	8-19-55	131	248	137	385	133	6.1		3.6
866	8-19-57	140	245	147	392	130	4.5		3.6
1046	8-24-58	163							3.6
514	9- 3-55	136				125	3.5		3.6
520	9- 5-55	165				131	4.4		3.6
526	9-29-55	156	253	146	399	137	5.0		3.7
548	10-30-55	205	265	157	422	140	6.1		3.8
Four-year olds:									
837	7- 6-57	224	278	165	443	147	8.8		4.4
839	7-11-57	166	260	153	413	141	7.0		4.5
519	9- 4-55		274	143	417	151	7.4		4.6
1058	9-20-58	237							4.6
1285	10- 1-55	217				143	8.0		4.7
531	10- 8-55	267				138	7.6		4.7
Five-year olds:									
822	6-22-57	218				155	11.2		5.4
833	7- 4-57	213	253	134	387	159	10.2		5.4
838	7-10-57	270	264	155	419	159	8.4		5.5
512	8-24-55	252	290	165	455	166	10.0		5.6
534	10-25-55	260				153	10.0		5.8

TABLE 1-Continued on page 60

TABLE 1. Continued

Testes weights (grams)			Histological evaluation			
Left	Right	Average	Semi-niferous tubules(d)	Sperma-togenesis(e)(f)	Leydig cell activity(g)	Epididymis(h)
31.0	30.3	30.6	O	M	A+	
24.8		24.8	O	M	A+	M
32.0	36.7	34.3	O-S	M	A+	
26.2	23.2	24.7	O-S	M-	A	
19.7	17.3	18.5	O-S	M-	A-	
27.4	28.1	27.7	O	M	A-	
22.6	33.6	27.6	R	MI	A-	D
14.8	14.8	14.8	R	MI	A-	At
15.1	15.6	15.3				
12.0	12.5	12.2	O	M-	A-	D
16.2	16.0	16.1	O	MI	I	D
14.1	13.2	13.6	R	MI	A-	D
15.0	15.0	15.0	R	MI	A-	At
28.8	29.9	29.3	O	M	A+	
28.6	33.2	30.9	O	M	A	
27.0	27.0	27.0	O	MI	A-	D
24.7		24.7	O	MI	A-	At
16.5	17.5	17.0				
14.4	12.9	13.6	R	MI	I	At
32.0	31.0	31.5	O	M	A+	
30.1	31.8	30.9	O	M	A	
39.9	43.3	41.6	O	M	A+	
31.4	28.9	30.1	R	MI	I	D
17.8	18.8	18.3	R	MI	I	At

TABLE 1. Continued - Reproduction in male black bears

Specimen number	Date collected	Body weight (lbs.)[a]	Skull measurements (mm.)[b] Length	Width	Total	Bacula Length (mm.)	Weight (grams)	Age (years) Known	Est.[c]
Over five years old:									
958	4- 8-58	242							6.2
804	5-21-57	325	311	181	492	185	15.8	7.3	
776	5-24-57	280 dr.	313	181	494	171	12.3		6.3
807	6-17-57	309	346	198	544	190	16.4	24.4	
861	7-31-57	367	325	191	516	185	15.3	7.6	
509	8- 1-55	247	305	185	490	171	14.3		7.6
810	8- 6-57	280	300	172	472	181	11.4	6.6	
1043	8-15-58	305							7 +
1057	9-10-58	325							7 +

(a) Total body weight, dr. - eviscerated weight.
(b) Skull measurements
    Length - Occipital to front of upper incisers
    Width - Outer edges of zygomatic arches
(c) Estimated by comparison of skull and bacula measurements where available, otherwise from body weights or testes weights or both for time of the year collected.
(d) Seminferous Tubules
    O - Open lumina
    S - Closed lumina
    O-S - Open and closed lumina
    R - Regressing
(e) Spermatogenesis - Spermatogenesis + spermiogenesis

TABLE 1. Continued

Testes weights (grams) Left	Right	Average	Histological evaluation: Seminiferous tubules(d)	Spermatogenesis(e)(f)	Leydig cell activity(g)	Epididymis(h)
47.1		47.1	S	M +	A	R
52.9	53.4	53.1	0-S	M	A +	
35.4	40.0	37.7	S	M +	A +	At
77.6	71.9	74.7	0-S	M	A +	
26.2	26.5	26.3	0-S	M-	A +	
43.6	44.6	44.1	0	M	A +	M
29.9	30.0	29.9	0-R	MI	I	
39.8		39.8	R	M-	A-	D
32.7	32.0	32.3				

(f) Spermatogenesis
- I - Not active, immature
- MI - Not active, ceased
- M - Active, to spermatids
- M- - Active, incomplete postseasonal
- M+- Active, incomplete preseasonal

(g) Leydig Cells
- A - Preseasonal low activity
- A+- Breeding season high activity
- A- - Postseasonal low activity
- I - Inactive

(h) Epididymis
- R - Repairing
- M - Maintained
- D - Declining
- At - Atrophic

TABLE 2. Reproduction in female black bears

Specimen number	Collection date	Body weight (lbs.)[a]	Skull measurements (mm.)[b] Length	Width	Total	Age (years)	Bred?
Immature:							
B-136	2- 8-58	123	259	143	402	3.0	No
B-153	2- 8-58	103				3.0	No
5503	2- 9-56	113	233	131	364	2.0	No
957	4- 8-58	134					No
806	6-16-57	187	257	159	416	3.5	No
510	8- 8-55	75	227	117	344	1.7[c]	No
691	9- 1-56	75				1.8[c]	No
1281	10- 1-55	100					No
Sexually Mature, Open or Bred:							
931	2-10-58	89	255	145	400		Yes
803	5-25-57	233				15.4	No
779	5-28-57	129					No
1029	7- 3-58	131					
849	7-20-57	281	262	155	417	5.6	No
851	7-20-57	285				8.6	Yes
1034	7-20-59	141					Yes
856	7-24-57	104	240	129	369		Yes
855	7-25-57	166	264	159	423		Yes
857	7-26-57	139	259	148	407		Yes
862	8- 2-57	198	265	158	423		Yes
809	8- 6-57	163	242	137	379	5.7	No
516	9- 4-55	246					Yes
521	9- 6-55	185	255	147	402		Yes
1282	10- 1-55	130					Yes
1283	10- 2-55	190					Yes
893	10- 8-57	278				8.9	Yes
532	10- 9-55	274	271	150	421		No
924	10-13-57	190 dr.					Yes

TABLE 2-Continued on page 64

TABLE 2. Continued

Ovarian weights (gms.)			Placental scars (d)		Ovarian histology (e)		
					Corpora lutea		
Left	Right	Average	Left cornu	Right cornu	Left	Right	Activity
0.9	1.2	1.0	0	0	0	0	
1.3	1.5	1.4	0	0	0	0	
0.6	0.5	0.6	0	0	0	0	
			0	0	0	0	
1.7	2.0	1.8	0	0	0	0	
1.3	1.2	1.2	0	0	0	0	
1.0	0.8	0.9	0	0	0	0	
0.9	0.8	0.8	0	0	0	0	
2.1	1.1	1.6			0	3	+
2.9	3.2	3.1	0	0	0	0	
2.5	2.4	2.4	1	0	0	0	
2.7	2.2	2.4	0	0	0	0	
3.0	2.9	2.9	1	1	2	1	++
					2	0	+++
1.2	0.6	0.9	0	0	2	0	+++
2.7	2.5	2.6	0	0	2	1	+
1.8	2.0	1.9	3	0	1	1	‡
2.1	2.2	2.2	1	2	2	1	
0.1	0.3	0.2	0	0	0	0	
2.4	0.9	1.6	0	0	0	2	+
	2.1		0	0		1	+++
1.3	0.7	1.0	0	0	2	0	+
1.6	2.4	2.0	1	1	0	2	+
1.3	1.3	1.3	0	0	1	1	+
4.2	3.3	3.8	0	0	0	0	
	1.2			0		2	

TABLE 2. Continued - Reproduction in female black bears

Specimen number	Collection date	Body weight (lbs.)(a)	Skull measurements (mm.)(b) Length	Width	Total	Age (years)	Bred?
Sexually Mature, Lactating or Post-lactating:							
801	5-20-57	285				7.4	No
640	6- 1-56	132					No
664	6-19-56	165					No
823	6-24-57	148	255	155	410		No
671	6-29-56		257	145	402		No
854	7-23-57	168	280	160	440		No
517	9- 4-55	210					No
522	9- 6-55						No
710	11-13-56	157	270	146	416		No

Remarks

B-136	Born 2-14-55, never bred, sibbling of B-153
B-153	Born 2-14-55, never bred, sibbling of B-136
806	Never bred, vulva swollen
931	141 lbs. when captured 9-4-57
803	Never bred
1029	Large follicle
849	Never bred, large follicle
809	Never bred, large cervical tumor

(a) Total body weight, dr. - eviscerated weight.
(b) Skull measurements: Length - Occipital to front of upper incisors; Width - Outer edges of zygomatic arches
(c) Estimated
(d) Single numerical entries designate tracts displaying placental scars of like appearance. Presumably, these were from the same pregnancy. Entries with "+" designations are for tracts displaying scars judged persisting from earlier pregnancies. (See Fig. 71)
(e) Corpora lutea were only observed from 7-20 to 2-10, i.e., during the normal period of gestation, and were never observed during lactation; activity state, + - low, ++ moderate, +++ high.

TABLE 2. Continued

Ovarian weights (gms.)			Placental scars(d)		Ovarian histology(e)		
					Corpora lutea		
Left	Right	Average	Left cornu	Right cornu	Left	Right	Activity
2.1	2.4	2.2	1	2	0	0	
2.3	2.5	2.4	2+1	2	0	0	
2.8	3.1	2.9	1	2+1	0	0	
2.2	2.3	2.3	2	1	0	0	
1.6	1.5	1.5	1	2	0	0	
6.4	4.4	5.4	1+1	2	0	0	
2.0	6.7	4.4	2	1+2	0	0	
4.3	4.3	4.3			0	0	
3.3	4.0	3.7	2	2	0	0	

893 Bred 6/22-23/57
532 Unbred captive
801 Bred 7-4-56, 3 cubs born last week of January, 1957
640 Accompanied by 2 cubs
823 Accompanied by 3 cubs
854 Captured with two cubs of year in both 1956 and 1957
522 Accompanied by 3 cubs
710 Accompanied by 2 cubs

Figure 1. Bear 858, 7/26, 300x, immature, post-breeding season. Seminiferous tubules solid and occupying minor portion of the testis mass. Intra-seminiferous cord areas occupied by loose connective tissue.

Figure 2. Bear 958, 4/8, 300x, mature, pre-breeding season. Seminiferous tubules with and without distinct lumina and occupying major portion of mass of testis.

Figure 3. Bear 958, 4/8, 645x, mature, pre-breeding season. Seminiferous tubules without distinct lumina, spermatogenesis not complete, Leydig cells sparse.

Figure 4. Bear 833, 7/4, 300x, mature, height of breeding season. Seminiferous tubules with lumina, occupying major portion of testis.

Figure 5. Bear 833, 7/4, 645x, mature. Spermatogenesis active in some tubules and incomplete in others, Leydig cells active.

Figure 6. Bear 833, 7/4, 1455x-oil, mature. Sertoli cells and spermatogonia apparent in tubule to right. Fat cells and highly vacuolated Leydig cells numerous in intra-seminiferous tubule areas.

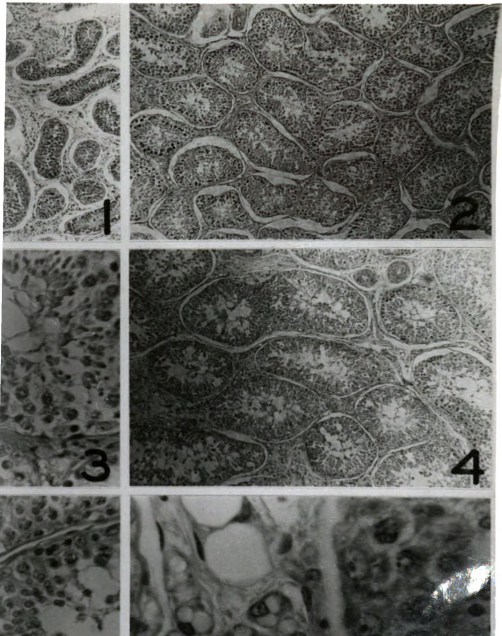
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Figure 7. Bear 514, 9/3, 300x, mature, post-breeding season. First sign of seminiferous tubule degeneration, numerous cytoplasmic and cellular extrusions into lumina of the tubules.

Figure 8. Bear 514, 9/3, 645x, mature, post-breeding season. Spermatogenesis ceased, spermatogonia resting, cellular extrusion into tubule lumen.

Figure 9. Bear 514, 9/3, 1455x, mature, post-breeding season. Leydig cells not as active as earlier, some nuclei pyknotic.

Figure 10. Bear 526, 9/29, 300x, mature, post-breeding season. Seminiferous tubules smaller and degeneration progressing.

Figure 11. Bear 526, 9/29, 645x, mature, post-breeding season. Seminiferous tubule epithelium disorganized, Leydig cells atrophic.

Figure 12. Bear 526, 9/29, 645x, mature, post-breeding season. Although seminiferous tubules are degenerate, some Leydig cell activity still apparent.

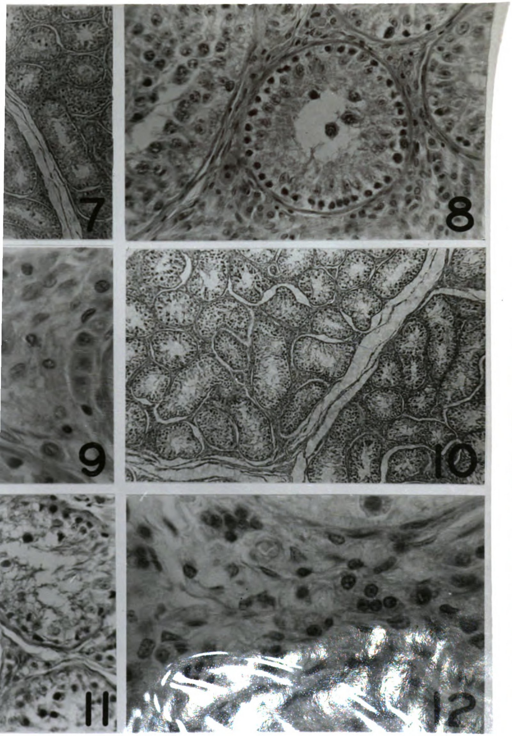
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Figure 13. Bear 534, 10/25, 300x, mature post-breeding season. Almost complete degeneration of the seminiferous tubules, with considerable fatty infiltration of the intra-tubular areas, Leydig cells sparse and inactive.

Figure 14. Bear 531, 10/8, 300x, mature, post-breeding season. Seminiferous tubule degeneration complete and occupying minor portion of testis. Leydig cells very sparse and inactive.

Figure 15. Bear 833, 7/4, 300x, mature, height of breeding season. Epididymis secretory and filled with spermatozoa.

Figure 16. Bear 833, 7/4, mature, height of breeding season. Epididymal epithelium pseudostratified, stereociliated and secretory.

Figure 17. Bear 514, 9/3, 645x, mature, post-breeding season. Epididymal epithelium regressing, secretions diminishing and stereocilia not as apparent.

Figure 18. Bear 548, 10/30, 300x, mature, post-breeding season. Epididymis non-functional and tubules surrounded by fibrous connective tissue.

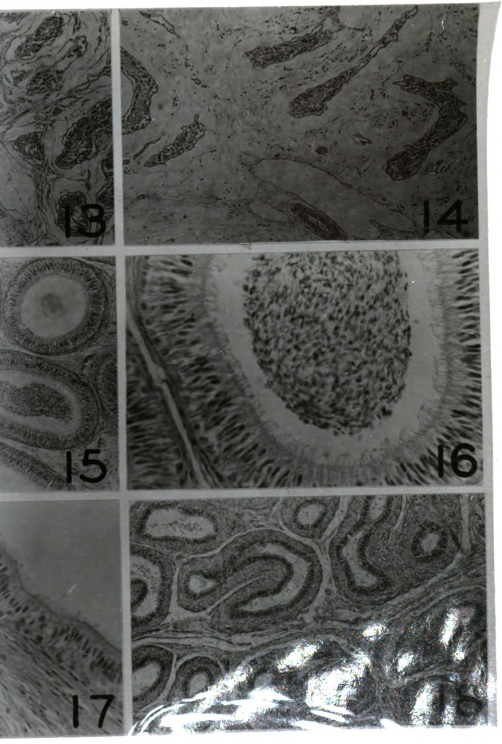
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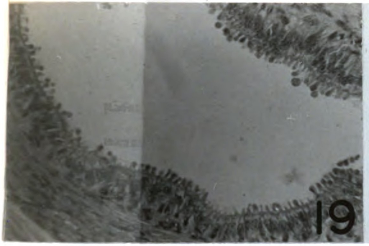
Figure 19. Bear 520, 9/5, 645x, mature, post-breeding season. Nuclear and cytoplasmic epididymal extrusions.

Figure 20. Bear 531, 10/8, 645x, mature, post-breeding season. Complete degeneration of the epididymis.



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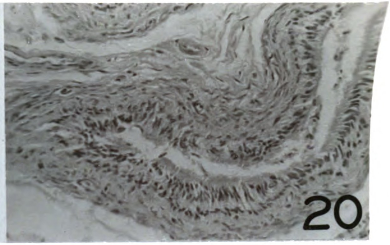

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Figure 21. Bear 5503, 2/9, 300x, immature bear. Pre-seasonal ovarian condition found in either immature or open mature bear. Large portion of ovary made up of fatty tissue, no evidence of follicular development at this time.

Figure 22. Bear 136, 2/8, 645x, immature bear. Pre-seasonal repair of ovarian tissue. Fatty tissue replaced by non-endocrine stromal tissue.

Figure 23. Bear 957, 4/8, 645x, immature bear, or mature bear 803, 5/25. Pre-seasonal changes in ovarian stroma to endocrine type cell in areas void of follicles.

Figure 24. Bear 803, 5/25, 300x, mature bear. Pre-seasonal replacement of small follicles with thecal-type cells, ovum remaining trapped within follicle.

Figure 25. Bear 803, 5/25, 645x, mature bear. Endocrine type cells of ovarian stroma and replaced follicles close to the breeding season. Compare to Figure 23.

Figure 26. Bear 803, 5/25, 1455x-oil, mature bear. Cells of ovarian stroma and replaced follicles not highly active, nuclei compact, cytoplasm dense.

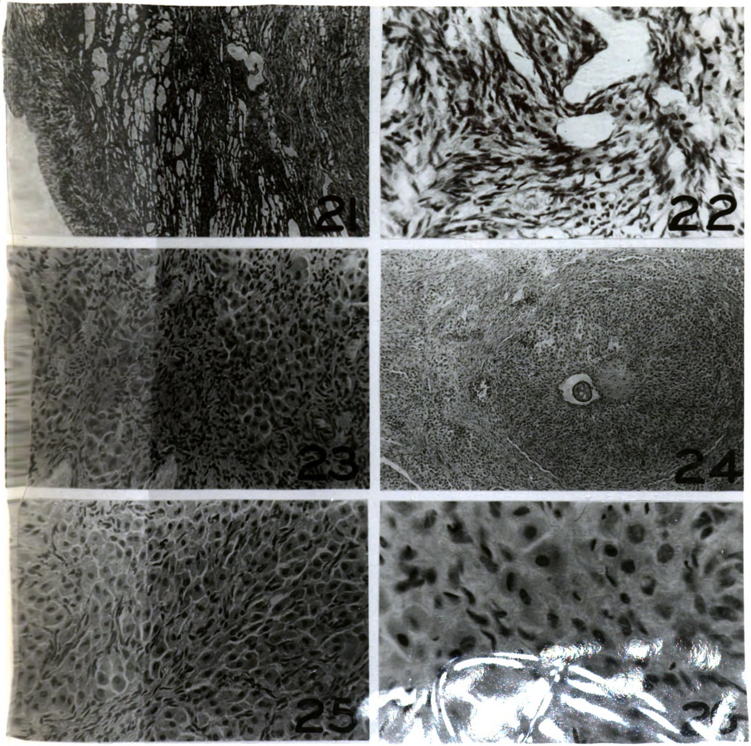
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Figure 27. Bear 957, 4/8, 1455x-oil, immature. Germinal epithelium distinct in pre-seasonal bear ovary.

Figure 28. Bear 803, 5/25, 645x, mature. Granulosa layer of tertiary follicle loosening prior to invasion of theca cells.

Figure 29. Bear 957, 4/8, 1455x-oil, immature. Primary follicles healthy and numerous in pre-seasonal bear ovary.

Figure 30. Bear 803, 5/25, 1455x-oil, mature. Nuclear membrane of tertiary follicle thickening prior to atrophy and replacement of follicle by thecal cells.

Figure 31. Bear 849, 7/20, 645x. Mature bear, not bred, shortly after the breeding season. No ovulation points apparent. Ovarian stroma and follicles replaced by thecal cells apparently declining in activity.

Figure 32. Bear 849, 7/20, 1455x, mature. Ovarian stroma inactive, and invaded by large numbers of fibroblasts.

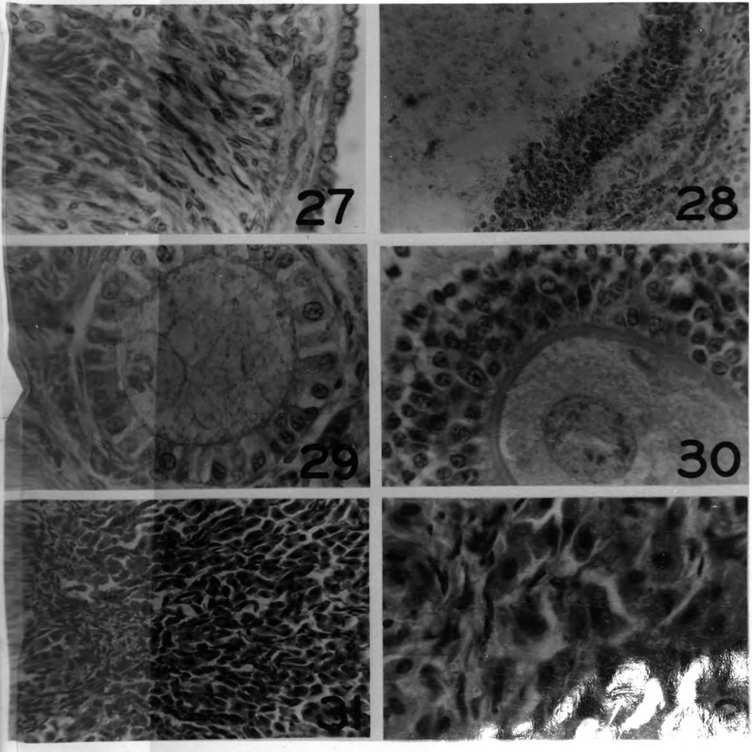
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Figure 33. Bear 851, 7/20, 1455x-oil, mature, bred the previous month. Early functional corpus luteum.

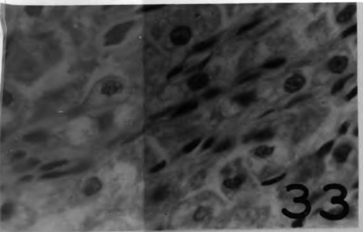
Figure 34. Bear 851 or Bear 855, 645x, mature bred. General ovarian stroma cells appear dense and inactive.

Figure 35. Bear 851 or Bear 855, 1455x, mature, bred. General ovarian stromal cells dispersed among fibrous connective tissue cells.

Figure 36. Bear 521, 9/6, 645x, mature, assumed pregnant. Highly vascular corpus luteum.

Figure 37. Bear 521, 9/6, 1455x-oil, mature, assumed pregnant. Corpus luteum appears highly active, nuclear chromatin for most part dispersed and the cytoplasm showing granules or vacuoles.

Figure 38. Bear 521, 9/6, 645x, mature, assumed pregnant. Ovarian stroma cells highly developed and although smaller than luteal cells appear similar. Compare to open mature bear (Figure 31), to earlier pregnancy (Figure 34) and to functional corpus luteum (Figure 36).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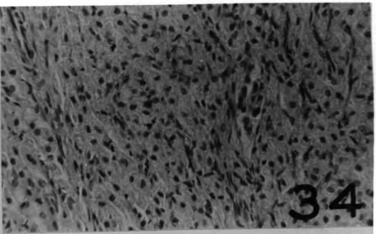
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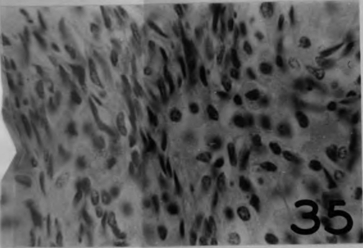
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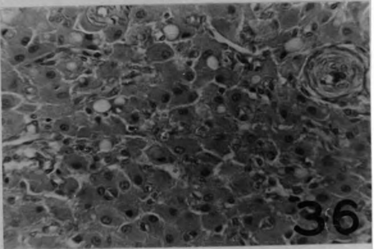
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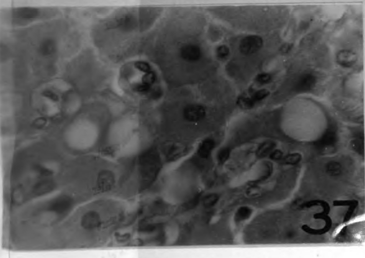
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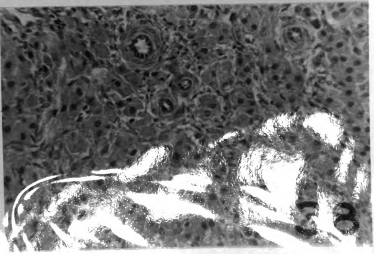
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Figure 39. Bear 521, 9/6, 1455x-oil, mature, assumed pregnant. Ovarian stroma. Compare to open mature bear (Figure 32), to earlier pregnancy (Figure 35) and to the functional corpus luteum (Figure 37).

Figure 40. Bear 521, 9/6, 645x, mature. Outline of position of older replaced follicle retained on ovary not containing corpus luteum. This tissue and surrounding stroma appear of endocrine nature, although not as highly functional as the corpus luteum.

Figure 41. Bear 521, 9/6, 1455x-oil. Mature, assumed pregnant. Follicle more recently replaced by thecal cells, and with trapped ovum, on same ovary as functional corpus luteum. Compare to ovarian stromal cells (Figure 39) and functional corpus luteum (Figure 37).

Figure 42. Bear 521, 9/6, 645x, mature, assumed pregnant. Tertiary follicle during replacement by thecal cells. Theca interna and externa not distinct but proliferating and filling follicle. Granulosa layer only a few cell layers thick and sloughing.

Figure 43. Bear 521, 9/6, mature, assumed pregnant. Degenerate secondary follicle not replaced by thecal cells.

Figure 44. Bear 516, 9/4, mature, assumed pregnant. Ovarian condition similar to Bear 521. Nest cells appear inactive and primary and secondary follicles sparse in ovary.

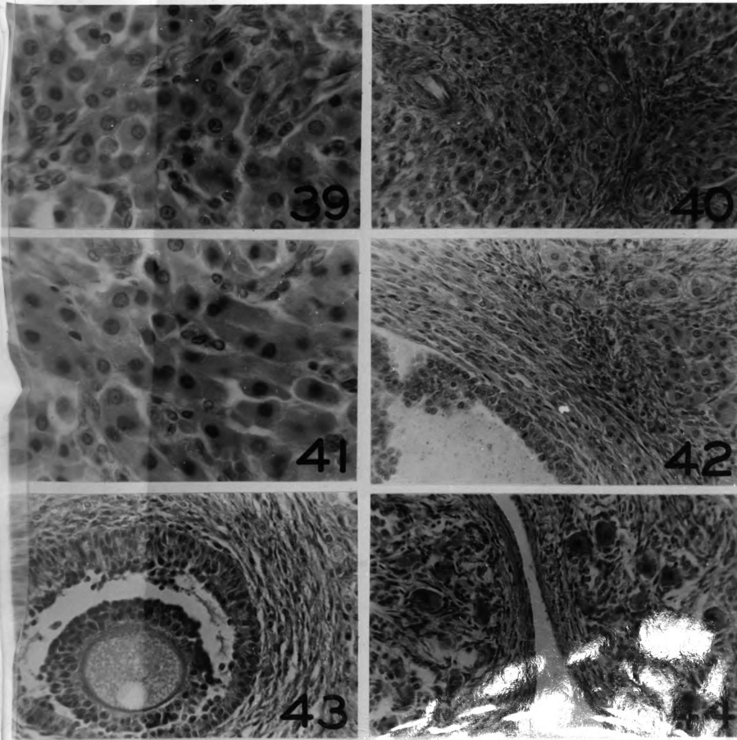
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Figure 45. Bear 516, 9/4, 645x, mature, assumed pregnant. General ovarian stroma of early pregnancy. Compare to Figure 38.

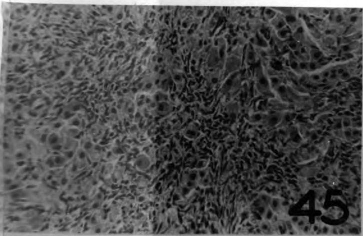
Figure 46. Bear 516, 9/4, 300x, mature, assumed pregnant. Corpus luteum of early pregnancy with marked vascularity.

Figure 47. Bear 516, 9/4, 645x, mature, assumed pregnant. Corpus luteum of early pregnancy, compare to Figure 36.

Figure 48. Bear 516, 9/4, 1455x-oil, mature, assumed pregnant. Corpus luteum of early pregnancy, compare to Figure 37.

Figure 49. Bear 516, 9/4, 645x. Paraluteal tissue in ovary containing corpus luteum. Compare to luteal tissue in original ovulation area (Figure 47).

Figure 50. Bear 516, 9/4, 1455x-oil. Paraluteal tissue in ovary containing corpus luteum. Compare to luteal tissue in original ovulation area (Figure 48).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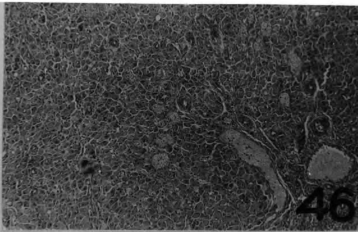
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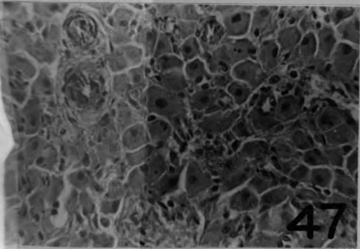
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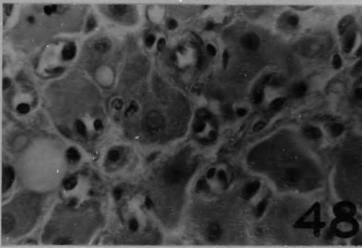
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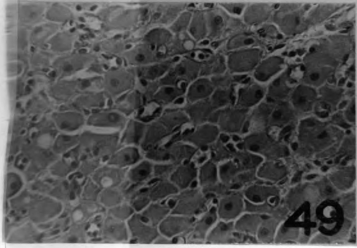
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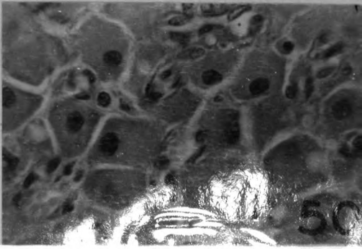
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Figure 51. Bear 516, 9/4, 645x, mature, assumed pregnant. Accessory luteal tissue of atropic follicle in ovary not containing functional corpus luteum. Compare to Figure 40.

Figure 52. Bear 1283, 10/2, 1455x-oil. Mature bear with two declining corpora lutea on one ovary. General ovarian stromal cells appear atrophic and inactive. Compare to Figure 39.

Figure 53. Bear 1283, 10/2, 1455x-oil. Mature bear with two declining corpora lutea on one ovary. Corpus luteum cells. Compare to Figure 48.

Figure 54. Bear 931, 2/10, 300x. Mature bear without cubs, shortly before whelping time. Highly vascular corpus luteum still apparent on ovary.

Figure 55. Bear 931, 2/10, 645x. Mature bear, declining corpus luteum of pregnancy. Compare vascularity to early pregnancy (Figure 36). Considerable numbers of red blood cells free in the luteal tissue.

Figure 56. Bear 931, 2/10, 1455x-oil, mature bear. Ovarian stroma cells appear inactive, some assuming wheel cell appearance of interstitial tissues. Compare to inactive stromal cells of early pregnancy (Figure 35).

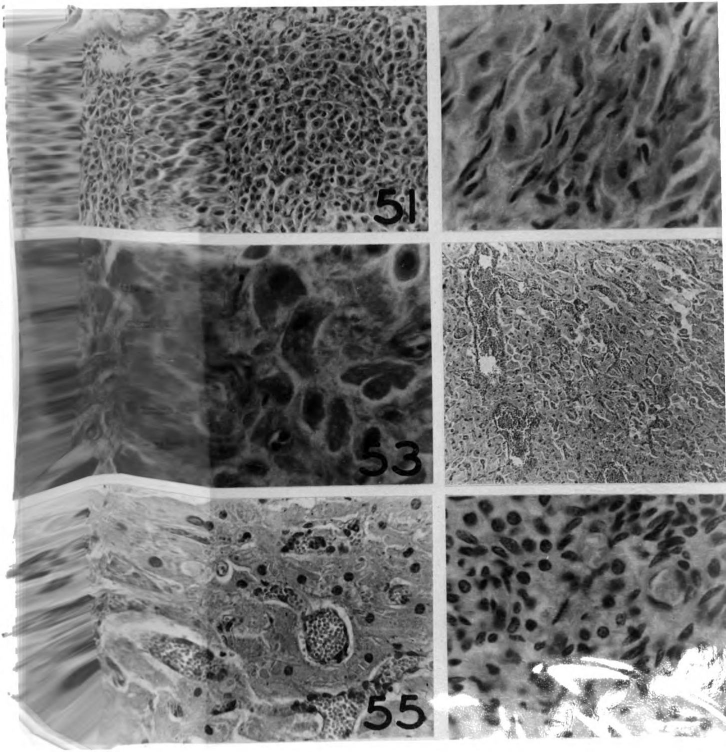
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Figure 57. Bear 801, 5/20, 300x, mature, lactating bear with cubs, one month prior to the normal breeding season. Follicles of all sizes replaced by tissue from ovarian stroma.

Figure 58. Bear 801, 5/20, 645x, mature, lactating with cubs. Endocrine type tissue comprising mass of ovary and apparently originating from the ovarian stroma, arranged in cords.

Figure 59. Bear 801, 5/20, 1455x-oil, mature, lactating bear with cubs. High magnification of tissue of Figure 58.

Figure 60. Bear 801, 5/20, 645x, mature, lactating bear with cubs. Replacement of small tertiary follicle by ovarian stroma. Thecal layer apparently not involved.

Figure 61. Bear 801, 5/20, 1455x-oil, mature lactating bear with cubs. Stromal cells or interstitial cells of lactation. Indistinguishable from cells replacing atretic follicles.

Figure 62. Bear 604, 6/19, 1455x-oil, mature lactating bear with cubs. Height of breeding season. Follicles not developing to mature size. Cells replacing follicles do not appear active.

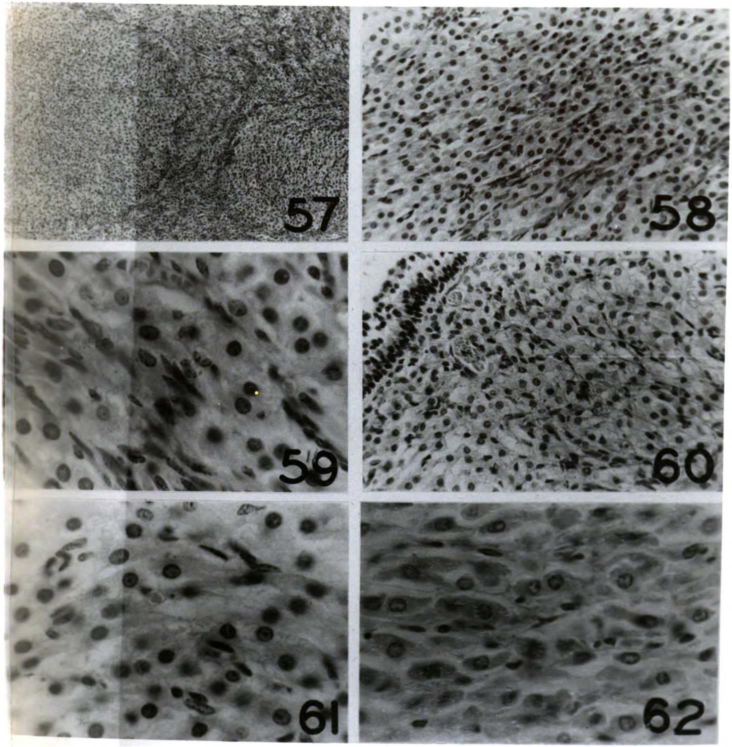
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Figure 63. Bear 664, 6/19, 1455x-oil. Mature, lactating with cubs. Degenerate tertiary follicle. Replacement of lumina by interstitial tissue not as active.

Figure 64. Bear 664, 6/19, 1455x-oil. Mature, lactating with cubs. Interstitial tissue cells smaller, cytoplasm more dense than in earlier lactation (Figures 59 and 61).

Figure 65. Bear 671, 6/29, 300x. Mature, cubs still running with her but probably weaned. Degenerate follicle replaced by thecal cells, the outline remaining intact.

Figure 66. Bear 522, 9/6, 645x. Mature, cubs still running with her but weaned. Cells replacing degenerate follicle appear inactive.

Figure 67. Bear 522, 9/6, 645x. Mature, post-lactation. Ovarian interstitial tissue appears inactive.

Figure 68. Bear 522, 9/6, 1455x-oil. Mature, post-lactation. Appearance of ovarian stromal cells inactive. Compare to Figures 59-61.

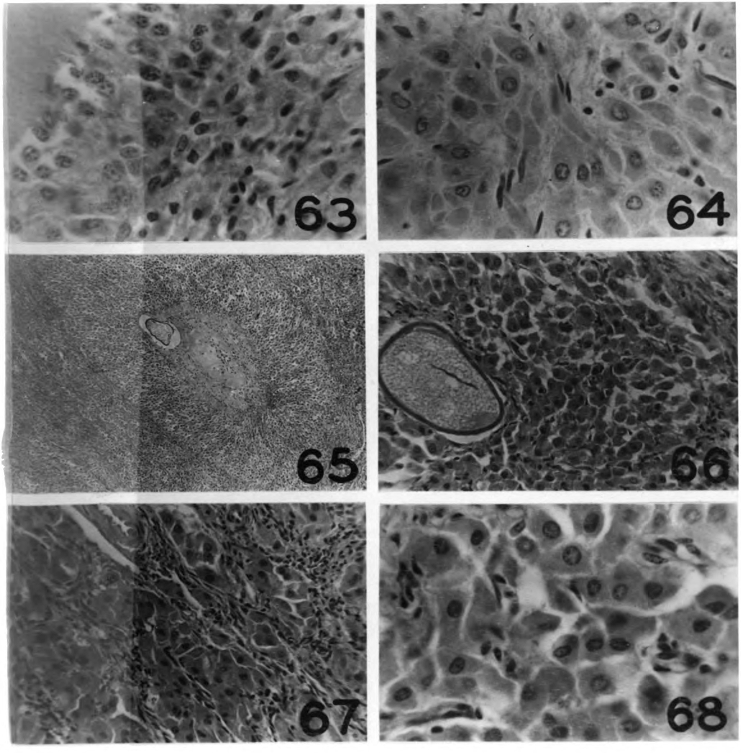
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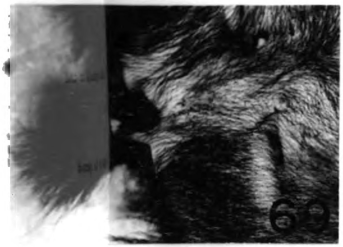
Figure 69. Enlargement of the external genitalia at the height of the breeding season.

Figure 70. Bear 823, 6/24. Appearance of the opened cornu and placental scars approximately five months following the birth of three cubs.

Figure 71. Bear 664, 6/19. Appearance of the opened cornu and placental scars five months post-partum. The small light scar is judged to have persisted from the pregnancy previous to the pregnancy giving rise to the three dark scars.

Figure 72. Bear 857, 7/26. Opened cornu with an atypical distribution of placentations.

Figure 73. Bear 862, 8/2. Appearance of placental scars presumed to be slightly older than shown in Figures 70, 71, and 72. Marked fixation bleaching evident.



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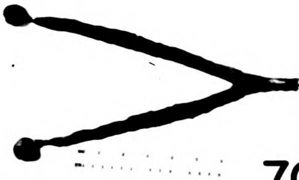

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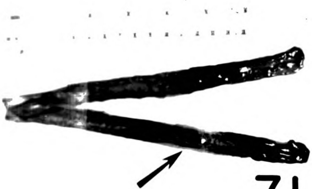

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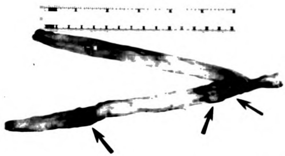

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SEASONAL VARIATIONS IN THE HEMATOLOGY AND PHYSIOLOGY OF BLACK BEARS

The object of this study was to investigate seasonal variations between certain physical and hematological values of the black bear, particularily variations occurring in some of the metabolic processes during the overwintering period of torpor, or dormancy.

Methods and Procedures

During 1956-57, four captive wild bears were held at the Cusino Wildlife Experiment Station, near Shingleton, Michigan. Two were subadult females, one a male cub and the other an adult male. The animals, in individual pens with dens and straw bedding, were maintained on a well-balanced commercial dogfood ration. All bears winter-denned from 25 December to 17 April with the exception of bear A, which entered the den on 26 November, and bear D, which emerged from its den on 1 April.

The bears were anesthetized with pentobarbital sodium (1 grain/cc.) four times in nine months, including twice during the overwinter period of torpor. Anesthetic injection was accomplished by first rendering the bears helpless by intramuscular injection of the muscle relaxant, succinyl choline chloride. About 30 minutes after anesthesia, studies of physical condition were made and blood samples of about 10 ml. each were collected from the jugular vein in vials containing the dried equivalent of 1 ml. of oxalate solution (4.8 gm. ammonium oxalate and 3.2 gm. potassium oxalate in 1000 ml. HOH).

Weights were taken on a Chatillon (300-lb. capacity) wall-mounted scale, temperatures were taken rectally, and pulse was determined by palpation over the heart. Packed cell volumes were determined with a Wintrobe hematocrit tube. Hemoglobin (direct method), blood sugar, total protein, albumin, globulin, phosphorus, and chloride were determined with a Fisher Clinical Electrophotometer using methods described in the Fisher Manual (1952). The results are presented in Table 4 and Fig. 74.

TABLE 4. Variations in hematology and physiology of black bears at four seasons

Bear	Age & Sex	Wt. lb.	HBG gm/ 100 ml.	WBC 1,000/ cmm.	RBC million cmm.	Temp. °F.	Pulse
A	Juv ♂	90	17.8		7.88	102.6	
B	Yrl ♀	113	17.2	9.80	8.06		
C	Adl ♂	252	14.6	12.40	7.76		
D	Yrl ♀	128	19.0	15.40	10.00		
Avg.		146	17.2	12.53	8.43		
A	Juv ♂	79	22.7	4.95	13.50	95.9	144
B	Yrl ♀	109	21.5	7.30	11.10	94.6	96
C	Adl ♂	232	18.3	8.70	7.14		
D	Yrl ♀	110	21.7	14.10	9.59		
Avg.		133	21.1	8.76	10.33	95.3	120
A	Juv ♂	69	16.6	5.90	7.13		
B	Yrl ♀	96	17.2	6.05	9.01		
C	Adl ♂	197	18.8	6.55	8.46		
D	Yrl ♀	125	16.6	7.00	8.21		
Avg.		122	17.3	6.38	8.21		
A	Juv ♂	137	17.3	8.20	7.75	98.8	122
B	Yrl ♀	161	18.0	15.00	10.17	98.4	176
C	Adl ♂	289	19.0	15.50	6.06	98.6	134
D	Yrl ♀	121	19.0	19.40	8.56	98.4	118
Avg.		177	18.3	14.53	8.14	98.6	138

TABLE 4. Continued

PCV %	Sugar mg/ 100 ml. blood	Tot. Prot. gm/ 100 ml. serum	ALB gm/ 100 ml. serum	GLOB gm/ 100 ml. serum	PHOS mg/ 100 ml. serum	CHLOR mg/ 100 ml. blood	Dates
52	49	5.0	2.4	2.6	4.0	320	2 Nov. 56
49	43	4.8	4.4	0.4	6.0	420	
44	36	5.5	2.9	2.6	5.0	450	
51	46	5.4	3.7	1.7	6.7	375	
49	44	5.2	3.4	1.8	5.4	391	
62	56	5.7			1.9	410	9 Feb. 57
58	26					330	
56	46	6.7	4.3	2.4			
66		8.5	5.0	3.5			
61	42.7	7.0	4.7	3.0		370	
55	60	5.1	4.4	0.7	5.0	500	17 Apr. 57
53	42	6.1	4.4	1.7	4.8	340	
55	54	5.7	4.7	1.0	5.2	440	
51	44	5.2	4.3	0.9	6.4	360	
54	50	5.5	4.5	1.1	5.4	410	
49	54	5.9	5.3	0.6	8.3	300	9 July 57
53	52	6.2	5.0	1.2	9.1	660	
43	48	6.5	5.5	1.0	7.9	420	
52	42	6.6	4.3	2.3	7.9	200	
49	49	6.3	5.0	1.3	8.3	395	

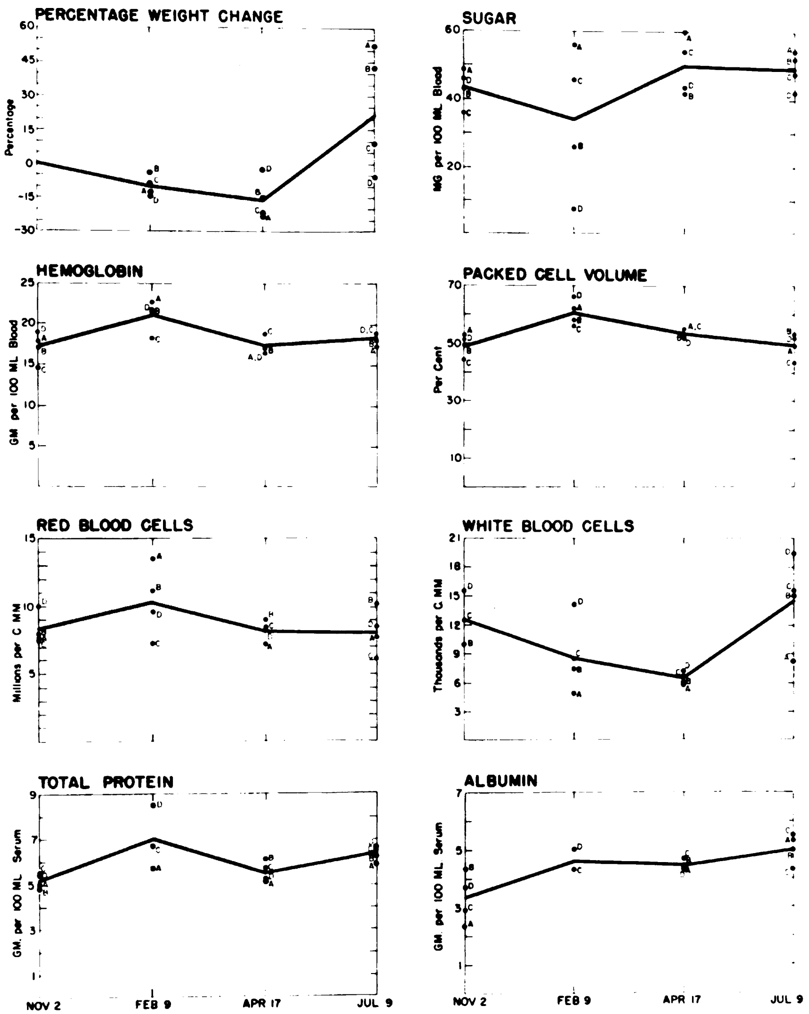


Figure 74. Graphs of factors varying with the seasons.

Physical Changes Noted Seasonally

Marked seasonal weight changes were observed in all four bears (Table 4, Fig. 74). A slight but progressive weight loss occurred during torpor. From 2 November to 9 February the mean weight loss was 9.4 per cent. Maximum and minimum percentage losses for this period were 14.1 and 3.4, respectively. Presumably these losses occurred during early dormancy since the bears were fed until denned 25 December.

By 17 April, the mean body weight loss increased to 15.6 per cent. The mean weight loss sustained by these bears during dormancy was actually even greater, since bear D emerged from dormancy 17 days before the April weighing and gained substantial weight. By February it had lost 14.1 per cent of its November weight, yet in April, doubtless because of its feeding after awakening, it weighed only 3 pounds less than it had in November. Weight losses for the remaining three bears over the November-April period amounted to 15, 22 and 23 per cent, respectively. These losses are considered minimal for torpid bears since the denning period was shortened by delaying denning for bears B, C and D by continued feeding until 23 December, and by disturbing the animals for handling in April.

These data indicate that non-parous black bears in this latitude sustain overwintering weight losses of about 20 per cent during dormancy. A similar weight loss has been reported for the woodchuck (Marmota monax), a true hibernator, also dependent solely upon fat as its energy source during dormancy (Rasmussen, 1916).

The weight loss of each bear was readily regained following dormancy (Fig. 74). By 9 July, the mean weight gain from the mean winter low was 55.7 per cent. Bear A, now 1-1/2 years of age, gained an astounding 98.5 per cent during this period. While these data demonstrate a remarkable ability of bears to make large short-term weight gains where food is provided, it is improbable that such gains are realized by bears in the wild, since natural foods appear limited during this period (Erickson, 1957).

The July body temperatures of these bears were similar (Fig. 74, Table 4) and averaged 98.6° F. It is assumed that this represents the temperature norm during non-dormancy. During torpor, a minimum temperature depression from 3 to 4 degrees apparently occurs, as indicated by the 95.3° F average February readings obtained for bears A and B. The two pulse determinations which could be made in winter (Table 4) yielded one low reading and one within the range of summer variations.

Hematological Changes Noted Seasonally

Although these data are too few to evaluate possible seasonal differences for all of the hematological factors involved for these bears, several were investigated sufficiently to demonstrate variations. The only marked deviations, however, occurred during early torpor (Table 4).

At that time a substantial increase was noted for circulating erythrocytes, with corresponding increases noted for hemoglobin, packed cell volumes, and total protein. These same factors near the end of winter dormancy revealed values similar to those for non-dormancy (Table 4, Fig. 74).

Similar increases of circulating erythrocyte counts, hemoglobins and packed cell volumes during hibernation have been reported for the ground squirrel (Citellus parryi) by Svihla and Bowman (1952) and by Svihla et al. (1953), and for the golden hamster (Mesocricetus auratus) by Suomalainen and Granstrom (1955) and by Lyman et al. (1957). Rasmussen (1916) noted a slight increase in circulating erythrocytes for the hibernating woodchuck but a lower hemoglobin for animals in a semidormant state than for those in deep hibernation. On the other hand, Stuckey and Coco (1942) noted a 37.9 per cent decrease in circulating erythrocytes and a 25.7 per cent decrease in hemoglobin for hibernating ground squirrels (Citellus tridecemlineatus). The biological significance of these conflicting reports awaits explanation. The results noted in the present study indicate marked changes in these factors during early torpor and a shift back to non-dormant values in late torpor. The differences noted in the literature may be due to data having been taken at different times within the hibernating period. This would appear especially

likely for animals which periodically awaken during hibernation.

The pronounced leukopenia noted for our bears during torpor (Table 4, Fig. 74) was reported in all of the previously cited works and appears to be characteristic of all true hibernators (Lyman et al., 1957). Other blood determinations in this study, however, are difficult to interpret because of the variations exhibited or because of inadequate data.

Blood sugar is of especial interest. In two bears, blood sugar increased during torpor and in the other two it decreased. Previous blood sugar determinations for black bears (Youatt and Erickson, 1958) also showed considerable variation. Sugar determinations for these captives during summer were appreciably below those for wild bears. Presumably the latter's sugar values were inflated by energy-rich foods such as berries and fruits, available to them at this time. Varied blood sugar values have been reported for other species during hibernation, indicating this is a highly variable factor among hibernators (Lyman and Chatfield, 1955; Stuckey and

Coco, 1942; Lyman, 1943). Lyman and LeDuc (1953) suggest that the reported differences in this factor may be due to differences in the habits of the animals. Thus, in those forms utilizing only fat for energy, such as the woodchuck, a much greater decline of blood sugar results than in those forms, such as the hamster, which periodically awaken to feed. The results of the present study tend to support this hypothesis and to place the bear in the category of semihibernators.

Although only one determination was obtained for blood phosphorus during early torpor, it possibly indicates that a marked decrease occurs at that time. Blood phosphorus levels during July were consistently higher than were the comparable values for November and April. Chloride determinations showed little seasonal variation.

TECHNIQUES FOR LIVE-TRAPPING AND

HANDLING BLACK BEARS

Lack of adequate techniques for capturing and handling black bears has handicapped previous efforts to obtain information on this species. This paper describes techniques developed at the Michigan Department of Conservation's Cusino Wildlife Experiment Station, in the Upper Peninsula of Michigan. Trapping was conducted principally in Alger and Schoolcraft counties, beginning in 1952 when one bear was captured. Four more were taken in 1953. Trapping activities were stepped up in the summers of 1955, 1956 and 1957, when 43, 48 and 63 animals, respectively, were taken. During the course of the project 159 bears were handled 182 times.

Trap Types

Bears were captured in several types of culvert traps (Figures 75 and 76), and in steel-spring traps (Figure 80). The most successful culvert traps were constructed of eight-foot sections of 36-inch steel culvert fitted with sheet-metal drop doors and open

Figure 75. Typical culvert trap set for black bears.

Figure 76. Rear view of two culvert trap types. At left: with hinged, swinging drop door, solid back and pull pin trigger. At right: with sliding drop door, metal-grid back, and lever-type trigger.

Figure 75.

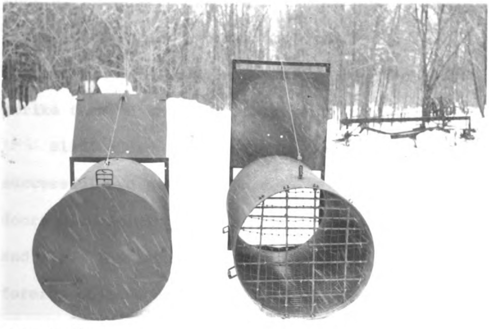


Figure 76.

metal-grid backs (Figure 76, right). However, number 4-1/2 steel-spring wolf traps proved more successful and economical for capturing bears than did the culvert traps.

Culvert Traps. The first traps used in this study were similar to those designed by the U. S. National Park Service for capturing and moving nuisance bears. In order to reduce construction cost and increase mobility, they were not mounted on trailer frames as were the Park Service traps.

Traps six feet in length were less successful in capturing bears than longer eight-foot sections. The shorter traps were ineffective for capturing large bears, since these animals could reach the bait without entering the trap, and the falling door would strike them on the back, allowing their escape.

Sliding drop doors (Figure 76, right) proved more successful and reliable on culvert traps than hinged doors with locking mechanisms (Figures 75, 76 left, and 79). The latter would not lock if obstructed by foreign objects or the bear's body, were difficult to adjust because of the impact which accompanied the traps' closing, and were easily damaged when the traps were moved. Judging from tracks found around traps, bears were more suspicious of the over-hanging hinged doors than of the sliding type.

While these modifications were important, the nature of the trap back was of greater consequence in determining trapping success. Trap backs were either solid or an open metal grid (Figure 76). The open grid back was added to our traps in the fall of 1955. Its design was prompted by the activity of bears repeatedly visiting traps with solid backs, but refusing to enter them. Two bears, including a 425-pound male, were readily trapped when a grid back was substituted. It was likewise more successful in 1956 (Table 5). The greater success of the grid-back trap was probably due to better circulation of air carrying odors from the bait, clear visibility through the trap, and the opportunity to examine and smell the bait closely from the rear of the trap. Sign indicated that bears usually inspected culvert traps thoroughly before entering.

The most successful method of releasing trap doors

TABLE 5. Success of three types of bear traps in 1956[1]

Type of trap	Corrected[2] trap nights	Bear visits	Escapes	Captures	Per cent trap effectiveness per Bear visit	Per cent trap effectiveness per Trap night
Culvert						
Solid back	91	6	0	1		
Open grid back	74	5	0	3		
Total	165	11	0	4	36	2
Steel spring	2,393	126	18	44	35	2

1 Data from trapping nuisance animals omitted.

2 Adjusted for capture of other animals and mechanical failure.

was a lever trigger mechanism (Figure 77). By providing several points on the lever arm for attaching bait wires, it was possible to regulate the force necessary to release the trap door. A pull-pin trigger release (Figure 78) was less sucessful, since it did not allow adjustment, was harder to set, and was less reliable.

As the trapping program progressed, lighter but more efficient traps were constructed. Thus 14-gauge culvert metal and one-eighth-inch sheet metal replaced heavier stocks. Other weight-reducing features, such as an open-grid trap door, might be effectively incorporated in future designs. In the present stage of development culvert traps can be moved and set by two workers.

The original trap was constructed with both the sliding door and back constructed of 2-inch wood planking reinforced by steel rods. These traps were cumbersome, the doors warped readily, were slow in closing action, and often did not hold large bears.

Steel Traps. Bears were more economically and productively live-trapped with modified No. 4-1/2

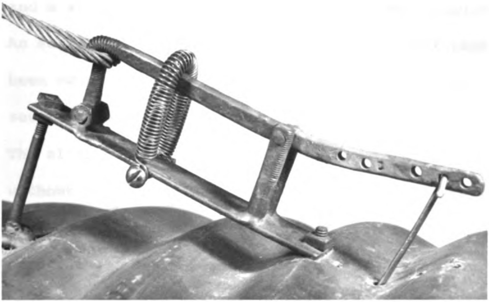


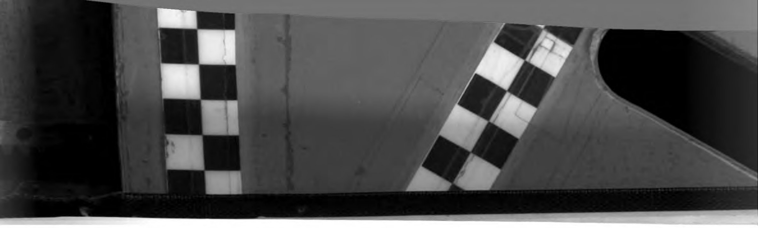
Figure 77. Lever-type trigger for culvert trap.

Figure 78. Pull-pin trigger for culvert trap.

steel-spring wolf traps. The trap-chain was lengthened to 5 or 6 feet, all connecting links were welded, and a stronger toggle or drag was attached (Figure 80). An additional short-chained safety toggle has recently been added to these traps since the couplings of several single-toggle traps were broken by bears. The altered traps will hold most animals securely without serious injury. Considering the extreme ruggedness of a bear's paws, the lack of trap injury is not surprising. Bears weighing as much as 257 pounds have been captured and handled in these traps. Several bears were captured in smaller steel traps. Four cubs or yearling animals were obtained from bounty trappers using No. 3 and 4 traps. We have captured other cubs by setting these smaller traps near the site of and shortly after the capture of the mother. Three large nuisance animals were taken in No. 5 bear traps by predatory animal control officers. Even these caused little injury to the foot itself although one bear broke an ulna bone while fighting the trap.

Figure 79. Latch for culvert trap; at left, with door open; at right with door closed.

Figure 80. No. 4-1/2 wolf trap with longer chain and larger toggle, for use on black bears. Man's hand indicates how a bear could prevent a trap from closing on its foot.



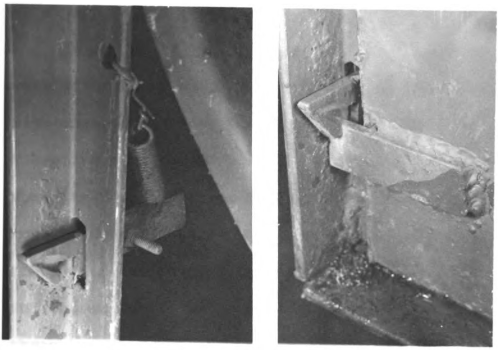


Figure 79.

Figure 80.

Trapping Techniques

Selection of Trapping Areas. Trapping sites were selected primarily by the amount and kind of bear sign observed. These were most readily found by traveling old logging trails. On moderately improved roads an 8-foot section of railroad iron or a conifer treetop dragged behind a vehicle obliterated old tracks and facilitated the search for fresh tracks on subsequent days. Other signs such as trampled trails through grassy areas, scats, mauled stumps and logs, and broken limbs of fruiting trees and shrubs were useful in locating potential trapping sites. Traps were commonly set in high-use natural feeding areas. Food sources resulting from human habitation, such as garbage dumps and apple orchards, were also frequented by bears and provided additional trap sites. Of the bears captured in this study, 139 were taken in wild areas, while only 43 were captured at artificial feeding areas. Many of the latter were trapped and moved as nuisance animals.

Natural feeding areas varied with the season. In the spring semi-open forest types, composed primarily of lush grasses, strawberries, and Juneberry (*Amelanchier* sp.) and other pioneer shrub species, seemed to have the higher populations. Abandoned homesteads and lumber camps, commonly interspersed throughout the area, were much frequented by bears at this season. Choice of summer habitat by bears was largely dependent upon the type and abundance of fruiting plants, largely shrubs or small trees. During the fall months trapping was most successful in areas containing abundant fruit crops, particularly black cherry (*Prunus serotina*). Abandoned apple orchards of homesteads and lumber camps were also frequently visited by bears during this season.

Trap Line Layout. Trap lines were either extensive, with traps set only at the most promising locations, or intensive, with a concentration of traps in restricted areas.

The extensive trap line was very successful since all sets were placed at relatively good sites. However, it had several disadvantages. Time to tend the line was materially lengthened, and vehicle operation and labor cost was increased. Also, trapped animals

were held longer before being handled, increasing the possibility of injury or escape. Extending the trap lines also provided greater opportunity for theft of traps and damage to sets or animals by vandals.

Intensive trap lines were confined, whenever possible, to a geographic unit one township or 36 square miles in size. Some advantages of this system were early handling of captured animals, decreased time and cost of tending the line, and rather thorough trapping of definite areas to determine populations. Disadvantages resulted from placing many sets in sites of limited potential and the inaccessibility of many areas.

Specific set locations were indicated primarily by bear sign. Traps placed near evidence of recent activity were generally the most successful. This was especially true where bears repeatedly traveled a trail or path.

Setting Culvert Traps. These sets were most successful when they were somewhat concealed and well stabilized with the rear of the trap elevated, and with dirt spread along the trap floor and in front of the

set. However, unless the traps were placed in shady locations, it was necessary to shelter them to keep the interior cool, and reduce the possibility of bears suffering from heat prostration. Bears were captured as readily in plain galvanized culvert traps as in those painted olive drab. However, the olive drab traps were less conspicuous and not as frequently molested by man. Four techniques insured best success in setting culvert traps.

(1) The trap mouth was faced in the anticipated direction of the bear's approach. Sets placed perpendicular and adjacent to game trails brought good results.

(2) Traps were stabilized to prevent their movement when entered.

(3) The rear of the trap was elevated, since bears appeared to enter a trap more readily if it was placed on an inclined plane.

(4) Dirt was spread both along the trap floor and immediately in front of the trap. This aided in determining if a bear visited the trap, and also appeared to lessen the animal's fear of the trap. The latter is possibly

related to the noise or feel of walking on the galvanized metal.

Setting Steel Traps. These sets consisted chiefly of modified dirt-hole cubby sets (Figures 81 and 82). They were most successfully employed if the dirt-holes were dug beneath logs, stumps, etc., thereby restricting the animal's approach to a single direction. Where site conditions were less favorable, dirt-hole cubby sets were made by digging a slanting hole into a small knoll or side hill and placing small logs in a V-formation to form the cubby. Sets of this type were less successful since the bears frequently succeeded in stealing the baits by tearing the cubbies apart from the sides or rear.

Initial attempts at steel-trapping bears were largely unsuccessful because bears frequently missed stepping in the traps, set them off without capture, or were caught lightly enough so that they could free themselves. Because of the comparatively small size of the traps--8-1/2 inch jaw spread--the bear's broad paw, unless precisely placed in the center of the trap, could prevent the trap jaws from closing (Figure 80). This difficulty was largely rectified with guide sticks

and a stepping stick (Figure 82). These devices did not alarm bears and served to assure accurate foot placement in traps. Six steps were used with good success for dirt-hole cubby sets.

(1) An inclining hole about 10 inches wide and 12 inches deep was dug with the removed earth spread near its mouth.

(2) Bait was then placed in the rear of the hole. Meat baits were securely staked.

(3) The trap was placed approximately 18 inches from the bait and 4 to 6 inches to either side of the cubby's midcenter line. Unless the trap was offset in this manner bears often stepped astraddle it.

(4) Best success was obtained by placing the long axis of the trap-jaws parallel with the midline of the set. When placed perpendicular, a high percentage of traps were set off without captures. Apparently the closing jaws threw the bear's foot clear.

(5) Traps were firmly seated and a trap cloth added to prevent dirt and objects from getting under the pan. The trap and toggle

were concealed with sifted earth so that the trap-pan was kept level with or slightly lower than the surrounding earth.

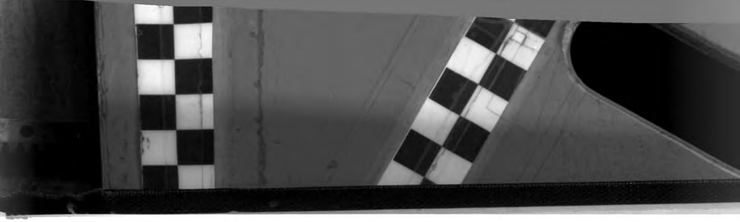
(6) The addition of guide and stepping sticks completed the set. These were about 1 inch in diameter, 12 inches long, and laid in box fashion around the trap-jaws. They were firmly placed to avoid being brushed into the set, with all but the stepping stick placed just outside the trap-jaws. The stepping stick was placed 2 or 3 inches ahead of the trap-jaws (Figure 82).

A variation of this trapping method consisted of concealing traps in loosened soil and scattering bait around the set. This worked very well for capturing cubs that were running free around a trapped female, as well as providing another alternative for capturing bears which were wary of cubby sets.

Scent was used at both dirt-hole cubby sets and in natural situations, usually on stumps or logs. Since bears seldom lingered in their investigations of scent, it was important that trap placement at scent sets be precise.

Figure 81. Typical dirt-hole cubby set with trap in place prior to concealment of the trap with earth.

Figure 82. Completed dirt-hole cubby set. Note placement of bait and stepping and guide sticks.



Trapping inefficiency due to the capture of other animals was reduced by setting traps to release only under heavy pressure. A spring, piece of sponge or rubber, or even a few folded leaves placed beneath the trap-pan served this purpose, provided room was allowed for the trap to release. Notching both the trap-pan sear and trigger-dog achieved the same result.

Baits. The most consistently successful bait used in live-trapping bears was fresh venison. Carcasses of lesser domestic and wild mammals and fish were less effective. Baited pits containing 15 to 10 pounds of fresh fish and offal were seldom eaten by bears. They were, however, frequently visited and occasionally wallowed in. Table garbage also provided an effective bait, as did anise-base commercial scent preparations.

Baits used with minor or negligible success were apples, peanut butter, molasses, and sorghum. Although honey is reputedly a preferred food of bears, it provoked only a mild response when used as bait.

Contrary to popular belief, bears showed a distinct aversion to eating putrid flesh. When baits became fetid or heavily infested with maggots they were

not effective. During warm summer weather it was necessary to rebait traps every three or four days to insure good trapping success.

Bears became more difficult to trap as summer advanced and were attracted to only the best baits at that time. This was undoubtedly due to bears becoming increasingly selective of their food as natural foods became more abundant in late summer and fall.

Responses of bears to various baits lead me to suspect that many of the popular conceptions relating to preferred food of bears possibly result from abnormal feeding habits during periods of low food availability, particularly in the spring. Thus, certain foods instead of being preferred, as commonly thought, may in reality be only subsistence foods.

Effective baits for culvert traps were large chunks of meat weighing over 10 pounds. They not only were more tempting to the bears than smaller baits, but also allowed secure attachment of the trigger wire. Trigger mechanisms were adjusted to release when a heavy pull of 35 to 40 pounds of pressure was applied. To a great extent this eliminated the probability of small animals springing

the traps.

Bears usually attempted to drag or carry off baits. They were seldom content to eat a meal, even when whole carcasses of deer were available, until they had moved them. This behavior necessitated staking baits used in steel-trap sets (Figures 81 and 82).

Handling Techniques

During this study bears were handled by two general methods. Animals captured in culvert traps were anesthetized with ether after the culvert had been converted into a relatively air-tight chamber. Those taken in steel spring traps were first securely tied and then administered ether or Pentobarbital Sodium.

In Culvert Traps. These traps were easily converted into anesthetizing chambers by caulking the door with cloths, and by banking with soil (Figure 83). The open metal-grid back was sealed by fitting the weighing canvas over the end of the trap and tightly securing it with a handling rope (Figure 84). Approximately 1 pound of ether was then sprayed into the

Figure 83. Spraying ether into sprung culvert trap to anesthetize captured bear. Note sealing of door with earth and cloths. Dark line down center of door is nasal discharge indicating that occupant is a bear.

Figure 84. Canvas sealing grid back of culvert trap to prevent escape of ether.

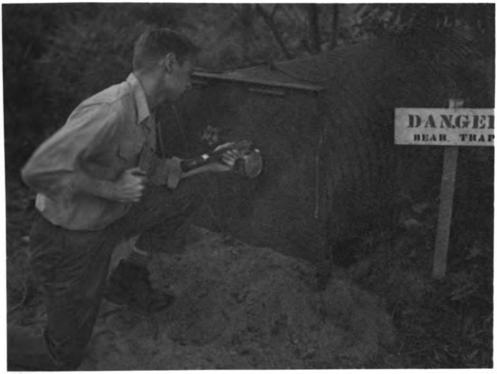


Figure 83.

Figure 84.

culvert through a small hole in the trap door (Figure 83). A rapid and continuous application of ether resulted in a shorter anesthetizing period. Since our culvert traps varied so in construction, their effectiveness as anesthetizing chambers varied. Consequently time required for sedation was not uniform, but approximated seven minutes on the average. When ether was correctly applied, bears went through the throes of violent muscular activity immediately before passing out. This reaction was practically the only indication that an animal was helpless. A strong light beam directed through the ether hole did not normally illuminate the trap enough to make the bear visible. Also, ether fumes generally prohibited close observation. Following the cessation of muscular activity, one to three minutes were allowed before the trap door was opened.

Initially, bears were continued under anesthesia by continued application of ether administered by means of an ether cone (Figures 85 and 86). This was a critical point, since too little ether allowed the animal to recover, while overdoses were likely to stop respiration. A good test for determining the

Figure 85. Placing ether cone on muzzle of bear; may be used on either culvert-trapped or steel-trapped bears.

Figure 86. Continued anesthetizing of culvert-trapped bear while placing tag on ear.

degree of anesthetization was the appearance and reflexes of the eyes.

Administration of ether was either continued or stopped depending on the extent of these reflexes. In some instances overdoses of ether produced cessation of breathing. However, this was usually overcome by means of artificial respiration.

Ear-tagging and toe-clipping of bears under ether should be performed prior to their removal from the trap, since pain induced by these operations appeared to produce quick recovery from anesthetization.

<u>In Steel Spring Traps</u>. Bears in steel traps were handled by first placing a "choker" over the animal's head and then securely tying the legs with heavy rope. The choker is a pliable chain loop fastened to the end of a 6-foot length of pipe held by a T-handle (Figure 87).

When approached, bears usually backed to the limit of their trap chain. It was found advantageous for members of the handling crew to approach the bear simultaneously from several directions. This maneuver usually resulted in the bear's standing quietly, and

thereby avoided the usual sudden lunges away from crews approaching from a single direction. Thus, the possibility of pulling out of the trap, or injury to the paw, was greatly reduced and placement of the choker on the calm or confused bear was facilitated.

Little difficulty was usually encountered unless the initial attempt to place the noose over the bear's head (Figure 87) was unsuccessful. The noose was twisted until it was just tight enough to hold the bear. If tightened too much, so that breathing was obstructed, even a docile animal would fight the handling operation. Once properly secured, the choker allowed one man to control the animal's head (Figure 88). Another crew member then grasped a rear leg, fastened a rope to it and secured it to a solid object, such as a tree (Figure 89). Unless the leg was secured in the first attempt the process became increasingly difficult, since the bear would withdraw its legs well under its body. The animal was then placed on its back, and additional ropes secured the remaining two legs.

Steel-trapped bears were then anesthetized with

Figure 87. Placing "choker" over the head of a steel-trapped bear.

Figure 88. Steel-trapped bear restrained by "choker". Handling crew can now grasp rear legs.

ether. (Later, when we became proficient in estimating weights, Pentobarbital Sodium was substituted as the anesthetic). The ether cone was quickly clapped over the animal's muzzle (Figure 85) and forcibly held in place while ether was applied. Again, this procedure became increasingly difficult and dangerous unless correctly performed at the first attempt. A slow spraying of ether into the nose, prior to fitting the cone, appeared to deaden the animal's reflexes, and rendered this operation less difficult. The animal usually quieted within a minute or so after ether was sprayed into the cone, and within five minutes anesthetization was complete. Recovery was rapid; within five minutes bears usually became active.

Evaluation of Pentobarbital Sodium. Although there is a great safety margin inherent in ether compared to other anesthetics, greater success and increased safety followed the use of Pentobarbital Sodium. Injection of Pentobarbital Sodium in the inguinal region of the peritoneal cavity (Figure 90) eliminated the dangerous operation of fitting the ether cone to the bear's muzzle. Although more rapid results could be obtained

Figure 89. Securing a steel-trapped bear with ropes preparatory for anesthetization.

Figure 90. Intra-paritoneal injection of Sodium Pentobarbital.

by intravenous injection, this technique was impractical because of the difficulty in locating veins and our limited opportunity to work freely about the animals. Pentobarbital Sodium was used with equal facility on both steel-trapped and culvert-trapped animals. It was essential, however, that culvert-trapped bears initially knocked out with ether be contained in the traps during the interval in which ether was removed and Pentobarbital Sodium took effect.

Effective anesthesia was produced using one cubic centimeter of Pentobarbital Sodium solution containing one grain of Pentobarbital Sodium, for each 5 pounds of body weight. Complete sedation was achieved in approximately 11 minutes (Table 6). Injection of Pentobarbital Sodium was best achieved with a large syringe and hypodermic needle. A 20 to 30 cubic centimeter syringe was easily handled in the field and was of sufficient capacity to anesthetize most animals with one application. Eighteen-gauge needles were better than smaller sizes. Less resistance was met in injecting the

TABLE 6. Pentobarbital Sodium as an anesthetic for bears

	Number	Actual dosage[1] (average pounds per cubic centimeter of Pentobarbital Sodium)	Time to produce sedation (minutes)	Recovery time (hours:minutes)
All animals handled:				
Males	13	5.66	10.6	
Females	19	5.38	11.2	
Both sexes	32	5.50	11.0	
Animals observed till recovery was complete:				
Males	5	6.19	11.6	2:29
Females	10	5.11	8.7	3:29
Both sexes	15	5.47	9.5	3:09

[1] Computed after weights were determined.

anesthetic, and it could be administered more rapidly. This was important since a quick movement of the animal might free the needle, and result in only a partial dose being administered. Since the remaining portion was usually lost there was no way of determining the amount actually delivered.

The major objection to the use of Pentobarbital Sodium was the necessity of making accurate weight estimates of bears for computing dosages. Underdoses prolonged sedation periods, while overdoses were fatal. A distinct source of dosage error was the fact that bears were often exceptionally fat. Estimates of body fats should not be included as weight in dosage determinations. Injecting Pentobarbital Sodium into muscle or fat deposits was avoided, since the sedative is released into the circulatory system much more slowly from such tissues. Faulty administration, rather than an underdose, was suspected if sedation did not occur in a reasonable period. Workers are cautioned to administer additional Pentobarbital Sodium only in small amounts.

A distinct advantage of Pentobarbital Sodium over ether, in addition to increased safety for the handlers, was that bears could be worked on at leisure once anesthetized. Pentobarbital Sodium solution administered at the prescribed rate remained effective approximately three hours (Table 6). Since the animals were completely narcotized, they could be readily examined and transported if necessary. Additional amounts could safely be injected to keep them out as long as necessary.

Bears were weighed in a heavy canvas sling raised by a hoist on the back of a pickup truck. A dial scale accurate to one-half pound was used to determine weight. Small bears were weighed with a scale suspended from a pole supported by two men.

Marking Black Bears

Bears were primarily marked with metal ear tags and secondarily by toe-clipping. Based on the inspection of 42 bears previously ear-tagged, little evidence was found that tags would not remain permanently. It therefore appears that auxiliary marking by toe-clipping is unnecessary.

The ear-tags used to mark bears were the Fretz

cattle tag manufactured by William, Cooper, and Nephews of Chicago, Illinois. They were attached with tagging pliers to the leading edge of the ear, approximately 1-1/2 inches above the skull. Some difficulty was experienced in making tag attachments because the ear is rather thick and vascular. Tagging pliers, properly gapped, with sharply honed cutting edges, resulted in the most satisfactory applications. Applied tags were inspected to make sure that they were well crimped, squarely attached, and free from protruding edges which might cause irritation. A tag properly attached also provided space between the tag and ear surfaces. Some space was also left between the end of the tag and the edge of the ear, since some initial swelling, and additional growth in young animals, was expected.

Toe-clipping was performed by removing toes either at the first or second joint. Both served well for identification, but the latter resulted in profuse bleeding and was discontinued. It was also easier to perform distal joint amputations. A sharp pen knife or scalpel inserted just behind the toe-nail resulted in quick removal Unless a great number of bears are to be marked we recommend that toe-clipping be restricted to rear feet, since the forefeet are used extensively in acquiring food This should also result in fewer losses of identification, since bears frequently lose front toes when captured in steel traps.

Reactions of Bears to Trapping Operations

Bears exhibited little evidence of trap shyness, except in areas trapped intensively. Six of fifteen recaptures were made within two weeks of initial capture and in the same trap types. However, track signs around sets indicated that individual animals became somewhat trap-wise. This was difficult to determine around culvert traps, since many bears, even in areas being initially trapped, would approach the trap without entering. In the case of steel traps, however, track signs indicated that some bears cautiously checked the sets from the side or rear, instead of approaching directly. Meat baits were occasionally stolen by these animals, but several were captured by placing well concealed steel traps

at these locations. Trap wariness was attributed to previous encounters with our traps. Even these individuals exhibited little fear of recent human activity. White signs, intended to protect persons from both the traps and trapped bears, and placed within a few feet of all sets, failed to frighten bears away from sets.

The behavior pattern of trapped bears was decidedly different from the expected. Those taken in culvert traps, particularly with solid backs, were seemingly indifferent to capture. Some were observed standing or sitting in the trap, but most were apparently asleep, lying on their backs with heads and forepaws resting on their chests. Seldom was an attempt made to fight the trap even though the handling crew worked noisily about. Even pounding on the trap back and door did not elicit a response. This was frustrating to the handling crew as it was often difficult to determine if a sprung trap actually contained a bear. In most cases it was possible to observe the animal by directing a light through the small ether hole. In others the animal could be detected by an odor peculiar to bears and by a nasal dischärge running from the ether holes in the door (Figure 83). The presence of deer and horseflies was also evidence of a capture.

Steel-trapped bears were more excitable than those in culvert traps, possibly because they were in some pain, were able to move about to some degree, and could observe the handling crew. However, the majority were docile, providing a minimum of resistance during handling. Some were completely resigned to capture, often rolling on their backs at the approach of the handling crew. Others snorted and rapidly champed their teeth when approached. Only three animals handled were exceedingly aggressive. One of these was a female protecting a captured cub.

Contrary to popular opinion most female bears did not display strong maternal protective instinct, and quickly abandoned cubs when danger was imminent. In only three of ten cases was the female detected in the vicinity where cubs of the year had been captured. Two of these mothers attempted to drive off the handling crew by rushing forward, snorting and rapidly champing their teeth. At no time did they

approach closer than ten feet. A particularly aggressive charge could be terminated by making a great deal of noise, particularly loud shouting, which seemed to unnerve the animal. In one instance the protective instinct was useful in capturing a protecting mother. Traps were placed along the route upon which she alternately charged and retreated. After several rushes the animal was caught. Although some cubs seemed to be definitely abandoned, a few apparently abandoned cubs captured in traps were later recovered with the mother, indicating that some females were skulking in nearby cover during the handling of the young.

An interesting observation on trapped females was their allowing young to suckle. This was at first perplexing to us for although teats often indicated a nursing condition lactation could not be demonstrated, and cubs could not often be seen. It was later observed that cubs were masking evidence of lactation by frequent nursing and then running off when disturbed.

Mortalities and Accidents to Trapped Bears

Mortalities of bears live-trapped in this study included the loss of two during anesthetization, one strangled in handling, two from heat prostration, two shot while in traps by hunters, and a cub which was killed and eaten by another bear. In the latter case, conclusive evidence of cannibalism was found from bear hair in feces voided by the killer bear while it was temporarily captured upon its return to the trapping site the following evening. Carcasses of two other bears, killed as nuisance animals, were eaten by bears during the spring period. Extreme hunger appears to be the motivating force in this cannibalism, since seven bear carcasses set out during the fall when other food was abundant, remained untouched.

Accidents to trapped bear included four cubs suffering broken metapodial bones when taken in steel traps. Subsequent recapture of two of these indicated that the fractures had healed rapidly. Three other cubs and a large male, caught in a No. 5 bear trap, suffered either a broken radius or ulna bone, or both. Recovery of three of these revealed that in two instances the fractures had mended satisfactorily. One cub had amputated a paw.

Two trapped bears had broken the mandibular su-

ture of the lower jaw. The breaks were repaired with pins, and the animals completely recovered within two weeks. Other bears were found with various injuries not incurred as a result of our trapping. Rapid recovery from these injuries indicates that the bear is very capable of withstanding infection. It likewise suggests that crippling loss from such injuries and wounds may be low.

Trapping Costs

At this stage of the study it has cost $96.85 to trap each bear. This included all expenses--wages, vehicle operation and maintenance, trap and equipment purchase, and baits. Subsequent trapping should materially reduce this figure, since the cost of equipment on hand can be prorated over a greater number of animals.

The average cost of culvert traps constructed at Cusino was $85.97, of which materials constituted $70.41 and labor $15.56. However, inexpensive prison inmate labor was employed for much of this work. A welder and helper worked approximately eight hours to construct each trap. Since these were pilot models requiring

considerable experimentation during building, it is expected that future construction costs will be materially reduced.

Steel wolf traps used in this study were purchased at a cost of $108.00 per dozen, or $9.00 each. Materials and labor to fit toggles to traps increased this cost by approximately $1.00. In addition to costing only a fraction as much as culvert traps, steel traps have several practical advantages. They are easily handled, can be set in greater numbers and in a greater variety of situations, work well with a greater range of baits, and can be easily cleaned and camouflaged. However, culvert traps are capable of capturing larger bears than steel traps, and although frequently molested by man, have never been stolen. Furthermore, animals in culvert traps are rarely injured or lost, while this possibility is ever present with steel traps.

Summary

Techniques are described as developed in Michigan for live-trapping, handling, and marking 159 black bears.

Bears were captured in several types of culvert

traps and in number 4-1/2 steel-spring wolf traps. The latter proved the most economical and practical.

The most successful culvert traps were constructed of 8-foot sections of 36-inch steel culvert. They were fitted at the back with an open metal grill, and at the front with a sliding drop door. A lever trigger mechanism, adjustable for force necessary to release the door, proved the best of several types.

A large piece of unspoiled meat over ten pounds in weight proved to be the most successful bait. When baits became fetid or infested with maggots they were not successful. Fish and a number of other baits were tried with negligible success.

Handling techniques varied according to the type of trap in which the bears were captured. Those taken in culvert traps were anesthetized with ether after the trap had first been rendered airtight. They were initially calm, and then went through a muscular excitation phase, the termination of which indicated an anesthetized condition. They were continued under anesthesia with ether administered via an ether cone, or by an intraperitoneal injection of Pentobarbital

Sodium. The latter rendered a bear helpless in about 11 minutes.

Bears captured in steel traps were handled by first placing a chain loop, at the end of a 6-foot section of pipe, over the animal's head and twisting it down snug. The bear's head could then be controlled by one man while another fastened ropes to the hind legs. The ropes were then secured so that the bear was tied belly up in a spread-eagle fashion. Ether was administered via the ether cone, a somewhat dangerous procedure, or the animal was given a shot of Pentobarbital Sodium in the peritoneal cavity.

All bears captured were marked with metal ear tags. Some were also marked by toe-clipping. Evidence now indicates that metal ear tags are a reliable marking technique.

Accidents to bears were few. Five bears were killed during 182 handlings of the 159 animals. Most of these losses occurred early in the program during development of techniques.

Average cost of each bear trapped in this study was $96.85. Future trapping costs will be lower as the cost of construction and purchase is prorated over the years.

POPULATION STRUCTURE, MOVEMENTS, AND MORTALITY OF TAGGED BLACK BEARS IN MICHIGAN

To provide insight into the population characteristics and movements of black bears, a live-trapping and tagging study was conducted near the Cusino Wildlife Experiment Station, Alger County, in the central part of the Upper Peninsula of Michigan.

Methods and Procedures

During the summers of 1952-57, 159 bears were captured 182 times. Most of these were captured within a 400-square-mile study area in Alger and Schoolcraft counties, although bears were captured also in most other Upper Peninsula counties (Fig. 91). Most were taken initially either in large box-traps made of corrugated steel culvert pipe or taken alive in No. 4-1/2 jaw-spring steel traps. Capture methods and tagging procedures have been previously described (Erickson, 1957).

Three adult females and 12 cubs were captured incidentally as parts of probable family groups which

remained near a captured member. In addition, 16 bears were acquired from bounty trappers, 5 were taken by state predatory animal control officers, and 3 were confiscated as illegally held captives. Tagged bears were released both at the sites of capture and at new locations.

Of 137 tagged bears released, 42 different animals yielded 48 returns. Twenty-six tag returns were from legal hunting kills, 17 from live recaptures, 3 from animals destroyed as nuisances, and 2 from highway fatalities.

These bears, captured in summer, were classified as cubs, yearlings, or "older animals". Cubs (5-8 months old) were readily identified by their small size and deciduous dentition. Yearling bears (17-20 months old), as determined from known age specimens, possessed clean, incompletely erupted adult dentition; in males the penis could be only partially extruded from the penis sheath; in females the teats measured not more than four millimeters in both length and basal diameter. Older bears were larger than cubs and yearlings; their teeth were stained and worn; the penis could be fully extruded from its sheath; and teat measurements exceeded the above.

Trapped bears were further classified according to apparent way of life as "wild", "dump", and "nuisance" animals. Wild bears were those taken in areas at least a half-mile from human habitation and included all bears trapped in the study area. Dump bears were those captured at garbage dumps or other artificial foraging sites. Nuisance bears were those trapped near human dwellings in response to requests for their removal.

The primary study area (Fig. 91) comprised 11 townships of wild habitat in Alger and Schoolcraft counties. It was selected primarily because general observations indicated that it supported one of the state's densest bear populations. Live-trapping efforts and bear captures were scattered throughout the area (Fig. 91) as influenced by access on the limited secondary roads and logging trails. The distribution of bears was also irregular and most traps were placed near bear sign. It is not known whether hunting--or trapping--pressure intensities followed bear distribbution patterns. Quite possibly, segments of the study area bear population were exposed neither to hunting nor

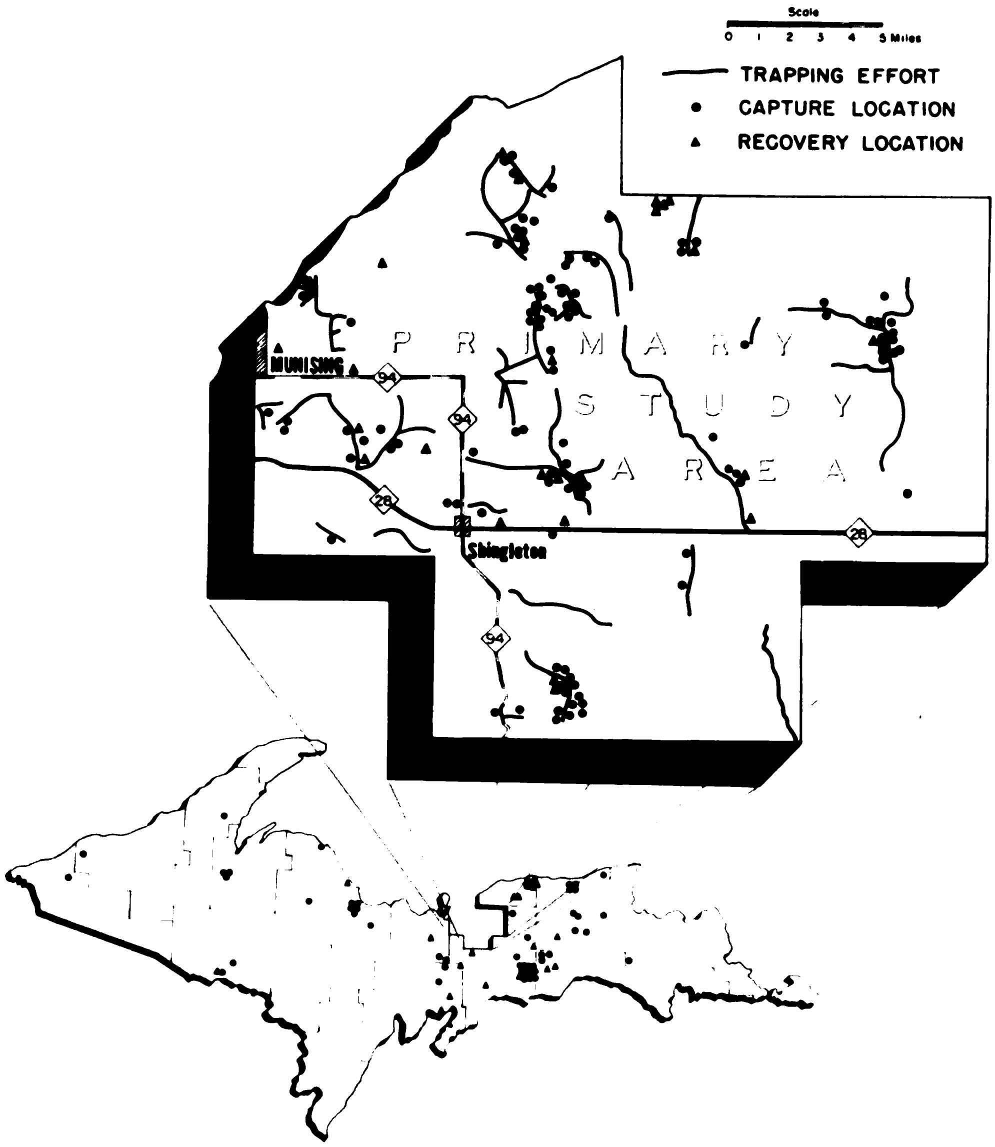


Figure 91. Primary study area and the locations of marked black bear releases and recoveries.

to trapping.

Population Characteristics

Size of Study Area Population. Population estimates of bears in the study area for the years 1955-57, have been calculated from marked-unmarked ratios among bears killed by hunting (Table 7).

TABLE 7. Population estimates of black bears on a 400 square-mile area in Alger and Schoolcraft Counties, Michigan

Year	Tagged bears	Tagged bears recovered	No. of bears known killed	Computed summer population
1955	24	2	7	84
1956	36	7	19	98
1957	24	2	14	168
Mean Population Estimate				117 (S.E. $\pm$ 78)

Hunters' reports of bear kills were for the most part volunteered, but other evidence of kills were obtained through taxidermists and similar sources. The population estimates are somewhat speculative, dependent on the degree to which the usual tag-ratio (Lincoln Index) assumptions were met. Especially since tagged bears from the study area were more likely to be tallied than untagged bears, which carried no incentive to report. It seems more probable that the population figures are under-estimates rather than overly large. Despite some uncertainty as to accuracy, however, this estimate of about three bears per square mile is the first of its kind for this species, and probably few investigators will have better opportunity to collect data with even these acknowledged limitations.

Assumptions considered sufficiently satisfied to permit calculation of population estimates are: (1) marked bears not losing their tags, and (2) no recruitment of young into the population measured. Among 48 recoveries of bears tagged in both ears, 46 animals retained both tags, and two animals had each lost one tag. The probability of a bear losing both markers was certainly slight, particularly since bears considered in these estimates were marked only a few months before the hunting season. There was no reproduction between marking and recovery.

Assumptions that may not have been strictly met and which therefore may detract from the accuracy of the estimates were: (1) equal mortality rates for both tagged and untagged bears, (2) proportional representation of

sex and age classes among marked bears, (3) no movements of bears into or out of the area, and (4) proportional recovery of marked and unmarked bears.

There was no evidence to demonstrate a differential mortality among either marked or unmarked specimens. The sex and age structure of the bear population on the study area was unknown except as extensive live-trapping with culvert traps and steel-spring traps may have provided a suitable sample. Emigration of marked bears from the study area did occur as shown by the recoveries of two animals off the area. Distortion of the estimates due to migration is considered slight, however, since movement studies of marked bears (see beyond) revealed that bears were generally quite sedentary. Furthermore, only several months elapsed each year between tagging and hunting. The movements of unmarked bears into and out of the study area were probably compensating, but both the emigration of marked bears and the immigration of unmarked bears would tend to produce an inflated population estimate. This could have compensated for proportionately higher returns of tagged animals.

Possible disproportionate recoveries of marked study-area bears is believed to be the most significant factor tending toward possible distortion of estimates of population size. All kills were reported voluntarily, and most kills of tagged bears are believed to have been tallied. While reports of all kills were verified, the large variety of sources of reports may have resulted in reports of unmarked bears being less complete than reports of marked specimens. If there was any failure to recover unmarked study-area bears, the resulting estimates are low.

The computed average of the population estimates (Table 7) is 117 bears for the study area, or one bear per 3.4 square miles. In the light of considerable experience on the area, and because of the improbability of receiving a proportionate number of reports of untagged bears killed, I feel that this is a low estimate. This opinion is based partly on the general observation that bear sign was more numerous than would be expected for the population density calculated. Searches for tracks, undertaken one day following the removal of old signs, often indicated several bears for each mile of road. These searches were conducted, however, in the

areas of highest bear density. It also may be significant that intensive trapping in a township (36 square miles) in the central portion of the study area in 1956 resulted in the capture of 23 bears; certainly not all bears there were captured.

A population density of one bear per three or four square miles is compatible with the known hunting-kill of bears in the study area for the years 1955, 1956 and 1957. For these three years, a combined kill of 65 bears was determined from a mail survey of known hunters in this area (Erickson, 1964). This is an average kill rate of one bear per 18-1/2 square miles. Compared with the estimated population density this indicates an 18 per cent annual rate of kill. Such a rate of kill, in comparison with known reproductive rates for the black bear (Erickson and Nellor, 1964), would permit a population to maintain itself.

Sex and Age Ratios of Captured Bears. A review of the sex and age of bears captured in this study (Table 8) indicates variation both according to manner of capture and the way of life of the bears. Culvert traps took predominantly older bears, principally males. Steel traps captured 12 cubs, 21 yearlings, and 33 older bears,

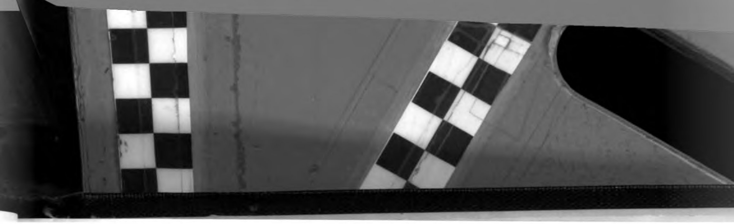


TABLE 8. Summary of black bears captured in tagging studies, 1952-57

Age class	Number of bears captured by various methods					
	Culvert box-traps			Steel spring-trap		
	Males	Females	Total	Males	Females	Total
Wild bears:						
Cubs	0	0	0	5	7	12(b)
Yearlings	2	2	4	9	11	20
Older bears	10	4	14	12	18	30
Total	12	6	18	26	36	62(b)
Percentage of total	67	33	100	42	58	100
Dump bears:						
Cubs	0	0	0	0	0	0
Yearlings	0	1	1	1	0	1
Older bears	21	5	26	2	0	2
Total	21	6	27	3	0	3
Percentage of total	78	22	100	(c)	(c)	
Nuisance bears:						
Cubs	0	0	0	0	0	0
Yearlings	0	0	0	0	0	0
Older bears	1	2	3	0	1	1
Total	1	2	3	0	1	1
Percentage of total	(c)	(c)		(c)	(c)	
All Bears:						
Cubs	0	0	0	5	7	12(b)
Yearlings	2	3	5	10	11	21
Older bears	32	11	43	14	19	33
Total	34	14	48	29	37	66(b)
Percentage of total	71	29	100	44	56	100

(a) Bounty trapping, predatory animal control trapping, confiscated captives, members of family groups.

(b) Does not include one cub of undetermined sex killed and eaten by another bear.

(c) Numbers too small to warrant use of percentages.

TABLE 8. Continued

Various other means[a]			All methods			Percent in each age class		
Males	Females	Total	Males	Females	Total	Males	Females	All bears
21	9	30	26	16	42[b]	42	28	36
1	2	3	12	15	27	20	27	23
1	3	4	23	25	48	38	45	41
23	14	37	61	56	117[b]			
62	38	100	52	48	100	100	100	100
0	0	0	0	0	0	0	(c)	0
0	0	0	1	1	2	4	(c)	7
0	0	0	23	5	28	96	(c)	93
0	0	0	24	6	30			
			80	20	100	100	(c)	100
2	0	2	2	0	2	(c)	(c)	18
0	0	0	0	0	0	(c)	(c)	0
5	0	5	6	3	9	(c)	(c)	82
7	0	7	8	3	11			
(c)	(c)		73	27	100	(c)	(c)	100
23	9	32	28	16	44[b]	30	25	28
1	2	3	13	16	29	14	25	18
6	3	9	52	33	85	56	50	54
30	14	44	93	65	158[b]			
68	32	100	59	41	100	100	100	100

with an overall proportion of 44 per cent males. Of bears not purposely trapped for study, but acquired otherwise, cubs and males predominated.

Statistically significant differences between culvert and steel trap captures occur in both sex and age proportions (Table 8). The 71 percent males taken in culvert traps is also a significant deviation from a population with an even sex ratio, but the proportion of males taken in steel-spring traps is not. Age data for both methods of capture (Table 8) are also quite different from age data reported among bears killed in the Upper Peninsula by hunters (Erickson, 1964). Sex and age ratio data for bears captured by miscellaneous means are largely without comparative value. Most were cubs, and captures among adults were selective with respect to sex.

That culvert traps were selective of older bears, particularly males, was true for both wild and dump bears (Table 8). Since culvert traps were capable of capturing bears regardless of size, the disproportionate take of adult males indicates that this group was perhaps more aggressive or less wary of the large culvert traps than were females and younger bears.

The No. 4-1/2 steel traps apparently selected younger bears, and among older bears, females. Only one bear taken in steel traps exceeded 200 pounds, a weight infrequently attained by wild female bears. Of bears captured under other circumstances 24 exceeded this weight, and all but one were males.

In view of selection under various capture regimens, the data of Table 8 provide only a limited basis for evaluating the sex and age composition of the bear population sampled. Sixty-four percent of 44 cubs and 45 percent of 29 yearling bears captured were males. Neither ratio is a significant deviation from a population evenly divided as to sex, although the data for cubs approaches statistical significance. The greatest deviation from an equal ratio of cub sexes was evident for miscellaneous captures and here undetermined factors seemed to influence selectivity for males. Older bears were mostly males, the distortion being attributed to bias in methods of capture.

Important data of Table 8 are the sex and age differences indicated for bears according to wildness. Chi-square tests indicate that sex and age ratios for dump bears are significantly different from those for animals captured in wild surroundings. The sex ratio for dump bears is also significantly different from a 50:50 ratio. Comparisons between culvert-trap captures of dump and wild area bears show a predominance of adult males among bears trapped in dumps. Although these differences are not statistically significant, it appears that the majority of dump bears are adult males.

Capture data for nuisance bears were too few for meaningful analysis of sex and age proportions. However, among 43 unmarked bears examined after being killed as nuisances during the period of this investigation (Cusino Experiment Station autopsy file, unpublished) 72 percent were males. Of 40 classified to age, 31 were adults, 5 were cubs, and 4 were yearlings. Chi-square tests show the sex ratio to be a significant deviation from a 50:50 ratio and the age proportions to be statistically different from those for captures of wild bears.

These observations indicate a greater tendency for older male bears to frequent dumps and to become nuisances. While bears foraging together at dump sites seem to show reasonable tolerances toward each other,

this may not be true for all categories of bears and competition may discourage weaker animals from frequenting these places. On the other hand, males may be merely less afraid of association with man than smaller bears and adult females. Perhaps, too, females with young avoid close association with both other bears and man. Only one of five adult females captured at dump sites was judged to be nursing young, and no cubs were captured at dumps.

Movements of Tagged Bears

Forty-eight movement records were obtained from 42 marked bears. Twenty-nine such reports were from 25 bears released where captured (Table 9), and 19 from 17 transplanted bears (Table 11). Elapsed time between releases and subsequent recoveries varied from 6 to 787 days and averaged 160 days (Tables 9-11).

Movements of Non-transplanted Bears. Twenty-five bears released where first captured, were recovered 29 times (Table 9; Fig. 92). Their mean minimum movement between points of release and of last capture was 4.6 miles, with an average time lapse of 195 days. The mean movement for 16 bears recovered dead (Table 9) was 6.7

TABLE 9. Twenty-nine movement records from 25 non-transplanted black bears, Alger & Schoolcraft Counties, 1955-57

Tag No.	Age	Sex [a]	Wildness class	Date Tagged	Date Recovered
5605	Adult	F	Wild	6/17/55	11/15/55
5609	Adult	M	Dump	6/26/55	8/ 9/56
5620	Adult	F	Wild	7/20/55	8/18/55
					10/13/57
5683	Adult	M	Dump	8/11/55	9/ 1/56
5626	Yearling	M	Wild	9/ 3/55	7/19/56
					12/ 1/56
5692	Adult	F	Wild	8/23/55	6/10/57
5628	Adult	M	Wild	9/ 4/55	6/ 8/57
5632	Adult	M	Wild	9/ 8/55	10/14/55
5668	Adult	M	Dump	9/24/55	10/25/55
5251	Adult	F	Wild	9/28/55	10/20/55
5974	Yearling	F	Wild	7/ 4/56	9/11/56
5923	Adult	M	Wild	7/11/56	9/26/56
5964	Cub	M	Wild	7/26/56	8/ 8/56
5917	Adult	F	Wild	7/29/56	8/14/56
					11/17/56
5905	Adult	F	Wild	7/31/56	9/30/56
5985	Adult	F	Wild	8/11/56	7/19/57
5991 [b]	Cub	M	Wild	8/14/56	11/17/56
5996 [b]	Cub	M	Wild	8/14/56	11/17/56
5942	Adult	M	Dump	8/17/56	8/24/56
					11/18/56
5944 [c]	Cub	M	Wild	8/17/56	7/31/57
5971 [c]	Cub	F	Wild	8/27/56	11/17/56
5998	Adult	F	Wild	8/28/56	11/17/56
B-105	Adult	M	Wild	6/ 5/57	11/16/57
B-119	Adult	M	Dump	6/15/57	9/ 5/57
B-145	Adult	M	Dump	7/14/57	8/19/57

(a) M=male; F=female.
(b) Cub of 5917.
(c) Cub of 5998.

TABLE 9. Continued

No. of days between release & recovery	Manner Captured	Manner Recovered	Airline Distance Moved (miles)
151	Box trap	Hunter	0.5
410	Box trap	Nuisance	5.8
29	Box trap	Steel trap	0.0
787		Hunter	2.0
386	Box trap	Hunter	11.9
319	Steel trap	Steel trap	1.6
454		Hunter	6.1
656	Steel trap	Steel trap	0.1
638	Steel trap	Box trap	1.0
36	Steel trap	Steel trap	5.5
31	Steel trap	Steel trap	0.0
22	Steel trap	Hunter	1.0
69	Steel trap	Steel trap	6.4
77	Steel trap	Killed by car	8.9
13	Steel trap	Steel trap	2.1
16	Steel trap	Steel trap	2.8
111		Hunter	1.6
61	Steel trap	Steel trap	1.9
332	Steel trap	Steel trap	2.7
95	By hand	Hunter	1.8
95	By hand	Hunter	1.8
7	Box trap	Box trap	0.0
93		Hunter	10.1
348	Steel trap	Steel trap	3.7
77	By Hand	Hunter	19.4
76	Steel trap	Hunter	19.4
164	Steel trap	Hunter	10.9
82	Steel trap	Hunter	5.0
36	Box trap	Killed by car	0.7

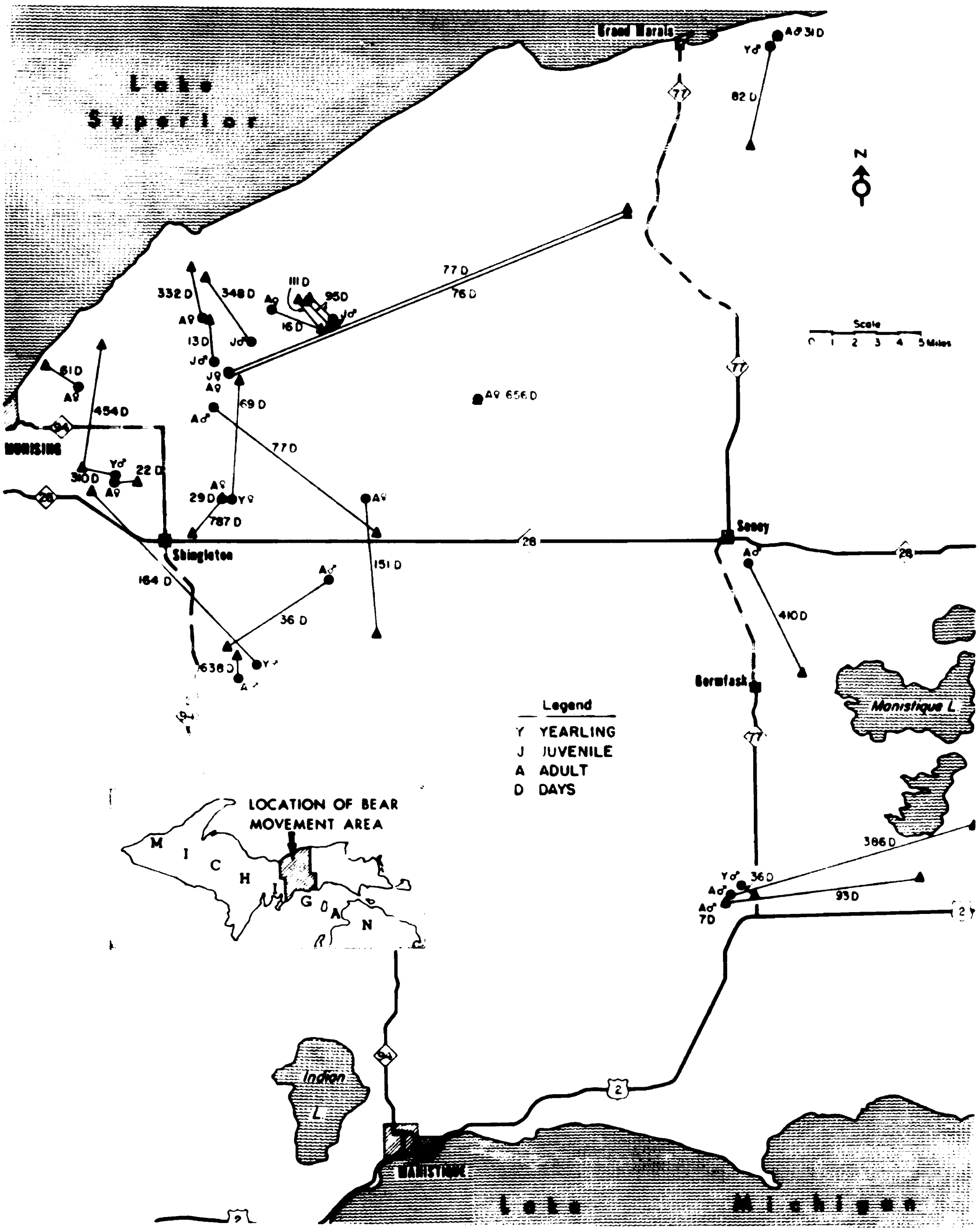


Figure 92. Movement of 25 bears released at the sites of their capture, 1955-57.

miles. The average movement for 13 re-trapped bears was 2.1 miles.

Since all trapping was in summer, the short average distance for bears recovered by re-trapping indicated that summer movements of bears were limited. The maximum recorded movement among these bears was 6.4 miles despite a more widespread trapping effort (Fig. 91). Bears tended to remain in the same general area from one year to the next. Three bears were recaptured nearby the summer following their initial captures, and two not far away two years after marking. The mean movement of these five bears was only 1.8 miles, and the greatest distance 3.7 miles.

All but two returns from dead bears came from the fall hunting period. The greater distances recorded for these animals may indicate either a general slight shift from a summer range to an autumn range, a tendency to travel over a wider area in the fall, or higher mortality among bears which chose or were forced to wander.

For records from all sources, the greatest recorded movement was 19.4 miles by a female and its cub recaptured 76 days after release. One adult male was recovered after moving 11.9 miles. Only five of 29 recaptures

disclosed movements greater than 10 miles. Six were between 2 and 5 miles, and 14 were within 2 miles of the capture site. The time elapsed between marking and recovery had little relation to the distances moved (Table 10), further indicating that black bears have limited home ranges.

Adult males apparently range more widely than adult females. Eleven movements of 10 adult males averaged 5.4 miles; three were in excess of 10 miles. Nine movements of seven adult females averaged only 1.4 miles. A tenth movement--19.4 miles by a sow and cub and the only one farther than 2.8 miles--raised the mean for all adult females to 3.2 miles.

Little information was gained about the dispersal of young bears, Four of the five returns of cubs occurred before family breakup, and their movements corresponded to those for their mothers (Table 9). The fifth cub was recovered a year later 3.7 miles from the site of original capture. This record, coupled with three returns from two bears marked as yearlings and which moved 6.4, 1.6 and 6.1 miles after 69, 319 and 454 days, respectively, show only limited dispersal among young bears.

There appeared to be little difference between the

TABLE 10. Movements of non-transplanted black bears in relation to time between marking and recovery, Alger and Schoolcraft Counties, 1955-57

Number of movements (a)	Time lapse between release and recovery (months)	Mean time lapse (days)	Mean distance moved (miles)
6	0- 1	19.7	1.0
3	1- 2	44.3	2.7
5	2- 3	76.2	11.8
4	3- 4	98.5	3.8
5	4-12	262.8	3.9
6	13-27	555.1	4.4
29	0-27	195.5	4.6

(a) Includes two recoveries each for four bears; actual number of bears was 25.

movements of dump bears and wild bears. Seven dump bears, all adult males, moved an average 4.8 miles. While this is somewhat less than the 6.6 mile mean movement of four wild adult males (Table 9), exclusion of two dump animals recovered at the original site yields a similar average movement of 6.7 miles.

Movements of Transplanted Bears. Nineteen returns were obtained from 17 transplanted bears (Table 11; Fig. 93). The exact sites of two of these tag recoveries were not ascertained, but one trapped in Iron County, Michigan, was recovered nearby in Wisconsin.

The distances that bears were transplanted varied from 2.4 to 158 miles, averaging 39.7 miles. It is probable that a few were not removed from their home ranges. Only three were recovered, however, near their capture sites. Three also were again caught near their transplant sites. Transplanted bears were recovered an average distance of 22.1 miles from the point of release. Recovery points averaged 34.1 miles from the point of original capture, indicating that most bears were removed from familiar range when transplanted and wandered considerably after release (Fig. 93).

Of three bears recovered near original capture

TABLE 11. **Nineteen movement records of 17 transplanted black bears, 1953-57**

Tag no.	Age	Sex[a]	Wildness class	Date tagged	Date recovered	No. of days between release and recovery -
3914	Adult	F	Wild	8/17/53	11/18/53	93
1016[b]	Cub	M	Wild	8/17/53	9/19/53	33
4048	Yearling	M	Wild	9/14/53	9/20/53	6
					10/ 3/53	19
5601	Cub	M	Wild	9/19/55	7/29/56	313
					10/15/56	391
5951	Adult	M	Nuisance	6/26/56	11/24/56	152
5962	Cub	F	Wild	7/23/56	11/17/56	117
5481	Cub	M	Wild	8/ 6/56	11/16/56	100
5510	Yearling	F	Wild	9/19/56[d]	9/11/57	15
5518	Cub	F	Wild	9/29/56	11/22/56	54
B-139	Adult	F	Dump	7/ 3/57	11/16/57	136
B-141	Adult	M	Nuisance	7/ 4/57	8/ 8/57	35
B-151	Adult	M	Nuisance	7/ 4/57	10/24/57	112
B-149	Adult	F	Dump	7/10/57	11/16/57	129
B-154	Cub	F	Wild	7/15/57	10/10/57	87
B-178	Adult	F	Dump	7/24/57	11/21/57	120
B-209	Cub	M	Wild	8/23/57	10/ 9/57	47
B-194	Cub	M	Wild	8/30/57	9/16/57	17

(a) **M = male; F = female.**
(b) **Cub of 3914.**
(c) **Capture location unknown.**
(d) **Held in captivity until 8/27/57.**
(e) **Kill location unknown.**

TABLE 11. Continued

Manner captured	Manner recovered	Airline distance (miles) From capture site to release site	From release site to recovery site	From recovery site to capture site
Box trap	Hunter	2.4	14.7	13.4
By hand	Hunter	2.4	15.5	14.0
Box trap	Box trap	5.8	5.8	0.0
	Hunter	5.8	6.0	1.4
Bounty trap	Box trap	(c)	16.1	(c)
	Hunter		14.2	(c)
Box trap	Hunter	47	35	54
Steel trap	Hunter	14.3	13.5	7.4
Steel trap	Hunter	14.4	2.3	16.2
Bounty trap	Steel trap	16.0	2.8	17.7
Steel trap	Hunter	38	19.6	43
Box trap	Hunter	6.1	(e)	(e)
Steel trap	Nuisance	96	102	6.0
Steel trap	Hunter	53	27	58
Box trap	Hunter	40	26	62
Steel trap	Hunter	16	(e)	(e)
Box trap	Hunter	64	45	19
Bounty trap	Hunter	158	6.8	156
By hand	Steel trap	39	34	43

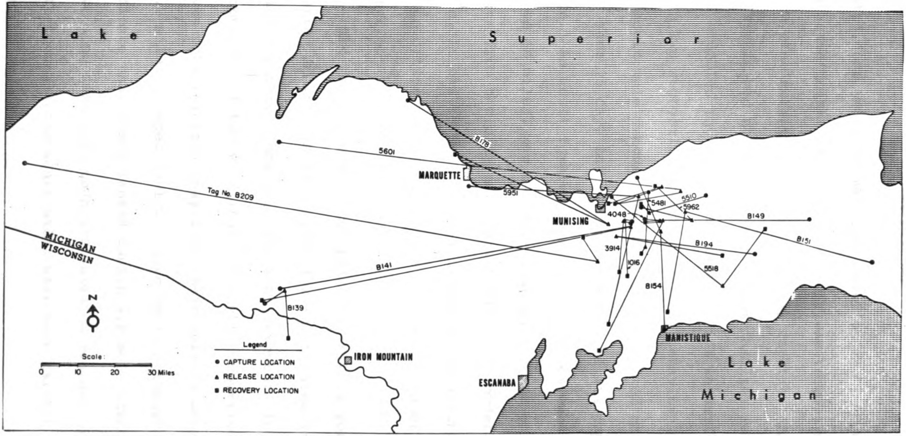


Figure 93. Movement of 19 transplanted bears, 1955-57.

sites, one yearling male was moved on two occasions to the same point 5.8 miles away. It was recovered in each case near the site of original capture. Apparently, either it had not been removed from familiar range, or had stumbled into familiar areas in its wanderings.

Two recoveries indicated homing behavior (Fig. 93). An adult male removed 96 miles from point of capture was shot 35 days later within 6 miles of its capture site. An adult female, separated from its cubs and removed 64 miles, was recovered 120 days later only 19 miles from the original capture site. In order to return, it had to follow a circuitous route around several large cities and farming areas on the shores of Lake Superior (Fig. 93).

The mean movement from point of release for transplanted adults was 54.7 miles for three males and 28.6 miles for three females. The mean movements in three recoveries of two yearlings and eight recoveries of seven cubs released away from their parents were 4.9 and 15.2 miles, respectively. These data, although limited, indicate that transplanted adults are more likely to move long distances than transplanted younger bears, and that transplanted adult males will move farther than adult female transplants.

<u>Management Implications of Movement Findings</u>. Recoveries of tagged bears in this study indicate only limited seasonal and annual movements. Assuming that home ranges are circular, and that recoveries indicate normal cruising diameters, then average minimal summer and annual ranges determined in this study are about 6 and 15 square miles, respectively. Ranges of adult males are about a third greater and those of adult females about a third smaller than the averages.

Davis (1953) and Stickel (1954) have described deficiencies likely to result from the calculation of home ranges on the basis of single recapture statistics. Unfortunately, difficulties inherent in studying bears preclude extensive compilations of multi-capture data. Despite their inadequacy, these data are indicative of prevailing conditions and may also be compared with the single recovery data of other studies.

These findings indicate that management units for bears need not be extensive. A small proportion of transplanted bears can be expected to display homing tendencies, even from distances over 60 miles. Most, however, appear to wander at random before establishing ne

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new ranges. Successful introductions of bears into unoccupied habitats thus appears to be feasible. Furthermore, troublesome bears can be transplanted without great likelihood of their return.

Mortality Analysis of Marked Bears

From 1952 through 1957 a total of 137 bears of all ages were marked and released, some at point of capture and some after being transplanted considerable distances. All seemed fully capable of survival after release. The reported deaths of 26 during the first year following their release indicated a minimum annual mortality of 19 per cent. In all, 31 animals were recovered as mortalities through 1957. In addition, data were obtained during the period 1955-57 by the Cusino Wildlife Experiment Station (autopsy file, unpublished) for 47 unmarked bears dying from causes other than hunting--3 struck by cars and 1 by a train, and 43 killed as nuisances.

Mortality and Sex and Age. Mortalities of marked bears according to sex, age, and wildness categories are recorded in Tables 9 and 11 and summarized in Table 12. Minimum one-year mortalities (not in tables) of 26, 4, and 21 per cent were realized for 35 cubs, 23 yearlings,

and 79 older-age bears, respectively. These rates of return were not statistically different from one another, although a larger body of data might support the logical conclusion that yearling bears sustain a lighter mortality than either cubs or older animals. The older-bear category is a group of year-classes not individually identifiable since criteria were not available for determining exact age.

Proportionately higher returns for older females than for older males (Table 12) indicates possible higher mortality rates among adult females. Higher mortality rates are indicated also for females accompanied by young, since first-year mortalities comprised 3 of 10 females with cubs, but only 4 of 21 females without cubs. There were no statistically significant differences, however, in returns by sex for any age class.

Mortality and Wildness. Mortality rates also varied between wildness categories. First-year mortalities were 30, 25, and 16 per cent, respectively, for 10 nuisance, 28 dump, and 99 wild bears. These values may indicate higher mortality rates for nuisance and dump bears, though the differences are not statistically significant. One-year hunting mortalities among these

TABLE 12. Causes of death of 31 tagged black bears, 1953-57

Age	Sex(a)	Number tagged and released	No. of mortalities according to cause of Hunting: Sept. 1-15	Oct. 1-Nov. 5	Nov. 15-30	Total
Nuisance bears:						
Cub	M	2	0	0	0	0
Adult	M	6	0	1	1	2
Adult	F	2	0	0	0	0
Totals		10	0	1	1	2
Dump bears:						
Yearling	M	1	0	0	0	0
Adult	M	22	2	0	1	3
Adult	F	5	0	0	3	3
Totals		28	2	0	4	6
"Wild" bears:						
Cub	M	21	0	2	3	5
Cub	F	12	0	1	3	4
Yearling	M	11	0	1	1	2
Yearling	F	11	0	0	0	0
Adult	M	20	0	0	1	1
Adult	F	24	0	2	4	6
Totals		99	0	6	12	18
Age and sex summary:						
Cubs	M&F	35	0	3	6	9
Yearlings	M&F	23	0	1	1	2
Adult	M	48	2	1	3	6
Adult	F	31	0	2	7	9
All adults	M&F	79	2	3	10	15
All bears		137	2	7	17	26

(a) M = male; F = female.

TABLE 12. Continued

death			Percent of mortalities in one year	Average survival after release (days)
Nuisance	Automobile	Total		
0	0	0		0
1	0	3		100
0	0	0		0
1	0	3	30	100
0	0	0		0
1	1	5		201
0	0	3		128
1	1	8	25	174
1	0	6		127
0	0	4		84
0	0	2		236
0	0	0		0
0	1	2		120
0	0	6		206
1	1	20	16	152
1	0	10	26	110
0	0	2	4	237
2	2	10		155
0	0	9		181
2	2	19	79	167
3	2	31	26	153

three groups of bears were 20, 18, and 15 per cent, respectively, perhaps indicating that dump and nuisance bears are also more vulnerable to legal hunting than strictly wild individuals.

Hunting Kill. Of 31 bears tagged and eventually recovered, 26 or 84 per cent were taken by legal hunting (Table 12). Three bears killed as nuisances and two killed by cars made up the remaining known deaths among marked animals. Of the 26 bears killed by hunters, 17 or 65 per cent were taken during the traditional November 15-30 deer-bear seasons. Special bear hunting seasons of September 1-15 during 1956-57 (2 bears), and October 1-November 5 in 1955-57 (7 bears), accounted for 8 and 27 per cent of the marked kill, respectively.

Whether mortality values of marked bears determined in this study were representative of the total bear population is questionable. Trapping, and it can be assumed hunting, took place on accessible areas, and the data are perhaps applicable only to those areas. There is reason to suspect, however, that hunting mortality exceeded even the 19 per cent annual rate determined for marked bears. This is so because deaths as a result of wounds, for which no measure could be obtained, must certainly have occurred. Failure of hunters to report kills of at least a few tagged bears is also quite possible.

The recent inauguration of special bear hunting seasons appears to have increased the bear harvest in the Upper Peninsula substantially. The kills in the September 1-15 seasons, first in Chippewa County in 1955 and Peninsula-wide in 1956 and 1957, are particularly significant. They demonstrate a definite interest in the hunting of bears as a sport separate from open seasons on deer and other game. It is to be hoped that heightened interest in the hunting of bears may raise their status as game animals to an extent that bear losses from nuisance control and accidents may be lessened.

<u>Losses from Bounty Trapping</u>. An important additional cause of mortality of bears in the Upper Peninsula is accidental capture of cubs and other small bears by bounty trappers of coyotes and bobcats. The extent of this loss is difficult to assess, but 14 cubs and 2 yearling bears were acquired from bounty traps within the study area during the summers of 1955-57 alone.

Bounty-trapping is intensive in the Upper Peninsula, and there is every reason to believe that substantial

numbers of bears are thus killed annually. Trappers are required by law to release captured bears, but obviously bears that are killed or die in traps are not advertised. Furthermore, it is customary for bounty traps to go unattended from one to two weeks at a time, and about half the trappers from whom captured bears were obtained did not attempt to release even cubs. Probably half the cubs captured by bounty trappers die in the traps.

Several methods of alleviating bounty-trapping losses are possible. Chief among these is stricter enforcement of laws requiring the release of trapped bears. It has been found, for example, that cubs injured by traps but otherwise healthy are self-sufficient when only five months old (Erickson, 1959). Required inspection of traps at least every five days would be a beneficial regulation, if enforceable, Also, limiting steel traps to sizes not larger than No. 3 (maximum jaw spread 5-1/2 inches) would materially reduce the number of bears captured and yet be adequate for all predators bountied in Michigan. At present, most Upper Peninsula trappers employ No. 4 traps and a few even No. 4-1/2 traps, but these sizes are unnecessary.

Undoubtedly, the above suggestions for limiting losses of bears would not meet with favor from the bounty trapper. The Michigan bounty system, however, is ostensibly maintained in order to encourage game increases, not decreases. From this standpoint, it seems hard to conceive of logical arguments in opposition to laws tending to protect the black bear.

Losses of Nuisance Bears. Presently, records of cause of death of both marked and unmarked nuisance bears reveal that unsanctioned shooting is a major factor in bear mortality. It is lamentable, but only 6 kills of 43 nuisance bears destroyed by citizens and investigated by the Cusino Station (autopsy file, unpublished) during this study were judged by Conservation Department personnel to have been justifiable. These few had caused property damage.

Although most persons who killed bears as nuisances justified their actions by declaring them a menace, two motives were suspected. The first was an expressed dislike of bears. Some persons killed as many as five in a single season, including cubs weighing as little as 14 pounds. A second motive was the desire to shoot a bear as a trophy. This was evidenced by the person's usual excitement and wish to keep trophies. Usually complainants baited bears by failing to dispose adequately of garbage and other refuse.

Regulations now require that out-of-season kills of bears doing damage be reported to conservation officers, and that their carcasses be salvaged or disposed of in a sanitary manner. These rules should be strictly enforced, and persons killing nuisance bears definitely should not be allowed to retain trophies.

With the bears' habitat increasingly invaded by new cabins and permanent dwellings, the potential exists for losing ever-increasing numbers of bears as nuisance mortalities. An educational and enforcement program designed to emphasize economic and sporting values and to minimize losses from nuisance causes is needed if maximum sport is to be realized from the Michigan bear resource.

Dumps as a Source of Nuisance Animals. There is limited evidence that dump bears are serving as a reservoir of potential nuisance animals. If their dependence on dumps could be discouraged, reduced nuisance mortality might result. That only 1 of 99 marked wild bears was recovered as a nuisance indicates that nuisance tendencies are less apt to develop in the truly wild population. As evidence of a circumstantial nature at least, a dumping ground near Marquette, Michigan, was regularly visited by about 10 bears. Shortly after its closure in July 1956, 17 camps and cabins within a four-mile radius were damaged by bears. At least 2 bears were shot as nuisances, 3 were steel-trapped and killed, 2 were removed by live-trapping, and 4 others were shot at but not recovered.

Since dumps may well serve as reservoirs of troublesome animals, remedial measures could be instituted, at least on an experimental basis. Garbage should be destroyed by burning or burying, and dumps should be located in areas unlikely to be frequented by bears. In localities where bears are causing property damage, evidence indicates that such difficulties may be lessened by the removal of bears from nearby dumps.

Undoubtedly, attempts to discourage dump-foraging by bears often would meet with public opposition, particularly in resort areas. In northern Michigan, many dumping sites have been chosen and maintained to attract bears. Dump bears in these areas are zealously valued as tourist attractions by business and resort groups, and

the countryside adjacent to dumps is frequently closed to hunting. The dubious value of displaying bears in the unsavory and unnatural situations provided by dumps, and the damage done by bears encouraged to seek kitchen refuse, must be weighed against the public returns from (1) reduced nuisance raids on the part of dump-trained bears, (2) increased opportunities for the hunting of wild bears, and (3) fewer but more thrilling tourist observations of genuinely wild bears.

Summary

The population dynamics and movements of tagged black bears were analyzed from a 5-year live-trapping study conducted at the Cusino Wildlife Experiment Station in the Upper Peninsula of Michigan, and during which 159 bears were handled 182 times. Forty-eight movement records were obtained from 42 bears, and 31 mortality observations were secured from 137 marked bears.

Bears were classified by age as cubs, yearlings and older animals, and by wildness as "wild", "dump" and "nuisance" bears. The sex and age composition of bears trapped in natural surroundings differed statistically from that determined for dump and nuisance bears.

The latter two categories were composed primarily of adult males. Culvert-traps were found to be selective of older and larger bears, particularly adult males. No. 4-1/2 steel-spring traps were selective of smaller and younger bears, including adult females.

A minimum population size of about 117 bears was estimated on a 400-square-mile study area as determined from marked-unmarked ratios. First-year recoveries of marked bears indicated a minimum annual mortality of 19 per cent. Minimum one-year mortalities of 26, 4, and 21 per cent, respectively, were indicated for cubs, yearlings, and combined older age classes. These mortality rates are not, however, statistically significant from one another. Returns of marked bears indicated greater mortality for females among older bears and especially for females with accompanying young. There were no statistically significant differences, however, between the rates of return by sex within any age class. First-year mortality rates for nuisance, dump and wild-trapped bears were 30, 25 and 16 per cent, respectively. These rates of return are not statistically significant from one another.

Legal hunting accounted for 84 per cent of the

known mortality among tagged bears. Of the legal kill, 65 per cent was taken during the traditional November 15-30 deer-bear hunting seasons. Special September 1-15 and October 1-November 5 bear hunting seasons accounted for 8 and 27 per cent, respectively, of tagged bears shot by hunters.

Mortality causes other than hunting also were identified for both marked and unmarked bears. Kills of nuisance animals and predator bounty-trapping were found to be important causes of death. Garbage dumps were identified as probable origin of troublesome bears. Remedial measures suggested for handling nuisance bear difficulties include reducing the attractiveness of dumps as foraging sites, and where reductions of nuisance bears are necessary the evidence indicates that difficulties may be lessened by removing bears from nearby dumps.

Methods advanced for relieving bounty-trapping losses include strict enforcement of laws relating to the release of accidentally-captured bears, required trap inspection at least every five days, and limiting size of steel traps for predator trapping to not larger than No. 3 (maximum jaw-spread 5-1/2 inches).

Normal movements of bears were found to be limited. Retrapped bears averaged movements of 2.8 miles for the summer. Fall recoveries showed a mean movement of 6.7 miles, possibly indicating some shifting of ranges at this season. The maximum recorded movement was 19.4 miles. Of 29 records, only 5 were in excess of 10 miles. Adult males were found to travel more widely than adult females; dispersal of young bears was limited. Assuming that home ranges are circular and that recovery distances represent normal cruising diameters, minimum summer and annual ranges are estimated as approximately 6 and 15 square miles, respectively.

Transplanted bears mostly re-established themselves in new areas, but two showed remarkable homing behavior. One returned 96 miles and another 64 miles to near point of capture. Movement data for black bears indicate that management areas need not be extensive. Apparently it is feasible to reintroduce black bears to depleted habitats, and in Michigan at least, troublesome individuals usually can be moved with small likelihood of return.

THE AGE OF SELF-SUFFICIENCY IN THE BLACK BEAR

The age at which young game animals become self-sufficient is little known. Yet this can be important in game management. A hunting season which permits killing the mother before the young become self-reliant necessarily results in the loss of her young as well. Transplanting young animals may be more practical than moving adults, providing the young are self-sufficient. For example, it may be quite easy to capture the young of species difficult to trap or handle as adults. Also it may be desirable to transplant animals exhibiting strong homing tendencies before this characteristic expresses itself. Several of these considerations are important in management of the black bear in northern Michigan.

This paper reports experiments to determine whether black bear cubs 5 to 8 months old can survive by themselves in Michigan's Upper Peninsula when released from the steel traps of predator trappers or when orphaned by hunters. Many dams apparently abandon trapped cubs (Erickson, 1957); and Michigan's early bearhunting season, traditionally open September 1, is responsible

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for some orphanned cubs.

Methods

To determine whether cubs deprived of their mothers could survive, certain cubs (experimental animals) were released far enough from their point of capture to insure that they would not find their mothers. Others (controls) were released at the point of capture, presumably to return to their mothers. The proportion of these cubs recovered subsequently (by hunters and my own live-trapping) indicated the comparative survival. Recoveries two weeks or longer after release were considered adequate evidence of self-sufficiency. As a further test cubs were released on "bearless" islands in Lake Michigan where survival over winter was considered proof of self-sufficiency.

In the summers of 1955-57, 23 experimental cubs were released in Michigan's Upper Peninsula--20 (12 males, 8 females) on the mainland in Alger and Schoolcraft counties, in moderately good to excellent bear range, and 3 (2 males, 1 female) on Poverty and Big Summer Islands in Delta County. In the summers of 1956-57, 12 control cubs (8 males, 4 females) were

released on the mainland. Nine of the experimental animals were obtained from coyote bounty trappers, 3 from persons illegally holding captives, and 11 were live-trapped. Eleven of the control cubs were live-trapped for the study and the other was captured by accident in a coyote set.

In order to prevent experimental cubs from rejoining their mothers, they were released in areas remote (up to 175 miles) from their points of capture. My previous experience with the movements of live-trapped bears indicated that even the two cubs released nearest to point of capture (about 4 miles) were not likely to rejoin their mothers. Actually the mothers of five were dead. Control cubs were released where captured. In 10 cases the mother was seen to accompany the cubs. Fresh sign indicated that the mother was also present at the other two releases. Metal ear tags marked both control and experimental animals.

Extreme dates of release of the experimental cubs were July 6 and September 29; of controls, June 21 and September 22. If we assume that the released cubs were born about February 1 (Seton, 1929; Aldous, 1937; Burt

1948; Matson, 1954), their ages ranged between 5 and 8 months at time of release. My only two records for parturition are for the last week of January and February 14. I believe that the assigned ages (Tables 13 and 14) are accurate to about two weeks.

At the time of release, the cubs varied markedly in size and physical condition. Weights of the 23 experimental cubs ranged from 18 to 81 pounds (average 31); the 12 control cubs, from 18 to 44 pounds (average 27). The weight difference between experimental and control animals was due, for the most part, to my holding seven test cubs briefly as captives before release. Since captives were provided with ample food, they made substantial weight gains. One retained for 3 months increased from 12 to 81 pounds. Exclusive of captives, 16 test cubs averaged 27 pounds, or the same as the controls.

Physical injuries to cubs in the study were frequent. Five experimental animals suffered foot amputations; two had foot lacerations and one a broken jaw (fractured mandibular suture). The controls included five with lacerated feet and two with broken

TABLE 13. Releases and recoveries of 20 bear cubs released alone[1]

Estimated age (months)	Sex	Weight at release (pounds)	Date of release	Time lapse until recovery (days)	Manner recovered	Distance Transferred (miles)	Remarks
5-1/2	F	25	7-15-57	88	Shot	17	Lacerated foot; orphan; held 6 days.
6	M	39	7-20-57			49	Amputated foot; held 19 days.
6	F	27	7-21-57			19	Orphan
6	F	21	7-23-56	117	Shot	15	Lacerated foot
6	F	20	7-30-57			176	Amputated foot
6	M	39	8- 5-56			4	
6	M	25	8- 6-56	102	Shot	14	
6	M	29	8- 9-56			119	Amputated foot; held 61 days.
6-1/2	M	25	8-15-56			4	Fractured mandibular suture; held 15 days.
6-1/2	F	26	8-18-55			36	
7	F	19	8-22-57			15	Orphan
7	M	18	8-22-57			15	Orphan
7	M	20	8-22-57			15	Orphan
7	M	18	8-23-57	47	Shot	165	Amputated hind foot
7	M	38	8-26-57			12	
7	M	35	8-30-57	17	Live-trap	38	
7	M	26	9- 6-56			8	
7-1/2	M	81	9-19-55	391	Shot	100	Amputated foot; held 3 months.
8	F	34	9-20-56			58	
8	F	45	9-29-56	54	Shot	35	

[1]Three cubs released on islands not included.

TABLE 14. Releases and recoveries of 12 bear cubs released with their dams.

Estimated age (months)	Sex	Weight at Release (pounds)	Date of Release	Time Lapse until Recovery (days)	Manner Recovered	Remarks
5-1/2	M	18	6-21-57			
5-1/2	M	18	6-21-57			
6	M	22	7-26-56			Lacerated foot; retrapped 8-8-56 but not considered in this analysis.
6	F	25	7-26-56			
6	M	25	8- 9-57			Lacerated foot
6	F	24	8-10-56			Lacerated foot
6-1/2	M	27	8-13-57			Lacerated foot
6-1/2	M	22	8-14-56	95	Shot	
6-1/2	M	26	8-14-56	95	Shot	
6-1/2	M	29	8-17-56	348	Retrapped	Lacerated foot
7	F	38	8-27-56	82	Shot	Broken radius and ulna; fracture mended when recovered.
7-1/2	F	44	9-22-57			Fractured leg

legs. Steel traps inflicted the foot and leg injuries. The foot amputations were necessitated by complications, arising from minor injuries, resulting from infrequent inspection of traplines by bounty trappers. In my own experience, steel trapping is not unduly injurious if one inspects his traps often. The jaw fracture apparently occurred when the cub struggled to free itself from the trap.

Mainland Releases

About one-third of the cubs were recovered, whether released on their own or in company with their dams. Of 20 experimental cubs released on their own in Alger and Schoolcraft counties, 7 were recovered, 6 during the fall following release and 1 the second fall after its release (Table 13). The proportion of returns from control cubs released with their mothers nearby (4 of 12) was quite similar (Table 14). Three of these cubs were recovered the fall after release, and one the next summer. Recovery intervals ranged from 17 to 391 days following release, and averaged 116 days for test animals and 155 days for controls.

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The fact that over a third of the test cubs were recovered is significant evidence that they survived and were self-sufficient to a considerable degree. Their recovery at about the same rate as the controls indicates that cubs of this age may survive by themselves as well as cubs accompanied by their mothers. Even the youngest and smallest cubs managed to survive. Three test cubs recovered were among the youngest released (Table 13). One cub weighed only 18 pounds when released, yet weighed 35 pounds when recovered 6 weeks later. Cubs of either sex appeared equally self-reliant (Tables 13 and 14). Returns were obtained from 3 of 8 female test cubs, as compared to 4 of 12 males. Both males and females occurred among recoveries of even the youngest cubs.

A significant finding was that physically-handicapped cubs survived almost as well as cubs in good physical condition (Tables 13 and 14). Among test animals, there were recoveries for 4 of 8 injured cubs as against 3 of 12 uninjured. Among the controls, two recoveries each resulted from seven injured and five uninjured cubs, respectively.

Test cubs also were able to adjust to unfamiliar

environments. All had been removed from the area of their capture. Recoveries resulted from 4 of 9 which were transferred 35 to 176 miles (average 75), and from 3 of 11 transferred only 4 to 19 miles (average 13).

Thus it appears that black bear cubs of either sex may be self-sufficient when as young as 5-1/2 months and as small as 18 pounds even though almost incapacitated by physical injury and released in unfamiliar range.

Island Releases

The Islands. Poverty Island, five miles offshore, is about 320 acres in area and has poor soils and numerous rocky outcrops and bluffs. Its fauna is sparse but includes several mice and the snowshoe hare (*Lepus americanus*). Deer (*Odocoileus virginianus*) are absent. The flora probably is representative of the poor soil portions of the Upper Peninsula mainland before widespread, intensive browsing by deer. Vegetation is predominantly white cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*), with striped maple (*Acer pensylvanicum*) and a dense stand of American yew

(Taxus canadensis) in the understory.

Big Summer Island, 2 miles offshore and about 3 square miles in size, in places has fairly good soil. There are fewer rock outcrops and no high shoreline bluffs. Few mammals occur on the island but deer are present. Unlike Poverty Island, it has little ground cover. Deer have eliminated the yew, severely browsed many deciduous plants, and in many areas killed even balsam fir. The dominant forest is white cedar and balsam fir, except for white birch (Betula papyrifera) and sugar maple (Acer saccharum), and some beech (Fagus grandifolia), quaking aspen (Populus tremuloides), and yellow birch (Betula lutea) in the center of the island.

On both islands important fruit-producing plants such as strawberries (Fragaria sp.), raspberries (Rubus sp.), juneberry (Amelanchier sp.), and pin and black cherries (Prunus pensylvanica and P. serotina), utilized heavily by bears on the mainland, are scarce and of poor quality. Because of this, I felt some apprehension over the suitability of the islands for the tests.

The Releases. We released 3 cubs, a 33-pound male about 5-1/4 months old on July 6, 1956, on Poverty Island, and a male and female, each 32 pounds and about 6-1/2 months old, on August 25, 1956, on Big Summer Island. Shortly thereafter a coyote trapper removed the male of the latter release to the mainland.

In early July, 1957, I revisited the islands and found ample recent sign of both cubs. On July 15, the cub on Poverty Island had to be shot because it was molesting a U. S. Coast Guard dwelling. At that time, it weighed 74 pounds and was in excellent condition.

It is possible that the Poverty Island bear obtained some food from refuse discarded by three guardsmen stationed there part of the year. This could not have been much, and I believe that the guardsmen complied with our request not to feed the animal. There was no human habitation of Big Summer Island. A possible food source on both islands may have been fish and other refuse washed onto the shores, but I saw none at the times of my visits. Numerous gulls frequenting the shores would certainly compete for such food.

The successful establishment of cubs on these islands provides further evidence that cub bears 5-1/2 months of age and older, irrespective of sex, are self-sufficient. A further point of significance is that we had raised both cubs in captivity. They had survived in a habitat judged inferior because of the limited availability of foods commonly considered staples for bears, and despite a lack of previous experience in foraging for food.

Summary

The self-sufficiency of 23 cub bears ranging from 5-1/4 to 8 months of age was tested in the Upper Peninsula of Michigan. On the mainland, 20 test cubs were released at points remote from their mothers and 12 control cubs were released with their mothers. Three test cubs were released on Lake Michigan islands devoid of bears.

One third of the cubs released on the mainland were recovered and two cubs released on islands survived the winter. Cubs released alone survived as well as cubs released with their dams. Both sexes survived equally well, and several cubs survived alone despite serious injuries. Black bear cubs of either

sex may be self-sufficient when as young as 5-1/2 months and as small as 18 pounds, even though handicapped by physical injury and released on unfamiliar range.

AN ANALYSIS OF BLACK BEAR KILL STATISTICS FOR MICHIGAN

Although the black bear is an important big game animal in many parts of North America, only scant data are available on the composition of harvests for the species. A dearth of data exists also on the evaluation of factors influencing bear harvests. This paper reports on research to determine (1) population characteristics of bears in Michigan, (2) factors affecting the hunting harvest, and (3) improved management procedures for the species.

Methods and Procedure

Kill data were studied for the 1955, 1956, and 1957 seasons, with limited information for 1954. Each year, one bear per hunter was permitted on either the small or big game hunting license. Hunting seasons were the traditional statewide November 15-30 deer and bear season; and special bear seasons October 1 - November 5, statewide, and September 1-15 in the Upper Peninsula. These seasons are hereafter referred to as November, October, and September seasons, respectively.

Bears could be hunted with dogs only during the special seasons.

Data for the analysis were obtained by personal interviews and mail surveys of hunters known to have killed bears. Personal interviews were made principally at roadside game-checking stations. Names and addresses of hunters to be contacted by mail questionnaires were obtained from taxidermists, game biologists and conservation officers, other Department of Conservation mail surveys, newspaper articles, and from other bear hunters (Table 15).

TABLE 15. Sources of the names of hunters killing bears in Michigan, 1954-57[a]

Source of contact	Number of bear kills reported
Taxidermists	773
Department of Conservation biologists and Conservation Officers	357
Checking stations and other field contacts	212
Supplied on returned questionnaires	175
Conservation Department sampling surveys	74
Newspapers	34
Total	1,625

[a] Some bears were reported through more than one source.

Information on the kills of 1,129 bears was reported: 73 in 1954; 260 in 1955; 418 in 1956; and 378 in 1957. Kills reported in 1955, 1956 and 1957 were believed to be representative of the annual bear kills for those years. Together they comprised 32 percent of the estimated total kill for that period (Table 16).

The information gained from hunters included the sexes and sizes of bears taken; where, when, and how kills were made; and certain factors influencing the taking of the animals. Questionnaires were alike each year except that in 1957 I asked for additional information on the hunting of bears by archers and with dogs.

In analyzing questionnaire returns it was assumed, except as otherwise tested, that hunters accurately answered the questions put to them. It was further assumed that hunters were able to identify their bears as (a) an adult female or cub of a family group, or (b) a bear other than a family group member. A review of the weights and sexes in reports of multiple kills indicated that this assumption was generally met. It was assumed further that all family groups were

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TABLE 16. Proportion of Michigan bear kill reported by questionnaires[a]

	Number of kills reported in questionnaires			Estimated total kill			Percentage of statewide kill reported by questionnaires
	Sept. 1-15 and Oct. 1-Nov. 5 seasons	Nov. 15-30 season	All seasons	Sept. 1-15 and Oct. 1-Nov. 5 seasons[b]	Nov. 15-30 season[c]	All seasons	
1955	85	175	260	301	620	921	28
1956	110	298	408	299	810	1,109	37
1957	115	260	375	363	820	1,183	32
Total	310	733	1,043[d]	963	2,250	3,213	32

(a) Sent to known successful bear hunters.

(b) Computed from questionnaire data by noting relation between Sept. and Oct. kill, and Nov. kill; e.g., in 1955, $\frac{85}{175} = \frac{X}{620}$; X = 301.

(c) From Table 17.

(d) Excluding 8 kills not identified as to season.

composed of mothers and cubs of the year, since (a) during extensive live-trapping of bears in Michigan (Erickson, 1957) all cubs captured in family groups were cubs of the year; (b) all yearlings captured, insofar as was known were not accompanied by adult females; and (c) my examinations of bears killed in the fall revealed no yearlings in the company of adult females.

Estimates of the Annual Bear Kill

These surveys were not intended to provide estimates of total kills for the entire state. However, estimates of the statewide annual bear kills during the traditional November deer and bear season have been made by the Michigan Department of Conservation since 1936 (Table 17). These estimates indicated annual kills as low as 563 and as high as 1,739 bears. Estimates prior to 1953 were voluntary hunter reports on postcards provided with hunting licenses. Those since 1953 were from a 2.5 percent (except 5 percent in 1957) sampling survey of licensed big game hunters in conjunction with assessment of the white-tailed deer kill.

These estimates of the bear kill may have varied somewhat from the true kill. The earlier

estimates, obtained by voluntary hunter reports, were likely inflated, as was true of estimates of the deer kill for the same period. Hayne and Eberhardt (1954) found a bias, in that successful deer hunters were more likely to report than unsuccessful hunters, resulting in inflated kill estimates. The recent estimates of the bear kill, based on standard sampling procedures, are without major bias, but show wide confidence limits because of the small proportion of big-game hunters who kill bears.

Trends of the bear kill in the Upper Peninsula during November seasons have been reflected also in the official counts of bears (Michigan Highway Department; Mackinac Bridge Authority) transported by hunters from the Upper to the Lower Peninsula via the Straits of Mackinac (Table 17). These data complement Conservation Department kill estimates for the Upper Peninsula (Figure 94) and suggest that Strait's data may provide an early, fairly reliable, post-season estimate of the kill, or at least the trend of the kill, for this region. For the 22 years for which these data are available, the Strait's counts have averaged 35 percent of the estimated annual November bear kill in the estimates, obtained [illegible]

likely inflated, [illegible]

kill for the same [illegible]

found a bias, [illegible]

more likely [illegible]

resulting in [illegible]

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procedures, [illegible]

confidence [illegible]

big-game hunt[illegible]

Trends [illegible]

during November [illegible]

the official [illegible] ([illegible]

Mackinac Bridge [illegible]

the Upper to the Lower [illegible]

Mackinac (Table [illegible]). [illegible]

Department kill [illegible]

(Figure 94) and [illegible]

an early, fairly [illegible]

the kill, or at least the trend of the [illegible], [illegible]

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available, the Straits's counts have averaged 35 percent

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TABLE 17. Michigan bear kill and hunter statistics

for November 15-30 seasons

Year	Kill estimates(a) Upper Peninsula	Kill estimates(a) Lower Peninsula	Kill estimates(a) Entire State	95 percent confidence limits	Bears tallied at Straits of Mackinac(b)	Hunters(c)
1936	306	320	626	-	69	136,930
1937	248	315	563	-	198	158,720
1938	270	328	598	-	56	163,950
1939	336	292	628	-	157	170,885
1940	556	233	789	-	243	177,770
1941	419	366	785	-	127	229,169
1942	354	303	657	-	200	217,715
1943	346	385	731	-	85	219,494
1944	608	410	1,018	-	229	229,210
1945	546	470	1,016	-	177	268,809
1946	953	697	1,650	-	314	349,918
1947	900	839	1,739	-	224	369,730
1948	988	562	1,550	-	277	381,158
1949	382	334	716	-	131	382,289
1950	815	364	1,179	-	281	385,266
1951	749	361	1,110	-	216	386,400
1952	840	317	1,157	-	406	455,900
1953	990	220	1,210	750-1,680	335	447,800
1954	690	500	1,190	740-1,650	200	417,090
1955	310	310	620	290- 950	165	421,510
1956	490	320	810	430-1,200	210	428,870
1957	620	200	820	550-1,100	157	419,325

(a) Compiled by the Game Division, Michigan Department of Conservation; based on voluntary hunter reports through 1952, and on a 2.5 percent mail sampling survey of licensed big game hunters since 1953 (5 percent in 1957).

(b) A tally of bears transported from the Upper Peninsula to the Lower Peninsula via the Straits of Mackinac and compiled by the Game Division, Michigan Department of Conservation; counts 1936-56 by Michigan Highway Department and 1957 by Mackinac Bridge Authority.

(c) Big game license sales (November seasons).

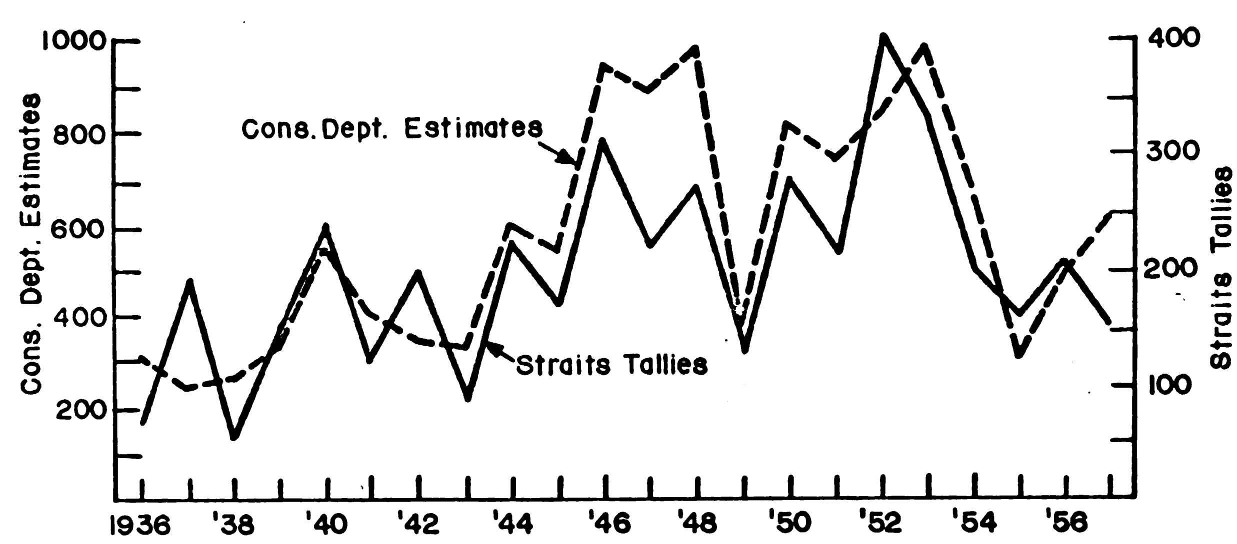


Figure 94. Estimated kill of bears in the Upper Peninsula and the number of bears tallied at the Straits of Mackinac.

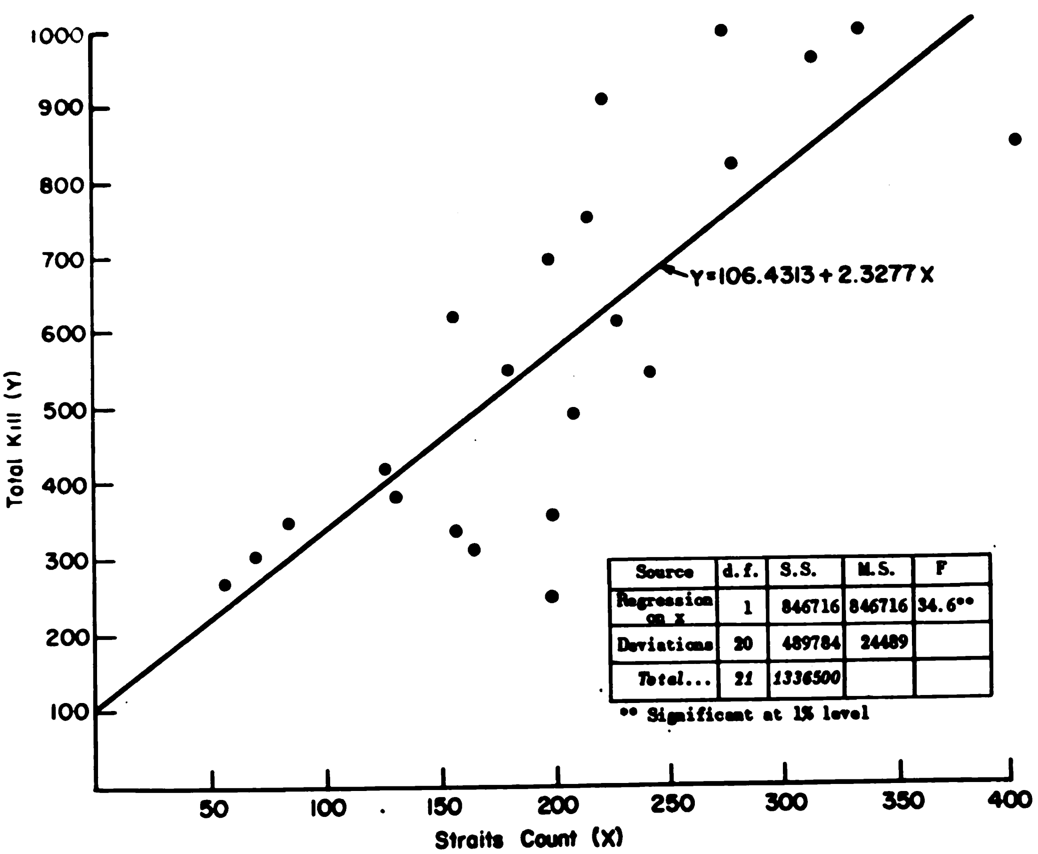
Upper Peninsula. Figure 95 shows this relationship, assumed to be linear, and the regression equation provides a means for predicting the size of future harvests.

As Figure 94 shows, kills of bears in Michigan's November seasons have fluctuated markedly. These variations can be attributed only in part to differing hunting pressures, which have shown a gradual increase over the years (Table 17). Weather is an important factor affecting the success of bear hunting during November seasons and probably was responsible for the wide fluctuations in take at that time (see beyond).

These data roughly portray trend indices of the annual kills of bears in Michigan. However, they are not reliable estimates of total hunting harvests, since special seasons and hunting regulations, except for the November season, have varied markedly from year to year (Stuewer, 1957).

Time of the Bear Kill

Kills by Season. Of 1,043 bear kills reported in 1955, 1956 and 1957, 70 percent were made in November seasons, while special October and September seasons contributed 18 and 12 percent, respectively



Source	d.f.	S.S.	M.S.	F
Regression on X	1	846716	846716	34.6**
Deviations	20	489784	24489	
Total...	21	1336500		

** Significant at 1% level

Figure 95. Regression line showing relation of the Upper Peninsula bear kill to the number of bears tallied at the Straits of Mackinac.

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(Table 18). Kill proportions for these seasons compare favorably with kills of marked bears during the same period by hunters (Erickson and Petrides, 1964).

While there were irregularities, there is little doubt that in these years November seasons contributed most to the hunter-take of bears in Michigan. This season in the Upper Peninsula alone accounted for over half of the statewide kill for each year of the survey. There is indication, however, that special seasons are beginning to gain favor with sportsmen, and that the take of bears in such seasons are apt to increase. This appears especially probable for the September season which since its inception has shown an increase in hunter interest (Table 18).

The proportion of bears taken in October seasons showed considerable annual variation in both the Upper and the Lower Peninsulas. Explanation for these irregularities is wanting and perhaps due to sampling in light of the limited kills for this season. Statewide kills for the October season have, however, remained quite similar. This suggests that hunters may have distributed their hunting efforts differently between the Upper and Lower Peninsulas in different years. The substantial

TABLE 18. Seasonal distribution of the bear kill in Michigan, 1955-57[a]

			Upper Peninsula			Lower Peninsula			Entire state	
Hunting season	Area-	Year	No. of kills reported	Percentage of Upper Peninsula kill	Percentage of state kill	No. of kills reported	Percentage of Lower Peninsula kill	Percentage of state kill	No. of kills reported	Percentage of total kill
Sept. 1-15[b]	Chippewa County	1955	20	12	8				20	8
	Upper Pen.	1956	44	15	11		No season		44	11
	Upper Pen.	1957	56	21	15				56	15
	Total		120	16	12				120	12
Oct. 1-Nov. 5	Entire state	1955	24	14	9	41	48	16	65	25
	"	1956	47	16	12	19	17	5	66	16
	"	1957	15	6	4	44	40	12	59	16
	Total		86	12	8	104	34	10	190	18
Nov. 15-30	Entire state	1955	130	75	50	45	52	17	175	67
	"	1956	208	70	51	90	83	22	298	73
	"	1957	192	73	51	68	61	18	260	69
	Total		530	72	51	203	66	19	733	70
All seasons			736	100	71	307	100	29	1,043[c]	100

(a) From a survey of known successful hunters.
(b) Chippewa County only in 1955.
(c) Excluding 5 Upper Peninsula and 3 Lower Peninsula kills not identified as to season.

importance of the October take of bears in the Lower Peninsula (34 percent of annual kill) was also in marked contrast to its seeming slight importance (only 12 percent) in the Upper Peninsula (Table 18).

To a large degree kills of bears in special seasons appeared due to the use of dogs. This form of hunting was initiated in Michigan in 1953 when the Department of Conservation sanctioned experimental hunts of this type. These were participated in by several hundred sportsmen, and regulations for special seasons have permitted the use of dogs for hunting bears since 1954. The growth of this form of hunting has been thwarted, however, by a scarcity of trained dog packs. Despite this limitation, it is significant that in 1957 a third of reported kills in the September season and half of the kills in the October season were made by this mode of hunting (Table 19). The proportion of bears reported taken with dogs during special seasons may have been exaggerated, however, due to our possibly more frequent contacts with hunters using dogs. The heavy take of bears in the October season in the Lower Peninsula is believed also to be attributable to accentuated interest there in the sport of hunting bears with dogs. In 1957, all but

2 of 31 reports of bears killed with dogs during this season were in the Lower Peninsula.

Archery hunting also contributed to the sport-take of Michigan bears (Table 19). With one exception, archers killed their bears only during the September and October special seasons. In all likelihood most of these kills were made incidental to archery hunting for deer.

Daily Kill Chronologies. The daily chronologies of kill, as constructed from hunters' reports, showed that heavy early season kills typified September and November seasons, in contrast to slower and more continuous harvests in October seasons (Figure 96).

In the September seasons (Upper Peninsula only), 23 percent of the kills occurred on opening day, and 49 percent in only 3 days of hunting. In the Lower Peninsula, kills in October seasons were essentially uniform throughout the 36-day season--25 percent in 7 days, and 50 percent by the 16th day. In the Upper Peninsula, kills in October seasons rose more sharply early in the season--24 percent in 3 days, and 50 percent by the 9th day.

TABLE 19. Special information regarding 1957 Michigan bear hunting[a]

Hunting season	No. of bears reported killed	Bears killed by hunters using dogs: Number, Upper Peninsula	Lower Peninsula	Entire state	Percentage of total reports	Bears killed by archers: Number, Upper Peninsula	Lower Peninsula	Entire state	Percentage of total reports
Sept. 1-15	56	18	(b)	18	32	3	0	3	5
Oct. 1-Nov. 5	59	2	29	31	52	3	1	4	7
Nov. 15-30	260	(b)	(b)	(b)	(b)	1	0	1	0
Total	375	20	29	49	43	7	1	8	2

(a) From special survey of known successful hunters.

(b) Hunting bears with dogs not permitted.

100
SEPTEMBER 1-15
100
Upper Peninsula 559 Kills

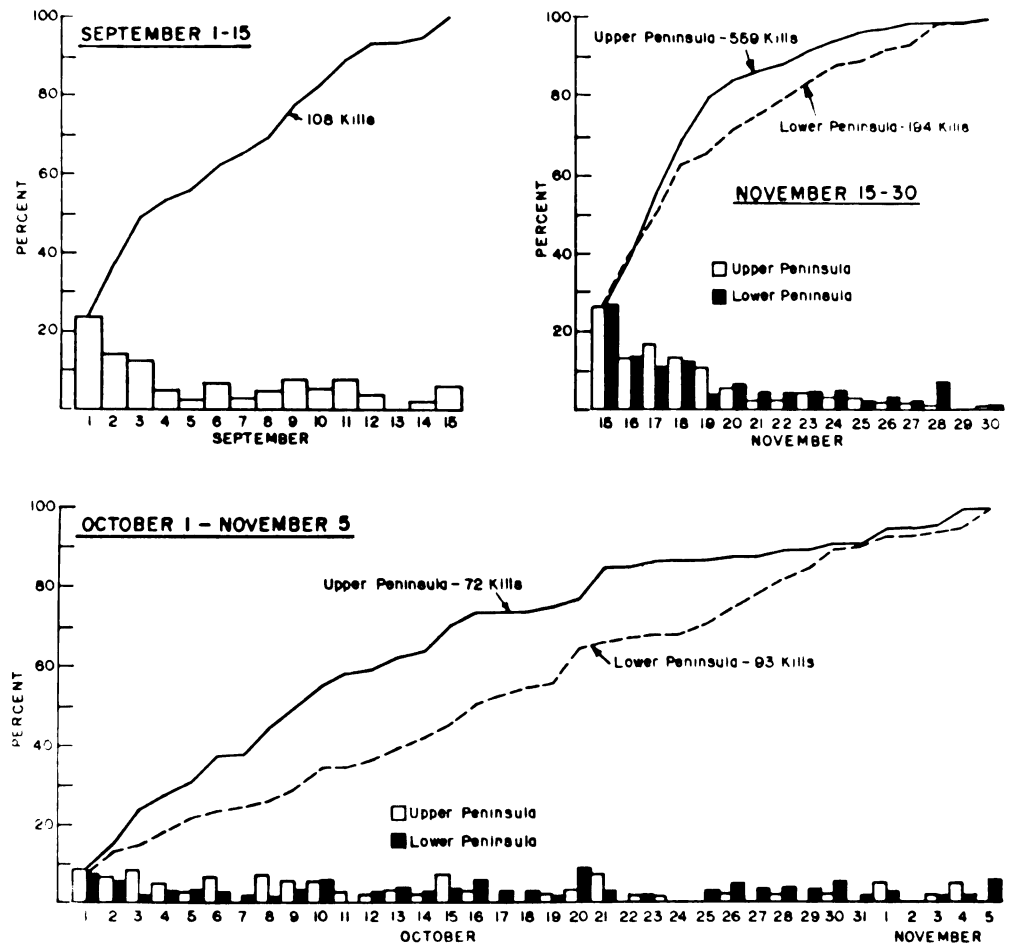

Figure 96. Daily and cumulative kill of bears in several seasons, 1955-57.

The chronologies of kill in the November seasons were similar in both the Upper and the Lower Peninsula. In both areas, 26 percent of the reported kill occurred on opening days, and over 50 percent in 3 days of hunting. Thereafter kills continued high until the 4th day in the Lower Peninsula and until the 5th day in the Upper Peninsula, by which time 62 and 80 percent of total kills, respectively, were attained.

Seasonal kill chronologies most likely paralleled the distribution of hunting effort since most hunting pressures in northern areas resulted from influxes of downstate hunters (see beyond). The heavy early-season takes during September and November seasons reflect heavy hunting pressures at these times. The relative uniformity of the take throughout the October seasons apparently resulted because the kill was effected largely by local hunters (see beyond), who presumably distributed their hunting efforts over the entire season.

Geographical Distribution of the Bear Kill

Regional Kill Distribution. In the years 1954-57 taken together, the Upper Peninsula bear kill comprised 72 percent of all reports and the Northern Lower Peninsula kill, 28 percent (Figure 97A; Table 20). These proportions remained consistent each year, with a maximum annual variation of only 6 percent.

In the Upper Peninsula bears were taken in every county (Figure 97; Table 21). The take reported for individual counties was highly variable, ranging from a low of 10 in Menominee county to a high of 116 in Chippewa county. Kill reports for 1955, 1956 and 1957 adjusted to estimates of total kill (Table 21) showed heaviest kill in Alger county where one bear was taken annually for each 11 square miles. Kill densities for Luce, Chippewa, Schoolcraft, Keweenaw, Mackinac and Delta counties also approach this figure. The sparsest kill was in Menominee county where the mean annual kill density was one bear per 105 square miles. The average kill density for the entire Upper Peninsula was one bear per 21 square miles.

In the Lower Peninsula most bear kills occurred in the northeastern fringe of the peninsula (Figure 97; Table 22). The lakeside counties of Presque Isle, Alcona, Alpena, and Cheboygan accounted for 60 percent of the total take. Kill reports adjusted to estimates

TABLE 20. Relative importance of Upper and Lower Peninsulas in Michigan bear kill, 1954-57[(a)]

	No. of kills reported statewide	Upper Peninsula		Lower Peninsula	
		No. of kills reported	Percentage of state kill	No. of kills reported	Percentage of state kill
1954[(b)]	73	64	(b)	9	(b)
1955	260	174	67	86	33
1956	416[(c)]	304	73	112	27
1957	375[(c)]	263	70	112	30
Total	1,124[(c)]	805	72	319	28

(a) From a survey of known successful hunters.

(b) Limited data obtained primarily from checking stations; distribution between Peninsulas not valid.

(c) Excludes two 1956 and three 1957 kills not identified as to Peninsula.

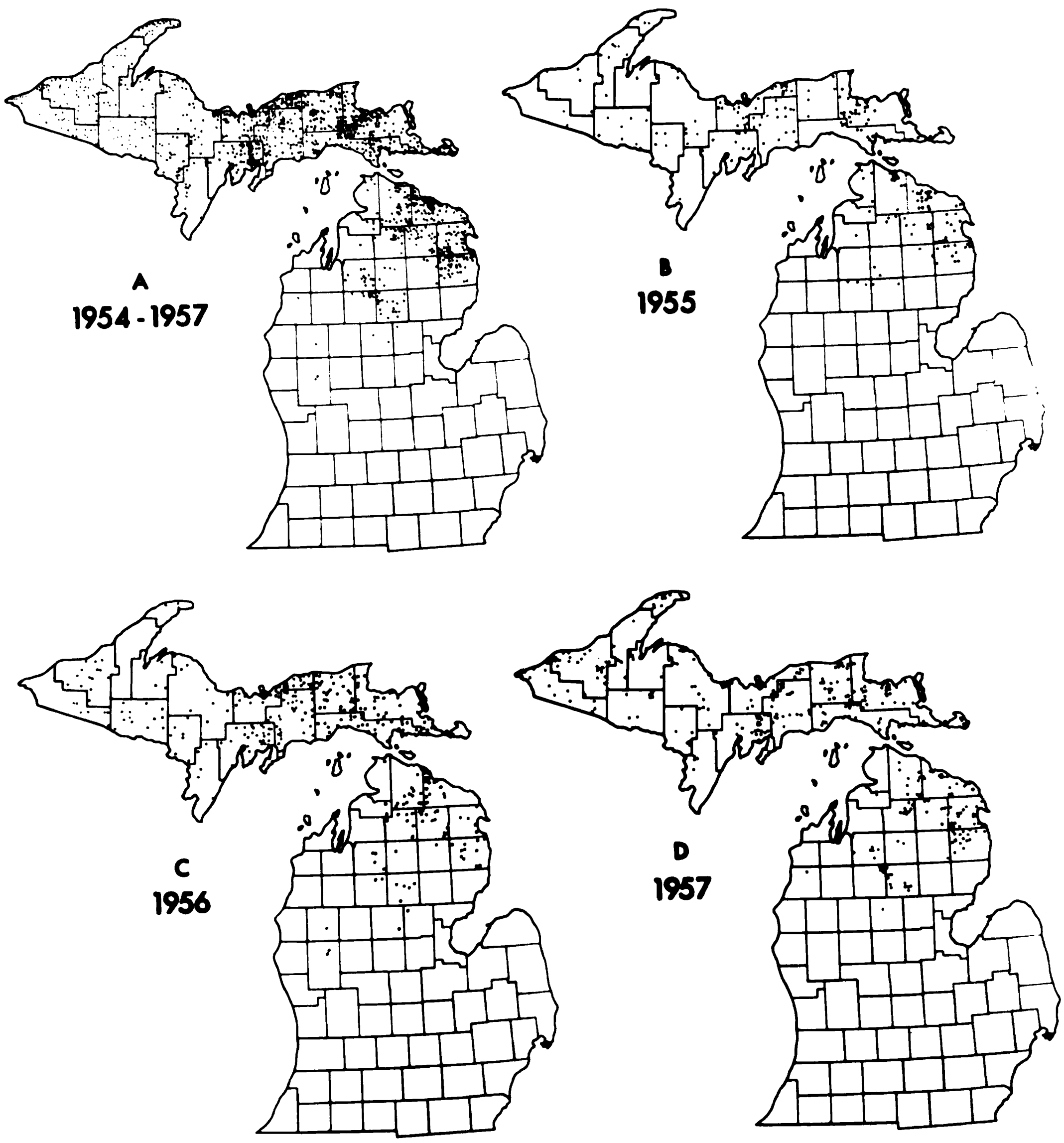

Figure 97. Bear kill distribution by years, 1954-57.

of total kill (Table 22) showed annual kill densities ranging from one bear per 10 square miles in Presque Isle county to one per 571 square miles in Lake county. The mean annual kill density for the 19 counties from which bears were reported taken in the Lower Peninsula was one bear per 34 square miles.

It is interesting to note that maximum kill densities were alike in both Upper and Lower Peninsulas. Kills for the two regions are not directly comparable, however, since the Lower Peninsula did not have September seasons, was subjected to heavier hunting pressures (Tables 21 and 22), and is more accessible by roads than the Upper Peninsula.

Seasonal Kill Distribution. Patterns of kill over the state differed notably in the several hunting seasons (Figure 98; Tables 23 and 24). During September seasons kills of bears in the Upper Peninsula ranged from heavy to light from east to west. The three most easterly counties, Chippewa, Luce and Mackinac, accounted for over half of the reported kill. Aside from an actual greater abundance of bears there, the heavy take of bears in the most easterly counties was likely caused by (1) the ready accessibility of this portion of the

TABLE 21. Bear kill and hunting pressure in Upper Peninsula counties, 1955-57

					Calculated annual means				
	Area in	Reported kill (a)							
County	sq. miles	1955	1956	1957	Kill (b)	Hunters per sq. mi. (c)	Kill per 100 sq. mi.	Hunters per kill (c)	Sq. mi. per kill
Alger	922	32	34	15	84	8	9	88	11
Baraga	912	2	3	6	12	5	1	380	76
Chippewa	1,562	35	41	40	121	8	8	103	13
Delta	1,170	13	32	27	75	7	6	109	16
Dickinson	769	5	9	6	22	7	3	245	35
Gogebic	1,113	3	10	21	35	6	3	191	32
Houghton	1,012	8	1	9	19	5	2	266	53
Iron	1,188	9	16	8	34	6	3	210	35
Keweenaw	335	3	4	16	24	5	7	70	14
Luce	910	9	41	23	76	8	8	96	12
Mackinac	1,016	14	34	18	69	8	7	118	15
Marquette	1,848	12	13	22	49	7	3	264	38
Menominee	1,047	1	5	4	10	7	1	733	105
Ontonogan	1,320	4	18	26	50	6	4	158	26
School-craft	1,185	24	43	22	93	8	8	102	13
	16,309	174	304	263	772	7	5	148	21

(a) From a survey of known successful hunters.

(b) Reported kills adjusted to estimated total kill for each year and averaged (Table 16).

(c) Determined from Michigan Department of Conservation mail surveys of big game hunters in November seasons.

TABLE 22. Bear kill and hunting pressure in Lower Peninsula counties, 1955-57

County	Area (sq. mi.)	Reported kill[a] 1955	Reported kill[a] 1956	Reported kill[a] 1957	Calculated annual means: Kill[b]	Hunters per sq. mi.[c]	Kill per 100 sq. mi.	Hunters per kill[c]	Sq. mi. per kill
Alcona	680	14	15	16	47	24	7	347	14
Alpena	580	13	5	22	42	23	7	318	14
Antrim	477	1			1	11	(d)	5,247	477
Charlevoix	416	5	3	1	9	11	2	508	46
Cheboygan	723	8	19	11	40	15	6	271	18
Clare	570		1	1	2	29	(d)	8,265	285
Crawford	562	2	1	2	5	24	1	2,697	112
Emmet	470	4	1		5	11	1	1,034	94
Gladwin	517		1		1	29	(d)	14,993	517
Kalkaska	562	1	9	7	18	24	3	749	31
Lake	571		1		1	23	(d)	13,133	571
Manistee	547			1	1	16	(d)	8,752	547
Missaukee	568	3	2	5	10	16	2	909	57
Montmorency	556	6	17	5	29	23	5	441	19
Newaygo	848		2		2	11	(d)	466	424
Oscoda	570	2	3	1	6	25	1	2,375	95
Otsego	522	3	6	9	19	23	4	632	27
Presque Isle	670	22	20	21	66	15	10	152	10
Roscommon	529	2	6	10	19	34	4	947	28
	10,938	86	112	112	323	20	3	677	34

(a) From a survey of known successful hunters.
(b) Reported kills adjusted to estimated total kill for each year and averaged (Table 16).
(c) Determined from Michigan Department of Conservation mail surveys of big game hunters in November seasons.
(d) Less than 0.5 bears killed per 100 sq. mi.

TABLE 23. **Seasonal variation in bear kill in Upper Peninsula counties, 1954-57**[a]

County	Number of kills reported: Sept. 1-15 season	Oct. 1-Nov. 5 season	Nov. 15-30 season	Season undetermined	All seasons
Alger	8	10	68	4	90
Baraga	1	3	9	0	13
Chippewa	43	9	69	2	123
Delta	9	11	54	1	75
Dickinson	0	2	20	4	26
Gogebic	4	8	22	1	35
Houghton	0	3	16	1	20
Iron	2	6	26	1	35
Keweenaw	5	1	18	2	26
Luce	18	3	58	0	79
Mackinac	14	9	48	0	71
Marquette	7	2	40	1	50
Menominee	1	2	7	0	10
Ontonogan	5	8	38	2	53
Schoolcraft	6	11	81	1	99
Totals	123	88	574	20	805

(a) From survey of known successful hunters.

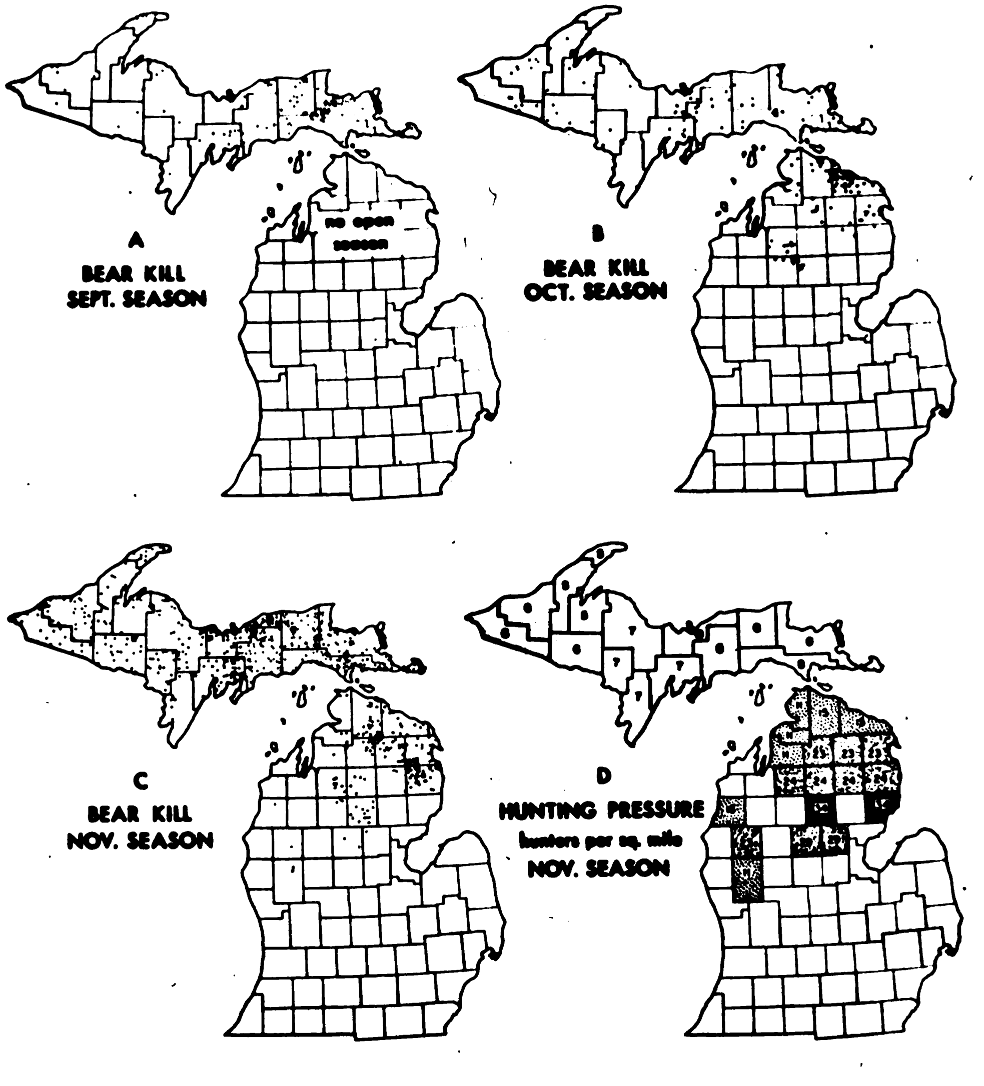

Figure 98. Bear kill distribution in the several hunting seasons, and hunting pressure distribution in the November season, 1954-57.

Upper Peninsula to downstate hunters, who made a majority of the kill (Table 25 and see beyond); and (2) general greater accessibility of these counties by road, favoring bear chases with dogs.

In the Upper Peninsula during the October seasons, when there apparently was little concerted hunting for bears, this imbalance of kill distribution did not appear (Figure 98B; Table 23). On the other hand, 74 percent of the October bear kill in the Lower Peninsula occurred in three northeasterly counties: Presque Isle, Cheboygan, and Alpena (Figure 98B; Table 24). Almost half of the kill was from Presque Isle county alone. Most of the kill in this area was presumably by hunters using dogs (Table 98).

During the November seasons the heaviest take in the Upper Peninsula was reported in Schoolcraft county (Figure 98C; Table 23), followed by Chippewa and Alger counties. Two-thirds of the kill occurred in the six most easterly counties. The kill was otherwise well distributed over the remaining nine counties of this region.

The distribution of November kills in the Lower Peninsula was predominantly within a few northeasterly

TABLE 24. Seasonal variation in bear kill in Lower Peninsula counties, 1954-57[a]

County	Number of kills reported: Oct. 1-Nov. 5 season	Nov. 15-30 season	Season undetermined	All seasons
Alcona	1	43	1	45
Alpena	13	27	1	41
Antrim	0	1	0	1
Charlevoix	1	8	0	9
Cheboygan	14	26	0	40
Clare	0	2	0	2
Crawford	0	5	0	5
Emmet	3	2	0	5
Gladwin	0	1	0	1
Iosco	1	0	0	1
Kalkaska	7	11	0	18
Lake	0	1	0	1
Manistee	0	1	0	1
Missaukee	7	3	0	10
Montmorency	3	25	0	28
Newaygo	0	2	0	2
Oscoda	3	2	1	6
Otsego	5	13	0	18
Presque Isle	50	17	0	67
Roscommon	4	13	1	18
Totals	112	203	4	319

(a) From survey of known successful hunters.

counties, as in October (Table 24). Alcona county alone accounted for 21 percent of the total kill reported, and with Alpena, Cheboygan and Montmorency counties comprised 60 percent of the reported take for this season in the Lower Peninsula. Only incidental kills occurred in Lower Michigan south of the northeast tier counties (Figure 98C).

The fact that the distribution of the bear kill varied considerably among the September, October and November seasons suggests that hunting efforts were differently distributed during the several seasons. This was particularly evident in the Lower Peninsula where kills in Presque Isle county comprised almost half of the take during special seasons, yet during November seasons they contributed only 8 percent of the kill.

<u>Hunting Residence and Kill Distribution</u>. Kill reports indicate that hunters from southern metropolitan areas took well over half of the bears killed in Michigan (Table 25). Only 23 percent of the bears reported taken in the Upper Peninsula were shot by residents of that region. Of the Lower Peninsula kill, 43 percent was made by residents of the northern half

of that region.

There was considerable variation in the residences of hunters taking bears during the several hunting seasons. The least local harvest and greatest influx of southern area hunters occurred during the November season. In this season only 14 percent of the Upper Peninsula kill and 33 percent of the northern Lower Peninsula kill was made by residents of those regions. In contrast, most October season kills (both Peninsulas) were by local hunters. Of kills in the September season (Upper Peninsula only), 37 percent were by Upper Peninsula hunters, 17 percent by northern Lower Peninsula hunters, 42 percent by southern Lower Peninsula hunters and 4 percent by non-resident hunters.

Hunting interest by residents of the Upper Peninsula appeared to be very local (Table 25). Ninety-nine percent of their bear kills were made in their home county or in an adjacent one. There was no report of a bear killed in the Lower Peninsula by an Upper Peninsula hunter.

Hunters residing in the northern Lower Peninsula were also primarily local in hunting interest (home county or adjacent county), although 44 percent took

TABLE 25. Hunter residence and the geographical distribution of the bear kill in Michigan, 1955-57[a]

Area and season	Bears killed										
	By local[b] hunters		By non-local[c] hunters								
			Upper Peninsula		Northern Lower Peninsula		Southern Lower Peninsula		Other states		
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	Total kill
Upper Peninsula:											
Sept. 1-15	42	35	3	2	20	17	51	42	5	4	121
Oct. 1-Nov. 5	48	59	1	1	8	10	23	28	2	2	82
Nov. 15-30	71	13	4	1	40	8	407	76	12	2	534
All seasons	161	22	8	1	68	9	481	65	19	3	737
Lower Peninsula:											
Oct. 1-Nov. 5	54	52	0	0	10	10	37	35	3	3	104
Nov. 15-30	57	28	0	0	10	5	132	66	2	1	201
All seasons	111	36	0	0	20	7	169	55	5	2	305
Entire state:											
Sept. 1-15	42	35	3	2	20	17	51	42	5	4	121
Oct. 1-Nov. 5	102	55	1	1	18	10	60	32	5	3	186
Nov. 15-30	128	17	4	1	50	7	539	73	14	2	735
All seasons	272	26	8	1	88	8	650	63	24	2	1,042

(a) From a survey of known successful hunters.

(b) Hunters killing bears in their county of residence or in a county adjacent to it.

(c) Hunters with more than one county intervening between county of residence and county of kill.

their bears in the Upper Peninsula or in areas in the Lower Peninsula more than one county removed from their home county. Southern Lower Michigan hunters made 74 percent of their kills in the Upper Peninsula. Two percent of the total kill was made by non-resident hunters, primarily from neighboring states, but some from as far away as Florida.

Hunting Pressure and Kill Distribution. Hunting pressure data for the November seasons (Figure 98D; Tables 21 and 22) showed the heavy degree to which downstate habitats were hunted in comparison to the Upper Peninsula, where, in addition, a decline in pressures was noted from east to west. Within the Lower Peninsula, reports of kill appeared to bear little relationship to hunting pressures. In the Upper Peninsula, however, the distribution and magnitude of kill generally paralleled hunter distribution. This suggests that the harvest of bears in the Upper Peninsula was not in excess of permissible yield levels.

In the Upper Peninsula, one bear was killed for each 148 November hunters afield (Table 21). In the Lower Peninsula, for those counties in which bears were reported killed, one bear was killed for every 677 their bears in the [illegible]

the Lower Peninsula [illegible]

their home county. [illegible]

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In the Upper Peninsula, one bear was killed for

each 148 November hunters afield (Table 21). In the

Lower Peninsula, for those counties in which bears

were reported killed, one bear was killed for every 677

November hunters (Table 22). The county with the highest hunter success was Keewenaw with one kill indicated for every 70 hunters. The greatest success for a Lower Peninsula county was in Presque Isle with one kill indicated per 152 hunters.

Population Characteristics of the Bear Kill

Sex Ratios, Their Validity and Significance. Among 1,000 kills of bears where the sex was reported, 56 percent were males (Table 26). It appeared doubtful, however, that males comprised this large a proportion of the harvest, since among 255 bear kills verified as to sex by Department of Conservation biologists males constituted only 48 percent. This was a highly significant difference from the 59 percent males among 745 reports of kills unverified as to sex (Table 26). Assuming that both groups were random samples, this difference suggests that unverified reports were biased to males.

Further examination of these data suggested that male report-distortion was general throughout the reports. Significant differences at the 1 percent probability level were found between verified and unverified sex ratios in Upper Peninsula kills, November season kills, and kills of older bears. True differences between

TABLE 26. Sex composition[a] of the bear kill in Michigan, 1955-57[b]

Verification of reports	Upper Peninsula Cubs M	Cubs F	Other Bears M	Other Bears F	Total reports No.	Per cent M	Lower Cubs M	Cubs F	Other bears M	Other bears F
Years:										
1955										
Verified	6	3	10	20	39	41	0	0	1	0
Unverified	11	8	67	45	131	59	7	7	46	22
1956										
Verified	7	10	42	35	94	52	7	3	3	10
Unverified	14	6	99	75	194	58	1	2	48	26
1957										
Verified	13	9	25	38	85	45	0	0	8	5
Unverified	28	13	62	67	170	53	5	3	49	34
Hunting seasons:										
Sept. 1-15										
Verified	1	1	13	7	22	64	No open season			
Unverified	9	7	35	42	93	47				
Oct. 1-Nov. 5										
Verified	1	0	11	6	18	67	0	0	3	6
Unverified	6	4	35	19	64	54	6	5	54	23
Nov. 15-30										
Verified	24	21	53	80	178	43	7	3	9	9
Unverified	38	16	158	126	338	58	7	7	89	59
All bears:										
Verified	26	22	77	93	218	47	7	3	12	15
Unverified	53	27	228	187	495	57	13	12	143	82

(a) In this table M - male; F - female.

(b) From a survey of known successful hunters.

TABLE 26. Continued

Peninsula Total reports No.	Peninsula Total reports Per cent M	Statewide Cubs M	Statewide Cubs F	Statewide Other bears M	Statewide Other bears F	Statewide Total reports No.	Statewide Total reports Per cent M
1	-	6	3	11	20	40	42
82	65	18	15	113	67	213	61
23	43	14	13	45	45	117	50
77	64	15	8	147	101	271	60
13	61	13	9	33	43	98	47
91	59	33	16	111	101	261	55
		1	1	13	7	22	64
		9	7	35	42	93	47
9	33	1	0	14	12	27	55
88	68	12	9	89	42	152	66
28	57	31	24	62	89	206	45
162	59	45	23	247	185	500	58
37	51	33	25	89	108	255	48
250	62	66	39	371	269	745	59

verified and unverified reports could not be demonstrated, however, for individual years, combined September and October seasons, Lower Peninsula kills, nor cub kills. Unfortunately, the limited number of verified reports in these categories precluded meaningful statistical comparisons. Nevertheless there was a tendency for higher proportions of males among unverified reports in most of the categories mentioned (Table 26).

To investigate this apparent bias, the procedures used to obtain the data were examined for sex ratio differences (1) between reports by hunters contacted through taxidermists and by other combined sources, (2) among first, second, and third questionnaire responses, and (3) among reports received shortly after kills were made and reports received some days later.

Only among reports for the latter category of comparison were significant differences noted. For this comparison the data were arranged into 25-day chronologically-divided groups according to the time period between kill and report dates. A 50-50 sex ratio was assumed, and the null hypypothesis made that no differences existed in the percentage of male bears reported between hunters shortly after the kills were made and hunters contacted numerous days after the time of kills. Chi-square tests (Table 27) showed that hunters were more likely to report male bears as the time increased between when bears were killed and when they were reported. Thus, while validated and early season reports indicated a kill sex ratio of essentially 1:1, the bias with elapsed time was strong enough to unduly distort the ratio based on all the bears reported (Table 26).

Why a portion of the later reports were seemingly misrepresented is unknown. However, as the bias was directly proportional to the increase in time between when bears were killed and reported, it appears to have been introduced unconsciously. Perhaps hunters uncertain as to the sex of their bears tended to indicate kills as males rather than to admit that the sex of the animal had not been determined, or was forgotten.

In view of the analysis above, there appears to have been no great deviation from 1:1 sex ratio in the bear kill. Verified reports showed 52 percent females. A slightly greater proportion of males was reported among kills from the Lower Peninsula than in the Upper Peninsula, but the difference was not significant.

TABLE 27. Reported sex ratios in the bear kill, 1955-57, as affected by time lapse between dates of kill and reporting (a)

Time period	No. of reports	Percent males	Chi-square(b)	Degrees of freedom
0-25 days	223	49	0.0404	1
26-50 "	44	59	1.4546	1
51-75 "	71	49	0.0140	1
76-100 "	96	54	0.6666	1
101-125 "	107	55	1.1308	1
126-150 "	125	56	1.8000	1
151-175 "	99	63	6.3132(c)	1
176-200 "	89	61	4.0572(c)	1
201-225 "	61	66	5.9180(c)	1
226- "	82	62	4.8730(c)	1
Total X^2	997	56	26.2718(d)	10

(a) From a survey of known successful hunters.

(b) Chi-square values as the data deviates from a 1:1 ratio.

(c) Significant at the 5 per cent level.

(d) Significant at the 1 per cent level.

Among verified reports, cubs showed 57 percent males, compared to 45 percent among older bears (Table 26). Neither value is significantly different from an even ratio (50 percent).

The sex ratio of bears taken in the three hunting seasons appeared to be dis-similar. September reports were essentially evenly divided between males and females. Reports for October seasons for both peninsulas indicated a preponderance of males. Unverified reports were 66 percent males, but verified reports suggested a lesser percentage. Verified reports from the November seasons showed 45 percent males.

Reasons for the apparent differences in the sex ratios of bears taken in the various seasons are unknown, except that differences in the time when male and female bears enter dens for the winter may have influenced the sex ratio of bears taken during the November seasons (see beyond).

<u>Productivity</u>. Among 176 family groups from which hunters reported killing bears, the mean litter size was 2.05 cubs. Litter size frequencies were 23 percent singletons, 52 percent twins, 20 percent triplets, and 4 percent quadruplets (Table 28). There were no

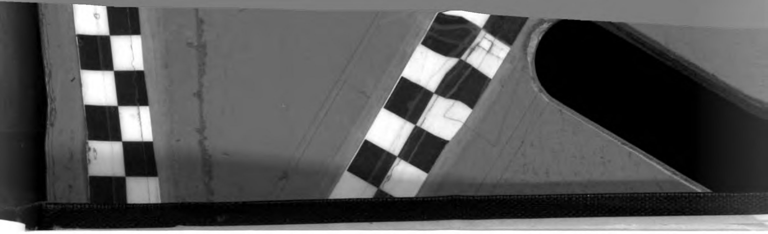

TABLE 28. Litter size of Michigan bears[a]

	No. of litters	No. of cubs	Adult females with 1 cub No.	1 cub Per cent	2 cubs No.	2 cubs Per cent	3 cubs No.	3 cubs Per cent	4 cubs No.	4 cubs Per cent	Mean litter size
Upper Peninsula:											
Years:											
1954	4	8	2	(b)	1	(b)	0	(b)	1	(b)	2.00
1955	27	54	5	18	17	63	5	18	0	0	2.00
1956	51	95	14	27	32	63	3	6	2	4	1.86
1957	47	100	11	23	20	42	15	32	1	2	2.13
Lower Peninsula:											
Years:											
1954	0	0	0	0	0	0	0	0	0	0	0.00
1955	18	39	2	11	11	61	5	28	0	0	2.17
1956	14	35	2	14	4	29	7	50	1	7	2.50
1957	15	30	5	33	7	47	1	7	2	13	2.00
Entire state:											
Years:											
1954	4	8	2	(b)	1	(b)	0	(b)	1	(b)	2.00
1955	45	93	7	15	28	62	10	22	0	0	2.07
1956	65	130	16	25	36	55	10	15	3	5	2.00
1957	62	130	16	26	27	43	16	26	3	5	2.10

(a) From a survey of known successful hunters; based on hunter reports of family groups from which bears were killed.

(b) Number too small for percent to be meaningful.

TABLE 28. Continued

	No. of litters	No. of cubs	Adult females with: 1 cub No.	1 cub Per cent.	2 cubs No.	2 cubs Per cent	3 cubs No.	3 cubs Per cent	4 cubs No.	4 cubs Per cent	Mean litter size
Upper Peninsula:											
Seasons:											
Sept. 1-15	27	53	7	26	15	55	4	15	1	4	1.96
Oct. 1-Nov.5	16	33	3	19	10	62	2	12	1	6	2.06
Nov. 15-30	86	171	22	26	45	52	17	20	2	2	1.99
Totals	129	257	32	25	70	54	23	18	4	3	1.99
Lower Peninsula:											
Seasons:											
Sept. 1-15			No open season								
Oct. 1-Nov.5	18	41	2	11	10	56	5	28	1	5	2.28
Nov. 15-30	29	63	7	24	12	41	8	28	2	7	2.17
Totals	47	104	9	19	22	47	13	27	3	6	2.21
Entire State:											
Seasons:											
Sept. 1-15	27	53	7	26	15	56	4	15	1	4	1.96
Oct. 1-Nov.5	34	74	5	15	20	59	7	21	2	6	2.18
Nov. 15-30	115	234	29	25	57	50	25	22	4	3	2.03
Totals	176	361	41	23	92	52	36	20	7	4	2.05

significant differences in litter sizes when considered by regions, years, or seasons. Evidently little selective hunting occurred in any age group in September and October seasons, since undiminished litter size values continued into the November seasons.

Population Elements in the Kill. Of 1,047 reports listing these data, 11 percent of the kills were identified as adult females with cubs, 18 percent were cubs, and 71 percent were other bears (Table 29). Differences in the proportions of these elements were not significant, between years, seasons or peninsulas.

Although it was not possible to determine actual mortality rates sustained by bears due to hunting, the mortality among family groups of bears was undoubtedly high (Table 30). Of 176 family groups from which bears were reported taken, 60 percent of the group-members were killed. Mortality was 70 percent among adult females and 55 percent for cubs. Thirty-two percent of the family groups were annihilated. There were no significant differences in family group mortalities between years. However, highly significant mortality differences existed between kills for the Upper and the Lower Peninsula, and between the kills for special bear

TABLE 29. Population elements in the hunter-kill of Michigan bears, 1955-57(a)

	Adult females with cubs		Cubs		Other bears		
	No.	Percent of total kills	No.	Percent of total kills	No.	Percent of total kills	Total kills
Upper Peninsula:							
Years:							
1955	24	14	32	18	119	68	175
1956	33	11	41	13	229	76	303
1957	35	13	67	25	161	61	263
Seasons:							
Sept. 1-15	17	14	20	16	84	69	121
Oct. 1-Nov. 5	8	9	12	14	66	77	86
Nov. 15-30	67	12	108	22	359	67	534
Totals	92	12	140	19	509	69	741
Lower Peninsula:							
Years:							
1955	10	12	14	16	61	72	85
1956	10	9	17	15	83	75	110
1957	9	8	13	12	89	80	111
Seasons:							
Sept. 1-15			No open season				
Oct. 1-Nov. 5	10	9	16	15	79	75	105
Nov. 15-30	19	9	28	14	154	76	201
Totals	29	9	44	14	233	76	306
Entire state:							
Years:							
1955	34	13	46	18	180	69	260
1956	43	10	58	14	312	75	413
1957	44	12	80	21	250	67	374
Seasons:							
Sept. 1-15	17	14	20	16	84	69	121
Oct. 1-Nov. 5	18	9	28	15	145	76	191
Nov. 15-30	86	12	136	18	513	70	735
Totals	121	11	184	18	742	71	1,047

(a) From a survey of known successful hunters.

seasons and the November seasons. These differences were due to accentuated mortality to family groups during November seasons in the Upper Peninsula (see beyond). Much of this kill was of bears already in dens (Table 30). Chi-square tests indicate significantly higher mortality for denned family groups than for family groups not in dens. Among the former, over 97 percent of the adult females and 83 percent of the cubs were killed, as compared with 65 percent of adult females and 52 percent of cubs among bears not in dens (Table 30). When mortalities among denned family groups were excluded from November kills there was no significant difference in family group mortalities between regions, seasons or years.

Habitats in Which Bears Were Killed

Cover types in which bears were killed were established from vegetation descriptions furnished by hunters (Table 31). The proportions of cover types present, however, and the hunting effort in each was unknown.

The upland hardwood type appeared to be highly favored by bears during all hunting seasons. However

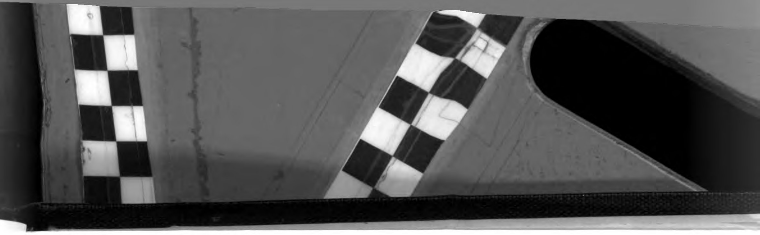

TABLE 30. Hunting mortalities among family groups of Michigan bears, 1954-57[a]

	No. of family groups	Total cubs	Females killed No.	Females killed Per cent	Cubs killed No.	Cubs killed Per cent	Total bears killed No.	Total bears killed Per cent	No. of families entirely killed No.	No. of families entirely killed Per cent
Upper Peninsula:										
Years:										
1954	4	8	4	(b)	4	(b)	8	(b)	2	(b)
1955	27	54	23	85	32	59	55	68	14	52
1956	51	95	34	67	49	51	83	57	14	27
1957	47	100	35	74	64	64	99	67	21	45
1954-57	129	257	96	74	149	58	245	63	51	39
Lower Peninsula:										
Years:										
1954	0	0	0	0	0	0	0	0	0	0
1955	18	39	9	50	14	36	23	40	0	0
1956	14	34	10	71	19	36	29	60	4	28
1957	15	30	9	60	15	50	24	53	2	13
1954-57	47	103	28	60	48	47	76	51	6	13
Entire state:										
Years:										
1954	4	8	4	(b)	4	(b)	8	(b)	2	(b)
1955	45	93	32	71	46	49	78	56	14	31
1956	65	129	44	68	68	53	112	58	18	28
1957	62	130	44	71	79	61	123	64	23	37
1954-57	176	360	124	70	197	55	321	60	57	32

(a) From a survey of known successful hunters, based on reports of family groups from which bears were killed.
(b) Number too small for percent to be meaningful.

TABLE 30. Continued

	No. of family groups	Total cubs	Females killed No.	Females killed Per cent	Cubs killed No.	Cubs killed Per cent	Total bears killed No.	Total bears killed Per cent	No. of families entirely killed No.	No. of families entirely killed Per cent
Upper Peninsula:										
Seasons:										
Sept. 1-15	27	53	18	67	23	43	41	51	7	26
Oct. 1-Nov. 5	16	33	9	56	12	36	21	43	1	6
Nov. 15-30	86	171	69	80	114	67	183	71	43	50
Totals	129	257	96	74	149	58	245	63	51	39
Denning (Nov. 15-30):										
In dens	38	77	37	97	66	86	103	90	30	79
Not in dens	48	94	32	67	48	51	80	56	13	27
Lower Peninsula:										
Seasons:										
Sept. 1-15			No open season							
Oct. 1-Nov. 5	18	41	9	50	16	39	25	42	2	11
Nov. 15-30	29	62	19	65	32	52	51	56	4	14
Totals	47	103	28	60	48	47	76	51	6	13
Denning (Nov. 15-30):										
In dens	2	5	2	100	2	40	4	57	1	50
Not in dens	27	57	17	63	30	53	47	56	3	11
Entire state:										
Seasons:										
Sept. 1-15	27	53	18	67	23	43	41	51	7	26
Oct. 1-Nov. 5	34	74	18	53	28	38	46	43	3	9
Nov. 15-30	115	233	88	76	146	63	234	67	47	41
Totals	176	360	124	70	197	55	321	60	57	32
Denning (Nov. 15-30):										
In dens	40	82	39	97	68	83	107	88	31	77
Not in dens	75	151	49	65	78	52	127	56	16	21

TABLE 31. Cover types where hunters killed bears in Michigan, 1954-57[a]

Cover types	Number of kills							
	Sept. 1-15 season		Oct. 1-Nov. 5 season		Nov. 15-30 season		All seasons	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Hardwood swamp	4	3	16	9	44	6	63	6
Conifer swamp	12	10	40	22	212	29	274	26
Mixed conifers and hardwood swamp	11	9	21	11	120	16	152	15
Upland hardwoods	57	49	63	34	197	27	317	31
Upland conifers	11	10	13	7	64	9	88	8
Mixed upland hardwoods and conifers	13	11	15	8	60	8	88	8
Mixed swamp and upland	3	3	6	3	8	1	17	2
Marsh	1	1	0	0	15	3	16	2
Slash	0	0	0	0	9	1	9	1
Orchard	1	1	10	5	3	(b)	14	1
Dump	4	3	0	0	1	(b)	5	(b)
Open field	0	0	1	1	1	(b)	2	(b)
Totals	117	100	185	100	734	100	1,036	100

(a) From a survey of known successful hunters.

(b) Less than 0.5 percent.

a marked shift to conifer and mixed conifer-hardwood swamp areas in November was indicated. Presumably upland hardwoods were used heavily as foraging areas by bears during the fall. Few of Michigan's forests are in a climax state, and most upland hardwood types provide an abundance of early to mid-successional shrubs and trees, such as cherries and service-berries which produce fleshy fruits. The indicated shift to swamps in November is seemingly for denning (see beyond).

When kill locations were plotted on a generalized cover map of Michigan (Figure 99), heaviest kills, doubtless reflecting both hunting effort and accessibility but presumably also bear numbers, occurred in early and mid-successional types such as cherry and aspen, inter-mixed with forest openings. Of mature successional types, kills in the oak woods predominated.

Bear Denning

Denning for the Winter and Its Effects on the Kill. About 37 percent of the bears reported killed in November were in dens (Table 32). The proportion of bears taken from dens was significantly greater in the Upper Peninsula than in the Lower Peninsula. This difference I attribute to the earlier inclemency of Upper Peninsula weather

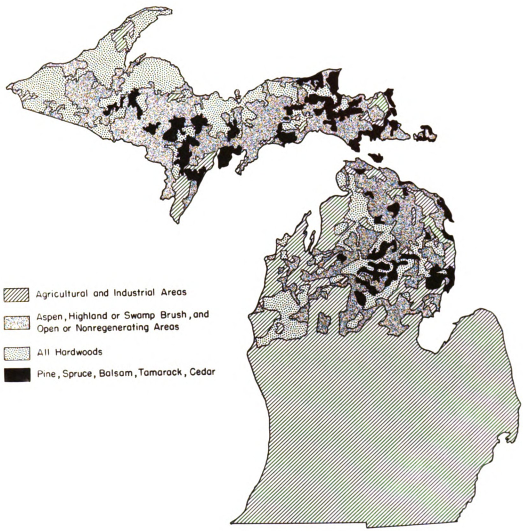

Figure 99. Major cover types in Michigan.

TABLE 32. Bears killed in dens during November 15-30 seasons in Michigan, 1954-57(a)

Sex and age(b)	1954 Upper Peninsula No. of kills	1954 Upper Peninsula Per cent in dens	1955 Upper Peninsula No. of kills	1955 Upper Peninsula Per cent in dens	1955 Lower Peninsula No. of kills	1955 Lower Peninsula Per cent in dens	1955 Entire state No. of kills	1955 Entire state Per cent in dens	1956 Upper Peninsula No. of kills	1956 Upper Peninsula Per cent in dens	1956 Lower Peninsula No. of kills	1956 Lower Peninsula Per cent in dens	1956 Entire state No. of kills	1956 Entire state Per cent in dens
Adults:														
Female	16	81	42	64	8	0	50	54	64	34	31	32	95	34
Male	11	54	51	16	18	28	69	19	75	29	29	3	104	22
Sex unknown	1	0	0	0	2	50	2	50	2	50	1	0	3	33
Total	28	68	93	38	28	21	121	34	141	32	61	18	202	28
Juveniles:														
Female	6	67	11	82	7	28	18	61	27	18	6	0	33	15
Male	6	67	20	65	6	0	26	50	29	38	13	8	41	29
Sex unknown	0	0	4	75	0	0	4	75	3	33	2	0	5	20
Total	12	67	35	71	13	15	48	56	58	29	21	5	79	23
All bears	40	67	128	47	41	19	169	40	199	31	82	15	281	26

(a) From a survey of known successful hunters.

(b) Considered adults if over 100 pounds dressed weight.

TABLE 32. Continued

Sex and age(b)	1957 Upper Peninsula No. of kills	1957 Upper Peninsula Per cent in dens	1957 Lower Peninsula No. of kills	1957 Lower Peninsula Per cent in dens	1957 Entire state No. of kills	1957 Entire state Per cent in dens	Totals--All years Upper Peninsula No. of kills	Totals--All years Upper Peninsula Per cent in dens	Totals--All years Lower Peninsula No. of kills	Totals--All years Lower Peninsula Per cent in dens	Totals--All years Entire state No. of kills	Totals--All years Entire state Per cent in dens
Adults:												
Female	65	54	20	35	85	49	187	51	59	29	246	46
Male	52	35	38	0	90	20	189	29	85	7	274	22
Sex unknown	1	0	1	100	2	50	4	25	4	50	8	37
Total	118	45	59	13	177	34	380	40	148	17	528	33
Juveniles:												
Female	27	74	5	20	32	66	71	53	18	17	89	46
Male	43	55	3	0	46	52	97	53	22	5	119	44
Sex unknown	4	50	0	0	4	50	11	54	2	0	13	46
Total	74	62	8	12	82	57	179	54	42	9	221	45
All bears	192	52	67	13	259	42	559	44	190	15	749	37

(Table 33).

A significantly lower proportion of bears was also reported killed in dens in 1956 than in 1955 and 1957 (Table 32). This difference was limited to the Upper Peninsula and appeared to be related to greater November snowfall in 1956 (Table 34). Temperature data for these years appeared to have little relationship to the denning of bears (Table 34).

The data of Table 32 also indicated that the proportion of adult male bears killed in dens was highly significantly lower than the proportion of adult female and juvenile bears. Apparently, fewer adult male bears were denned during the hunting seasons.

Time of Denning. The denning chronology of bears reported in this study indicated similar denning progressions in 1955 and 1957, with a somewhat later denning progression in 1956 (Tables 35 and 36). Reports for all years indicated that denning progressed quite uniformly, without peak denning periods. The wide area over which kills of bears occurred may, however, have masked local peaks of denning.

The earliest reports of denned bears were October 13 in the Upper Peninsula and October 27 in the Lower

TABLE 33. Comparative November temperatures and snowfall in the Upper and Lower Peninsulas, 1955-57[a]

		Average Temperature (F°)			Snowfall (in.)	
		Maximum	Minimum	Monthly average	total	Average depth
Upper Peninsula:						
Western Division (Average of 17 stations)	1955	35.4	20.9	28.2	24.2	13.4
	1956	39.2	25.3	32.3	30.0	14.5
	1957	38.4	25.6	32.0	27.6	14.4
	Average	37.6	24.0	30.8	27.3	14.1
Eastern Division (Average of 14 stations)[b]	1955	37.3	23.9	30.6	14.8	8.1
	1956	41.2	27.7	34.5	19.9	10.7
	1957	40.5	28.5	34.6	14.7	4.9
	Average	39.7	26.8	33.2	16.5	7.9
Lower Peninsula:						
Northwest Division (Average of 13 stations)	1955	39.6	26.8	33.2	14.2	6.1
	1956	44.7	29.9	37.7	12.1	6.7
	1957	42.9	30.7	36.8	8.3	3.7
	Average	42.4	29.1	35.9	11.6	5.6
Northeast Division (Average of 18 stations)	1955	39.6	25.3	32.5	14.8	6.7
	1956	44.2	27.9	36.1	9.8	5.5
	1957	43.6	29.0	36.3	6.1	3.4
	Average	42.5	27.4	35.0	10.3	5.2

(a) Compiled from Climatological Data, Michigan, Weather Bureau, U. S. Dept. of Commerce.

(b) 13 stations in 1957.

TABLE 34. Upper Peninsula November temperatures and snowfall, 1955-57[a]

	Day of month														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15[b]
Temperatures (^{o}F.):															
1955	37	29	27	27	32	28	25	28	28	34	32	29	28	22	27
1956	43	54	52	51	51	42	33	28	26	17	30	29	26	29	30
1957	40	41	39	33	29	27	36	30	22	17	24	34	38	39	35
Snowfall (inches):															
1955			0.8	0.3		0.1	0.3	0.2	0.2					0.1	0.9
1956							0.1	0.8		0.7		0.6			1.8
1957				0.1				1.0	2.5	0.9					0.2
Snow on Ground (inches):															
1955			0.5	0.7	0.4		0.1	0.1	0.1					0.1	0.3
1956								0.1	0.1	0.3	0.2	0.4			1.1
1957								0.6	2.9	3.1	1.4	0.5	0.3		

(a) Compiled for 13 stations, Climatological Data, Michigan, Weather Bureau, U. S. Department of Commerce.

(b) Hunting season opens November 15.

TABLE 34. Continued

	Day of month															Nov. 1-30	Nov. 15-30
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
Temperatures (^{o}F.):																	
1955	17	13	21	16	18	22	23	18	7	14	17	8	-2	16	14	22(c)	15(c)
1956	21	14	23	27	28	25	7	1	10	21	18	9	18	9	13	26	17
1957	32	30	28	25	24	21	14	18	17	15	14	28	28	19	9	27	22
Snowfall (inches):																	
1955	2.2	2.2	2.1	0.4	0.4		1.8	0.9	0.3	0.7	0.1	0.6	1.7	3.3	0.3	19.9(d)	17.9(d)
1956	3.0	0.1			0.1	6.1	2.6	0.7	0.5	2.2	0.6		1.0	0.3	0.6	21.8	19.6
1957	0.6	0.3	2.8	4.8	1.4	0.6		0.8	1.0	0.3	0.2	0.1		1.1	1.0	19.7	15.2
Snow on Ground (inches):																	
1955	1.9	3.4	3.9	4.1	3.4	3.5	4.2	3.4	3.5	3.8	4.0	4.2	5.7	8.5	8.5	2.3(c)	4.4(c)
1956	3.9	3.5	2.7	2.0	1.5	6.2	8.8	8.7	8.5	9.7	10.3	9.5	9.7	9.9	9.8	3.6	6.6
1957	0.4	0.5	1.9	5.2	5.8	6.4	6.4	5.1	5.5	5.5	5.1	4.1	3.1	3.5	5.0	2.4	4.0

(c) Mean values for period.

(d) Total for period.

Peninsula. Of 9 bears denned in October, 1 was an adult male, 5 were single adult females, and 1 was a mother with two cubs (Table 35). All of these records except one were from the Upper Peninsula.

Winter denning of bears in the Upper Peninsula was apparently more advanced than in the Lower Peninsula. Opening-day kills in November seasons in the Upper Peninsula averaged 37 percent denned bears, and almost all bears killed at the close of the season were denned. In contrast, opening-day November kills in the Lower Peninsula averaged only 8 percent denned bears, and although late kill reports were few a high precentage of bears was indicated as still active at the season's close.

When compared with adult male bears, winter denning by adult females and juvenile bears collectively was indicated to be more abrupt, commenced sooner, and completed earlier (Table 35).

Although kill reports for October and early November were limited, data for all seasons indicate that first denning by bears in Michigan generally commences in the Upper Peninsula in early October and is largely complete by December. Early denning appears

TABLE 35. The progression of winter-denning of Michigan bears, 1954-57[a]

Dates	Upper Peninsula: Number of bears: Adult females: In dens	Adult females: Not in dens	Adult males: In dens	Adult males: Not in dens	Juveniles: In dens	Juveniles: Not in dens	All bears: No.	All bears: Per cent in dens	Lower: Number of: Adult females: In dens	Adult females: Not in dens	Adult males: In dens	Adult males: Not in dens
Oct. ?	1											
13	1											
20	1											
26											1	
27	1				2							
29	1											
Nov. 4	1											
Nov. 15	21	24	9	41	22	24	141	37	1	11	1	29
16	11	18	7	18	6	9	69	35	3	3	0	13
17	15	14	5	20	13	18	85	39	0	6	0	8
18	13	12	4	19	13	11	72	42	4	5	0	9
19	13	7	8	12	14	4	58	60	0	1	0	5
20	2	10	1	4	2	8	57	18	0	2	1	4
21	5	1	0	3	4	0	13	69	1	4	2	1
22	3	1	2	1	2	3	12	58	2	1	0	2
23	4	2	2	2	9	1	20	75	3	2	0	2
24	5	0	3	6	1	0	15	60	0	3	0	2
25	2	0	3	3	3	1	12	75	0	0	1	1
26	1	0	4	1	2	0	8	87	1	1	0	0
27	2	0	2	1	0	0	5	80	1	0	1	0
28	0	0	2	1	0	0	3	67	1	3	0	2
29	0	0	0	0	0	0	0	0	0	0	0	0
30	1	0	1	0	0	0	2	100	0	0	0	1
Totals[b]	98	89	53	132	91	79	542		17	42	6	79
Percent in dens	52		29		53			45	29		7	

(a) From a survey of known successful hunters; includes only bears of known sex and date of kill.

(b) Totals for Nov. 15-30 seasons only.

TABLE 35. Continued

Peninsula bears: Juveniles: In dens	Peninsula bears: Juveniles: Not in dens	Peninsula bears: All bears: No.	Peninsula bears: All bears: Per cent in dens	Entire state: Adult females: In dens	Entire state: Adult females: Not in dens	Entire state: Adult males: In dens	Entire state: Adult males: Not in dens	Entire state: Juveniles: In dens	Entire state: Juveniles: Not in dens	Entire state: All bears: No.	Entire state: All bears: Per cent in dens
2	6	50	8	57	38	80	12	54	44	191	29
0	5	24	14	35	40	38	18	20	40	93	29
0	5	19	0	35	43	33	15	36	36	104	32
0	5	23	17	34	50	32	12	29	45	95	36
0	1	7	0	21	62	25	32	19	74	65	54
0	4	11	9	14	14	10	20	14	14	38	16
0	0	8	37	11	54	6	33	4	100	21	57
1	0	6	50	7	71	5	40	6	50	20	55
0	0	7	43	11	64	6	33	10	90	27	67
0	4	9	0	8	62	11	27	5	20	24	37
0	1	3	33	2	100	8	50	5	60	15	60
1	2	5	40	3	67	5	80	5	60	13	69
0	0	2	100	3	100	4	75	0	0	7	86
0	3	9	11	4	25	5	40	3	0	12	25
0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	1	100	2	50	0	0	3	67
4	36	184		246		270		210		726	
10			15		47		22		45		37

TABLE 36. The chronology of bear denning in Michigan[a]

Date	1955			1956			1957			All years		
	Number		Per cent in dens	Number		Per cent in dens	Number		Per cent in dens	Number		Per cent in dens
	In dens	Not in dens		In dens	Not in dens		In dens	Not in dens		In dens	Not in dens	
Upper Peninsula:												
Nov. 15	13	14	48	11	46	19	22	26	46	46	86	35
16	8	9	47	4	21	16	11	14	44	23	44	34
17	8	10	44	8	19	30	14	23	39	30	52	37
18	2	15	12	8	19	30	18	9	67	28	43	39
19	10	5	67	10	10	50	10	7	59	30	22	58
20	2	5	(b)	1	10	9	2	7	(b)	5	22	18
21	2	1	(b)	4	1	(b)	2	2	(b)	8	4	67
22	1	1	(b)	0	1	(b)	5	3	(b)	6	5	54
23	3	2	(b)	2	2	(b)	10	2	93	15	6	71
24	4	3	(b)	3	3	(b)	1	0	(b)	8	6	57
25	6	2	(b)	2	2	(b)	0	0	(b)	8	4	67
26	0	0	(b)	6	1	(b)	1	0	(b)	7	1	(b)
27	1	0	(b)	2	1	(b)	1	0	(b)	4	1	(b)
28	0	1	(b)	1	0	(b)	1	0	(b)	2	1	(b)
29	0	0	(b)	0	0	(b)	0	0	(b)	0	0	(b)
30	0	0	(b)	1	0	(b)	1	0	(b)	2	0	(b)
Totals	60	68	47	63	136	31	99	93	52	222	297	43

TABLE 36. Continued

Lower Peninsula:

Nov. 15	2	3	(b)	2	17	10	0	26	0	4	46	8
16	1	5	(b)	3	9	25	0	7	(b)	4	21	16
17	0	4	(b)	0	9	(b)	0	7	(b)	0	20	0
18	0	3	(b)	1	12	8	3	4	(b)	4	19	17
19	0	4	(b)	0	2	(b)	0	1	(b)	0	7	(b)
20	1	3	(b)	0	6	(b)	0	1	(b)	1	10	9
21	2	1	(b)	1	1	(b)	0	3	(b)	3	5	(b)
22	0	1	(b)	3	0	(b)	0	2	(b)	3	3	(b)
23	0	1	(b)	1	1	(b)	2	3	(b)	3	5	(b)
24	0	2	(b)	0	6	(b)	0	1	(b)	0	9	(b)
25	1	0	(b)	0	0	(b)	0	2	(b)	1	2	(b)
26	0	3	(b)	0	0	(b)	2	0	(b)	2	3	(b)
27	1	0	(b)	0	0	(b)	1	0	(b)	2	0	(b)
28	0	3	(b)	1	8	(b)	0	0	(b)	1	11	8
29	0	0	(b)	0	0	(b)	0	0	(b)	0	0	(b)
30	0	0	(b)	0	1	(b)	0	0	(b)	0	1	(b)
Totals	8	33	19	12	72	14	8	57	12	28	162	15

(a) From a survey of known successful hunters.

(b) Number too small for percent to be meaningful.

to be largely by female and juvenile bears; their denning is apparently completed about two weeks before adult males. Similar denning patterns were indicated for bears in the Lower Peninsula, except for a two-week lag. This pattern of events resulted in approximately parallel denning chronologies for adult male bears in the Upper Peninsula and adult female bears in the Lower Peninsula (Table 35).

Vulnerability of Denned and Undenned Bears to Hunting. There was no evidence in this study to demonstrate differential hunting mortality for bears either in or out of dens. Essentially constant sex ratios persisted among shot adult bears throughout the November seasons (Tables 32 and 35). This suggested equal vulnerability, since relatively fewer male than female bears were denned during the hunting seasons (Table 32). While denned bears were perhaps less likely to be chanced upon by hunters, they were apparently killed in approximate equal proportion to bears not in dens, due to their greater vulnerability once discovered (Table 30).

Most bears appeared to remain active until the ground was snow covered (Compare Tables 34, 35 and 37). It is therefore likely that a large number of bears

killed in dens were actually tracked to dens and killed. Had track sign not occurred fewer of these bears might have been killed. Unfortunately, it was not determined to what degree hunters were successful in tracking bears to dens. However, hunters voluntarily reported that of 34 animals tracked they had killed 22 in dens. A number of hunters reported also that their attention was drawn to dens by signs of recent den construction (Table 37). These bits of evidence indicate that bears in dens without visible signs of their presence may suffer lighter mortality than active bears.

Den Descriptions. The locations where bears denned varied considerably (Table 38). However, most bears favored dens dug beneath objects such as logs or stumps, or holes dug into hillsides. This preference held for both sexes and all ages. Many bears expended considerable effort constructing dens, as evidenced by their lining dens with leaves, bracken fern, and marsh grass. Track signs indicated that some bears had spent several days preparing dens (Table 37). Thus, although the onset of actual denning may have been triggered either directly or indirectly by climatic factors, the evidence indicates that there was preparation for the event.

TABLE 37. The relation of den evidence to the kill of bears by Michigan hunters, 1955-57[a]

Year	Bears not in dens killed[b] largely because the attention of hunters was drawn to dens	Bears killed[c] in dens largely because signs of dens and tracks led hunters to dens	Bears killed in dens where external evidence of dens was obscured
1955	8	13	55
1956	12	16	59
1957	13	7	100
	33	36	214

(a) From a survey of known successful hunters, 1955-57.

(b) Most such reports indicated that bears were within 100 yards of dens.

(c) Includes 22 bears tracked to dens.

TABLE 38. Den types in which Michigan hunters killed bears, 1954-57[a]

Den type	Adult males[b] No. of dens Lined	Adult males[b] No. of dens Unlined	Adult males[b] Per cent Lined	Adult females without cubs[b] No. of dens Lined	Adult females without cubs[b] No. of dens Unlined	Adult females without cubs[b] Per cent Lined
Hole in knoll or hillside	5	7	42	9	8	53
Under stump, log, etc.	9	19	32	19	16	54
Under brush or slash	0	7	(e)	4	5	(e)
Hollow standing treetop	0	0	(e)	0	1	(e)
Hollow tree base	0	0	(e)	0	2	(e)
Hollow stump	4	3	(e)	1	4	(e)
Hollow log or fallen tree	0	1	(e)	0	1	(e)
Rock crevice	0	0	(e)	0	0	(e)
Unsheltered depression	2	5	(e)	1	4	(e)
Under deserted dwelling	0	0	(e)	0	0	(e)
Not described	1	1	(e)	0	5	(e)
Total	21	43	33	34	46	42

(a) From a survey of known successful hunters.

(b) Bears exceeding 100 pounds dressed weight.

(c) Parenthesis indicates number of cubs.

(d) Bears, other than members of family groups, less than 100 pounds dressed weight.

(e) Number too small for percent to be meaningful.

(f) Less than 0.5 percent.

TABLE 38. Continued

Females with cubs(c)			Juvenile bears(d)			All bears			
No. of dens		Per cent	No. of dens		Per cent	No. of dens		Per cent	Per cent of
Lined	Unlined	Lined	Lined	Unlined	Lined	Lined	Unlined	Lined	den types
1 (2)	6 (8)	(e)	4	4	(e)	19	25	43	21
7 (14)	10 (22)	41	7	8	47	42	53	44	46
5 (10)	2 (3)	(e)	1	0	(e)	10	14	42	11
0	1 (2)	(e)	0	2	(e)	0	4	(e)	2
2 (4)	2 (3)	(e)	0	0	(e)	2	4	(e)	3
0	0	(e)	0	0	(e)	5	7	42	6
1 (4)	1 (3)	(e)	1	1	(e)	2	4	(e)	3
0	1 (3)	(e)	1	0	(e)	1	1	(e)	1
0	2 (4)	(e)	0	0	(e)	3	11	21	7
0	0	(e)	0	1	(e)	0	1	(e)	(f)
1 (2)	2 (3)	(e)	0	1	(e)	2	9	18	0
17 (36)	27 (51)	39	14	17	45	86	133	39	100

Fewer adult male bears than adult female or juvenile bears were reported as having lined their dens (Table 38). While this observation might be taken as evidence that adult males were less careful with preparations of winter dens, it seems more probable that materials for den construction were not as readily available to adult male bears due to their tendency for later denning.

Summary

Kill data of black bears in Michigan for the years 1955 through 1957 were analyzed from a questionnaire survey of hunters. Data were obtained from 1,129 kills. Sixty-nine percent of all kills occurred in the Upper Peninsula and 31 percent in the northern part of the Lower Peninsula. The bear harvests in these years were apportioned 70 percent November 15-30, 18 percent October 1-November 5, and 12 percent September 1-15. In the September and November seasons one-fourth of all kills occurred on opening days, and half in the first three days of hunting. Harvests were spread uniformily throughout October seasons.

Mean annual kill densities were calculated as one bear per 21 square miles in the Upper Peninsula and one

per 34 square miles in the northern Lower Peninsula. Most Lower Peninsula kills occurred in the northeast lakeside counties. Kills in the Upper Peninsula paralleled hunting effort, indicating that kills there were below sustained yield levels.

Annual hunter success was calculated as one bear per 148 hunters in the Upper Peninsula and one bear per 677 hunters in the Lower Peninsula. Southern Lower Peninsula hunters made 63 percent of the kills reported, northern Lower Peninsula hunters 19 percent, Upper Peninsula hunters 16 percent, and non-resident hunters 2 percent.

Sex ratios reported by hunters were found to be biased toward males. The degree of bias was directly proportional to the time elapsed between kills and reports of kills. Kills confirmed as to sex were 52 percent females.

The mean litter size in 176 reports was 2.05 cubs. Litter size frequencies were 23 percent singletons, 52 percent twins, 20 percent triplets, and 4 percent quadruplets. Identifiable population elements in the kill were 11 percent mothers with cubs, 18 percent cubs, and 71 percent other bears. In family groups from which bears were reported killed, mortality was 70 percent among

mothers and 55 percent among cubs. All members of 32 percent of the family groups were killed.

Thirty-seven percent of the bears killed November 15-30 were in dens. The proportion of bears killed in dens was significantly larger in the Upper Peninsula than in the Lower Peninsula. Bears in and out of dens appeared equally vulnerable to hunters. Females and cubs denned on an average about two weeks earlier than adult males. First denning was in mid-October. Most dens were in holes beneath logs or in hillsides. A high proportion of bear dens were lined with leaves, grass, or ferns. Females were more likely to line their dens than males.

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APPENDIX I.

SEASONAL VARIATIONS IN THE HEMATOLOGY AND PHYSIOLOGY OF BLACK BEARS

ALBERT W. ERICKSON AND WILLIAM G. YOUATT

SEASONAL VARIATIONS IN THE HEMATOLOGY AND PHYSIOLOGY OF BLACK BEARS

By Albert W. Erickson and William G. Youatt

Abstract: During 1956 and 1957, four black bears (*Ursus americanus*) were held captive in northern Michigan. They were dormant in winter quarters from approximately 25 December to 17 April, during which time all lost weight. Four times over a 9-month period the bears were anesthetized and various physiological and hematological values were obtained.

One aspect of a recent study of the black bear, *Ursus americanus*, in Michigan involved seasonal variations in certain physiological and hematological values. We wanted to determine what variations occurred in some of the metabolic processes during the overwintering period of torpor, or dormancy, of black bears.

During 1956–57, four captive wild bears were held at the Cusino Wildlife Experiment Station, near Shingleton, Michigan. Two were subadult females, one a male cub and the other an adult male. The animals, in individual pens with dens and straw bedding, were maintained on a well-balanced commercial dogfood ration. All bears winter-denned from 25 December to 17 April with the exception of bear *A*, which entered the den on 26 November, and bear *D*, which emerged from its den on 1 April.

The bears were anesthetized with pentobarbital sodium (1 grain/cc) four times in nine months, including twice during the overwinter period of torpor. Anesthetic injection was accomplished by first rendering the bears helpless by intramuscular injection of the muscle relaxant, succinyl choline chloride. About 30 minutes after anesthesia, studies of physical condition were made and blood samples of about 10 ml each were collected from the jugular vein in vials containing the dried equivalent of 1 ml of oxalate solution (4.8 gm ammonium oxalate and 3.2 gm potassium oxalate in 1000 ml HOH).

Weights were taken on a Chatillon (300-lb capacity) wall-mounted scale, temperatures were taken rectally, and pulse was determined by palpation over the heart. Packed cell volumes were determined with a Wintrobe hematocrit tube. Hemoglobin (direct method), blood sugar, total protein, albumin, globulin, phosphorus, and chloride were determined with a Fisher Clinical

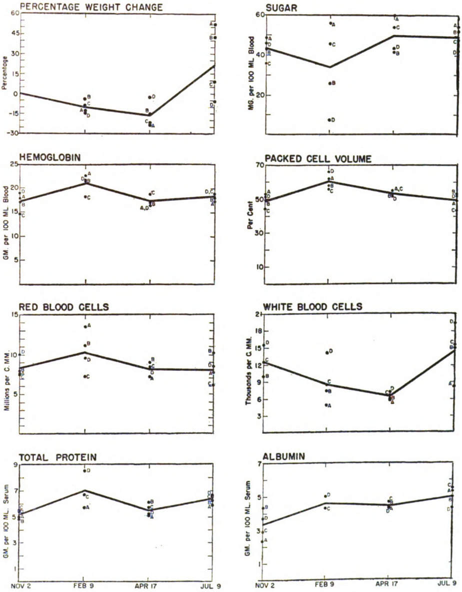

FIG. 1.—Graphs of factors varying with the seasons.

Electrophotometer using methods described in the Fisher Manual (1952). The results are presented in Table 1 and Fig. 1.

Physical changes noted seasonally.—Marked seasonal weight changes were observed in all four bears (Table 1, Fig. 1). A slight but progressive weight loss occurred during torpor. From 2 November to 9 February the mean weight loss was 9.4 per cent. Maximum and minimum percentage losses for this period were 14.1 and 3.4, respectively. Presumably these losses occurred during early dormancy since the bears were fed until denned.

By 17 April, the mean body weight loss increased to 15.6 per cent. The mean weight loss sustained by these bears during dormancy was actually even greater, since bear *D* emerged from dormancy 17 days before the April weighing and gained substantial weight. By February it had lost 14.1 per cent of its November weight, yet in April, doubtless because of its feeding after awakening, it weighed only 3 pounds less than it had in November. Weight losses for the remaining three bears over the November–April period amounted to 15, 22 and 23 per cent, respectively. These losses are considered minimal for torpid bears since the denning period was shortened by delaying denning for bears *B*, *C* and *D* by continued feeding until 23 December, and by disturbing the animals for handling in April.

These data indicate that non-parous black bears in this latitude, even though not true hibernators (Lyman and Chatfield, 1955), sustain overwintering weight losses of about 20 per cent during dormancy. A similar weight loss has been reported for the woodchuck (*Marmota monax*), a true hibernator, also dependent solely upon fat as its energy source during dormancy (Rasmussen, 1916).

Bear *D*, which emerged early from dormancy, sustained the largest weight loss between November and February. This may indicate that the physical condition in which bears enter the winter dens influences the duration and time of their emergence from dormancy. This is consistent with the theory advanced by Grinnell *et al.* (1937) which states that the length of the period of dormancy is regulated by the abundance or scarcity of food.

The weight loss of each bear was readily regained following dormancy (Fig. 1). By 9 July, the mean weight gain from the mean winter low was 55.7 per cent. Bear *A*, now 1½ years of age, gained an astounding 98.5 per cent during this period. While these data demonstrate a remarkable ability of bears to make large short-term weight gains where food is provided, it is improbable that such gains are realized by bears in the wild, since natural foods appear limited during this period (Erickson, 1957).

The July body temperatures of these bears were similar (Fig. 1, Table 1) and averaged 98.6°F. It is assumed that this represents the temperature norm during non-dormancy. During torpor, a temperature depression from 3 to 4 degrees apparently occurs, as indicated by the 95.3°F average February readings obtained for bears *A* and *B*. The two pulse determinations which

TABLE 1.—*Variations in hematology and physiology of black bears at four seasons*

BEAR	AGE and SEX	Wt, lb	HBG gm/100 ml	WBC 1,000/cmm	RBC million/cmm	TEMP, °F	PULSE	PCV %	SUGAR mg/100 ml blood	TOT PROT gm/100 ml serum	ALB gm/100 ml serum	GLOB gm/100 ml serum	PHOS mg/100 ml serum	CHLOR mg/100 ml blood	Dates
A	Juv ♂	90	17.8	–	7.88	102.6	–	52	49	5.0	2.4	2.6	4.0	320	2 Nov. 56
B	Yrl ♀	113	17.2	9.80	8.06	–	–	49	43	4.8	4.4	0.4	6.0	420	
C	Adl ♂	252	14.6	12.40	7.76	–	–	44	36	5.5	2.9	2.6	5.0	450	
D	Yrl ♀	128	19.0	15.40	10.00	–	–	51	46	5.4	3.7	1.7	6.7	375	
Avg.		146	17.2	12.53	8.43	–	–	49	44	5.2	3.4	1.8	5.4	391	
A	Juv ♂	79	22.7	4.95	13.50	95.9	144	62	56	5.7	–	–	1.9	410	9 Feb. 57
B	Yrl ♀	109	21.5	7.30	11.10	94.6	96	58	26	–	–	–	–	330	
C	Adl ♂	232	18.3	8.70	7.14	–	–	56	46	6.7	4.3	2.4	–	–	
D	Yrl ♀	110	21.7	14.10	9.59	–	–	66	–	8.5	5.0	3.5	–	–	
Avg.		133	21.1	8.76	10.33	95.3	120	61	42.7	7.0	4.7	3.0	–	370	
A	Juv ♂	69	16.6	5.90	7.13	–	–	55	60	5.1	4.4	0.7	5.0	500	17 Apr. 57
B	Yrl ♀	96	17.2	6.05	9.01	–	–	53	42	6.1	4.4	1.7	4.8	340	
C	Adl ♂	197	18.8	6.55	8.46	–	–	55	54	5.7	4.7	1.0	5.2	440	
D	Yrl ♀	125	16.6	7.00	8.21	–	–	51	44	5.2	4.3	0.9	6.4	360	
Avg.		122	17.3	6.38	8.21	–	–	54	50	5.5	4.5	1.1	5.4	410	
A	Juv ♂	137	17.3	8.20	7.75	98.8	122	49	54	5.9	5.3	0.6	8.3	300	9 July 57
B	Yrl ♀	161	18.0	15.00	10.17	98.4	176	53	52	6.2	5.0	1.2	9.1	660	
C	Adl ♂	289	19.0	15.50	6.06	98.6	134	43	48	6.5	5.5	1.0	7.9	420	
D	Yrl ♀	121	19.0	19.40	8.56	98.4	118	52	42	6.6	4.3	2.3	7.9	200	
Avg.		177	18.3	14.53	8.14	98.6	138	49	49	6.3	5.0	1.3	8.3	395	

could be made in winter (Table 1) yielded one low reading and one within the range of summer variations.

Hematological changes noted seasonally.—Although our data are too few to evaluate possible seasonal differences for all of the hematological factors involved for these bears, several were investigated sufficiently to demonstrate variations. The only marked deviations, however, occurred during early torpor.

At that time a substantial increase was noted for circulating erythrocytes, with corresponding increases noted for hemoglobin, packed cell volumes, and total protein. These same factors near the end of winter dormancy revealed values similar to those for non-dormancy (Table 1, Fig. 1).

Similar increases of circulating erythrocyte counts, hemoglobins and packed cell volumes during hibernation have been reported for the ground squirrel (*Citellus parryi*) by Svihla and Bowman (1952) and by Svihla *et al.* (1953), and for the golden hamster (*Mesocricetus auratus*) by Suomalainen and Granstrom (1955) and by Lyman *et al.* (1957). Rasmussen (1916) noted a slight increase in circulating erythrocytes for the hibernating woodchuck but a lower hemoglobin for animals in a semidormant state than for those in deep hibernation. On the other hand, Stuckey and Coco (1942) noted a 37.9 per cent decrease in circulating erythrocytes and a 25.7 per cent decrease in hemoglobin for hibernating ground squirrels (*Citellus tridecemlineatus*). The biological significance of these conflicting reports awaits explanation. The results noted in the present study indicate marked changes in these factors during early torpor and a shift back to non-dormant values in late torpor. The differences noted in the literature may be due to data having been taken at different times within the hibernating period. This would appear especially likely for animals which periodically awaken during hibernation.

The pronounced leukopenia noted for our bears during torpor (Table 1, Fig. 1) was reported in all of the previously cited works and appears to be characteristic of all true hibernators (Lyman *et al.*, 1957). Other blood determinations in this study, however, are difficult to interpret because of the variations exhibited or because of inadequate data.

Blood sugar is of especial interest. In two bears, blood sugar increased during torpor and in the other two it decreased. Previous blood sugar determinations for black bears (Youatt and Erickson, 1958) also showed considerable variation. Sugar determinations for these captives during summer were appreciably below those for wild bears. Presumably the latter's sugar values were inflated by energy-rich foods such as berries and fruits, available to them at this time. Varied blood sugar values have been reported for other species during hibernation, indicating this is a highly variable factor among hibernators (Lyman and Chatfield, 1955; Stuckey and Coco, 1942; Lyman, 1943). Lyman and LeDuc (1953) suggest that the reported differences in this factor may be due to differences in the habits of the animals. Thus, in those forms utilizing only fat for energy, such as the woodchuck, a much greater decline of blood sugar results than in those forms, such as the hamster, which periodically awaken to feed. The results of the present study tend to support this hypothesis and to place the bear in the category of semihibernators.

Although only one determination was obtained for blood phosphorus during early torpor, it possibly indicates that a marked decrease occurs at that time. Blood phosphorus levels during July were consistently higher than were the comparable values for November and April. Chloride determinations showed little seasonal variation.

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[A joint contribution of Federal Aid in Wildlife Restoration Project W-70-R, Cusino Wildlife Experiment Station, Michigan Department of Conservation, and of the Department of Fisheries and Wildlife, Michigan State University. Submitted by the senior author as a portion of a dissertation in partial fulfillment of the requirements for the Ph.D. degree at Michigan State University.]

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APPENDIX II.

TECHNIQUES FOR LIVE-TRAPPING AND HANDLING BLACK BEARS[1]

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Lack of adequate techniques for capturing and handling black bears (*Ursus americanus*) has handicapped previous efforts to obtain information on this species. This paper describes techniques developed at the Michigan Department of Conservation's Cusino Wildlife Experiment Station, in the Upper Peninsula of Michigan. Trapping was conducted principally in Alger and Schoolcraft counties, beginning in 1952 when one bear was captured. Four more were taken in 1953. Trapping activities were stepped up in the summers of 1955 and 1956, when 43 and 48 animals, respectively, were taken. During the course of the project 96 bears were handled 109 times.

TRAP TYPES

Bears were captured in several types of culvert traps (Figures 1 and 2), and in steel-spring traps (Figure 6). The most successful culvert traps were constructed of eight-foot sections of 36-inch steel culvert fitted with sheet-metal drop doors and open metal-grid backs (Figure 2, right). However, number 4½ steel-spring wolf traps proved more successful and economical for capturing bears than did the culvert traps.

[1]A joint contribution of Federal Aid in Wildlife Restoration Project W-70-R, Cusino Wildlife Experiment Station, Game Division, Michigan Department of Conservation and the Fisheries and Wildlife Department, Michigan State University.
Appreciation is extended to Mr. H. D. Ruhl, Chief, Game Division, Michigan Department of Conservation, and to Dr. G. A. Petrides, Associate Professor, Michigan State University, for encouragement and assistance during this investigation.
I am particularly indebted to Dr. S. C. Whitlock and Mr. D. F. Switzenberg. Without their enthusiasm and guidance this project would have had little chance for success. For help in preparation of the manuscript thanks are extended to R. A. MacMullan, Dr. C. T. Black and L. J. Verme.
To my many other colleagues who generously contributed time and assistance to the study, I offer my sincere thanks.

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Figure 1. Typical culvert trap set for black bears.

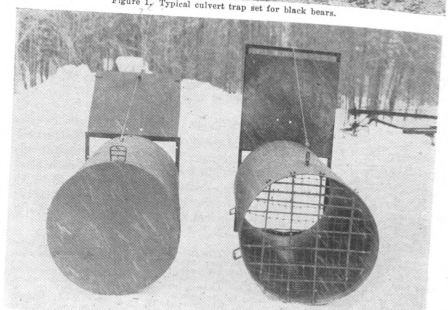

Figure 2. Rear view of two culvert trap types. At left: with hinged, swinging drop door, solid back and pull-pin trigger. At right: with sliding drop door, metal-grid back, and lever-type trigger.

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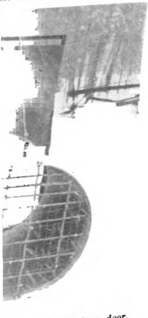
...for black bears.



...ed, swinging drop door, ...tal-grid back, and lever-

Culvert Traps. The first traps used in this study were similar to those designed by the U. S. National Park Service for capturing and moving nuisance bears. In order to reduce construction cost and increase mobility, they were not mounted on trailer frames as were the Park Service traps.

Traps six feet in length were less successful in capturing bears than longer eight-foot sections. The shorter traps were ineffective for capturing large bears, since these animals could reach the bait without entering the trap, and the falling door would strike them on the back, allowing their escape.

Sliding drop doors (Figure 2, right) proved more successful and reliable on culvert traps than hinged doors with locking mechanisms (Figures 1, 2 left, and 5). The latter would not lock if obstructed by foreign objects or the bear's body, were difficult to adjust because of the impact which accompanied the traps' closing, and were easily damaged when the traps were moved. Judging from tracks found around traps, bears were more suspicious of the over-hanging hinged doors than of the sliding type.

While these modifications were important, the nature of the trap back was of greater consequence in determining trapping success. Trap backs were either solid or an open metal grid (Figure 2). The open grid back was added to our traps in the fall of 1955. Its design was prompted by the activity of bears repeatedly visiting traps with solid backs, but refusing to enter them. Two bears, including a 425-pound male, were readily trapped when a grid back was substituted. It was likewise more successful in 1956 (Table 1). The greater success of the grid-back trap was probably due to better circulation of air carrying odors from the bait, clear visibility through the trap, and the opportunity to examine and smell the bait closely from the rear of the trap. Sign indicated that bears usually inspected culvert traps thoroughly before entering.

The most successful method of releasing trap doors was a lever trigger mechanism (Figure 3). By providing several points on the

TABLE 1. SUCCESS OF THREE TYPES OF BEAR TRAPS IN 1956[1]

Type of trap	Corrected[2] trap nights	Bear visits	Escapes	Captures	Per cent trap effectiveness per	
					Bear visit	Trap night
Culvert						
Solid back	91	6	0	1		
Open grid back	74	5	0	3		
Total	165	11	0	4	36	2
Steel spring	2,393	126	18	44	35	2

[1]Data from trapping nuisance animals omitted.
[2]Adjusted for capture of other animals and mechanical failure.

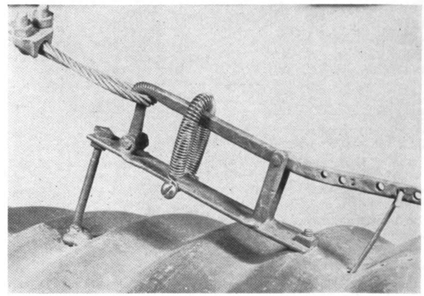


Figure 3. Lever-type trigger for culvert trap.

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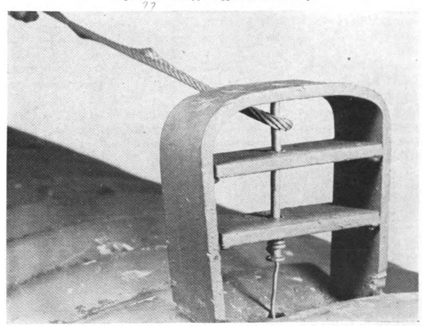

Figure 4. Pull-pin trigger for culvert trap.

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lever arm for attaching bait wires, it was possible to regulate the force necessary to release the trap door. A pull-pin trigger release (Figure 4) was less successful, since it did not allow adjustment, was harder to set, and was less reliable.

As the trapping program progressed, lighter but more efficient traps were constructed. Thus 14-gauge culvert metal and one-eighth-inch sheet metal replaced heavier stocks. Other weight-reducing features, such as an open-grid trap door, might be effectively incorporated in future designs. In the present stage of development culvert traps can be moved and set by two workers.

The original trap was constructed with both the sliding door and back constructed of 2-inch wood planking reinforced by steel rods. These traps were cumbersome, the doors warped readily, were slow in closing action, and often did not hold large bears.

Steel Traps. Bears were more economically and productively live-trapped with modified No. 4½ steel-spring wolf traps. The trap-chain was lengthened to 5 or 6 feet, all connecting links were welded, and a stronger toggle or drag was attached (Figure 6). An additional short-chained safety toggle has recently been added to these traps since the couplings of several single-toggle traps were broken by bears. The altered traps will hold most animals securely without serious injury. Considering the extreme ruggedness of a bear's paws, the lack of trap injury is not surprising. Bears weighing as much as 257 pounds have been captured and handled in these traps. Several bears were captured in smaller steel traps. Four cubs or yearling animals were obtained from bounty trappers using No. 3 and 4 traps. We have captured other cubs by setting these smaller traps near the site of and shortly after the capture of the mother. Three large nuisance animals were taken in No. 5 bear traps by predatory animal control officers. Even these caused little injury to the foot itself although one bear broke an ulna bone while fighting the trap.

Trapping Techniques

Selection of Trapping Areas. Trapping sites were selected primarily by the amount and kind of bear sign observed. These were most readily found by traveling old logging trails. On moderately improved roads an 8-foot section of railroad iron or a conifer treetop dragged behind a vehicle obliterated old tracks and facilitated the search for fresh tracks on subsequent days. Other signs such as trampled trails through grassy areas, scats, mauled stumps and logs, and broken limbs of fruiting trees and shrubs were useful in locating potential trapping sites

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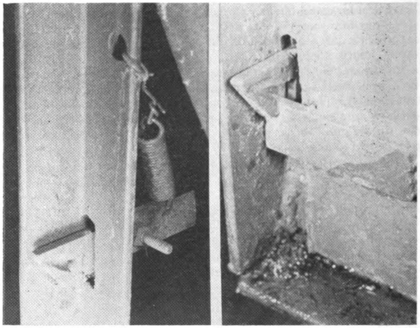

Figure 5. Latch for culvert trap; at left, with door open; at right, with door closed.

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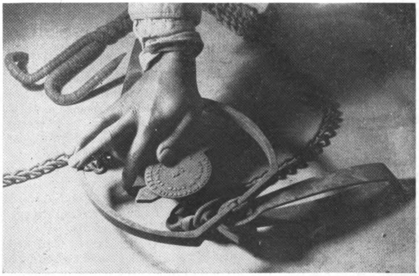

Figure 6. No. 4½ wolf trap with longer chain and larger toggle, for use on black bears. Man's hand indicates how a bear could prevent a trap from closing on its foot.

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Traps were commonly set in high-use natural feeding areas. Food sources resulting from human habitation, such as garbage dumps and apple orchards, were also frequented by bears and provided additional trap sites. Of the bears captured in this study, 92 were taken in wild areas, while only 17 were captured at artificial feeding areas. Many of the latter were trapped and moved as nuisance animals.

Natural feeding areas varied with the season. In the spring semi-open forest types, composed primarily of lush grasses, strawberries, and Juneberry (*Amelanchier* sp.) and other pioneer shrub species, seemed to have the higher populations. Abandoned homesteads and lumber camps, commonly interspersed throughout the area, were much frequented by bears at this season. Choice of summer habitat by bears was largely dependent upon the type and abundance of fruiting plants, largely shrubs or small trees. During the fall months trapping was most successful in areas containing abundant fruit crops, particularly black cherry (*Prunus serotina*). Abandoned apple orchards of homesteads and lumber camps were also frequently visited by bears during this season.

Trap Line Layout. Trap lines were either extensive, with traps set only at the most promising locations, or intensive, with a concentration of traps in restricted areas.

The extensive trap line was very successful since all sets were placed at relatively good sites. However, it had several disadvantages. Time to tend the line was materially lengthened, and vehicle operation and labor cost was increased. Also, trapped animals were held longer before being handled, increasing the possibility of injury or escape. Extending the trap lines also provided greater opportunity for theft of traps and damage to sets or animals by vandals.

Intensive trap lines were confined, whenever possible, to a geographic unit one township or 36 square miles in size. Some advantages of this system were early handling of captured animals, decreased time and cost of tending the line, and rather thorough trapping of definite areas to determine populations. Disadvantages resulted from placing many sets in sites of limited potential and the inaccessibility of many areas.

Specific set locations were indicated primarily by bear sign. Traps placed near evidence of recent activity were generally the most successful. This was especially true where bears repeatedly traveled a trail or path.

Setting Culvert Traps. These sets were most successful when they were somewhat concealed and well stabilized with the rear of the trap elevated, and with dirt spread along the trap floor and in front of the set. However, unless the traps were placed in shady locations, it was necessary to shelter them to keep the interior cool, and reduce the possibility of bears suffering from heat prostration. Bears were captured as readily in plain galvanized culvert traps as in those painted olive drab. However, the olive drab traps were less conspicuous and not as frequently molested by man. Four techniques insured best success in setting culvert traps.

(1) The trap mouth was faced in the anticipated direction of the bear's approach. Sets placed perpendicular and adjacent to game trails brought good results.
(2) Traps were stabilized to prevent their movement when entered.
(3) The rear of the trap was elevated, since bears appeared to enter a trap more readily if it was placed on an inclined plane.
(4) Dirt was spread both along the trap floor and immediately in front of the trap. This aided in determining if a bear visited the trap, and also appeared to lessen the animal's fear of the trap. The latter is possibly related to the noise or feel of walking on the galvanized metal.

Setting Steel Traps. These sets consisted chiefly of modified dirt-hole cubby sets (Figures 7 and 8). They were most successfully employed if the dirt-holes were dug beneath logs, stumps, etc., thereby restricting the animal's approach to a single direction. Where site conditions were less favorable, dirt-hole cubby sets were made by digging a slanting hole into a small knoll or side hill and placing small logs in a V-formation to form the cubby. Sets of this type were less successful since the bears frequently succeeded in stealing the baits by tearing the cubbies apart from the sides or rear.

Initial attempts at steel-trapping bears were largely unsuccessful because bears frequently missed stepping in the traps, set them off without capture, or were caught lightly enough so that they could free themselves. Because of the comparatively small size of the traps — 8½-inch jaw spread — the bear's broad paw, unless precisely placed in the center of the trap, could prevent the trap jaws from closing (Figure 6). This difficulty was largely rectified with guide sticks and a stepping stick (Figure 8). These devices did not alarm bears and served to assure accurate foot placement in traps. Six steps were used with good success for dirt-hole cubby sets.

(1) An inclining hole about 10 inches wide and 12 inches deep was dug with the removed earth spread near its mouth.
(2) Bait was then placed in the rear of the hole. Meat baits were securely staked.
(3) The trap was placed approximately 18 inches from the bait

and 4 to 6 inches to either side of the cubby's midcenter line. Unless the trap was offset in this manner bears often stepped astraddle it.

(4) Best success was obtained by placing the long axis of the trap-jaws parallel with the midline of the set. When placed perpendicular, a high percentage of traps were set off without captures. Apparently the closing jaws threw the bear's foot clear.

(5) Traps were firmly seated and a trap cloth added to prevent objects from getting under the pan. The trap and toggle were concealed with sifted earth so that the trap-pan was kept level with or slightly lower than the surrounding earth.

(6) The addition of guide and stepping sticks completed the set. These were about 1 inch in diameter, 12 inches long, and laid in box fashion around the trap-jaws. They were firmly placed to avoid being brushed into the set, with all but the stepping stick placed just outside the trap-jaws. The stepping stick was placed 2 or 3 inches ahead of the trap-jaws (Figure 8).

A variation of this trapping method consisted of concealing traps in loosened soil and scattering bait around the set. This worked very well for capturing cubs that were running free around a trapped female, as well as providing another alternative for capturing bears which were wary of cubby sets.

Scent was used at both dirt-hole cubby sets and in natural situations, usually on stumps or logs. Since bears seldom lingered in their investigations of scent, it was important that trap placement at scent sets be precise.

Trapping inefficiency due to the capture of other animals was reduced by setting traps to release only under heavy pressure. A spring, piece of sponge or rubber, or even a few folded leaves placed beneath the trap-pan served this purpose, provided room was allowed for the trap to release. Notching both the trap-pan sear and trigger-dog achieved the same result.

Baits. The most consistently successful bait used in live-trapping bears was fresh venison. Carcasses of lesser domestic and wild mammals and fish were less effective. Baited pits containing 15 to 10 pounds of fresh fish and offal were seldom eaten by bears. They were, however, frequently visited and occasionally wallowed in. Table garbage also provided an effective bait, as did anise-base commercial scent preparations.

Baits used with minor or negligible success were apples, peanut butter, molasses, and sorghum. Although honey is reputedly a pre-

Figure 7. Typical dirt-hole cubby set with trap in place prior to concealment of trap with earth.
with earth.

Figure 8. Completed dirt-hole cubby set. Note placement of bait and stepping and guide sticks.

ferred food of bears, it provoked only a mild response when used as bait.

Contrary to popular belief, bears showed a distinct aversion to eating putrid flesh. When baits became fetid or heavily infested with maggots they were not effective. During warm summer weather it was necessary to rebait traps every three or four days to insure good trapping success.

Bears became more difficult to trap as summer advanced and were attracted to only the best baits at that time. This was undoubtedly due to bears becoming increasingly selective of their food as natural foods became more abundant in late summer and fall.

Responses of bears to various baits lead me to suspect that many of the popular conceptions relating to preferred food of bears possibly result from abnormal feeding habits during periods of low food availability, particularly in the spring. Thus, certain foods instead of being preferred, as commonly thought, may in reality be only subsistence foods.

Effective baits for culvert traps were large chunks of meat weighing over 10 pounds. They not only were more tempting to the bears than smaller baits, but also allowed secure attachment of the trigger wire. Trigger mechanisms were adjusted to release when a heavy pull of 35 to 40 pounds of pressure was applied. To a great extent this eliminated the probability of small animals springing the traps.

Bears usually attempted to drag or carry off baits. They were seldom content to eat a meal, even when whole carcasses of deer were available, until they had moved them. This behavior necessitated staking baits used in steel-trap sets (Figures 7 and 8).

HANDLING TECHNIQUES

During this study bears were handled by two general methods. Animals captured in culvert traps were anesthetized with ether after the culvert had been converted into a relatively air-tight chamber. Those taken in steel spring traps were first securely tied and then administered ether or Halatal.[1]

In Culvert Traps. These traps were easily converted into anesthetizing chambers by caulking the door with cloths, and by banking with soil (Figure 9). The open metal-grid back was sealed by fitting the weighing canvas over the end of the trap and tightly securing it with a handling rope (Figure 10). Approximately 1 pound of ether was then sprayed into the culvert through a small hole in the trap door (Figure 9). A rapid and continuous application of ether resulted in a shorter

[1]Pentobarbital Sodium, a monosodium salt of ethyl (1-methylbutyl) barbituric acid; produced by Jensen-Salsbury Laboratories, Inc., Kansas City, Missouri.

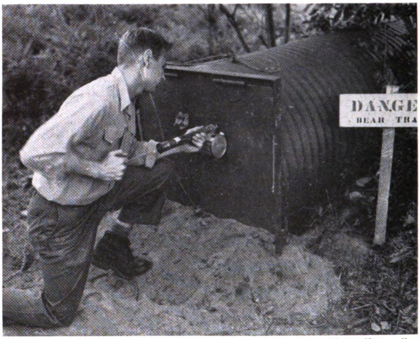

Figure 9. Spraying ether into sprung culvert trap to anesthetize captured bear. Note sealing of door with earth and cloths. Dark line down center of door is nasal discharge indicating that occupant is a bear.

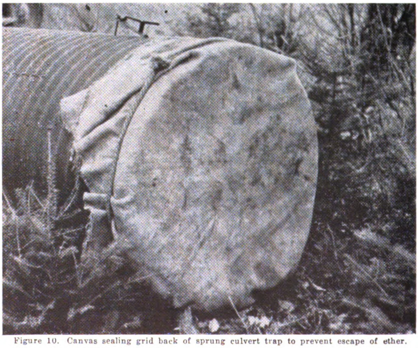

Figure 10. Canvas sealing grid back of sprung culvert trap to prevent escape of ether.

anesthetizing period. Since our culvert traps varied so in construction, their effectiveness as anesthetizing chambers varied. Consequently time required for sedation was not uniform, but approximated seven minutes on the average. When ether was correctly applied, bears went through the throes of violent muscular activity immediately before passing out. This reaction was practically the only indication that an animal was helpless. A strong light beam directed through the ether hole did not normally illuminate the trap enough to make the bear visible. Also, ether fumes generally prohibited close observation. Following the cessation of muscular activity, one to three minutes were allowed before the trap door was opened.

Initially, bears were continued under anesthesia by continued application of ether administered by means of an ether cone (Figures 11 and 12). This was a critical point, since too little ether allowed the animal to recover, while overdoses were likely to stop respiration. A good test for determining the degree of anesthetization was the appearance and reflexes of the eyes.

Administration of ether was either continued or stopped depending on the extent of these reflexes. In some instances overdoses of ether produced cessation of breathing. However, this was usually overcome by means of artificial respiration.

Ear-tagging and toe-clipping of bears under ether should be performed prior to their removal from the trap, since pain induced by these operations appeared to produce quick recovery from anesthetization.

In Steel Spring Traps. Bears in steel traps were handled by first placing a "choker" over the animal's head and then securely tying the legs with heavy rope. The choker is a pliable chain loop fastened to the end of a 6-foot length of pipe held by a T-handle (Figure 13).

When approached, bears usually backed to the limit of their trap chain. It was found advantageous for members of the handling crew to approach the bear simultaneously from several directions. This maneuver usually resulted in the bear's standing quietly, and thereby avoided the usual sudden lunges away from crews approaching from a single direction. Thus, the possibility of pulling out of the trap, or injury to the paw, was greatly reduced and placement of the choker on the calm or confused bear was facilitated.

Little difficulty was usually encountered unless the initial attempt to place the noose over the bear's head (Figure 13) was unsuccessful. The noose was twisted until it was just tight enough to hold the bear. If tightened too much, so that breathing was obstructed, even a docile animal would fight the handling operation. Once properly se-

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Figure 11. Placing ether cone on muzzle of bear; may be used on either culvert-trapped or steel-trapped bears.

Figure 12 Continued anesthetizing of culvert-trapped bear while placing tag on ear.

cured, the choker allowed one man to control the animal's head (Figure 14). Another crew member then grasped a rear leg, fastened a rope to it and secured it to a solid object, such as a tree (Figure 15). Unless the leg was secured in the first attempt the process became increasingly difficult, since the bear would withdraw its legs well under its body. The animal was then placed on its back, and additional ropes secured the remaining two legs.

Steel-trapped bears were then anesthetized with ether. (Later, when we became proficient in estimating weights, Halatal was substituted as the anesthetic). The ether cone was quickly clapped over the animal's muzzle (Figure 11) and forcibly held in place while ether was applied. Again, this procedure became increasingly difficult and dangerous unless correctly performed at the first attempt. A slow spraying of ether into the nose, prior to fitting the cone, appeared to deaden the animal's reflexes, and rendered this operation less difficult. The animal usually quieted within a minute or so after ether was sprayed into the cone, and within five minutes anesthetization was complete. Recovery was rapid; within five minutes bears usually became active.

Evaluation of Halatal. Although there is a great safety margin inherent in ether compared to other anesthetics, greater success and increased safety followed the use of Halatal. Injection of Halatal in the inguinal region of the peritoneal cavity (Figure 16) eliminated the dangerous operation of fitting the ether cone to the bear's muzzle. Although more rapid results could be obtained by intravenous injection, this technique was impractical because of the difficulty in locating veins and our limited opportunity to work freely about the animals. Halatal was used with equal facility on both steel-trapped and culvert-trapped animals. It was essential, however, that culvert-trapped bears initially knocked out with ether be contained in the traps during the interval in which ether was removed and Halatal took effect.

Effective anesthesia was produced using one cubic centimeter of Halatal solution, which contains one grain of Pentobarbital Sodium, for each 5 pounds of body weight. Complete sedation was achieved in approximately 11 minutes (Table 2). Injection of Halatal was best achieved with a large syringe and hypodermic needle. A 20 to 30 cubic centimeter syringe was easily handled in the field and was of sufficient capacity to anesthetize most animals with one application. Eighteen-gauge needles were better than smaller sizes. Less resistance was met in injecting the anesthetic, and it could be administered more rapidly. This was important since a quick movement of the animal might free the needle, and result in only a partial dose being ad-

Figure 13. Placing "choker" over head of steel-trapped bear.

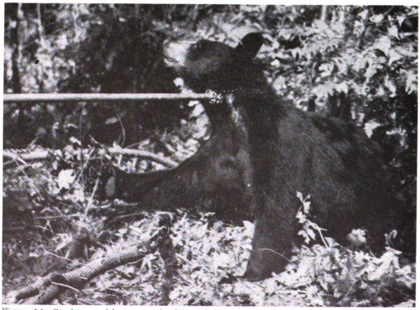

Figure 14. Steel-trapped bear restrained by "choker." Handling crew can now grasp rear legs.

TABLE 2. HALATAL AS AN ANESTHETIC FOR BEARS

	Number	Actual dosage[1] (average pounds per cubic centimeter of Halatal)	Time to produce sedation (minutes)	Recovery time (hours: minutes)
All animals handled:				
Males	13	5.66	10.6	
Females	19	5.38	11.2	
Both sexes	32	5.50	11.0	
Animals observed till recovery was complete:				
Males	5	6.19	11.6	2:29
Females	10	5.11	8.7	3:29
Both sexes	15	5.47	9.5	3:09

[1]Computed after weights were determined.

ministered. Since the remaining portion was usually lost there was no way of determining the amount actually delivered.

The major objection to the use of Halatal was the necessity of making accurate weight estimates of bears for computing dosages. Underdoses prolonged sedation periods, while overdoses were fatal. A distinct source of dosage error was the fact that bears were often exceptionally fat. Estimates of body fats should not be included as weight in dosage determinations. Injecting Halatal into muscle or fat deposits was avoided, since the sedative is released into the circulatory system much more slowly from such tissues. Faulty administration, rather than an underdose, was suspected if sedation did not occur in a reasonable period. Workers are cautioned to administer additional Halatal only in small amounts.

A distinct advantage of Halatal over ether, in addition to increased safety for the handlers, was that bears could be worked on at leisure once anesthetized. Halatal solution administered at the prescribed rate remained effective approximately three hours (Table 2). Since the animals were completely narcotized, they could be readily examined and transported if necessary. Additional amounts could safely be injected to keep them out as long as necessary.

Bears were weighed in a heavy canvas sling raised by a hoist on the back of a pickup truck (Figure 17). A dial scale accurate to one-half pound was used to determine weight. Small bears were weighed with a scale suspended from a pole supported by two men.

MARKING BLACK BEARS

Bears were primarily marked with metal ear tags (Figures 12 and 18) and secondarily by toe-clipping. Based on the inspection of 28 bears previously ear-tagged, little evidence was found that tags would not remain permanently. It therefore appears that auxiliary marking by toe-clipping is unnecessary.

Figure 15. Placing steel-trapped bear on its back and securing it with ropes, preparatory for anesthetization.

Figure 16. Administering Halatal anesthetic.

The ear-tags used to mark bears were the Fretz cattle tag manufactured by William, Cooper, and Nephews of Chicago, Illinois. They were attached with tagging pliers to the leading edge of the ear, approximately 1½ inches above the skull (Figure 18). Some difficulty was experienced in making tag attachments because the ear is rather thick and vascular. Tagging pliers, properly gapped, with sharply honed cutting edges, resulted in the most satisfactory applications. Applied tags were inspected to make sure that they were well crimped, squarely attached, and free from protruding edges which might cause irritation. A tag properly attached also provided space between the tag and ear surfaces. Some space was also left between the end of the tag and the edge of the ear, since some initial swelling, and additional growth in young animals, was expected.

Toe-clipping was performed by removing toes either at the first or second joint. Both served well for identification, but the latter resulted in profuse bleeding and was discontinued. It was also easier to perform distal joint amputations. A sharp pen knife or scalpel inserted just behind the toe-nail resulted in quick removal. Unless a great number of bears are to be marked we recommend that toe-clipping be restricted to rear feet, since the forefeet are used extensively in acquiring food. This should also result in fewer losses of identification, since bears frequently lose front toes when captured in steel traps.

REACTIONS OF BEARS TO TRAPPING OPERATIONS

Bears exhibited little evidence of trap shyness, except in areas trapped intensively. Six of fifteen recaptures were made within two weeks of initial capture and in the same trap types. However, track signs around sets indicated that individual animals became somewhat trap-wise. This was difficult to determine around culvert traps, since many bears, even in areas being initially trapped, would approach the trap without entering. In the case of steel traps, however, track signs indicated that some bears cautiously checked the sets from the side or rear, instead of approaching directly. Meat baits were occasionally stolen by these animals, but several were captured by placing well concealed steel traps at these locations. Trap wariness was attributed to previous encounters with our traps. Even these individuals exhibited little fear of recent human activity. White signs, intended to protect persons from both the traps and trapped bears, and placed within a few feet of all sets, failed to frighten bears away from sets.

The behavior pattern of trapped bears was decidedly different from the expected. Those taken in culvert traps, particularly with solid backs, were seemingly indifferent to capture. Some were ob-

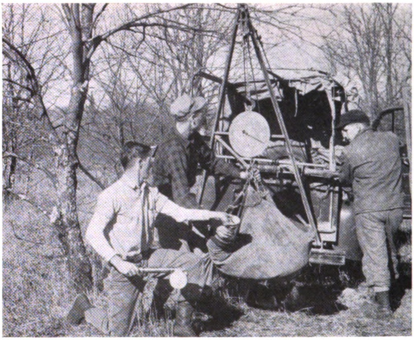

Figure 17 Weighing anesthetized bear using detachable hoist mounted on truck.

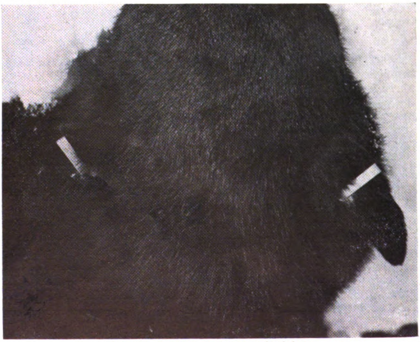

Figure 18. Location of ear tags on black bear.

served standing or sitting in the trap, but most were apparently asleep, lying on their backs with heads and forepaws resting on their chests. Seldom was an attempt made to fight the trap even though the handling crew worked noisily about. Even pounding on the trap back and door did not elicit a response. This was frustrating to the handling crew as it was often difficult to determine if a sprung trap actually contained a bear. In most cases it was possible to observe the animal by directing a light through the small ether hole. In others the animal could be detected by an odor peculiar to bears and by a nasal discharge running from the ether holes in the door (Figure 9). The presence of deer- and horseflies was also evidence of a capture.

Steel-trapped bears were more excitable than those in culvert traps, possibly because they were in some pain, were able to move about to some degree, and could observe the handling crew. However, the majority were docile, providing a minimum of resistance during handling. Some were completely resigned to capture, often rolling on their backs at the approach of the handling crew. Others snorted and rapidly champed their teeth when approached. Only three animals handled were exceedingly aggressive. One of these was a female protecting a captured cub.

Contrary to popular opinion most female bears did not display strong maternal protective instinct, and quickly abandoned cubs when danger was imminent. In only three of ten cases was the female detected in the vicinity where cubs of the year had been captured. Two of these mothers attempted to drive off the handling crew by rushing forward, snorting and rapidly champing their teeth. At no time did they approach closer than ten feet. A particularly aggressive charge could be terminated by making a great deal of noise, particularly loud shouting, which seemed to unnerve the animal. In one instance the protective instinct was useful in capturing a protecting mother. Traps were placed along the route upon which she alternately charged and retreated. After several rushes the animal was caught. Although some cubs seemed to be definitely abandoned, a few apparently abandoned cubs captured in traps were later recovered with the mother, indicating that some females were skulking in nearby cover during the handling of the young.

An interesting observation on trapped females was their allowing young to suckle. This was at first perplexing to us for although teats often indicated a nursing condition lactation could not be demonstrated, and cubs could not often be seen. It was later observed that cubs were masking evidence of lactation by frequent nursing and then running off when disturbed.

Mortalities and Accidents to Trapped Bears

Mortalities of bears live-trapped in this study included the loss of two during anesthetization, one strangled in handling, two from heat prostration, two shot while in traps by hunters, and a cub which was killed and eaten by another bear. In the latter case, conclusive evidence of cannibalism was found from bear hair in feces voided by the killer bear while it was temporarily captured upon its return to the trapping site the following evening. Carcasses of two other bears, killed as nuisance animals, were eaten by bears during the spring period. Extreme hunger appears to be the motivating force in this cannibalism, since seven bear carcasses set out during the fall when other food was abundant, remained untouched.

Accidents to trapped bear included four cubs suffering broken metapodial bones when taken in steel traps. Subsequent recapture of two of these indicated that the fractures had healed rapidly. Three other cubs and a large male, caught in a No. 5 bear trap, suffered either a broken radius or ulna bone, or both. Recovery of three of these revealed that in two instances the fractures had mended satisfactorily. One cub had amputated a paw.

Two trapped bears had broken the mandibular suture of the lower jaw. The breaks were repaired with brass bolts, and the animals completely recovered within two weeks. Other bears were found with various injuries not incurred as a result of our trapping. Rapid recovery from these injuries indicates that the bear is very capable of withstanding infection. It likewise suggests that crippling loss from such injuries and wounds may be low.

Trapping Costs

At this stage of the study it has cost $96.85 to trap each bear. This included all expenses—wages, vehicle operation and maintenance, trap and equipment purchase, and baits. Subsequent trapping should materially reduce this figure, since the cost of equipment on hand can be prorated over a greater number of animals.

The average cost of culvert traps constructed at Cusino was $85.97, of which materials constituted $70.41 and labor $15.56. However, inexpensive prison inmate labor was employed for much of this work. A welder and helper worked approximately eight hours to construct each trap. Since these were pilot models requiring considerable experimentation during building, it is expected that future construction costs will be materially reduced.

Steel wolf traps used in this study were purchased at a cost of $108 00 per dozen, or $9.00 each. Materials and labor to fit toggles to traps increased this cost by approximately $1.00. In addition to costing only a fraction as much as culvert traps, steel traps have several practical advantages. They are easily handled, can be set in greater numbers and in a greater variety of situations, work well with a greater range of baits, and can be easily cleaned and camouflaged. However, culvert traps are capable of capturing larger bears than steel traps, and although frequently molested by man, have never been stolen. Furthermore, animals in culvert traps are rarely injured or lost, while this possibility is ever present with steel traps.

SUMMARY

Techniques are described as developed in Michigan for live-trapping, handling, and marking 96 black bears.

Bears were captured in several types of culvert traps and in number 4½ steel-spring wolf traps. The latter proved the most economical and practical.

The most successful culvert traps were constructed of 8-foot sections of 36-inch steel culvert. They were fitted at the back with an open metal grill, and at the front with a sliding drop door. A lever trigger mechanism, adjustable for force necessary to release the door, proved the best of several types.

A large piece of unspoiled venison over ten pounds in weight proved to be the most successful bait. When baits became fetid or infested with maggots they were not successful. Fish and a number of other baits were tried with negligible success.

Handling techniques varied according to the type of trap in which the bears were captured. Those taken in culvert traps were anesthetized with ether after the trap had first been rendered airtight. They were initially calm, and then went through a muscular excitation phase, the termination of which indicated an anesthetized condition. They were continued under anesthesia with ether administered via an ether cone, or by an intraperitoneal injection of Halatal. The latter rendered a bear helpless in about 11 minutes.

Bears captured in steel traps were handled by first placing a chain loop, at the end of a 6-foot section of pipe, over the animal's head and twisting it down snug. The bear's head could then be controlled by one man while another fastened ropes to the hind legs. The ropes were then secured so that the bear was tied belly up in a spread-eagle fashion. Ether was administered via the ether cone, a somewhat dangerous procedure, or the animal was given a shot of Halatal in the peritoneal cavity.

All bears captured were marked with metal ear tags. Some were

also marked by toe-clipping. Evidence now indicates that metal ear tags are a reliable marking technique.

Accidents to bears were few. Five bears were killed during 109 handlings of the 96 animals. Most of these losses occurred early in the program during development of techniques.

Average cost of each bear trapped in this study was $96.85. Future trapping costs will be lower as the cost of construction and purchase is prorated over the years.

DISCUSSION

MR. BOB COONEY [Montana]: This was a very interesting paper. We intend to get into grizzly bear work pretty intensively in Montana in the next several years and will probably be doing some marking at t[illegible] time. There are some phases we are rather apprehensive about. More particularly, we have to get our traps into the wilderness where the bears are. I was wondering why you didn't mention toe-clipping to a greater extent. You mentioned the indication of tracks from toe-clipping.

MR. ERICKSON: We have marked bears by toe-clipping and thought we could identify their movements from track sign. It was found, however, that unless you have a perfect situation for observing tracks such identification is difficult. As a marking technique we have found toe-clipping of bears to be unreliable through loss of identification. As we have a terrific amount of bounty trapping in the area we work, and in the State as a whole, many bears lose toes. Many have lost toes previous to our getting them. If toe-clipping is to be performed we recommend it be confined to the rear feet for two reasons. First, as the bear uses its front paws extensively in acquiring food, this would not detract from its capacity for obtaining food. Secondly, rear-toe-clipping would alleviate to some extent the losses of identficaitoin as few bear lose toes from their rear feet.

MR. HUGH BLACK [New York State]: Would you care to comment on the difference you found between trapping males and females?

MR. ERICKSON: We have found great deviations from the fifty-fifty sex ratio in our trapping operations.

Culvert traps appear to be selective of males in our population. We have trapped bears associated with dumping locales as well as wild animals. Those taken at dumping locations were caught in the ratio of five males to one female. Wild trapped animals occurred in the ratio of only two males to one female. This is in comparison of all sexes and age classes.

These results indicate culvert traps to be selective toward males. They further indicate that bears foraging at dumps are primarily males. Of course, our figures are not extensive enough at this time to be but tentative.

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APPENDIX III.

THE AGE OF SELF-SUFFICIENCY IN THE BLACK BEAR

BY ALBERT W. ERICKSON

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THE AGE OF SELF-SUFFICIENCY IN THE BLACK BEAR[1]

Albert W. Erickson

Cusino Wildlife Experiment Station, Shingleton, Michigan[2]

The age at which young game animals become self-sufficient is little known. Yet this can be important in game management. A hunting season which permits killing the mother before the young become self-reliant necessarily results in the loss of her young as well. Transplanting young animals may be more practical than moving adults, providing the young are self-sufficient. For example, it may be quite easy to capture the young of species difficult to trap or handle as adults. Also it may be desirable to transplant animals exhibiting strong homing tendencies before this characteristic expresses itself. Several of these considerations are important in management of the black bear (*Ursus americanus*) in northern Michigan.

This paper reports experiments to determine whether black bear cubs 5 to 8 months old can survive by themselves in Michigan's Upper Peninsula when released from the steel traps of predator trappers or when orphaned by hunters. Many dams apparently abandon trapped cubs (Erickson, 1957); and Michigan's early bearhunting season, traditionally open September 1, is responsible for some orphanned cubs.

METHODS

To determine whether cubs deprived of their mothers could survive, I released certain cubs (experimental animals) far enough from their point of capture to insure that they would not find their mothers. I then released others (controls) at the point of capture, presumably to return to their mothers. The proportion of these cubs recovered subsequently (by hunters and my own live-trapping) indicated the comparative survival. Recoveries 2 weeks or longer after release were considered adequate evidence of sulf-sufficiency. As a further test I released cubs on "bearless" islands in Lake Michigan where survival over winter was considered proof of self-sufficiency.

In the summers of 1955–57, 23 experimental cubs were released in Michigan's Upper Peninsula—20 (12 males, 8 females) on the mainland in Alger and Schoolcraft Counties, in moderately good to excellent bear range, and 3 (2 males, 1 female) on Poverty and Big Summer Islands in Delta

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[1] A joint contribution of Federal Aid in Wildlife Restoration Project W-70-R, Cusino Wildlife Exp. Sta., Game Division, Mich. Dept. of Conservation, and the Fisheries and Wildlife Dept., Mich. State University, submitted as a portion of the dissertation in partial fulfillment for the Ph.D. degree at Mich. State University. I am grateful to the many persons who contributed time and assistance to this study; to David Arnold and John Chriske of the Mich. Dept. of Conservation, for assistance rendered in transporting and studying cubs released on islands; to Prof. George A. Petrides of Mich. State University, for helpful advice, criticism and review of the manuscript; to Dr. C. T. Black of the Mich. Dept. of Conservation for editing and review of the manuscript.

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County. In the summers of 1956–57, 12 control cubs (8 males, 4 females) were released on the mainland. Nine of the experimental animals were obtained from coyote bounty trappers, 3 from persons illegally holding captives, and 11 were live-trapped. Eleven of the control cubs were live-trapped for the study and the other was captured by accident in a coyote set.

In order to prevent experimental cubs from rejoining their mothers, they were released in areas remote (up to 175 miles) from their points of capture. My previous experience with the movements of live-trapped bears indicated that even the two cubs released nearest to point of capture (about 4 miles) were not likely to rejoin their mothers. Actually the mothers of five were dead. Control cubs were released where captured. In 10 cases the mother was seen to accompany the cubs. Fresh sign indicated that the mother was also present at the other two releases. Metal ear tags marked both control and experimental animals.

Extreme dates of release of the experimental cubs were July 6 and September 29; of controls, June 21 and September 22. If we assume that the released cubs were born about February 1 (Seton, 1929; Aldous, 1937; Burt, 1948; Matson, 1954), their ages ranged between 5 and 8 months at time of release. My only two records for parturition are for the last week of January and February 14. I believe that the assigned ages (Tables 1, 2) are accurate to about two weeks.

At the time of release, the cubs varied markedly in size and physical condition. Weights of the 23 experimental cubs ranged from 18 to 81 pounds (average 31); the 12 control cubs, from 18 to 44 pounds (average 27). The weight difference between experimental and control animals was due, for the most part, to my holding seven test cubs briefly as captives before release. Since captives were provided with ample food, they made substantial weight gains. One retained for 3 months increased from 12 to 81 pounds. Exclusive of captives, 16 test

TABLE 1.—RELEASES AND RECOVERIES OF 20 BEAR CUBS RELEASED ALONE[1]

Estimated Age (months)	Sex	Weight at Release (pounds)	Date of Release	Time Lapse until Recovery (days)	Manner Recovered	Distance Transferred (miles)	Remarks
5½	F	25	7/15/57	88	Shot	17	Lacerated foot; orphan; held 6 days
6	M	39	7/20/57			49	Amputated foot; held 19 days
6	F	27	7/21/57			19	Orphan
6	F	21	7/23/56	117	Shot	15	Lacerated foot
6	F	20	7/30/57			176	Amputated foot
6	M	39	8/ 5/56			4	
6	M	25	8/ 6/56	102	Shot	14	
6	M	29	8/ 9/56			119	Amputated foot; held 61 days
6½	M	25	8/15/56			4	Fractured mandibular suture; held 15 days
6½	F	26	8/18/55			36	
7	F	19	8/22/57			15	Orphan
7	M	18	8/22/57			15	Orphan
7	M	20	8/22/57			15	Orphan
7	M	18	8/23/57	47	Shot	165	Amputated hind foot
7	M	38	8/26/57			12	
7	M	35	8/30/57	17	Live-trap	38	
7	M	26	9/ 6/56			8	
7½	M	81	9/19/55	391	Shot	100	Amputated foot; held 3 months
8	F	34	9/20/56			58	
8	F	45	9/29/56	54	Shot	35	

[1] Three cubs released on islands not included.

TABLE 2.—RELEASES AND RECOVERIES OF 12 BEAR CUBS RELEASED WITH THEIR DAMS

Estimated Age (months)	Sex	Weight at Release (pounds)	Date of Release	Time Lapse until Recovery (days)	Manner Recovered	Remarks
5½	M	18	6/21/57			
5½	M	18	6/21/57			
6	M	22	7/26/56			Lacerated foot; retrapped 8/8/56 but not considered in this analysis
6	F	25	7/26/56			
6	M	25	8/ 9/57			Lacerated foot
6	F	24	8/10/56			Lacerated foot
6½	M	27	8/13/57			Lacerated foot
6½	M	22	8/14/56	95	Shot	
6½	M	26	8/14/56	95	Shot	
6½	M	29	8/17/56	348	Retrapped	Lacerated foot
7	F	38	8/27/56	82	Shot	Broken radius and ulna; fracture mended when recovered
7½	F	44	9/22/57			Fractured leg

cubs averaged 27 pounds, or the same as the controls.

Physical injuries to cubs in the study were frequent. Five experimental animals suffered foot amputations; two had foot lacerations and one a broken jaw (fractured mandibular suture). The controls included five with lacerated feet and two with broken legs. Steel traps inflicted the foot and leg injuries. The foot amputations were necessitated by complications, arising from minor injuries, resulting from infrequent inspection of traplines by bounty trappers. In my own experience, steel trapping is not unduly injurious if one inspects his traps often. The jaw fracture apparently occurred when the cub struggled to free itself from the trap.

MAINLAND RELEASES

About one-third of the cubs were recovered, whether released on their own or in company with their dams. Of 20 experimental cubs released on their own in Alger and Schoolcraft Counties, 7 were recovered, 6 during the fall following release and 1 the second fall after its release (Table 1). The proportion of returns from control cubs released with their mothers nearby (4 of 12) was quite similar (Table 2). Three of these cubs were recovered the fall after release, and one the next summer. Recovery intervals ranged from 17 to 391 days following release, and averaged 116 days for test animals and 155 days for controls.

The fact that over a third of the test cubs were recovered is significant evidence that they survived and were self-sufficient to a considerable degree. Their recovery at about the same rate as the controls indicates that cubs of this age may survive by themselves as well as cubs accompanied by their mothers. Even the youngest and smallest cubs managed to survive. Three test cubs recovered were among the youngest released (Table 1). One cub weighed only 18 pounds when released, yet weighed 35 pounds when recovered 6 weeks later. Cubs of either sex appeared equally self-reliant (Tables 1, 2). Returns were obtained from 3 of 8 female test cubs, as compared to 4 of 12 males. Both males and females occurred among recoveries of even the youngest cubs.

A significant finding was that physically-handicapped cubs survived almost as well as cubs in good physical condition (Tables 1, 2). Among test animals, there were recoveries for 4 of 8 injured cubs as against 3 of 12 uninjured. Among the controls, two recoveries each resulted from seven injured and five uninjured cubs, respectively.

Test cubs also were able to adjust to unfamiliar environments. All had been removed from the area of their capture. Recoveries resulted from 4 of 9 which were transferred 35 to 176 miles (average 75), and from 3 of 11 transferred only 4 to 19 miles (average 13).

Thus it appears that black bear cubs of either sex may be self-sufficient when as young as $5\frac{1}{2}$ months and as small as 18 pounds even though almost incapacitated by physical injury and released in unfamiliar range.

ISLAND RELEASES

The Islands

Poverty Island, five miles offshore, is about 320 acres in area and has poor soils and numerous rocky outcrops and bluffs. Its fauna is sparse but includes several mice and the snowshoe hare (*Lepus americanus*). Deer (*Odocoileus virginianus*) are absent. The flora probably is representative of the poor soil portions of the Upper Peninsula mainland before widespread, intensive browsing by deer. Vegetation is predominantly white cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*), with striped maple (*Acer pensylvanicum*) and a dense stand of American yew (*Taxus canadensis*) in the understory.

Big Summer Island, 2 miles offshore and about 3 square miles in size, in places has fairly good soil. There are fewer rock outcrops and no high shoreline bluffs. Few mammals occur on the island but deer are present. Unlike Poverty Island, it has little ground cover. Deer have eliminated the yew, severely browsed many deciduous plants, and in many areas killed even balsam fir. The dominant forest is white cedar and balsam fir, except for white birch (*Betula papyrifera*) and sugar maple (*Acer saccharum*), and some beech (*Fagus grandifolia*), quaking aspen (*Populus tremuloides*), and yellow birch (*Betula lutea*) in the center of the island.

On both islands important fruit-producing plants such as strawberries (*Fragaria* sp.), raspberries (*Rubus* sp.), juneberry (*Amelanchier* sp.), and pin and black cherries (*Prunus pensylvanica* and *P. serotina*), utilized heavily by bears on the mainland, are scarce and of poor quality. Because of this, I felt some apprehension over the suitability of the islands for the tests.

The Releases

We released 3 cubs, a 33-pound male about $5\frac{1}{4}$ months old on July 6, 1956, on Poverty Island, and a male and female, each 32 pounds and about $6\frac{1}{2}$ months old, on August 25, 1956, on Big Summer Island. Shortly thereafter a coyote trapper removed the male of the latter release to the mainland.

In early July, 1957, I revisited the islands and found ample recent sign of both cubs. On July 15, the cub on Poverty Island had to be shot because it was molesting a U.S. Coast Guard dwelling. At that time, it weighed 74 pounds and was in excellent condition.

It is possible that the Poverty Island bear obtained some food from refuse discarded by three guardsmen stationed there part of the year. This could not have been much, and I believe that the guardsmen complied with our request not to feed the animal. There was no human habitation of Big Summer Island. A possible food source on both islands may have been fish and other refuse washed onto the shores, but I saw none at the times of my visits. Numerous gulls frequenting the shores would certainly compete for such food.

The successful establishment of cubs on these islands provides further evidence that cub bears $5\frac{1}{2}$ months of age and older, irrespective of sex, are self-sufficient. A further point of significance is that we had raised both cubs in captivity. They had survived in a habitat judged inferior because of the limited availability of foods commonly considered staples for bears, and despite a lack of previous experience in foraging for food.

SUMMARY

The self-sufficiency of 23 cub bears ranging from $5\frac{1}{4}$ to 8 months of age was tested in the Upper Peninsula of Michigan. On the mainland, 20 test cubs were released at points remote from their mothers and 12 control cubs were released with their

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mothers. Three test cubs were released on Lake Michigan islands devoid of bears.

One third of the cubs released on the mainland were recovered and two cubs released on islands survived the winter. Cubs released alone survived as well as cubs released with their dams. Both sexes survived equally well, and several cubs survived alone despite serious injuries. Black bear cubs of either sex may be self-sufficient when as young as 5½ months and as small as 18 pounds, even though handicapped by physical injury and released on unfamiliar range.

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