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A Population Study of the Rocky Mountain Bighorn Sheep (Ovise Canadensis canadensis Shaw) on Wildhorse Island

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A POPULATION STUDY OF THE ROCKY MOUNTAIN BIGHORN SHEEP (*Ovis canadensis canadensis* SHAW) ON WILDHORSE ISLAND

by

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INTRODUCTION

The decrease in numbers of bighorn sheep in the United States has been described by Seton (1927) and Jackson (1944). Although less than a century ago these animals were abundant west of the 100th meridian, today they are comparatively rare. Most of those who have studied bighorns including Mills (1937) and Packard (1946) partially attribute recent depletion to low productivity or poor survival of lambs. A major objective of the present study was to quantitatively determine the annual increment and loss in a small isolated sheep population. To accomplish this an attempt was made to mark all lambs at birth. Precise counts were then periodically made of the lambs and also of the entire adult population.

This study was carried on under the direction of the Montana Cooperative Wildlife Research Unit with the cooperation of the Montana Fish and Game Department. Funds were supplied by the Wildlife Restoration Division of the State of Montana Fish and Game Department. During the course of this study I received invaluable assistance from many persons, only a few of whom I can mention here. Foremost among these were Dr. Philip L. Wright and Dr. John J. Craighead under whose direction the study was carried out and who gave counsel and assistance in all phases of work. I am also grateful to the following persons without whose aid I could not have carried out this

program. Dr. E. L. Cheatum, Mr. Robert Lambeth and Mr. Lloyd McDowell helped decide primary objectives of the study and then contributed efforts to get the project underway. Professor Melvin Morris and Mr. Lowell Adams provided valuable advice regarding editing of the manuscript. Dr. Ludvig Browman, Mr. Robert Cooney, Mr. Faye Couey and Dr. Joseph Krammer provided many useful suggestions. Dr. LeRoy Harvey identified over 100 plant specimens and Dr. Royal Bruce Brunson identified the land snails collected from the island. Mr. Barnet owner of Wildhorse Island permitted me to carry out the study there. The Thain and Ernest White families provided many practical helps. Mr. Raleigh Smedley of the Western Montana Council of the Boy Scouts of America provided my wife and me with comfortable quarters on Melita Island during 1953. Mr. and Mrs. Harold Wyman were gracious in providing much of the care and expense necessary to keep a foster lamb. My wife, Lorretta, was helpful in many ways.

THE STUDY AREA

Time and place of study. The sheep population studied is located on Wildhorse Island in Flathead Lake, Montana. About three days a week were spent on the island between June 29 and August 4, 1951. Full time field work was carried out from April 1, 1952 through July 15, 1953. Four visits ranging from two to eight days in length were made to the island during the spring and summer of 1954.

General description of island. Wildhorse Island is about two miles wide and three miles long and comprises approximately 2,500 acres. Its high point is 900 feet above the lake which has an elevation of 2,893 feet above sea level. The island is essentially a homocline of green argillite having a dip angle of 25° in an E.N.E. direction. Soils are of glacial origin. There is little level surface on the island. The annual rainfall for the island and mainland is about 14 inches and the average growing season is 135 days according to the Yearbook of Agriculture (1941). Temperatures ranged from minus 27° F. to 105° F. over a 23 year period. The north half of the island is covered with yellow pine, Pinus ponderosa, and Douglas fir, Pseudotsuga taxifolia. Other trees particularly Juniperus scopulorum, Populus trichocarpa and Cartaegus spp. are found along all the shores. The south facing

Plate 1

View of a south slope of Wildhorse Island
taken in April 1953
from Melita Island - two miles to the south

Ear ribbon on one of several lambs
which were marked soon after birth and never seen again.

slopes (Plate 1, upper) are palouse prairie and include Agropyron spicatum, Poa secunda and Festuca scabrella. However, Bromus tectorum forms a disclimax to these native bunch grasses on most of the prairie.

Date _____ Time first seen ____ T. hrs. obs. ____ Man hrs. S. ____ E. ____ T. ____

Group symbol

Ewes			Lambs			Yrlgs.			Rams					Un-	Agg.
M.	I.	T.	U.	M.	T.	♂	♀	T.	5yr.	4yr.	3yr.	2yr.	T.	known	T.

Feeding etc. time:

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
B. grass																			
C. grass																			
Blue grass																			
Browse																			
Forb																			
(																			
(																			
(																			

	Number				Position	Time	Feed & other activity
Horse	Adult	Colt		T.			
Deer	♀	♂	F.	T.			

Time: Sheep activity:

Figure 1: Form sheet used for recording population and food habit data.

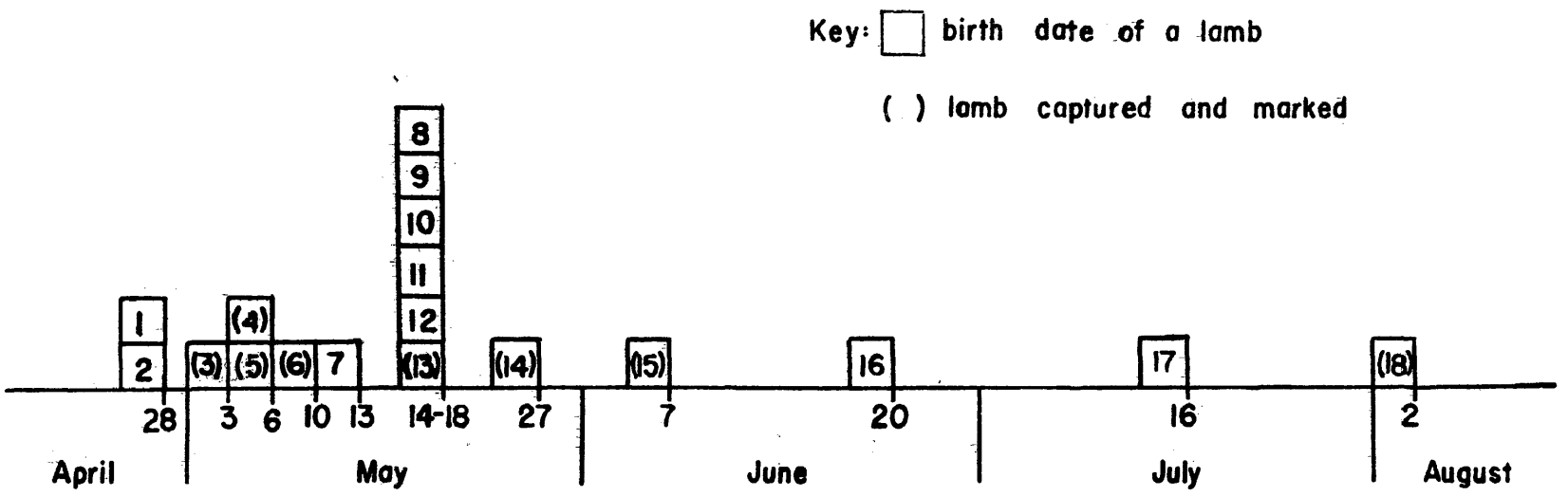

Figure 2: Progress of 1952 lambing.

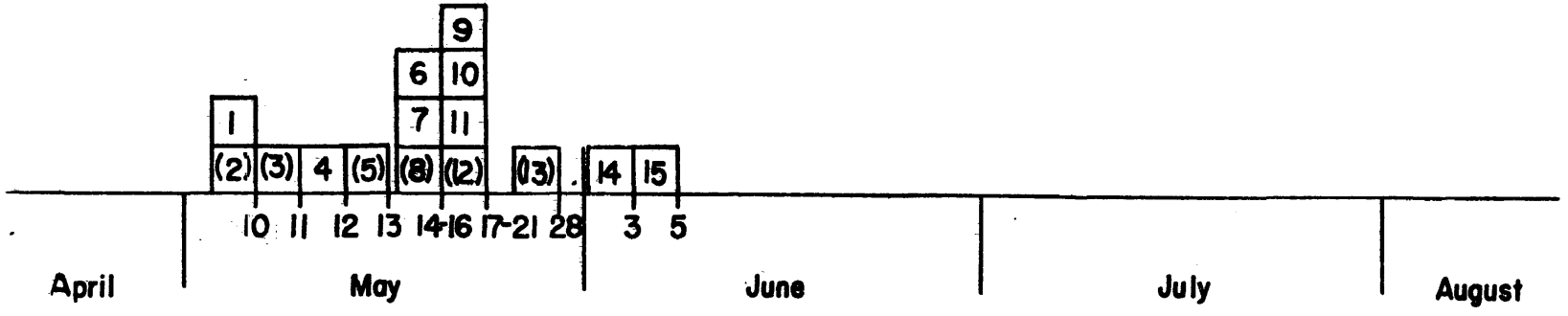

Figure 3: Progress of 1953 lambing.

INVENTORY OF POPULATION

Adult census. Form sheets were used to record numbers, sex and age classes (Figure 1.). Periodic counts were made of the sheep population. The minimum number of adult sheep known to be present in the population was obtained by totaling the maximum number of unduplicated individuals observed for each age class. Minimum totals are presented in Table 1 for the summers of 1951, 1952, 1953 and 1954.

Table 1: Minimum number of sheep known to be present at the end of lambing seasons.

	Ewes		Number lambs born	Yrlgs.		Rams		Total
	mat.	2 yr. old		♀	♂	mat.	2 yr old	
Summer 1951	11	?	11	?	4	12	?	38+
Summer 1952	18	3	18	4	6	17	?	66
Summer 1953	22	4	15	8	7	21	6	83
Summer 1954	27	5+	18	7	6	20+	4+	87+

An aerial census made prior to the 1953 lambing season yielded a count of 63 which is in close agreement with the count of 66 presented in Table 1. It is believed that about 100 sheep existed on the island during the summer of 1954 but the count was incomplete.

Lamb census. To determine the annual increment during 1952 and 1953 lambs were marked as soon after birth as possible. With individual lambs recognizable in the field, duplication in counts of marked and unmarked lambs was avoided. When a

large number of unmarked lambs were seen, the number was added to the number of marked lambs and this total was regarded as the minimum number of lambs produced by a given date. Figures 2 and 3 show the progress of lambing during 1952 and 1953. The exact time of birth is known for many of the marked lambs. Other lambs were usually seen when very young and their ages were estimated and their approximate birth dates recorded. Thus Figures 2 and 3 show actual and estimated birth dates of the 33 lambs known to be produced in 1952 and 1953. Each numbered block in Figures 2 and 3 represent the birth date of a lamb during the two lambing seasons. Parenthesis within the block indicate that this lamb was captured and marked. Eight captures were made in 1952 and six in 1953 which is nearly half the known lamb crop for each year. Results of an aerial census made on June 10, 1953 confirmed the lamb count obtained by the above method. In 1951 11 lambs were counted. In 1952 and 1953 there were 18 and 15 lambs recorded respectively. A minimum of 18 lambs was counted in 1954. These counts are thought to represent an accurate determination of the minimum annual increment. It is of interest to note that known lambing occurred during five different months in 1952 and two months of 1953. Most of the lambs were dropped in mid-May during these two years.

Methods of capturing lambs. In order that the productivity of the herd and the survival of individual lambs could be determined it was desirable to capture and mark as many lambs as soon after birth as possible. During 1952 and 1953, 19 captures were made of 14 different lambs. Most of these were from newborn to a few days old when captured. The oldest was about two months. Some of the technics used to capture lambs are discussed below.

The most successful capturing technic consisted of systematically covering the lambing areas. Lambing occurred in three localities each consisting of less than one-half square mile of the highest and most rugged terrain on the island. Each of these areas was covered every few days during the lambing season. It was difficult to catch lambs that were with their mothers; however, when they could be separated from their mothers or when found alone, they could be driven into a blind corner and captured. Occasionally it was possible to locate a hidden lamb by its movement or bleat. This was especially true when a call was imitated which is often made by ewes when returning to find a cached lamb. When the call was made the lamb would reveal itself. Eleven captures were made of eight different lambs using the above technics and twelve other lambs were nearly captured in this way. To increase captures, two dogs trained by domestic sheep herders

to catch and hold lambs were experimentally used to catch wild lambs. Each dog was able to catch a lamb but failed to perform properly after being attacked by a wild ewe. Both were lacking the fortitude seen in some sheep dogs. On ten other occasions it was possible to get within three to twenty feet of young lambs which were temporarily stranded on precipices. The ruggedness of such terrain prevented the dogs from working satisfactorily. Attempts to use a lariat and a sheep hook were unsuccessful.

A second method of capturing lambs consisted of following ewes which were about to give birth to lambs. Prior to and during the lambing season, ewes were noticed to show a number of symptoms of late pregnancy. These symptoms were: tendency to split from the main herd, usually alone but sometimes with a few other sheep; increase in frequency of urination from a normal rate of once per several hours to as often as once per half hour; extreme restlessness and hyperpnea; movements along abdomen apparently due to activity of the fetus; dilation and blue coloring of the vulva; extrusion and bursting of amnionic sack. By observing these symptoms one could be present at the time of birth and easily capture the newborn lamb. Four different lambs were captured using this method.

Still another method which shows promising possibilities is the spot lighting of lambs at night. A band of sheep

containing lambs was followed until they bedded down for the night. On very dark nights one could often get close to or even among the animals. Spotting was most effective when two operators worked together. The first man flashed the spot light in the eyes of a lamb while the second man dashed forth to grab it. In 1952, three captures were thus made in 13 attempts.

One ewe and her lamb were caught in a corral trap.

Evaluation of marks for recognizing individuals. Several different methods of marking sheep were used with varying success during the study. This provided an opportunity to evaluate visibility and durability of marking devices.

The most successful mark for field recognition of individual lambs was the ear ribbon (Plate 1, lower). Ribbons of various material, color, weight and size were tied to aluminum strap tags which pierced the pinna of six lambs. The following notes pertaining to their effectiveness were made: The fluttering of 12 inches long light weight ribbons seemed to "annoy" the lambs. Ribbons of heavier material such as grosgrain rayon, seemed to be less disturbing. One aluminum tag and the ribbon were known to be ripped off a few days after they were installed. One ribbon of a plastic material designed for upholstering outdoor furniture became cracked after two months. Two other ribbons were intact after 14 months when the field work terminated.

Various colored discs of heavy plastic two and one-fourth inches square were attached with aluminum strap tags to the pinna of three lambs and one ewe. The plastic discs lasted from one to four months. Two animals retained the aluminum tags which caused the entire pinna to lop in one case and the tip to bend over in the other. A third sheep had the lower half of the pinna ripped off along with the aluminum tag and plastic tag. These three animals were still regularily recognized by their pinna abnormalties. The fourth was never again recognized after losing the plastic tag. Sheep chewed plastic tags and ribbons on other sheep. Magpies pecked at them.

Pinnae were cut on four individuals. These sheep were less easily recognized than those with tags or ribbons.

Coat coloring material were used and a black dye[1] proved to have better color contrast on the pelage of the sheep than black or red paints.[2] The dye could be applied to the full length of the hairs more easily than the paint and it took only 30 minutes to dry while paint took 24 hours. However, the lesser viscosity of the dye caused it to smear while the paint did not smear. Thus the dye was superior in all respects except its tendency to smear.

The population could be readily keyed into age and sex groupings. Within these groups it was possible to recognize

[1]This dye was developed by Dr. Jassman of the State of Montana Livestock Sanitary Board, Helena

[2]Minneapolis Sheep Paint Co., Minnesota

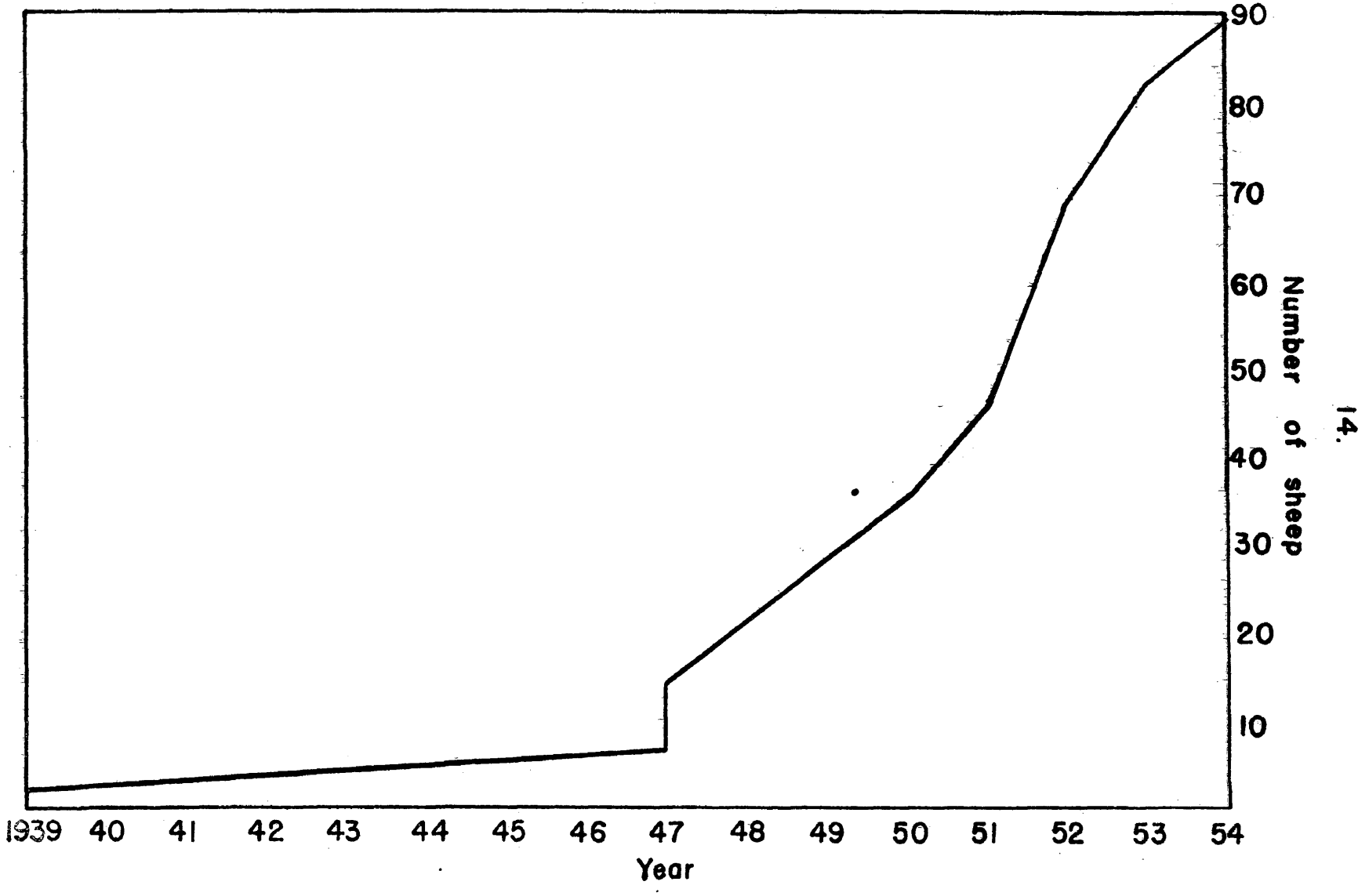

Figure 4: Growth of wild sheep population on Wildhorse Island.

individual sheep by their respective peculiar markings. The most promising natural mark for recognizing individuals in the lamb age group was the shape and size of the tail and dorsal stripe. This criterion was first used on lambs about six months old when the peculiar tail shapes of several artificially marked lambs were noticed. After several weeks a few of these lambs were recognized by their tail shapes and verified by artificial marks.

One ewe was easily recognized because it had only one horn. The shedding of pelage varies greatly with individuals in the spring and this provided a temporary recognition.

In a few cases leadership behavior was useful for recognizing individuals which were also artificailly marked.

POPULATION DYNAMICS

History and early growth of population. Two plantings of bighorn sheep on Wildhorse Island gave rise to the population now found there.

During 1939 a male and a female sheep of yearling age were put on the island. These were captured as lambs in the Mission Range about 50 miles south of Wildhorse Island and were raised by Mrs. Pat Shay of Hot Springs, Montana.

During May of 1947 the Montana Fish and Game Department released seven more sheep on the island. These were trapped at Wagner Basin in the Sun River Canyon of Montana. The following records were kept of their sex and age:

3 ewes (1 pregnant)
1 two year old male
2 older males
7 (with unborn lamb)

At the time this second group was released on the island, members of the Montana Fish and Game Department made a census and reported that the original pair had increased to a total of:

3 ewes (1 with lamb)
1 two year old male
1 older male
6 (with lamb) established by the spring of 1947.

However, it was suspected that a few more sheep were present. Adding the established 1939 group to the plant made in 1947 gives the following minimum total:

6 ewes
2 lambs (one unborn)
2 two year old males
3 older males
13 minus 1 older male which is known to have died = 12

These data are entered on Figure 4.

Recent growth of population. The censuses made during the study period provided the recent data found in Figure 4. As that figure shows, a rather constant rate of increase occurred from 1951 to 1954 inclusive. Eleven to 18 lambs were born each season. By referring to Table 2 it is noted that both productivity and lamb survival were high during 1951 and 1952. However, the lamb crop was considerably below optimum during 1953 and 1954. This shortage in the lamb crops could be due to low productivity of the ewes or poor survival of early-age lambs.

Table 2: Ewe-lamb statistics.

Year	1951	1952	1953	1954
Number of mature ewes	11	18	22	27
Number of lambs known to be produced	11	18	15	18
Per cent of mature ewes known to produce lambs	100%	100%	68%	67%
Ewe-lamb ratio shortly after lambing season and one or more years later	1-.91	1-.89	1-.59	1-.63

By referring to Table 2 it will be noted that during 1951, 11 mature ewes were counted and 11 lambs were known to have been born. At least ten of these lambs were still alive when

the study terminated. This is a ewe-lamb ratio of 1 mature ewe to .91 lambs. Table 2 shows that during 1952, 18 mature ewes were thought to be present and 18 lambs were known to be produced. Two of these lambs are known to have disappeared soon after birth leaving a ratio of 1 mature ewe to .89 lambs. Two others were fostered by the worker, and not returned to the island. The remaining ones were present one year later. From Table 2 it can be seen that during 1953, 22 mature ewes were counted but only 15 lambs were known to have been born. Two of these disappeared soon after birth so that after mid-June and when the study ended a year later there were 13 lambs left. This is a ratio of 1 mature ewe to .59 lambs. Table 2 shows that in 1954, 27 mature ewes were counted but only 18 lambs were known to have been born. It is suspected that at least one of these lambs disappeared at a few days of age leaving a ratio of 1 mature ewe to .63 lambs. Other workers (Spencer 1943, Murie 1944) in the populations they studied, considered .5 to .7 lambs per mature ewe to be a satisfactory survival rate at one year after birth.

Survival of lambs after they reached about one week of age and of yearlings was very high.

No cases of twins were observed.

Lamb mortality and sickness. A number of mortality factors were believed to be operating among the sheep and these affected the lambs especially. While it was not

possible to conclusively evaluate the relative importance of these factors in reducing the population, some evidence of their values was obtained. This information was gained from observations of marked lambs which were sick, dying or otherwise subjected to mortality influences.

Figure 2 shows that eight lambs were captured and marked in 1952 when a minimum of 18 were known to be born. Figure 3 shows that in 1953 six were marked of 15 known to be born. Captures were fairly well distributed throughout the lambing season (see Figure 2 and 3), so that as lambing progressed about one-half of the lambs known to have been born at any particular time interval were marked. In every case the lambs were seen to be recovered by their mothers soon after marking. It is believed that capturing and handling caused no permanent ill effects. During 1952, two lambs were marked on May 6. During 1953, two lambs were marked on May 10 and 13. These were never seen again after they were a few days old and it is believed that they died. All had figures dyed on their bodies and their pinnae were cut, had colored plastic tags or ribbons. Other lambs marked in the same manner were regularly seen for many months.

On June 10, 1952, a two day old lamb was captured and "grafted" to a lactating domestic ewe which was brought to

the island. The two animals soon accepted each other and were allowed to run outside. The lamb appeared to be healthy and playful. A few days later a light rain fell intermittently. No effort was made to shelter the animals which were in about the same amount of cover the wild sheep have been seen to enter during rainy peiods. The lamb became damp and its hairs clumped together in pointed tufts by evening but it didn't appear to be uncomfortable. Sporadic light rain continued during the night and later the next day the lamb became wet to the skin. At this point it was thoroughly dried and put in a shelter. Even so, the lamb became prostrate within 48 hours. With treatment--heat lamps and penicillin--it temporarily recovered. Treatment was discontinued and after three weeks the lamb suddenly died. The following is taken from a report made by E. L. Cheatum of the Montana Cooperative Wildlife Research Unit who autopsied the animal: "Dr. Jeffers reported that he isolated in pure culture Pasteurella multocida from the lung abscess...The diagnosis is hemorrhagic septicemia with acute pneumonitis and a lung abscess is the outstanding feature in gross pathology."

Wet weather is known to have occurred during the time the lambs in question were born, marked and disappeared. It is suspected that rain may contribute to the death of lambs in the wild as it apparently did to a foster lamb.

Another example occurred in June, 1954. The ewe involved is known to have dropped a lamb on June 23. The next day the ewe and lamb were flushed from the protection in which they were found during a rain storm. I remained in the vicinity while a severe rain fell for much of the next two days and nights. Following this a lone ewe was seen in the area and appeared to be searching for something. Instead of feeding she continuously wandered about the locality. During the next few days she called for hours at a time sometimes far into the night so that her bleat became hoarse. No very young lambs were seen again in this area or elsewhere on the island although field work continued for four more days.

Chapman (1908) in referring to mountain goat kids, stated, "Strange to say, their soft, wooly coats were found but a poor protection against soaking rain; so that the keeper had to shut them in shelter when a storm began."

The following ailments were further observed among lambs.

A two day old lamb was captured on August 4, 1952 and raised using a canned milk formula fed through a nipple (Plate 2, upper). After it was several months old, it was subjected to several stresses and its vitality lowered. The animal developed most of the overt symptoms described by Cowen (1951) for hemorrhagic septicaemia, such as inflamation of the nasal cavity, loss of appetite, excessive thirst, fever,

general lack of vigor, stiff legged gait, hyperpnea, and shivering. The animal was taken to a veterinarian, who recognized the symptoms to be similar to those shown by domestic sheep when afflicted with hemorrhagic septicaemia. He administered hemorrhagic septicaemia serum of bovine origin which usually shows favorable results in domestic sheep within 48 hours. No therapeutic action was noted after several days and the animals vigor continued to decline. This suggests that there may be a difference in the disease of wild and domestic sheep. Penicillin was then administered and within ten days the animal was again in thrifty condition.

On one occasion a frisking lamb was seen to fall about 25 feet, hit a ledge while inverted, then bounce and fall eight more feet. After lying a few seconds, it got it its feet and walked slowly to its mother.

One of the fostered lambs went into a coma when it was about two weeks old and again when it was thirty days old. Each time it lay on its belly, uttered a soft moan and rolled on its side. It became completely limp and didn't respond to handling. After about 30 seconds it acted as if it were awakening from a deep sleep. No unusual behavior followed.

On one occasion a newborn lamb attempted to arise as it was approached. As it struggled, large pieces were torn from

its hooves which were not yet hardened. The lamb was prevented from further injuring itself and it seemed to suffer no ill affects.

One lamb was found with a broken hind foot. The bone was set and splints were bound to the foot with friction tape. After two weeks the splints were lost and the lamb seemed to suffer no further ill affects.

Evidence to explain the above mentioned low productivity of ewes or poor survival of lambs during 1953 and 1954 was incomplete. During mid-June through mid-July 1953, the dry-band (see herd composition) consisted of nine ewes. During late June and July 1954, the dry-band contained ten ewes. It has been stated that a few of the ewes of the dry-band were known to have produced lambs which were marked and which disappeared soon after they were born. It is possible that other ewes of the dry-band may also have lost their lambs soon after they were born. Thus the problem could be largely one of lamb survival rather than lamb production. On the other hand, enlargement of the udder was characteristic of ewes which were known to have recently produced lambs. Yet some of the ewes of the dry-band showed a lack of development of the udder and this was interpreted to mean they had not produced lambs. Apparently lower ewe-lamb ratios of 1953 and 1954 were the result of lower production as well as lamb mortality.

It is of interest to note that one marked ewe produced a lamb in 1952 which survived. In 1953 the same ewe produced a lamb and joined the wet-band. This marked lamb disappeared after a few days and the ewe joined a dry-band during June and July. In 1954 the ewe again produced a lamb which was surviving when the study terminated.

Adult mortality and sickness. Very little mortality occurred among the adults. Probably this slight mortality was not important as a factor limiting the increase of the population. The few known deaths resulted from various causes.

On January 10, 1953 a ewe which had been dead for several days was found. A hemorrhagic area, ten inches in diamter was found on the right side of the thorax. The lungs were the color of healthy liver but no consolidation or coagulation had resulted. Dr. Edmund E. Jeffers, (Montana State University bacteriology department) injected fluid taken from its thorasic cavity into mice and found that it had a lethal affect. Similar injections into domestic sheep had no perceivable affects. Jeffers believed the animal had been afflicted with hemorrhagic septicemia but was unable to find Pasteurella multocida. Instead, a type C Streptococcus was found in nearly pure culture. Jeffers felt that P. multocida may have been the terminal cause of death but the organism disappeared

soon afterwards. The Streptococcus, a secondary invader caused death in mice but apparently the domestic sheep were immuned to it.

Accórding to the literature, hemorrhagic septicemia appears to be a common disease in wild sheep. Cowan (1951) referring to it in western Canada, states, "This disease seems to be one of the great, if not the greatest, causes of epidemic (epizootic ?) death in the bighorn-sheep population." This disease is thought to be the cause of depletion in the Tarryall, Colorado herd during 1923-24, according to Spencer (1943).

Although this disease has been of much concern to domestic stockmen for many years little is known about its mode of transmission. American Magpies, Pica pica hudsonia, were known to have fed on the ewe found dead on January 10, 1953. They have also been seen many times picking at ear tags and apparently ticks on the backs of healthy bighorns. It is possible that they are instrumental in transmitting disease organisms of large mammals.

The skull of an eight year old ram was found which had a crack extending from the left lacrimal bone to the occupital. In the region of the frontal bone it was about three-eights inches wide and eroded. The injury probably incurred in a fight and was no doubt the cause of death.

Predation. Although several kinds of predators occurred on the island, the preponderence of evidence indicated that they probably did not exert an appreciable influence on the sheep population.

By capturing and marking badgers, Taxidea taxus, it was determined that at least five individuals were visiting the island camp during June 1952. Badgers were known to be active in the lambing areas during lambing. They were thought to be abundant over much of the island. During the study period marmots were scarce while pocket gophers and ground squirrels had disappeared although all were reported as being abundant a few years earlier. This scarcity of usual badger food items apparently caused them to seek food from the large mammals. Badgers were known to devour and bury horse and deer carcasses in remarkably short lengths of time. It is very likely that they would quickly devour carcasses of lambs which might have died from other causes. They may be capable of capturing the very young lambs particularly when they are cached.

Bald eagles, Haliaeetus leucocephalus, were known to have a brood on the island during both 1952 and 1953 lambing seasons. Eagles are reported to have nested on the island for many years. The food remains collected at the active nest on the island were mostly fish, birds, hare, mice, marmot and mule deer. No evidence of bighorn was found.

A government hunter took from one to three coyotes, Canis latrans, from the island every other year since 1942. Besides the ten coyotes he took official government credit for, others were probably killed by the poison baits he distributed on the island. No fresh sign was seen after May 1952 when the last coyote was taken. Evidently badgers, eagles and coyotes were present on the island for many years during the time when this population showed high productivity and good survival in becoming established. It would appear that these predators had not prevented this population from increasing rapidly.

Parastitic disease. The sheep on Wildhorse Island were found to be infected by two parasites. A biting louse was recovered from a ewe in February 1953. This specimen is now number 32,023 in the collection of the Rocky Mountain Laboratory, Hamilton, Montana. Dr. William Jellison of that laboratory believes this specimen represents an undescribed species.

Laboratory analysis were made to detect lung worms, Protostrongylus sp., in bighorn sheep on Wildhorse Island. The life cycle of the worm has not been definitely determined but is probably similar to that of closely related worms for which the life cycle has been worked out.

In working with Protostrongylus rufescens, a lung worm of domestic sheep, Hobmaier and Hobmaier (1930) found that

adult worms produced eggs which hatched in the lungs. Embryos were coughed up, swallowed and passed out in the feces. These embroys invade dry geophilus snails through the mucus glands of the foot. (The genera Zonitoides, Retinella, Vitrina and Euconulus were collected on the island along with several slugs.) Here the embroys complete two molts in about two weeks after which they became infective. They are then eaten by the sheep. Whether the sheep usually consumes the entire snail or only the embroy which encysts on vegetation after leaving the snail has not been demonstrated. The embryos presumably penetrate the intestinal mucosae and enter the lymphatic system. From here they are carried to the blood stream then through the right side of the heart and to the capillary beds of the lungs. They burst out of the capillary beds and eventually enter the small bronchioles completing the life cycle.

Couey (1950) found that infestations in wild sheep built up during the spring but dropped off after July. In this study 80 fecal samples of 20 to 30 pellets were collected mostly during June of 1953 and examined. Records were made of the sex and age of each sheep along with the time the sample was dropped. In the case of ewes it was noted whether the animal was a member of the dry or wet band. The collection of 80 samples are thought to represent most of the individuals of the 1953 population.

There may be some appreciable time lapse between the time of maximum infestation and the time maximum egg production ensues. Since worms cannot multiply to additional adult worms inside the host, fluctuations in number of embryo revealed by fecal analysis may result from seasonal reinfestation of the host or from varied egg production of individual worms within the host. Couey (1950) states, "Numerous tests were made to see if different pellets from the same collection contained the same number of larvae. They checked favorably.... form a rough index as to the degree of infestation."

Six pellets from each sample were broken up and placed in a petri dish containing lukewarm water. After thirty minutes, the larger pellet particles were removed with forceps and discarded. The contents of the petri dish were then examined under a 32mm objective of a compound microscope. If embryos were present in the pellets, they could be seen swimming in the water, having been activated by this treatment. The total number of embroys seen was recorded for each sample of six pellets.

1. Of 21 ewes which produced lambs 10 or 48% were afflicted with worms.

2. Of 9 mature ewes which currently were without lambs, 2 or 22% were infested.

3. Of this total of 30 adult females, 12 or 40% were considered infested.

4. Of 16 adult males, 11 or 69% were infested.

5. Of the total of 80 samples, including mature and immature animals, 26 or about 33% showed infestation.

6. Lung worms were first found in a marked wild lamb after it was three months old. Its mother, also a marked animal, was known to be afflicted.

7. A fostered lamb which often followed the worker about the island in wild sheep habitat never contracted worms, by the time it was nearly two years old. A two day old wild lamb was adopted by a domestic ewe which was known to be lightly afflicted with lung worms. One month later this lamb died of pneumonia but fecal samples and autopsy indicated absence of helminths. Samples used to obtain these data were not included in the aforementioned 80 samples.

8. Using only one pellet per sample in a similar analysis, Couey (1950) regarded an infestation as being heavy when several dozen embryo per field-of-view could be seen in the miscroscope. In the present analysis, using six fecal pellets, one worm was seen per many field-of-views. The greatest number of worms seen per sample of six pellets was twelve. One to three was the usual number of embryos seen in positive samples. Consequently, all infestations are regarded as being light.

Plate 2

A foster lamb at 15 days of age.

The same foster lamb at $16\frac{1}{2}$ months of age.

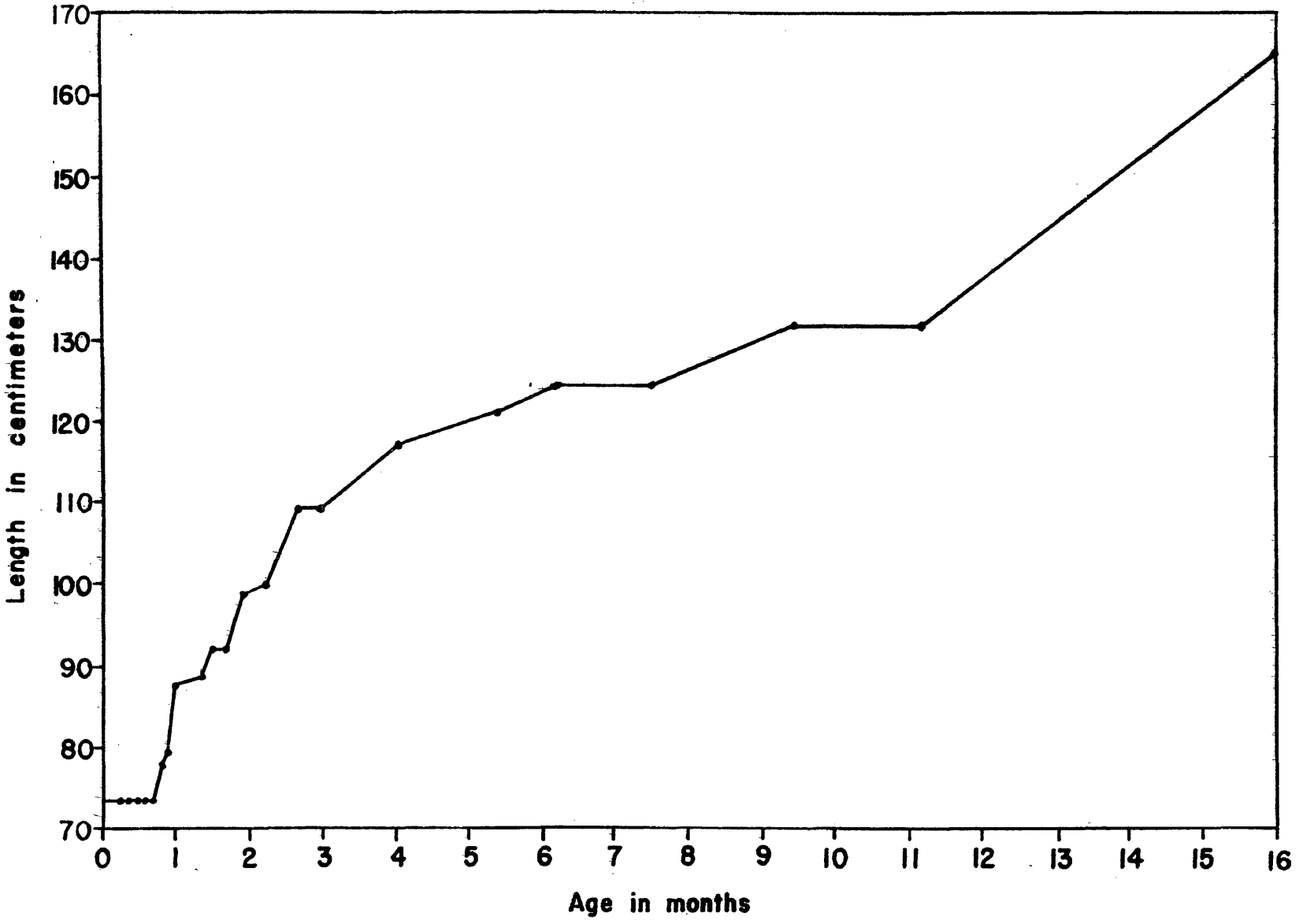

Figure 5: Total length following body contour of captive lamb.

9. Since the ewes which were known to have produced lambs had a higher percentage of infestation than those which were without lambs, apparently light infestation of lung worms in ewes had no adverse affect on lamb production.

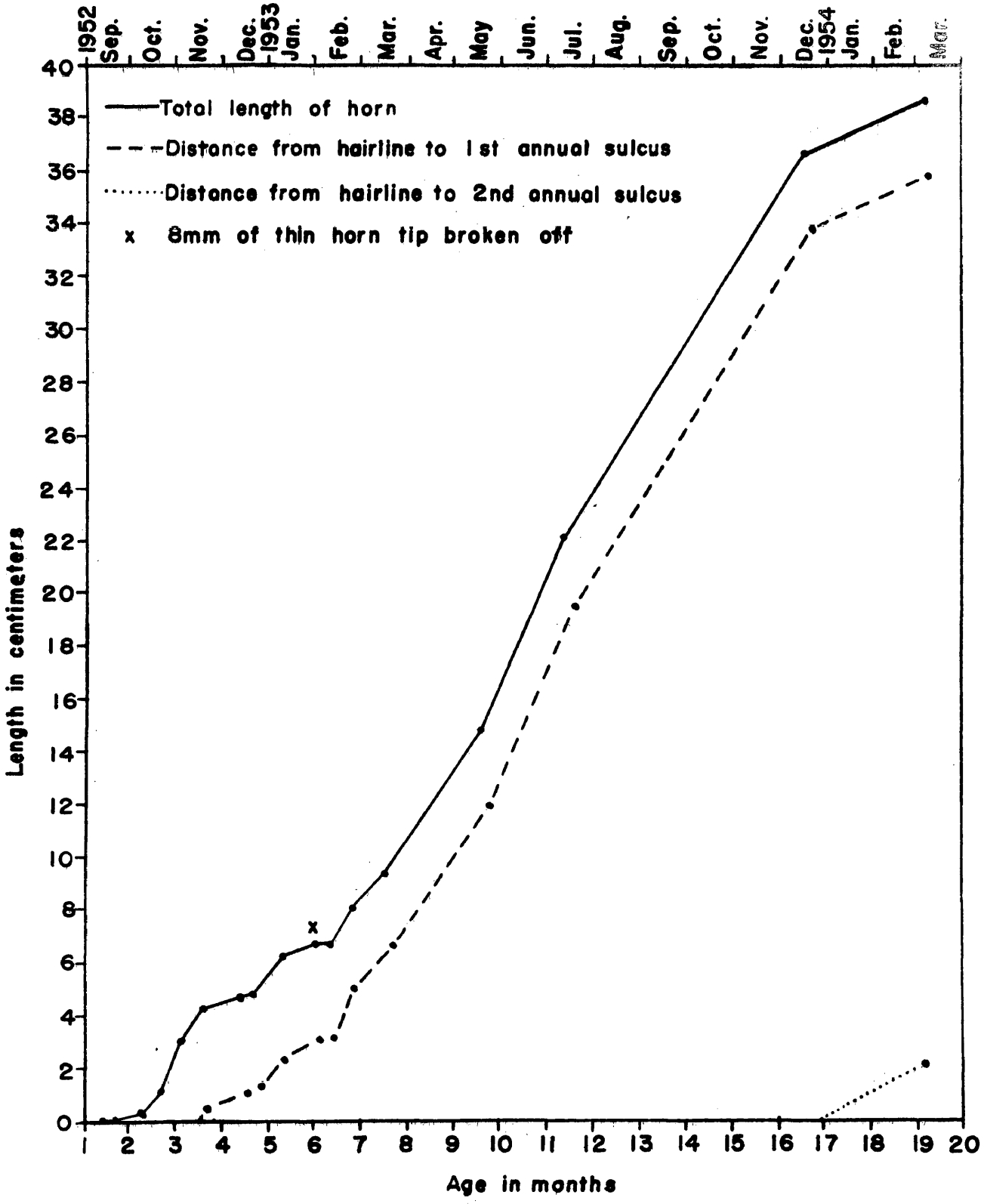

Figure 6: Horn growth of captive lamb.

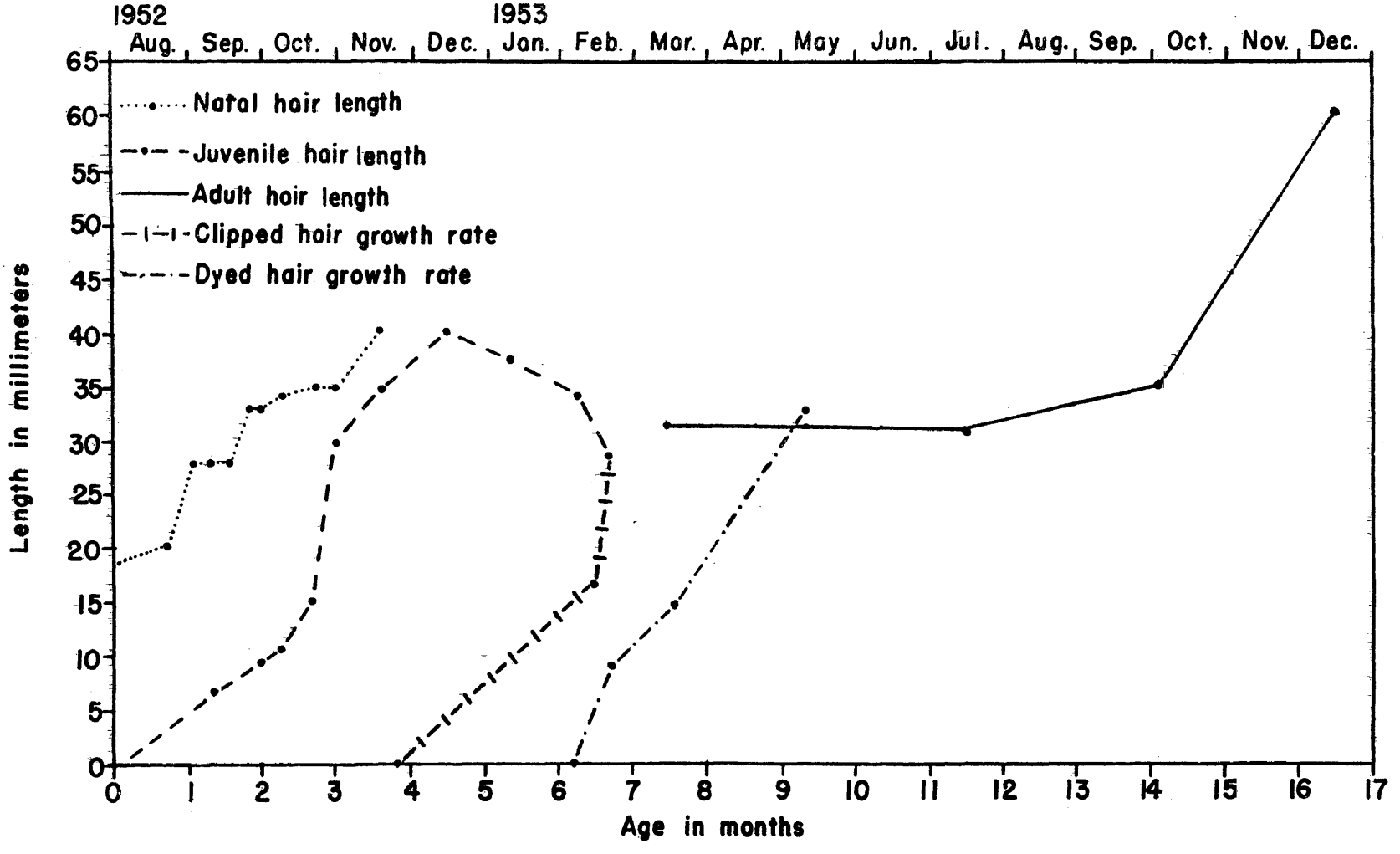

Figure 7: Hair growth of captive lamb.

BIOLOGY OF BIGHORNS

Breeding habits. The determination of productivity in this population was a primary objective. Other investigators (Rush 1935, Pulling 1945) have stated that the manner in which breeding occurs and the relationship of receptive ewes to breeding rams has a direct bearing on the productivity of the herd. Consequently, a special effort was made to observe breeding behavior.

The mature ram herds associated with the ewes from October 24 through January 15 during the 1952-1953 breeding season. Males did not become members of the older ram herd until they were about three years old. However, these young males were seen to mount members of the ewe herd, including mature ewes, between mid-September 1952 and February 1953, particularly when older males were not present. Ewes were no receptive toward these attempts at breeding by young males and usually broke away soon after being mounted. Since lambing was observed to take place from May 10 through June 14, 1953, all conceptions apparently took place between mid-November and mid-December 1952, that is, while the older ram herds were associating with the ewes. This would seem to indicate that the breeding mentioned above was unsuccessful.

During the time when herds of older rams associated with the ewes a breeding pattern was observed which usually involved

the older rams but in at least one case a two year old male is thought to have been the sire. The ewe concerned in this latter case is known to have produced a lamb the following June. After observing six instances of this breeding pattern, four steps became evident, only the details of which varied. These are described.

Step 1. Beginning of courtship. As a mature ewe apparently began to approach estrus, one to a few males repeatedly smelled the urine and feces she deposited. Soon they located her and smelled about her genitalia. After smelling, a ram would stretch out his neck, head and upper lip and slowly rotate his head to one side. It was noted that the ewe at times seemed to arouse only one male although more mature rams were present. Some rams were seen to eat very little food for several days while persistently attending ewes in this way.

Step 2. The chase. The ewe was apparently "annoyed" by this incessant attention and the attempts to mount her and she tried to elude the rams by running a short distance and facing about. Later she ran longer distances with the rams in pursuit. Sometimes the ewe dashed to rocky ledges. Here she might stand on a shelf where only one animal could safely remain. The males waited close by until she moved off and the chase was resumed.

Step 3. Isolation. Often all but one ram eventually dropped out the chase. The precipitate ewe often ran out of sight of the main herd causing herself and the pursuing ram to be isolated from it. Or the ewe eventually ran into or was chased into a blind corner. This might be a peninsula, a rock crevice or a precipice with only one safe exit route. The male then prevented the ewe from leaving by bodily blocking her at the only exit each time she attempted to escape. The main herd might move miles away while she was so "captured" and thus the pair became isolated from other bighorns. The effectiveness of this isolating mechanism for eliminating third parties may be reflected in the following example. A marked ewe was observed several times each month between June 1952 and June 1953. Invariably her lamb, also marked was with her except on one occasion, while the ewe and a ram were isolated during the breeding season for three days in November.

Step 4. Copulation. Apparently several days after the initial interest was shown toward the ewe, true estrus came about. Only after isolation were ewes seen to accept a male in copulation. In fact such ewes appeared to be as eager to copulate as the males. (Perhaps such a ewe would have copulated with other males had they been present and willing at

this time. This may occur in some instances.) On one occasion a few other males were present while a pair copulated but they seemed to be uninterested in the ewe and to be following the breeding male. Copulation lasted only a few seconds and was repeated every few minutes for several times. Then the pair rested or fed before copulating again.

At no time were large numbers of males seen to mass breed or "damage" a ewe. Although ewes appeared to be "harrassed" during step 1 and 2, it is believed that this condition did not prevent them from becoming gravid. Such conditions have been described by Rush (1935) and Pulling (1945). Although such evidence is meager it is used by bighorn managers to support principles for managing this species including open hunting season on mature bighorn rams. The theory is that if only one male were present per several ewes, damage caused by over harrassment and over servicing by male bighorns which supposedly results in low productivity would be decreased. The evidence from the present study which is based on only six observations of breeding pairs, was that each female appeared to be bred by a different ram. This implies that continued harvesting of rams to the extent of markedly altering sex ratio may not be desirable.

By Seton's definition we might call this kind of breeding a degree of monogamy. Seton (1927) states, "There are four

degrees of monogamy among animals:

1st. That in which a male and a female remain together for perhaps a week; after which the female no longer desires a mate, and the male seeks a second. That is, one mate at a time, but perhaps five or six in the season.

2nd. ..., wherein the pair continue together during the mating season of a week or more, then separate completely.

3rd. ..., in which the pair continue together with little interruption, until the young are able to care for themselves (say for four or five months), the father faithfully helping in caring for the young.

4th. ..., pair and live together continuously till one is removed by death."

Breeding of the Wildhorse Island sheep would seem to be in the 2nd degree of monogamy. During the breeding season of 1952 several vists were made to another bighorn sheep range in Granite County, Montana. All four steps of the monogamy described were observed in this group. During December 1952 suggestions of the last two steps were observed among the sheep in the Sun River Canyon herd of Montana.

Extensive chases after ewes by rams during the breeding season have been described by several authors. Spencer (1943) mentions some of the mechanics which cause the dropping out of rams during these chases. Jones (1950) mentions what may be the isolation stage in the Sierra Nevada sheep, "On November 21 further observations were made... The only sheep seen were a ewe and a ram that were together, though fresh tracks of others were everywhere." Perhaps the above illustrations are fragmentary examples of the stages of monogamous breeding. If so, this would mean that monogamy

isn't confined to this area. Until more conclusive data are obtained perhaps the question of what is a desirable sex ratio for bighorns should remain open.

Gestation Period. Observations showed the peak of 1952 breeding to occur about November 29. The lambing culminated about May 30, 1953. This agrees with similar evidence obtained by Frost (1942) who stated that the gestation period lasts about 180 days in this species.

A marked ewe was seen in copulation on November 23, 1952. She gave birth to a lamb on May 27, 1953 apparently having a gestation period of about 180 days.

Physical development of lambs. One important aspect of the population dynamics is the survival and development of the lambs. Since details of physical and behavioral development were difficult to obtain in the field, two lambs were taken captive to use for developmental studies. Information obtained from these foster lambs was substantiated by comparative observations of wild lambs wherever possible.

Thus during 1952, two lambs were taken to be fostered one of which is still being observed (Plate 2, lower). Of 12 other lambs captured, marked and released during the study, five were recaptured. The recaptures made of known age lambs from a few days old through two months of age revealed that the pelage,

hoof and teeth development of foster lambs were typical. Until 11 months of age one foster lamb occasionally romped with and enticed other known age wild lambs to within a few feet of the observer who could then make approximate comparisons between the foster and wild lambs. These opportunities showed that the body length and weight along with the horn development of the foster lamb were approximately the same as those of wild lambs which were about the same age.

Most of the following data were obtained from the foster lamb. The variations noted while observing other lambs are mentioned.

1. Body length. Figure 5 shows the body length of the animal for various ages. It should be noted that the animal suffered an illness at four months of age. This may have caused the curve to tend to level off. The rapid growth shown after eleven months of age may be due to the fact that it was put on a grain and protein "pellet" diet.

2. Body weight. Lambs weighed from nine to twelve pounds at birth with most being about ten pounds. Weight was gained rather uniformly at about ten pounds per month so that by 16 months of age the fostered lamb weighed 160 pounds.

3. Horn development. Hair disappeared at the horn sites at one and one-half months of age and horn buttons were

evident soon afterwards. Horns grew at about 15mm per month from two through six months of age and about 30mm per month for the next ten months (Figure 6). Measurements were taken along the front curve from the hairline to the tip of the horn. The first annual sulcus developed at three and one-half months of age on a lamb born on August 2. Sulci form at the hairline and migrate distally as the horn grows. A second annual sulcus developed at 17 months of age. The first sulcus developed during November, 1952 and the second during December 1953. The rut occurs among bighorns about this time and may be associated with the development of sulci. However, it should be noted that this animal was subject to stress and nearly died during mid-November 1952 and late November 1953. Extremes of horn growth in eight months old lambs ranged from no perceivable growth on a female to over 15cm growth on a male. These were both seen at a distance of fifteen feet.

4. Hoof development. Hooves as measured along the front edge from hairline to tip were about 27mm long at birth. By 17 months of age they were over 50mm long. Three sulci developed in the hooves of a fostered lamb. The first sulcus appeared at the time of birth, the second and third when the animal was under stress and nearly died. The three sulci and and artifact all migrated distally at a uniform rate of 9.5 to 10mm per month.

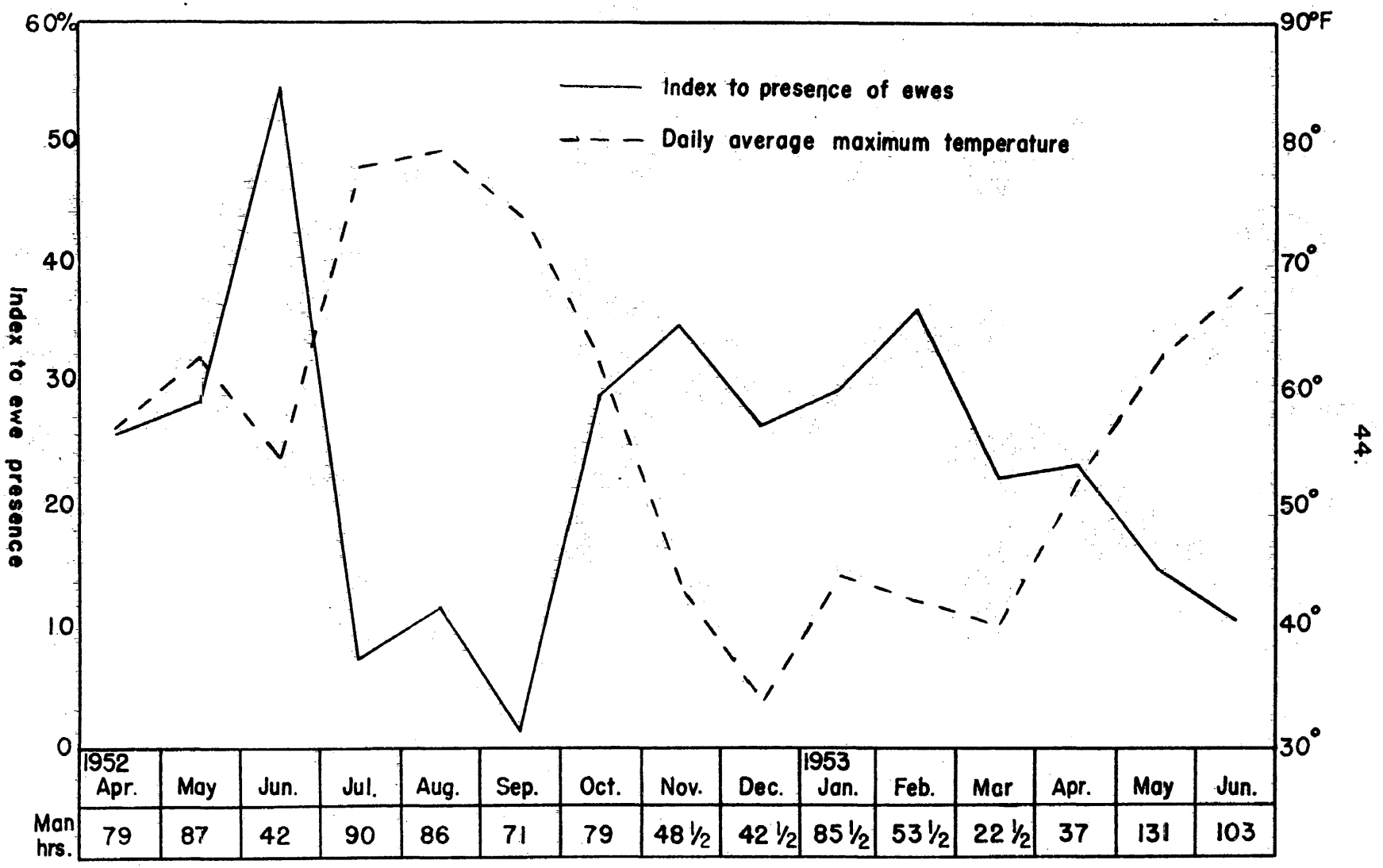

Figure 8: Temperature and presence of ewes on south half of Wildhorse Island. (See text for further explanation.)

5. Pelage. Lambs are born with a fluffy pelage which isn't as dense as the pelage of older sheep. Figure 7 shows this pelage was about 20mm long at birth. All measurements were taken on the back and sides of the animal. The hair grew at about 7mm per month until it was about 40mm long. At this length most of this hair was shed except at the horn sites where it remained most of the winter. Hair was shaved or dyed to the skin surface on various parts of the animals body at intervals to facilitate the measuring of hair growth. The color of this hair was buff on most of the lambs handled during the study but one lamb was a uniform grizzled gray. On some lambs there were various degrees of contrasting dark brown patches particularly on the wrists, chest, tail, dorsal stripe and about the eyes. A rump patch was not evident. The skin of the groin was naked and usually black. This pelage consists of guard hairs which are not uniformly crimped. On the scrotum it is short and forms tight curls. The horn sites were marked by hair whorles. This coat is referred to as the natal pelage.

Commencing about one week after birth a second pelage grew in to replace the natal hair (Figure 7). This coat was sleek during the summer compared to the natal hair and it resembled the summer coat of adult animals. Its rate of growth varied from about 5mm per month during the summer to

about 1mm per day during part of the fall and winter. These growth rates are shown on the lines labeled juvenile hair length, clipped hair growth rate and dyed hair growth rate of Figure 7. However, breaking of the tips caused a length of about 30 to 40mm to be maintained for this coat. On some of the marked wild lambs it must have grown at a faster rate on the neck as they were estimated to have hair over 15cm long here when they were six months old. Apparently this length could be attained because there was little breaking off of the hair tips especially on the neck area. Thus lambs were seen to have proportionally more mantle or long and dark hair on their necks during the winter than older sheep. The lambs began wearing the sleek coat after July while older sheep shed the winter coat and were sleek about two months earlier. Consequently, this second coat is called a juvenile pelage. Both the juvenile and adult pelages contain wool or under fur. The guard hair in these pelages were uniformly crimped and the unbroken tips were darker than the bases. The hair of the juvenile and adult coats seem to become more dense as well as longer during the fall and winter so that it does not lie flat and is no longer sleek. The winter pelage is shed in the spring and is replaced by the sleek coat. Only one molt occurs each year.

While marking sheep, hairs on the sides were dyed all the way to the skin surface. Nevertheless, lambs which were marked before they were a week old retained the marks for only a few weeks. This no doubt resulted because of shedding of the natal hairs. Animals marked during the summer which had juvenile or adult pelages retained the marks for several months. That they lost the marks eventually was probably due to the hair growing out and breaking off at the tips, much as occurred on the foster lamb. It is deduced that the neck may be the best area for dying animals in the juvenile pelage because this hair may not break off as it apparently does on the remainder of the body.

6. Tooth development. Table 3 shows the eruption of incisor and canine teeth at various ages. Usually the variation found among these four teeth during the first two months of age did not exceed 1 or 2 mm. By referring to Table 3, it is evident that after three months of age wear on a tooth can exceed growth so that the tooth becomes shorter.

Periodic jaw x-rays taken of a foster lamb revealed eruption of cheek teeth through the jaw bone as is shown in Table 4.

Testes descended at about five months of age.

Of six male lambs, four had one pair of mammae and two had two pair. Of six females, all had one pair of mammae.

Table 3: Eruption of incisor and canine teeth in millimeters above the gumline on buccal side.

Age	Incisor			Canine
	1	2	3	
30 min.	1 - 2	0 - 1	0 - .5	0
24 hrs.	2	0 - 1	0 - .5	0
3 days	3	2	1	0
5 "	5	3	2	0 - 1
7 "	7	4	2	1
2 wks.	8	5	3	2
3 "	9	5	4	3
1 mo.	9	6	5	4
2 "	9	7	6	6
3 "	10	8	6	8
5 "	9	9	8	7
9 "	11	9	7	7
16 "	6*	10	8	7

* first permanent incisor

Table 4: Eruption of teeth through jaw bone as revealed by x-ray.

Age	Dental formula			
	Incisor	Canine	Premolar	Molar
19 days	$\frac{0}{3}$	$\frac{0}{1}$	$\frac{3}{3}$	$\frac{0}{X}$
25[1]/ "	$\frac{0}{3}$	$\frac{0}{1}$	$\frac{3}{3}$	$\frac{X}{1}$
53 "	$\frac{0}{3}$	$\frac{0}{1}$	$\frac{3}{3}$	$\frac{1}{1}$
3 mos.	$\frac{0}{3}$	$\frac{0}{1}$	$\frac{3}{3}$	$\frac{1}{1}$
$4\frac{1}{2}$ "	$\frac{0}{3}$	$\frac{0}{1}$	$\frac{3}{3}$	$\frac{1}{1}$
$7\frac{1}{2}$ "	$\frac{0}{3}$	$\frac{0}{1}$	$\frac{3}{3}$	$\frac{1}{2}$ plus X

continued on next page

Age	Dental formula			
	Incisor	Canine	Premolar	Molar
11 mos.	$\frac{0}{3}$	$\frac{0}{1}$	$\frac{3}{3}$	$\frac{2}{2}$
19 "	$\frac{0}{3}$*/	$\frac{0}{1}$	$\frac{3}{3}$	$\frac{3}{3}$

1. known age skull
X a tooth forming in jaw but no erupted through bone
* 1st deciduous incisor replaced by permanent tooth at 16 months of age. Second permanent incisor erupted through gum at 22 months of age.

Formation and composition of herds. Intraspecific social relationships are often of great importance in the population dynamics of a species. In bighorn sheep there are clear-cut herd relationships among the age and sex groups. On Wildhorse Island the social organization consisted primarily of two units - the ram herd and the ewe herd. The latter divided again into the wet-band (female with lambs) and the dry-band (females without lambs) during and following the lambing season.

Rams three years of age and older maintained spearate herds except during the fall when they sought out and bred the ewes. All lambs, yearlings, and two year old females associated with the ewe herds. Two year old males often formed separate herds.

The following details were noted regarding the forming of ewe herds into two distinct kinds of bands during the lambing season. In the spring individuals or small groups of ewes left the ewe-lamb herds and sought out secluded places to

lamb. After lambing a ewe stayed with her lamb or cached it near the birth site for several days before the lamb was able to follow the ewe and come out into the open. When the ewe came out of seclusion with her lamb, other sheep were encountered but for about one week the mother would not allow certain other sheep to be near her lamb and either attacked or drove them away. These included her offspring from the previous year and other lambs and yearlings as well as mature ewes which had not yet dropped their own lambs. Instead of driving away other recently parous ewes she associated with them. Such ewes with young lambs didn't rejoin the original band of ewes but banded together among themselves. These groups are referred to as wet-bands. The collection of mature ewes which had not yet dropped lambs for the current season along with sterile ewe and ewes which lost their lambs are referred to as dry-bands. This is a situation similar to that observed by Murie (1944) among the dall sheep, Ovis dalli dalli, in Alaska. He states, "The tendency for ewes with lambs to bunch up is probably a natural out come of their all having the same inclination to remain in the rougher terrain. Later there is more intermingling of the ewes with lambs and those without lambs." On Wildhorse Island, the wet and dry-bands were often seen in areas having about the same degree of roughness. Wet-bands increased while dry-bands decreased in size as ewes left

the dry-band to lamb and then joined a wet-band. On a number of days all the wet ewes had gathered into a single band and dry ewes into another band. Thus it was possible to account for all or most of the mature ewes known to be present by censusing the wet and dry-bands. Some of the more complete counts obtained during one season are tallied in Table 5.

Table 5: Total number of ewes found in the wet and dry-bands during part of the 1952 lambing season.

Date of census	No. of mature ewes in wet-band with lambs	No. of mature ewes in dry-bands without lambs
May 4	2	12
5	3	12
13	5	8
27	6	6
June 1	12	3
8	10	4
19	13	2

Wet-bands were most evident early in and during the culmination of the lambing season. After a wet-ewe had her lamb in the open for about a week, apparently it became too active for her to keep continuous account of and her defense of it subsided. At times this caused segregating of wet-ewes and dry-ewes to become less definite. The last two or three mothers to bring forth their lambs in 1952 defended them as vigorously as the first ones had but by this date there were no longer exclusive wet-bands and such ewes were seen to join mixed groups.

From mid-June through mid-July 1953, nine lambless ewes all over four years of age comprised the dry-band. It and the wet-band containing 13 lambs, were continously watched for several days at a time. At times the two bands intermingled but the nine lambless ewes, some of them recognizable as individuals, usually fed independently of the wet-band.

The tendency for ewes to lamb alone is reflected in ten cases for which data are fairly complete. Five of these ewes lambed while alone and two cases of paired ewes lambing together were noted. In only one case was a yearling present. Thus after the mature ewes left a dry-band to lamb, the young from the previous year were often left without leadership and showed erratic behavior. These isolated groups of from two to eight immature sheep were frequently seen in early May but were not seen without older animals during the remainder of the year. Later during the lambing season groups of immature sheep were often seen following the recently formed wet-bands at distances of 50 feet or more.

Two cases of pairs of ewes staying together and dropping their lambs on the same daywere noted. One of these pairs separated from the dry-band two weeks before their lambs were born. On several occasions their two young lambs were cared for by one ewe while the other ewe was feeding a mile or more away. On two occasions one of this pair of ewes stayed with

the lambs while the other dramatically attempted to entice me from the area. Both of the lambs were observed to nurse simultaneously from the same ewe before they were 18 hours old.

For the first few days after a ewe brought her young lamb into the open, the lamb stayed close to her. After a few more days lambs showed more interest in each other, except when the herd was resting for then each lamb laid next to its mother. While the herd was feeding it was usual to see groups of older lambs dashing about often a 100 yards or more away from their mothers. Occasionally a yearling was seen to join in play with the lamb group.

On January 20, 1953, a herd of 18 ewes and lambs was being observed. At 2:15 p.m. it began to rain. A few minutes later one ewe left the group for a timbered area 100 feet from where the other ewes continued to graze in the open. All of the nine lambs in the group followed the lone ewe into the timber.

One marked ewe was observed at least once a month for over a year. Her lamb, also marked, was always present until she dropped another lamb. A single exception occurred during the time the ewe was being courted for three days during Novemeber.

Seasonal distribution. Knowledge of distribution and movement are usually important in defining the limits of a

popultaion unit. Since this group of sheep is confined to an island its physical limits are ridgedly defined and studies of distribution are not essential to a study of dynamics in this population. However, the nature of this study required that many continuous hours be spent in the field. During this time data on distribution and movement in relation to temperature were recorded. This data revealed a response among ewes to temperature in the form of seasonal distribution.

It was very difficult to stalk and observe sheep on the north half of the island since it is covered with timber. Consequently, observation of sheep were made almost entirely on the south half of the island which is palouse prairie.

With occasional exceptions the ram herds confined their activity to the north half of the island, except for about three months in the fall when they joined the ewes for the rut.

Ewes were observed regularly on the south half of the island except during the hot summer months. During the warmest months they were found here on cool days and at dawn and dusk on warm days, i.e. when temperature was below about 70° F. A typical form sheet for a warm summer day provided the following excerpts:

Sept. 1, 1952. 0600 hrs. Temp. 50° F. Animals are grazing arduously on Power's Knoll (south half of island). Direction of movement is random.

0630 hrs. Temp. 58° F. Animals are grazing less arduously.
0700 hrs. Temp. 70° F. Some animals are moving north.
0800 hrs. Temp. 81° F. Some animals have disappeared into the timber.
0900 hrs. Temp. 90° F. All animals have disappeared into the timber.

At noon on many summer days the difference in temperature between the cool north and warmer south halves of the island was 25° F. or more. It was suspected that the ewes retired from the prairie to escape the heat. The following attempt was made to compare presence of ewes on the prairie with temperature.

In order to obtain an index to the degree ewes were present on the prairie the number of man hours spent observing each month was divided by the number of man hours spent observing and searching for ewes during the month. This percentage illustrates the portion of time which was spent observing ewes and thus a rough index to the presence of ewes on the prairie was obtained for each month. A percentage of less than ten indicates that over 90% of my time was spent looking for animals and little observing was accomplished. Higher percentages indicate that less time was spent looking for ewes probably because of greater numbers present. Only the time between 9:00 a.m. and 4:00 p.m. was used to compute these percentages since this eliminates the cooler hours of the summer days when the ewes were usually present.

Figure 8 illustrates the index to the presence of ewes on the south half of the island for 15 months of the study period. The daily maximum temperatures, averaged for each month are also entered on Figure 8. These were obtained from Mr. Claude Meeker who operates a weather station 1.5 miles from Wildhorse Island but on an exposure site comparable to the islands prairie.

It is noted that the percentage indices are lowest during those months having highest temperatures. Perhaps these data illustrate a thermotropism of bighorn ewes.

Use of water and general food habits. Food supply is thought to be one of the most important resistance factors which affects productivity and survival in mammal populations. Therefore, considerable time was devoted to the study of general food habits of sheep and the competition for food between sheep and other grazing animals. An evaluation of the availalbe food was also carried out.

Although thousands of sheep hours were recorded during the study sheep were seen to drink water only a few times. On a few occasions sheep were seen at the lake shore and seepage areas which are near the shore. However, instead of taking water on these visits usually only the vegetation and the exposed soil were consumed. There is no running water on the island except run off following rains and thaws.

During June 1952, sheep were leaving mats of shed hair at almost every place they visited. At this time the entire lake shore and seepage areas were systematically examined for hair and feces but no evidence of their visits was found. During warm and dry weather sheep were on several occasions continuously observed for as long as nine days and were never seen to drink water. Jardine (1915) tells of domestic sheep going through the entire Montana summer without drinking water. Stoddart and Smith (1943) state that sheep in South Africa suffered no ill affects after not drinking water for several years.

The fostered lambs regularly drank water when it was available after they were about 10 days of age. One also went for seven hot days and longer without a drink.

During the study period observations were made almost daily of the food habits of bighorns. Direct observations were made of the kinds of plants the animals were utilizing and the number of animal-hours they fed on these plants. An animal-hour is defined as one animal feeding for one hour. Since small groups generally fed together and ate approximately the same plant species, these groups were observed and the feeding time was computed for the group as a whole. Any exceptions to the general feeding pattern were noted and recorded

separately. Data were recorded wherever and whenever feeding sheep were located. However, an effort was made to observe all major cover types each working day so that observed utilization in any one type would not be slighted because the type was not widely distributed. Identification of the major plants being utilized was often made with the aid of a telescope or the feeding area was examined immediately after the animals moved away.

The number of hours that sheep fed on three major plant classes as well as seasonal use is presented in Table 6. For convenience data were summarized by quarters of the year. The first quarter corresponds roughly to the astronomical winter season, the second quarter to the astronomical spring, etcetera. Beginning in the 2nd quarter of 1952 and continuing through the 2nd quarter of 1953, totals of 410, 652, 424, 483 and 289 sheep were observed in determining feeding habits during the respective quarters (Table 6). The total of 2,258 observations of sheep represent 4,553 feeding hours.

The data of Table 6 show that 80% of the year around diet consisted of grasses, with browse and forbs forming 16% and 4% respectively.

Data from the 2nd quarters of 1952 and 1953 indicate that browse and forbs receive greater utilization at this

time than during any other quarter of the year. Grasses receive correspondingly less use in the 2nd quarter but also form a major portion of the diet then, as well as constituting the bulk during other quarters. The species most utilized in these food classes are:

Grasses	Browse	Forbs
Bromus tectorum	Amelanchier alnifolia	Balsamorhiza sagittata
Agropyron spicatum	Philadelphus lewisii	many annuals
Festuca idahoensis	Acer glabrum	
Koeleria cristata	Prunus melanocarpa	
Festuca scabrella	Artemisia tridentata	
Poa secunda		
Poa compressa		
Poa pratensis		

During the 2nd quarter of 1952 all grasses produced green growth and these were taken without any preference being noted. During the 3rd quarter of 1952 only Poa compressa remained green and it was somewhat preferred to other grasses. The heavy use of grass during the 4th quarter of 1952 consisted almost entirely of the smutted heads of cheat grass, Bromus tectorum, perhaps because by this date the native grasses had been largely consumed by the abundant horses and deer that inhabit the island. During the 1st quarter of 1953 unusually mild weather and much rain caused the grasses, particularly Bromus tectorum, to produce green growth about January 10. Sheep immediately switched to this green grass which formed the bulk of the winter diet.

There were indications that the sheep would have shown greater preference for browse during the 4th quarter if the

Table 6: Feeding habits of bighorn sheep.

Plant food	1952						Plant food	1953					
	2nd quarter		3rd quarter		4th quarter			1st quarter		2nd quarter		Total	
	Animal hrs	%	Animal hrs	%	Animal hrs	%		Animal hrs	%	Animal hrs	%	Animal hrs	%
Grass	806	54	753	84	718	93	Grass	869	97	149	38	3994	80
Browse	508	34	108	12	46	6	Browse	20	2	209	53	891	16
Forbs	179	12	36	4	8	1	Forbs	10	1	35	9	268	4
Total animal-hours	1493	100	897	100	772	100	Total animal-hours	998	100	393	100	4553	100
Number animals	410		652		424		Number animals	483		289		2258	

use by deer had not been so great. Browse utilization was over 100% by the 4th quarter and apparently the sheep had to resort largely to grass at this time.

Balsamorhiza sagittata received more use by sheep than all other forbs combined. Both leaves and flowers were readily taken by deer and sheep from April through June when the plant was green.

The dried cheat grass which was eaten by sheep in the 4th quarter was not that which had gone to seed but that which had been attacked by a smut and didn't produce mature seed. It was notices that sheep uprooted the entire cheat grass plants but chewed off and consumed only the smutted heads. The stems, roots and soil collected at the corner of the sheep's mouth where they became a bundle before dropping to the ground. This phenomenom presented the following opportunity of determining the quantity of smutted cheat grass heads consumed by a sheep. Observations revealed that sheep produced from 25 to 40 and an average of 30 such bundles of cheat grass stems per hour. One particular ewe was observed to drop 31 bundles during an hour of feeding. The course it used while feeding was followed and the first bundle it dropped during the hour was examined. The number and approximate size of culms in the bundle were noted. Then from the same

area cheat grass plants were picked to form a bundle like the one the ewe had dropped. The heads of this bundle were cut off at the same length the ewe had chewed the heads from its bundle and this was weighed. The remainder of the bundle was discarded. This was repeated for all 31 bundles. Field weight of the heads of the 31 bundles was 2.3 ounces and was assumed to equal the amount consumed by the ewe during one hour. During this time of year animals were known to be feeding nearly 12 hours per day and many were seen to eat nothing but smutted cheat grass heads for several consecutive days. Apparently this ewe consumed (12 hrs. x 2.3 ounces per hour or) 1 3/4 pounds of food per day. The weight of the ewe was judged to be 110 pounds. Therefore, only about 1.6 pounds of food were consumed each day per 100 pounds of body weight. Nichol (1938) working with Arizona deer found that 2.35 pounds of food per day per 100 pounds of body weight was required for maintenance.

The above information indicates that there is a food shortage probably resulting from over utilization of the range. Since food supply is important in the dynamics of a population it was believed that time spent surveying the range would be well spent. Consequently, a range inventory was carried out and the results are presented.

RANGE SURVEY

In order that the number of animal units being supported by this range could be determined, size estimates were made of the horse and deer populations.

Diagnostic natural marks, particularly the shape of the face blaze allowed individual horses to be recognized. The traits of each horse encountered were recorded. When after several months no additional horses were observed it was assumed that all horses had been encountered. The number of horses recorded for the summer of 1953 totaled about 80 adults and 20 colts.

The number of mule deer, Odocoileus hemionus, on the island was not definitely determined. The largest number seen at one time was almost 100. On this occasion about one-twelfth of the island was in view from the observation point. The largest count obtained while walking the length of the island was 200 different deer. As many as 30 to 40 animals were seen in a group many times. It is believed that 300 to 400 is a conservative estimate for the number of adult deer on the island during 1953.

In this study the horse is used as a standard for the animal-unit. Deer and sheep are referred to as one-fifth

animal-unit since the body weight and food consumption are about that fraction of the horses. The term animal-unit month, (A.U.M.) refers to the food requirement for one animal-unit for one month. A conservative estimate of food requirement of grazing animals of Wildhorse Island is shown on Table 7.

During the summer of 1953, a brief range survey was made to determine the carrying capacity of the island for grazing animals. The results are shown on Table 8.

Table 7: Food requirements for adult grazing animals on Wildhorse Island during the summer of 1953.

	No. of adults	Animal-units	Range use in months per year	Animal-unit months
Horse	80	80	12	960
Deer	300	60	12	720
Sheep	65	13	12	150
				1830 A.U.M. per yr. required

Table 8: 1953 carrying capacity of the island for grazing animals.

	Surface acres	Major forage plants	Yield in A.U.M.
Timber (waste)	500	00	00
Timber (open)	1000	Ppr, AGR, Pco	100
Palouse (good condition)	50	Asp, Fid, Pse	50
Palouse (fair condition)	250	Asp, Ppr, Kcr, Bte	80
Palouse (poor condition)	600	Bte, Bsa	120
Browse	100	Aal, Ple	10
Totals	2500A.		360 A.U.M. available per year

Since 1,830 A.U.M.'s are required per year for the grazing animals on the island and only 360 A.U.M.'s are available, the requirement is over five times proper use. This is a conservative estimate since utilization cuts were not applied. These would subtract from the available animal-unit months on such areas as steep slopes, distant from water, natural barriers and poor range condition. Methods used to determine carrying capacity were patterned after Humphrey (1945). The fact that ten horses and about 50 deer carcasses were found in emaciated condition during April 1952, probably reflects the inadequacy of forage during an average winter.

Food habits of horse and deer were not studied as intensively as those of sheep. However, a few hours a week were devoted to learning something of forage competition between these three species. All three are primarily grazers on this island. Horses depend almost exclusively on grasses the year around. The only herb receiving important use by horses was the flower of balsam root, Balsamhoriza saggittata, and almost no browse was taken. All three large mammal species preferred the flowers of balsam root in the spring, horses picking them by the peduncle while sheep and deer just ate the heads off. Although balsam root has a density of

nearly 40% as measured by ocular estimate on much of the island, only about one-third of its flowers remained long enough to produce seed in 1952. During 1953 when large mammal populations were greater nearly every flower was consumed.

Deer too subsisted primarily on grasses but took browse and herbs in the spring. Browse utilization in spring and summer was over 100% so that little browsing was observed in the fall.

It is believed that horses produce the most damage to the grazing range. This is true for several reasons. The horse population has the highest food requirement and horses graze almost exclusively on the few desirable native bunch grasses through out the year. In the spring, as herbs became available they are significant in the diet of the sheep and deer. This offers some relief to the more critically utilized grasses. However, horses eat few herbs in the spring and subsist primarily on grass. According to Platt and Jackson (1946), "It is the heavy spring use that kills the native grass." Furthermore, as grasses produce green growth in the spring horses tend to graze at the lower elevations which are already in critical condition. Sheep tend to utilize higher elevations in the spring. These are generally in better condition and more able to withstand use.

The horse population is known to have reached a peak of about 100 animals in 1953. Evidence indicates that deer have apparently been increasing since about 1920. It is believed that utilization of the range was greater in 1953 and 1954 than any other time since wild sheep were introduced on the island. Perhaps this lowered the nutritional plane of the sheep and partly accounts for their reduced reproductive capacity during these two years.

The range survey revealed that undesirable plant species are abundant, that plant density is low and that plant litter is almost absent, all of which indicate that this range is not in good condition. The presence of erosion pavement, pedestaling of plants and the lack of reproduction of desirable species indicate that range trend is downward.

On much of the island, cheat grass, Bromus tectorum, now forms a disclimax community to the native bunch grass which was described on the island by Dice (1923) 35 years ago. Reseeding of desirable grasses which requires cultivation would be difficult on most of the island because of the steepness of slopes. Professor Melvin Morris visited the island several times during the study. He felt that reduced grazing pressure would result in some reestablishment of native bunch grasses even though their density is low at

present. It would also be desirable to rotate use on the various parts of the range.

The large horse and deer populations make up the bulk of the grazing pressure and are largely responsible for the rapidly deteriorating condition of this range. In order to prevent further regression of this range and to decrease soil erosion the horse and deer populations should be markedly reduced.

SUMMARY

A study was made of the bighorn sheep population on Wildhorse Island of Flathead Lake, Montana. This population is restricted to a few square miles and this offers an unusual opportunity for intensive study. Approximately three days a week were spent on the island between June 29 and August 4, 1951. Full time field work was carried out from April 1, 1952 through July 15, 1953. Four vists ranging from two to eight days in length were made to the island during the spring and summer of 1954. Results obtained during the study period included the following:

1. Data were obtained regarding productivity and lamb survival over a four year period. In 1951, 11 mature ewes were present and 11 lambs were produced. Ten of these survived after one year leaving a ratio of 1 mature ewe per .91 lambs. During 1952, 18 mature ewes were known to be present and 18 lambs were known to have been produced. About one-half of these were captured and marked. Two of these were known to have disappeared soon after birth leaving a ratio of 1 mature ewe to .89 lambs one year later. In 1953, 22 mature ewes were present but only 15 lambs were known to have been born. About one-half of these lambs were captured and marked. Two disappeared soon after birth. This left a ratio of 1 mature

ewe per .59 lambs after one year. In 1954, 27 mature ewes were present on the island. Only 18 lambs were tallied in late June. One of these apparently disappeared at an early age leaving a ratio of 1 mature ewe per .63 lambs. Productivity was at optimum level during 1951 and 1952. Survival was also high but the few mentioned deaths occurred.

2. During 1953 and 1954 a large number of mature females were without lambs. It is believed that capturing and handling of lambs caused no measurable affect on lamb survival. Lamb mortality was attributed largely to wet weather. A foster lamb contracted pneumonia after a severe soaking; and spring rains were closely associated with all other cases where lambs disappeared.

3. Observation of some of the mature ewes which were without lambs after 1953 and 1954 lambing seasons revealed a lack of development of the udder. In some instances this condition indicated that they had not recently dropped lambs. Thus the low ewe-lamb ratios of 1953 and 1954 were considered to be the result of low productivity as well as mortality.

4. Survival of lambs after they reached about one week of age and of yearlings was very high each year.

5. A breeding pattern is described which may be considered a form of monogamy. If this breeding behavior is as

prevalent in other sheep herds as it appears to be in the Wildhorse Island herd then continued harvesting of bighorn rams to the point were sex ratios are markedly altered may be undesirable.

6. The observed breeding and lambing of a marked ewe revealed the gestation period to be about 180 days.

7. Development of some physical characteristics of lambs are described. These are based primarily on periodic measurements taken from two fostered lambs and seventeen captures made of 12 other lambs.

Lambs ranged from 60.5 to 71.5 cm in length at birth. By three months of age they were over 100cm long and by 16 months males were about 160 cm long.

Ten pounds was the usual birth weight and also the average amount gained each month. At 16 months of age a male weighed 160 pounds. Females were not as heavy.

Hair disappeared at the horn sites at one and one-half months of age and horn buttons were evident soon afterwards. Horns grew at about 15mm per month from two through six months of age and about 30mm per month for the next 10 months. Annual sulci developed during November of 1952 and 1953.

Hooves were 27mm long at birth. Although wear might temporarily exceed growth they continued to become longer

so that by 19 months of age they were 50mm long. The growth rate was rather uniform through out the year at 9.5 to 10mm per month.

Natal pelage was 22mm long at birth. By three and one-half months of age it was 40mm long but mostly shed by this time. Juvenile pelage grew from 5mm per month during the summer to as fast as 1mm per day during the winter.

The incisor teeth may or may not be erupted through the gum line at birth. By one week of age the incisors and the canines were usually erupted. By three months of age the deciduous front teeth were fully erupted. The first permanent incisor appeared at 16 months of age. Usually the lamb is born with cheek teeth not erupted although the first upper premolar may be felt through the gum. Jaw x-rays revealed that a full mouth was first gained at about one and one-half years of age.

Testes descended at about five months of age.

8. Results of a general study of food habits showed that grasses form the bulk of the year-around diet. Browse and forbs were of considerable importance during the spring.

9. Information was obtained regarding formation and composition of the herds throughout the year. Rams three years of age and older maintained separate herds except

during the fall when they sought out and bred the ewes. All lambs, yearlings and two year old females associated with the ewe herds. Two year old males often formed separate herds. In the spring individuals left the ewe herds to lamb. As lambing progressed new groups made up solely of ewes with young lambs were observed. These are referred to as wet-bands. The collections of ewes which had not yet dropped their lambs was well as sterile ewes and ewes which had lost their lambs are referred to as dry-bands. The fact that wet ewes would not allow any sheep except other wet ewes to be near their lambs is thought to be associated with this segregation. Wet-bands increased while dry-bands decreased in size as ewes left the dry-bands to lamb and then joined wet-bands.

10. An index to the presence of ewes on the island's prairie was devised. Data were gathered for 15 consecutive months and compared with monthly temperatures on the prairie. The number of ewes present in the open grassland was lowest during those months when temperatures were highest. The data may show a thermotropism of bighorn ewes.

11. A range survey was conducted on the island to determine the amount of available forage. The size of horse, deer and sheep populations were also determined. Results indicated that the food requirement for the grazing animals

on Wildhorse Island was in excess of five times proper range use. It is suggested that horse and deer populations be markedly reduced.

12. Analysis of fecal samples revealed that about one-third of this population is lightly infested with lung worms, Protostrongylus sp. Since the ewes which were known to have produced lambs showed a higher percentage of infestation (48%) than those which were currently without lambs (22%), apparently light infestation of lung worms in ewes had no adverse affect on lamb production.

LITERATURE CITED

Chapman, C. A. 1908. Capturing the kids of the mountain goats. N.Y. Zoo. Soc. Bul. July 1908 : 429

Couey, F. M. 1950. Rocky mountain bighorn sheep of Montana. Sur. and Invest. of Mont. Wild. Res. under Fed. Aid in Rest. Act Bul. No. 2. Helena, Montana : 79 p

Cowan, I. M. 1951. The diseases and parasites of big game mammals of Western Canada. Proc. 5th Ann. Game Conv. : 64 p

Dice, L. R. 1923. Mammal associations and habitats of the Flathead Lake region, Montana. Ecology 4 : 247-260

Frost, N. M. 1942. Gestation period of bighorn sheep. J. of Mamm. 23(2) : 215

Hobmaier, A. and M. Hobmaier. 1930. Life history of Protostrongylus rufescens. Proc. Soc. Exp. Biol. and Med. 28(2) : 156-158

Humphrey, R. R. 1945. Range condition - a classification of the palouse grass type. S.C.S., Washington D.C.

Jackson, H. T. 1944. Big game resources of the United States, 1937-1942 F.&W.S.,Rep.8, U.S. Gov't. Ptg. Off., Washington D.C. : 56 p

Jardine, J. T. 1915. Grazing sheep on range without water. National Wool Growers Mag. 5(9) : 7-10

Jones, F.L. 1950. Survey of the Sierra Nevada bighorn. Sierra Club Bul. 7, San Francisco, Calif., June 1950 : 76 p

Mills, H. B. 1937. A preliminary study of the bighorn of Yellowstone National Park. J. of Mamm. 18(2) : 205-212

Murie, A. 1944. The wolves of Mount McKinley. Fauna Series No. 5. U. S. Gov't. Ptg. Off., Washington D.C. : 238 p

Nichol, A. A. 1938. Experimental feeding of deer, Ariz. Agric. Exp. Sta. Tech. Bul. 75, Palmer

Packard, F. M. 1946. An ecological study of bighorn sheep in Rocky Mountain National Park, Colorado. J. of Mamm. 27(1) : 3-27

Platt, K. and E. R. Jackman. 1946. The cheat grass problem in Oregon. Ore. State Col., Corvallis. Ext. Bul. 668 : 48 p

Pulling, A. V. S. 1945. Non-breeding in bighorn sheep. J. of Wild. Mgt. 9(2) : 155-156

Rush, W. M. 1935. The rocky mountain bighorn. Col. Forester Mag. Wild. Ed. Colo. State Agr. Col., Fort Collins

Seton, E. T. 1927. Lives of game animals. Doubleday Doran & Co., N. Y. Vol. 3 : 492 p

Spencer. C. C. 1943. Notes on the life history of the rocky mountain bighorn sheep in the Tarryall Mountains of Colorado. J. of Mamm. 24(1) : 1-11

Stoddard, L. A. and A. D. Smith. 1943. Range management. McGraw-Hill Book Co. Inc., N. Y. City : 547 p

U. S. Dept. of Agric. 1941. Climate and man. Dept. of Agric. Yr. Book. 1941. U. S. Gov't. Ptg. Off., Washington D. C. 1248 p