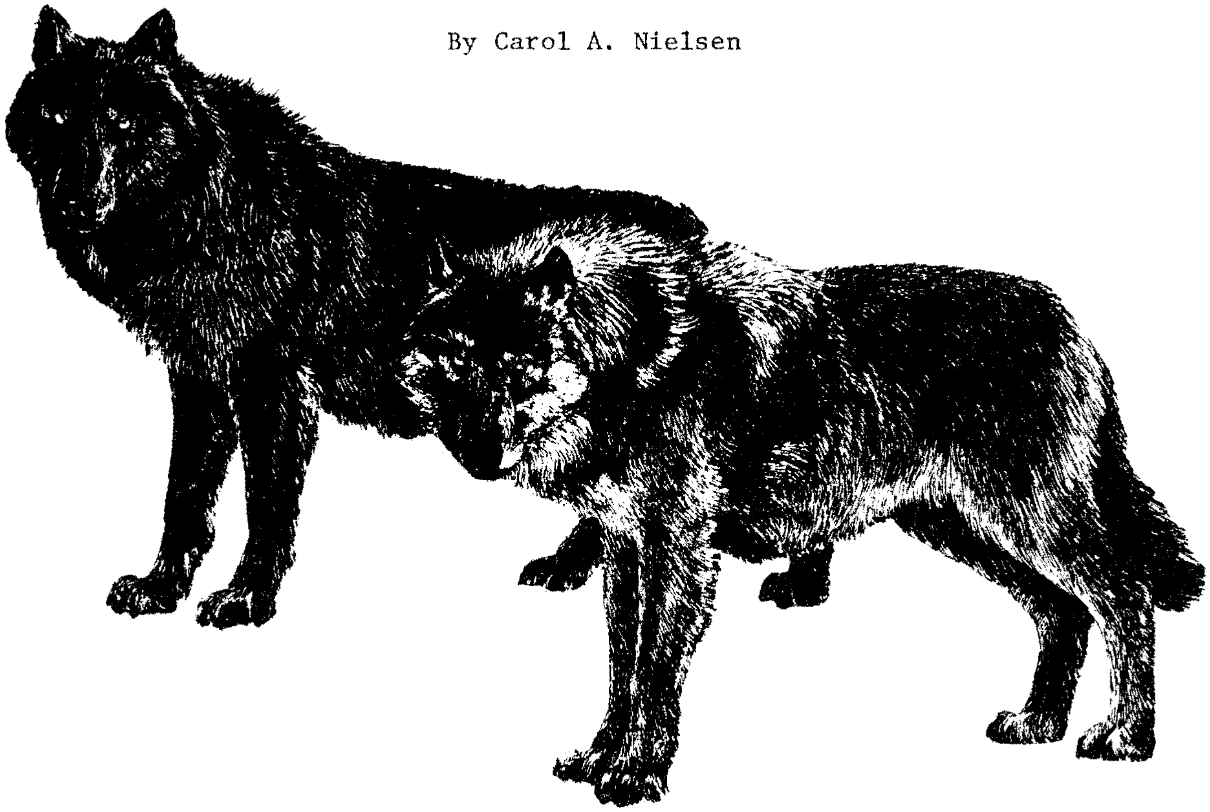
ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

WOLF NECROPSY REPORT: PRELIMINARY PATHOLOGICAL OBSERVATIONS

By Carol A. Nielsen



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Special Report
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SPECIAL REPORT

State: Alaska

Cooperator: Carol A. Nielsen

Project Nos.: W-17-8 and W-17-9 Project Title: Big Game Investigations

Job No.: 14.0 S&I Job Title: Wolf Necropsy Report: Preliminary Pathological Observations

Period Covered: January 1, 1976 through December 31, 1976

SUMMARY

Organ weights and preliminary gross pathological information were collected from 112 Alaskan wolves. These included 89 taken by aerial hunting, 22 taken by trappers, and one killed in a road accident. Nearly all wolves were from Units 13 and 20.

Age and sex differences in body weight were reflected as similar average organ weight differences for the heart, liver, and kidney. Increase in organ weight, except for the liver, was apparent with increasing age in adult females but not in adult males. Thyroid weight increased with age and body weight for both sexes, but adrenal weight for adults showed no sex or nutritional status variations. Involution of the thymus was correlated with age, female reproductive history, traumatic injuries, and particularly with nutritional status (as indicated by kidney and subcutaneous fat). No relationship between thymic involution and adrenal weight was apparent.

Possible pathological changes were rarely encountered in the heart, spleen, gallbladder, adrenals, and thyroids. Pathological changes of a more significant, but unfortunately nonspecific, nature were occasionally noted in the liver, kidney and bladder. Progressive renal cortical scarring seemed to occur with the greatest frequency. Histopathological and serum analyses are necessary to implicate possible microbiological or parasitic etiologies.

Evidence of traumatic injuries was abundant. In 50.9 percent of the wolves examined such injuries as dents in the skull, damage to the teeth, fractures of the ribs or long bones, abcesses and abrasions of the skin and subcutis, and damaged or missing ears or toes had occurred. The incidence of traumatic injuries increased with age and showed geographical variations. Fractures were more frequent in certain parts of Unit 20A (the flats-east and foothills-west areas) than in other parts, and were more abundant among the Unit 20A than the Unit 13 wolves.

Results of serum analyses, histopathological examinations, and endocrine and other studies now in progress should help clarify and finalize the preliminary biological and pathological necropsy findings reported here.

CONTENTS

BACKGROUND

A variety of health-related factors influence the survival of individual animals in the wild and are thus important parameters in the dynamics of wild populations. Wolf (*Canis lupus*) populations in Alaska have been known to fluctuate widely but are held below their theoretical rate of increase by mortality in all age classes (Rausch 1966). Causes of health-related mortality have not been systematically investigated among Alaskan wolves. Numerous incidental observations, however, indicate possible health-related mortality factors. Limited food resources, leading to low nutritional levels, reduced vigor, and ultimately to mortality, constitute an obvious health-related factor. Rausch (1969) attributed the high differential mortality of pups to this cause. Among Canadian wolves, high mortality of juveniles was also observed (Pimlott et al. 1969, Kuyt 1972). However, after finding serological evidence of low-level enzootic canine distemper and infectious canine hepatitis in northern Canadian wolves, Choquette and Kuyt (1974) speculated that these diseases might account for differential pup mortality.

Evidence of other debilitating diseases in free-living wolves has occasionally been published. Murie (1944) postulated that mange, distemper and rabies are important controls on Alaskan wolf populations, and cited in support a number of early references and incidental observations. Rausch (1958) recounted a few cases of rabies in Alaskan wolves, and Neiland (1970b, 1972 and 1975) found serological indications of brucellosis in some wolves. Rabies may be contracted from the arctic fox (*Alopex lagopus*) population of coastal Alaska, which periodically suffers outbreaks of this viral disease (Rausch 1958), and infections of *Brucella suis* biotype 4 could be acquired from infected caribou (*Rangifer tarandus*) prey (Neiland 1970b, 1974 and 1975). Experimental studies by Neiland (1974) also indicated that infections of rangiferine brucellosis in wolves may lead to reproductive failure via abortion or neonatal mortality. Mech (1970) summarized a variety of diseases and conditions encountered among wolves in captivity.

Several excellent studies of wolf helminth parasites in a number of wild populations have been published. Mech (1966 and 1970) listed those done in various parts of the world. Systematic examinations of 200 Alaskan wolves by Rausch and Williamson (1959) and of 98 Albertan wolves by Holmes and Podesta (1968) reflected a high occurrence of trematodes, nematodes, and, particularly, of gastrointestinal cestodes. Observations of gastrointestinal cestodes in Alaskan wolves have also been made by Garceau and Atwell (1961) and Neiland (1967, 1969 and 1970a). After a careful review of the helminth parasites reported for various populations of North American wolves, Holmes and Podesta (1968) concluded that their helminth faunas were basically similar because of similar food habits.

Apparently the food habits and general mode of life of wolves also lead to numerous traumatic injuries, judging from the number of incidental reports in the literature (see Mech 1970). Intraspecific strife and consequent injuries in Alaskan wolves have been reported by Murie (1944), Rausch (1966) and Stephenson and Johnson (1973). Although cannibalism of injured wolves has been reported in Alaska on a number of occasions (Rausch 1966, 1967, Stephenson and Johnson 1973), feeding of an injured wolf by its associates has also been noted (Burkholder 1959, Rausch 1966). In his examination of 4000 radii-ulnae and 1250 skulls, Rausch (1966) found "numerous" fractures that had healed or were healing, including compression fractures of the skull. Missing teeth (Stephenson and Sexton 1974) and loss of a foot (Stephenson and Johnson 1973) have also been noted among Alaskan wolves. Stephenson and Johnson (1973) cited two cases of three-legged female wolves successfully rearing pups.

No information on the weight of normal organs of free-living wolves has appeared in the literature, although data on growth and development are available for wolves in Minnesota (Van Ballenberghe and Mech 1975). Age-related changes in the bones and teeth of Alaskan wolves have been investigated by Rausch and Winters (1964) and by Stephenson and Sexton (1974). Differences in the morphology of the skull according to sex (Stephenson and Johnson 1973) and Alaskan locality (Pedersen, in prep.) have also been examined.

The maximum life span of captive wolves is between 10 and 16 years (Young 1944). That apparently few wolves in the Alaskan wild attain the age of even seven years (Stephenson and Sexton 1974) is perhaps understandable, considering their rugged mode of life. Yet no systematic investigation of wild individuals has been done to determine the incidence of the potential mortality factors (disease, accidents, etc.) cited by many investigators as population regulators (Rausch 1966, 1969, Pimlott et al. 1969, Stephenson and Johnson 1973). Examination of the fresh carcasses of wild individuals obtained in control programs could give evidence of the incidence of debilitating conditions or progressive lesions acting in the population and of their potential as mortality factors. Alaska Department of Fish and Game wolf reduction programs in Game Management Units 20A and 13 during late winter and early spring 1976 provided the opportunity for such a systematic investigation.

OBJECTIVES

A. To obtain basic morphological and physiological data on free-living Alaskan wolves.

    1. To compare these data with similar information from free-living wolves in other geographic areas and with captive wolves.

    2. To establish a normal range of necropsy data for comparison with (and possible delineation of) situations involving pathological changes.

B. To investigate possible methods of elucidating the clinical history of free-living wolves.

    1. To relate a possible clinical history to other facets of the basic biology of the individual, including nutritional status, pack association, social status, reproductive history, etc.

    2. To relate information on prior exposure to potential pathogens obtained from serum to pathological changes observed at necropsy.

C. To identify and determine the incidence and distribution of parasites and diseases of potential pathological significance to free-living Alaskan wolves.

    1. To determine the extent to which these pathogens affect productivity, mortality, and distribution of the wolf population.

    2. To clarify means by which potential pathogens in the wolf population might ultimately affect the populations of related species.

PROCEDURES

Between January 15 and March 17, 1976, a total of 112 wolf carcasses were available for necropsy and study. Of these, 89 were collected by aerial shooting during wolf reduction programs by the Department of Fish and Game and included 64 wolves from Unit 20A and 25 wolves from Unit 13. Procedures and precise locations of the aerial hunts are described elsewhere (Stephenson and Shepherd, in prep.). An additional 19 wolf carcasses were obtained from trappers operating during the same period of time in the same areas (11 wolves from Unit 20A, 8 wolves from Unit 13). Thus, 75 and 33 wolf carcasses were presented from Units 20A and 13, respectively. Also available were the carcasses of three wolves trapped at Yakutat (Unit 5) on February 29 and of one wolf killed by a vehicle near Toolik (Unit 26) on March 21, 1976. Of the total 112 carcasses examined, 89 were obtained by aerial hunting, 22 by trapping, and one from a road kill.

The 75 Unit 20A wolves were taken from eight geographic areas: four in the flats or lowlands (flats-east, Fairbanks, flats-buttes, and flats-westcentral) and four in the foothills along the southern boundary (foothills-east, foothills-Little Delta, foothills-central, and foothills-west; see Fig. 1-1). One to three wolf packs were found in each area, so the 75 wolves were associated in 20 packs.* In Fig. 1-1, a one- or two-letter code is circled on the map to indicate the precise collection location of each pack. Individual pack members are identified by five-digit numbers adjacent to the appropriate pack affiliation (see also Table 1-1).

The 33 Unit 13 wolves were taken from four geographic areas: Delta and Maclaren (Subunit 13B), Brushkana-Butte Creek (Subunit 13D), Deadman (also Subunit 13D), and the Gulkana and Copper River valleys (see Fig. 1-2). All wolves from the last area, encompassing Subunits 13A and 13D, were trapped. The 33 wolves were associated in 10 packs.* In Fig. 1-2, a three-letter code is circled on the map to indicate the precise collection locations of each pack, with associated individual members identified by the adjacent five-digit numbers (see also Table 1-1).

Of the 112 wolf carcasses examined, 55 were presented fresh and 57 frozen. All 55 of the fresh carcasses were obtained in the Unit 20A aerial hunt. These carcasses were skinned within 12 hours of death (except that the hides of 3 wolves, #61404, 61405, and 61406, remained on the carcass for approximately 20 hours) and were necropsied from 4 to 30 hours post mortem. The 57 frozen carcasses included all 22 of those obtained from trappers, all 25 from the Unit 13 aerial hunt, 9 wolves from the Unit 20A aerial hunt, and the single Unit 26 road-killed wolf. Because of the variable conditions under which they were kept, the carcasses presented by trappers and those from the Unit 13 aerial hunt may have partially thawed and refrozen before necropsy.

The 64 wolves collected in the Unit 20A hunt were weighed and measured before skinning. An attempt was made to collect serum from whole wolves by puncturing the hide with a sharp instrument just anterior to the sternum on the ventrum, and penetrating the anterior thoracic cavity. When present, blood was drained from the thoracic cavity by elevating the animals' hindquarters and centrifuged, and the resulting supernatant was collected and frozen as "serum." Unfortunately, the composition of the supernatant cannot fairly be called "serum" because blood collected in this way from wolves dead between 3 and 8 hours undoubtedly contains pleural effusions and other thoracic cavity fluids and contaminants. However, no other means of obtaining serum were available under the conditions of collection.

Serum specimens were also obtained from 37 Unit 20A wolves and 3 Unit 13 wolves using the above method. These specimens were sent to various laboratories for a number of analyses, including determination of possible brucellosis, leptospirosis, infectious canine hepatitis, and distemper titers. Results of these analyses are presently unavailable.

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*"Pack" is used here in its broadest sense, since social affiliation of individual wolves is difficult to ascertain, except by geographic proximity. This is particularly true for wolves trapped by the public. Assignment to packs was clearer for wolves taken in the aerial hunt. Approximated pack affiliations of these individuals is discussed elsewhere (Stephenson and Shepherd, in prep.).

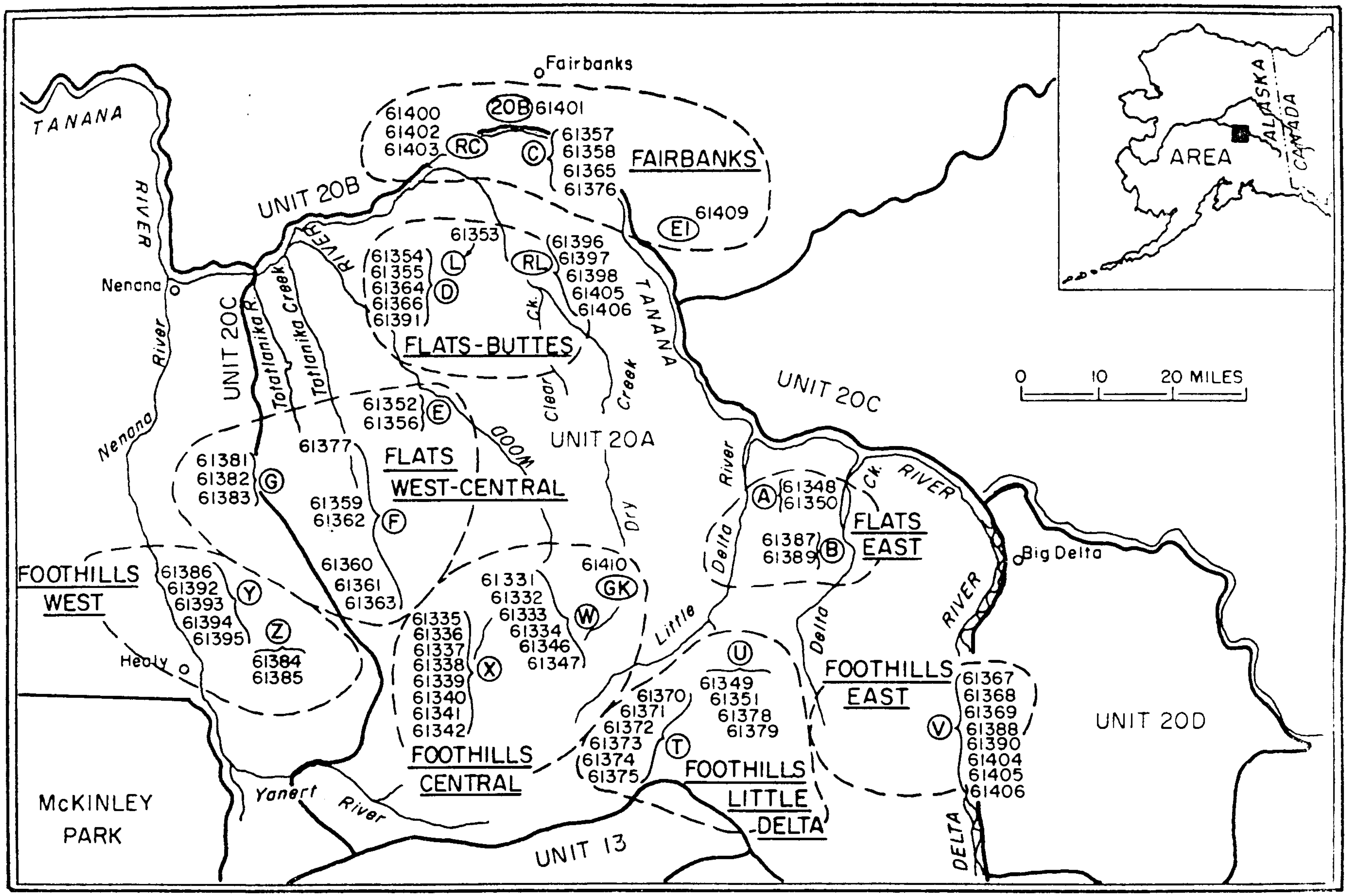

Fig. 1-1. General locations of collection, wolves taken in Unit 20 during spring 1976: Major collection areas are underlined, packs are indicated by a one- or two-letter code, and individuals are numbered (see text, Report 1 and Table 1-1).

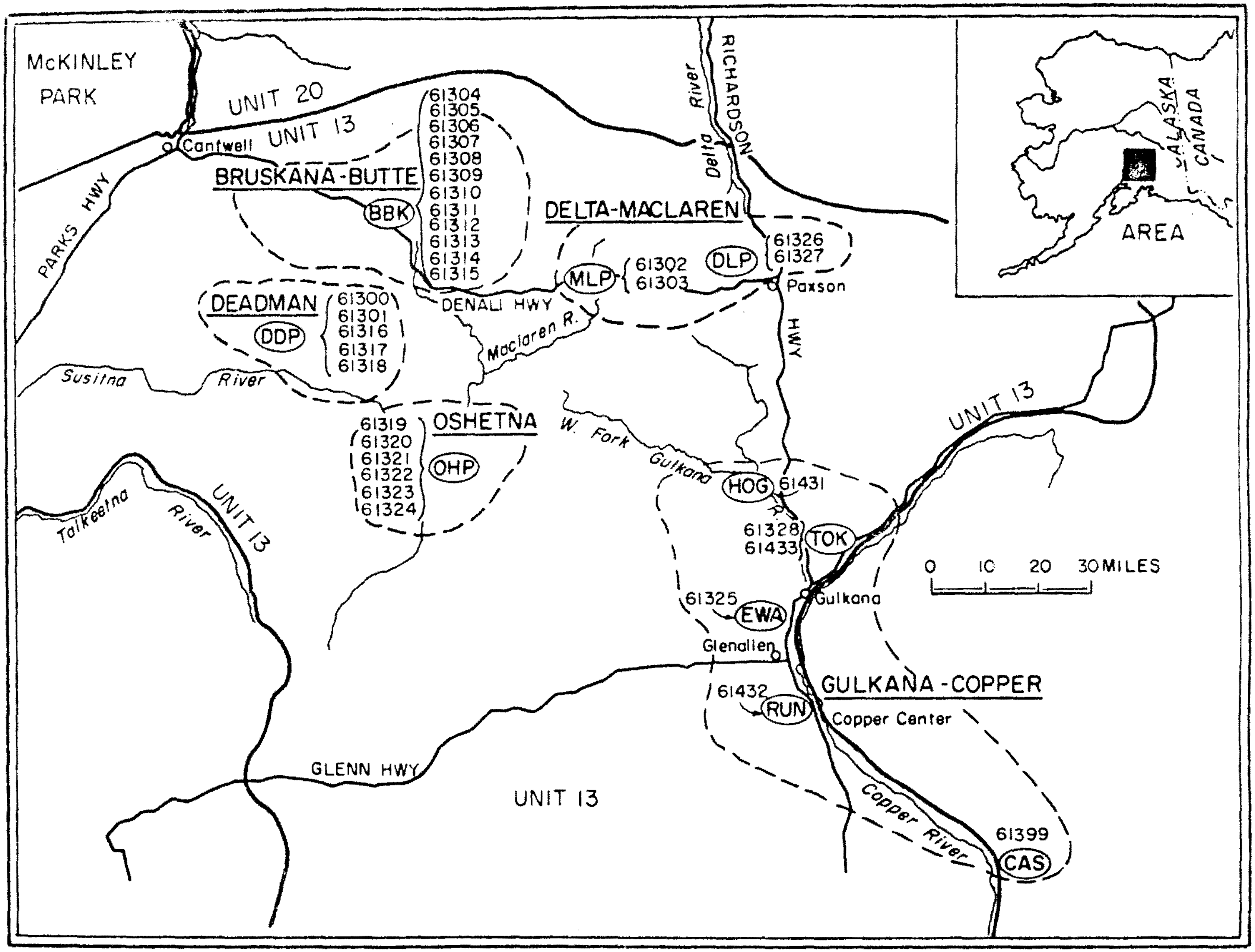

Fig. 1-2. General locations of collection, wolves taken in Unit 13 during spring 1976: Major collection areas are underlined, packs are indicated by a three-letter code, and individuals are numbered (see text, Report 1 and Table 1-1).

The condition of the hide and subcutis, including abrasions, abscesses and missing appendages, was noted as each of the 64 aerially collected Unit 20A wolves were skinned. Testes were also collected and weighed during skinning. Necropsies then proceeded as described below.

First, measurements of subcutaneous fat depths were made at the sternum, flank and rump (discussed by Stephenson, in prep.). The carcass was then opened by a mid-ventral incision from just anterior to the sternum to the anus, and attention was first directed to the thoracic cavity. The anterior mediastinum was carefully excised and gently washed of any blood, and possible thymic tissue was noted. The heart and lungs were removed as one unit, and the ribs were examined for possible healed fractures. The heart was freed by severing the major vessels several centimeters anterior to the atria. The pericardium was opened and both aspects were examined. Residual blood was expressed by manual pressure on the ventricles and was casually examined for the presence of heartworms. The organ was then rinsed and weighed. A cut through the right atrium to the apex of the right ventricle and spiralled around through the proximal pulmonary artery allowed inspection of the lumens and valves of the right heart. A similar opening of the left atrium and ventricle through to the ascending aorta allowed inspection of the left heart. The trachea and bronchi were opened longitudinally and visually inspected to the level of the second bronchi. The lungs, which were frequently in poor condition because of shot damage, were inspected and palpated.

Next, attention was directed to the abdominal cavity. The portal vein was severed just posterior to the diaphragm, and after being freed of its other mesenteric attachments the liver was removed together with the attached gallbladder and proximal bile duct. The gallbladder and proximal bile ducts were sliced open, and both the resulting bile and the exposed mucosa were macroscopically inspected for parasites or abnormal features. The liver was then rinsed and weighed and both aspects were examined. Post mortem color changes and subcapsular air bubbles were commonly observed features. Approximately five parallel slices were made deep into the parenchyma of each major lobe to detect abnormal texture, etc. A 10-gram sample of liver tissue was collected from the left lateral lobe and, together with a 10-gram sample of skeletal muscle from the thigh, was frozen for later analysis by Dr. U. S. Seal of the Veterans Administration Hospital, Minneapolis. Dr. Seal's results were not available at the time of this writing.

The stomach was then partially freed by severing the esophagus just anterior to the cardia. The stomach and intestines were reflected back out of the abdominal cavity, and the former organ was opened for an evaluation of its contents (Stephenson, in prep.). The remainder of the gastrointestinal tract was not examined further, and its helminthofauna was not collected.

The spleen was freed from its mesenteric attachments and weighed. Both aspects of its surface were noted, and its parenchyma and texture were examined by several deep slices along its longitudinal axis.

Both adrenals were then carefully removed from their fat-embedded position adjacent to the spine and just anterior to their associated kidneys. The adrenals were weighed and preserved in buffered 10 percent formalin. The kidneys were removed by saggital cuts through the retroperitoneal fat as delineated by their respective posterior boundaries. Each kidney was weighed with its capsular fat, then the fat was stripped off the capsule (capsular adhesions, if present, were noted) and the kidney was weighed again. Resultant kidney fat index values were obtained by subtraction. After both exterior aspects of each kidney were examined, each organ was cut longitudinally in half from the hilus toward the lateral capsular surface, and any internal abnormalities of the cortices and medulla were noted.

The female reproductive tract, including the ovary, oviduct and bipartite uterus, was removed as a single unit. The uterus was opened longitudinally and examined for evidence of placental scarring. Any fetuses were removed, measured, and their state of development noted. The entire reproductive tract was then preserved in formalin for later evaluation (see Stephenson, in prep.).

The bladder was freed by its connection with the urethra. It was opened, the unstretched wall thickness measured, and its lumenal mucosa visually inspected. Calculi on the mucosal surface or in the retained urine were retrieved and stored dry.

Both thyroid lobes, located on either side of the cricoid cartilage in the cervical region, were then freed of fat, weighed, and preserved in buffered 10 percent formalin. Finally, any other abnormal features that were macroscopically apparent, primarily healing limb fractures, were noted. All apparent lesion specimens were preserved in buffered 10 percent formalin; healing costal and limb fracture specimens were frozen.

A number of biological specimens for other studies were collected from each animal at the end of the necropsy procedure. These included the head (severed from the body at the first cervical vertebra), one radius-ulna unit, one femur, and one complete hindquarter. The first three specimens were cleaned and retained for later examination as the skull and radius-ulna. One lower canine tooth was extracted from each skull and the root cementum was used to determine the wolf's age according to the method described by Stephenson and Sexton (1974; see also Stephenson, in prep.). The condition of the femur was only casually noted before evaluation of its marrow fat index (Stephenson, in prep.). The hindquarters were analyzed in a radio-cesium food habits study by Dr. D. Holleman, Institute of Arctic Biology, University of Alaska and R. O. Stephenson, Alaska Deptartment of Fish and Game. Their results are discussed elsewhere (Holleman and Stephenson, in prep.). In addition, several of the whole carcasses (including organs) were used by Dr. J. R. Luick, Institute of Arctic Biology, University of Alaska, in various metabolic studies. Dr. Luick's results were not available at the time of writing. Finally, normal specimens of the biceps brachii muscle from eight wolves were preserved for Dr. L. M. Julian of the School of Veterinary Medicine, University of California at Davis, for use in his studies of muscle fiber size in canines. Dr. Julian's results are also unknown at this writing.

FINDINGS AND DISCUSSION

Report 1. Weights of normal organs

A. Background data

Since the age, weight, and nutritional status of individual wolves form the basic framework in which organ weights are evaluated, this information is presented in Table 1-1, 1-2 and 1-3. Individual animals are listed by area of collection (Game Management Unit, locale) and apparent pack affiliation, with different packs assigned letter names and abbreviation (see Procedures, also Figs. 1-1, 1-2, and Table 1-2) for the purposes of identification in these reports. Table 1-4 lists the sex and age distribution of whole body weights (in kilograms). Male wolves apparently reach an adult weight by their second full year of life, while female whole body weight increases slowly to the fifth year. Thus the average body weights are greatest for male adults, with female adults and male pups next, and female pups least. These whole weight differences are reflected in the relative weights of the heart, liver, kidney and thyroid as discussed below. Other aspects of body weight, growth, nutrition, and other biological findings are presented and discussed elsewhere (Stephenson, in prep.).

Standards for evaluating the nutritional status of free-living wolves have apparently not been published previously. Accordingly, the following measurements of body fat depots were used for evaluation: (1) subcutaneous fat depth was measured at the sternum, flank, and rump; (2) the capsular fat surrounding the kidneys was weighed and averaged; and (3) the amount of omental fat in the abdominal cavity was subjectively evaluated. Table 1-1 presents these results.

To evaluate relative nutritional conditions, the average kidney capsular fat weight was plotted vs. the average subcutaneous fat depth (Table 1-1) for each individual (with amount of omental fat indicated). Thus a distribution of individual nutritional conditions was observed for wolves in each of the three major collection areas: Unit 20A, flats (Fig. 1-3), Unit 20A, foothills (Fig. 1-4), and Unit 13 (Fig. 1-5). The distribution indicated that subcutaneous fat depth decreased prior to severe decreases in perirenal fat, particularly among the Unit 20A flats wolves. Seasonal, annual and geographic variations in diet and food availability undoubtedly affect fat reserves (Stephenson, in prep.). Each distribution was somewhat arbitrarily grouped, as indicated on the figures, into the relative nutritional categories "good," "fair," and "poor."

Most wolves grouped in the "good" nutritional status category displayed an average kidney capsular fat weight of greater than 100 g, an average subcutaneous fat depth of more than 5 mm, and an abundant amount of omental fat. Wolves grouped in the "poor" category generally ble 1-1. Wolf body fat reserves, including (1) subcutaneous fat depth at three locations, and average, (2) kidney fat for both kidneys, and average, and (3) relative amount of omental fat. Body conditions at the time of collection (present) and in the immediate past is estimated from these reserves.

				Body Fat									Assessed condition	
			Age	Subcutaneous (mm)				Kidney (g)						
Pack	Number	Sex	(yr.)	Sternum	Flank	Rump	x	Right	Left	x	Omental	Trapped	Present	Past
Flats - East														
A	61348	M	4	5	13	10	9.3	84	116	100	Abund.		Good	Fair
B	61389	M	3	15	10	7	10.7	137	141	139	Abund.		Good	Good
A	61350	F	2	5	8	3	5.3	72	95	84	Abund.		Fair	Good
B	61387	F	5	4	18	5	9.0	180	173	177	Some		Good	*Poor
Fairbanks														
C	61357	M	6	TR	TR	TR	TR	23	28	26	Light		Poor	-
C	61358	M	4	1	3	2	2.0	50	64	57	Some		Fair	-
C	61365	M	3	7	3	2	4.0	60	72	66	-		Fair	-
C	61376	M	4	3	4	4	3.7	53	50	52	Abund.		Fair	*Good
20B	61401	M	5	8	8	3	6.7	81	91	86	Light	X	Fair	*Poor
RC	61402	F	3	6	10	10	8.7	124	119	122	Modr.	X	Good	Fair
RC	61403	F	5	5	13	4	7.3	133	153	143	Abund.	X	Good	-
[illegible]	61409	F	AD	1	11	7	6.3	36	37	37	-	X	Fair	-
RC	61400	F	PUP	2	9	2	4.3	38	33	36	Modr.	X	Poor	*Good
Flats - Buttes														
L	61353	M	5	20	7	10	12.3	71	38	55	Modr.		Fair	Good
D	61355	M	4	TR	1	2	TR	13	15	14	Light		Poor	-
D	61364	M	4	2	1	4	2.3	28	27	28	Light		Poor	-
D	61391	M	4	3	3	1	2.3	28	47	38	Light		Poor	-
D	61354	M	5	1	3	1	2.5	24	44	34	Light		Poor	-
RL	61396	M	PUP	TR	1	0	TR	9	10	10	Light	X	Poor	-
RL	61398	M	PUP	8	7	6	7.0	18	23	21	Some	X	Poor	-
D	61366	F	5	5	TR	1	TR	44	57	51	Some		Poor	Good
RL	61397	F	5	12	7	4	7.7	54	49	52	Some	X	Poor	Fair
RL	61407	F	3	2	0	TR	TR	18	15	17	None	X	Poor	-
RL	61408	F	PUP	8	1	5	4.7	35	35	35	-	X	Fair	-
Flats - Westcentral														
E	61352	M	3	15	10	5	10.0	107	-	107	Abund.		Good	-
E	61356	M	4	10	12	7	14.5	139	131	135	Modr.		Good	Fair
F	61359	M	4	13	-	5	9.0	109	136	123	Abund.		Good	-
F	61360	M	2	13	10	30	17.7	143	151	147	Abund.		Good	Good
F	61361	M	2	15	-	5	10.0	123	175	149	Abund.		Good	Good
F	61377	M	4	1	2	1	1.3	34	49	42	Some		Fair	-
G	61381	M	3	10	23	15	16.0	93	119	106	-		Good	-
F	61362	M	PUP	10	3	8	7.0	126	170	148	Abund.		Good	-
G	61382	F	3	8	13	10	10.3	72	-	72	-		Fair	-
G	61383	F	PUP	7	11	5	7.7	68	94	81	Abund.		Fair	Good
F	61363	F	2	6	3	5	4.7	153	175	164	Abund.		Good	Good

Table 1-1. (Continued).

				Body Fat									Assessed condition	
			Age	Subcutaneous (mm)				Kidney (g)						
Pack	Number	Sex	(yr.)	Sternum	Flank	Rump	$\bar{x}$	Right	Left	$\bar{x}$	Omental	Trapped	Present	Past
Foothills - East														
V	61367	M	4	1	1	3	1.7	71	77	74	Some		Fair	-
V	61368	M	3	5	3	2	3.3	82	84	83	Modr.		Fair	-
V	61404	M	3	10	20	8	12.7	77	-	77	Modr.		Fair	-
V	61406	M	4	8	10	2	6.7	61	105	83	Some		Fair	-
V	61369	F	2	5	4	7	5.3	59	54	57	Abund.		Fair	Good
V	61388	F	7	4	5	2	3.7	95	102	99	-		Fair	-
V	61390	F	5	30	15	8	17.7	101	115	108	Abund.		Good	Fair
V	61405	F	3	12	6	4	7.3	76	100	88	Modr.		Fair	-
Foothills - Little Delta														
F	61370	M	5	3	2	4	3.0	73	70	72	Abund.		Fair	*Good
T	61374	M	4	6	3	3	4.0	38	62	50	Modr.		Fair	Good
U	61378	M	3	TR	TR	TR	TR	14	-	14	Light		Poor	-
U	61379	M	6	TR	TR	TR	TR	89	116	103	Light		Fair	*Poor
U	61351	M	PUP	3	3	3	3.0	34	45	40	Modr.		Poor	Good
T	61375	F	6	15	15	4	11.3	101	102	102	Modr.		Good	Fair
T	61372	F	3	8	8	10	8.7	41	58	50	Abund.		Fair	Good
T	61371	F	PUP	15	5	15	11.7	36	58	47	Abund.		Fair	Good
T	61373	F	PUP	9	3	10	7.3	41	70	56	Abund.		Fair	Good
U	61349	F	PUP	0	0	0	0	8	-	8	None		Poor	-
Foothills - Central														
W	61332	M	3	-	-	-	Abund.	120	-	120	Modr.		Good	-
W	61333	M	2	-	-	-	Abund.	105	-	105	Abund.		Good	Good
GK	61410	M	4	1	1	TR	TR	14	20	17	None	X	Poor	-
X	61336	M	2	-	-	-	Modr.	56	-	56	Modr.		Fair	-
X	61337	M	3	-	-	-	Modr.	47	-	47	Modr.		Fair	-
X	61339	M	3	-	-	-	Modr.	72	-	72	Modr.		Fair	-
X	61340	M	3	-	-	-	Modr.	67	69	68	Modr.		Fair	-
X	61338	M	PUP	-	-	-	Modr.	46	-	46	Modr.		Fair	-
X	61342	M	PUP	-	-	-	Modr.	37	-	37	Modr.		Fair	Poor
W	61331	M	PUP	-	-	-	Abund.	97	93	95	Modr.		Good	-
W	61334	M	PUP	-	-	-	Abund.	60	69	65	Abund.		Fair	Good
X	61341	F	2	-	-	-	Modr.	48	-	48	Modr.		Fair	-
W	61346	F	2	3	3	5	3.7	138	131	135	Modr.		Good	Fair
W	61347	F	4	3	10	2	5.0	108	-	108	Modr.		Good	Fair
X	61335	F	PUP	-	-	-	Modr.	36	-	36	Modr.		Fair	Poor
Foothills - West														
Z	61384	M	5	5	18	10	11	115	-	115	-		Good	-
Y	61395	M	4	6	7	16	10	109	173	141	Some		Good	*Poor
Z	61385	M	PUP	5	15	5	8	102	140	121	-		Good	-
Y	61392	M	PUP	14	10	8	10.7	79	81	80	Abund.		Fair	Good

Table 1-1. (Continued).

				Body Fat									Assessed condition	
			Age	Subcutaneous (mm)				Kidney (g)						
Pack	Number	Sex	(yr.)	Sternum	Flank	Rump	$\overline{x}$	Right	Left	$\overline{x}$	Omental	Trapped	Present	Past
Foothills - West (cont.)														
Y	61386	F	3	5	18	5	9.3	112	173	143	-		Good	-
Y	61393	F	5	14	34	14	20.6	125	169	147	Abund.		Good	Good
Y	61394	F	3	17	20	15	17.3	142	-	142	Abund.		Good	Good
Delta Pack														
DLP	61326	M	PUP	1	2	1	1.3	-	-	-	Light	X	Poor	
DLP	61327	F	PUP	1	2	2	1.7	-	-	-	Light	X	Poor	
Maclaren Pack														
MLP	61302	M	PUP	5	20	10	11.7	125	-	125	Abund.		Good	Good
MLP	61303	M	PUP	12	10	15	12.3	125	-	125	Abund.		Good	Good
Brushkana - Butte Pack														
BBK	61304	M	4	10	15	-	12.5	139	-	139	Abund.		Good	Good
BBK	61304	M	3	4	8	4	5.3	94	85	90	Modr.		Fair	-
BBK	61311	M	2	10	18	3	10.3	140	145	143	Abund.		Good	Good
BBK	61309	M	PUP	15	20	13	16.0	100	155	128	Abund.		Good	Good
BK	61313	M	PUP	10	15	1	8.7	120	125	73	-		Fair	-
BBK	61307	F	4	18	2	20	13.3	170	195	122	Abund.		Good	Good
BBK	61314	F	5	12	20	12	14.7	170	150	160	-		Good	Good
BBK	61306	F	PUP	10	20	13	14.3	100	150	125	-		Good	Good
BBK	61308	F	PUP	12	23	5	13.3	-	-	-	Abund.		Good	-
BBK	61310	F	PUP	13	22	11	15.3	135	115	125	Abund.		Good	Good
BBK	61312	F	2	12	13	4	9.7	155	130	143	-		Good	Good
BBK	61315	F	PUP	10	20	20	16.7	130	-	130	-		Good	Good
Deadman Pack														
DDP	61317	M	3	5	12	7	8.0	59	77	68	-		Fair	-
DDP	61300	M	PUP	5	20	10	11.7	70	-	70	-		Fair	-
DDP	61301	M	PUP	3	20	5	9.3	88	-	88	Abund.		Good	Fair
DDP	61318	F	4	20	15	15	16.7	110	-	110	-		Good	Fair
DDP	61316	F	PUP	12	20	50	27.3	140	180	160	-		Good	Good
Oshetna Pack														
OHP	61319	M	AD	-	-	-	-	-	-	-	-		?	-
OHP	61320	M	AD	-	-	-	-	-	-	-	-		?	-
OHP	61321	M	3	4	10	5	6.3	100	85	62	-		Fair	-
OHP	61324	M	3	5	10	7	7.3	56	62	59	Some		Fair	-
OHP	61323	F	AD	0	TR	TR	TR	30	28	26	-		Poor	-
OHP	61322	F	2	5	5	-	5.0	74	74	74	Modr.		Fair	-

Table 1-1. (Continued).

				Body Fat									Assessed condition	
			Age	Subcutaneous (mm)				Kidney (g)						
Pack	Number	Sex	(yr.)	Sternum	Flank	Rump	$\bar{x}$	Right	Left	$\bar{x}$	Omental	Trapped	Present	Past
Gulkana Area														
13A	61325	M	PUP	TR	3	2	TR	27	20	24	-	X	Poor	-
13C	61431	M	PUP	15	5	12	10.7	73	97	85	Abund.	SN	Good	-
13C	61433	M	PUP	TR	TR	0	TR	21	22	22	Light	X	Poor	-
13C	61328	F	3	TR	3	1	TR	-	-	-	Modr.	X	Poor	Fair
Copper Area														
13D	61432	M	5	15	10	3	9.3	119	-	119	Modr.	X	Good	Fair
13D	61399	M	PUP	0	0	0	0	11	23	17	None	?	Poor	-
Yakutat: Unit 5														
-	61345	M	AD	3	10	15	9.3	128	113	121	Abund.		Good	Good
-	61343	M	3	15	35	10	20.0	110	150	130	Abund.		Good	Good
-	61344	F	PUP	-	20	10	15.0	128	99	114	Abund.		Good	Good
Toolik: Unit 26														
-	61380	F	4	3	8	1	4.0	67	56	62	Light	AC	Fair	Poor

Abbreviations:

-	:	not available
TR	:	Trace
Modr.	:	Moderate
Abund.	:	Abundant
SN	:	Snared
AC	:	Accident (road kill)

*Indicates lack of correspondence between relative omental fat vs. kidney capsular and subcutaneous fat levels (see Text, part A).

Table 1-2. Summary of body conditions as determined by fat reserves (see Table 1-1) for wolves grouped into known pack associations.

		General pack condition		Total collected from pack	No. adults		*Fraction of females pregnant	No. pups
Area	Pack	Present	Poss. Past		Male	Female		
Unit 20A								
Flats - East								
	A	Good/Fair	Good/Fair	2	1	1	1/1	-
	B	Good	-	2	1	1	1/1	-
Fairbanks								
	C	Fair	-	4	4	-	-	-
(trapped)	RC	(Good)	-	3	-	2	2/2	1
(trapped)	EI	(Fair)	-	1	-	1	0/1	-
(trapped)	20B	(Fair)	(Poor)	1	1	-	-	-
Flats - Buttes								
	L	Fair	Good	1	1	-	-	-
	D	Poor	-	5	4	1	1/1	-
(trapped)	RL	(Poor)	-	5	3	2	1/2	3
Flats - Westcentral								
	E	Good	-	2	2	-	-	-
	F	Good/Fair	Good	6	4	1	1/1	1
	G	Fair	-	3	1	1	1/1	1
Foothills - East								
	V	Fair	-	8	4	4	1/4	-
Foothills - Little Delta								
	T	Fair	Good	6	2	2	1/2	2
	U	Poor	-	4	2	-	-	2
Foothills - Central								
(trapped)	GK	(Poor)	-	1	1	-	0/2	2
	W	Good	Good/Fair	6	2	2	0/2	2
	X	Fair	-	8	4	1	1/1	3
Foothills - West								
	Y	Good	Good	5	1	3	3/3	1
	Z	Good	-	2	1	-	-	1
Subtotal 20 associations				75	34	22	14/22	17
Unit 13								
Delta & Maclaren								
(trapped)	DLP	(Poor)	-	2	-	-	-	2
	MLP	Good	Good	2	-	-	2	2

Table 1-2. (Continued).

Area	Pack	General pack condition		Total collected from pack	No. adults		*Fraction of females pregnant	No. pups
		Present	Poss. Past		Male	Female		
Brushkana - Butte Creek								
	BBK	Good	Good	12	3	3	0/3 early	6
Deadman								
	DDP	Good/Fair		5	1	1	1/1	3
Oshetna								
	OHP	Fair	-	6	4	2	1/2	-
Gulkana & Copper								
(mapped)	EWA	(Poor)	-	1	-	-	-	1
(snared)	HOG	(Good)	-	1	-	-	-	1
(trapped)	TOK	(Poor)	-	2	-	1	0/1	1
(trapped)	RUN	(Good)	-	1	1	-	-	-
(?)	CAS	(Poor)	-	1	-	-	-	1
Subtotal	10 associations			33	10	5	2/6	17
Units 5 & 26								
Yakutat & Toolik								
	YAK	Good	Good	3	2	-	-	1
accident	TOO	Fair	Poor	1	-	1	0/1	-
Subtotal	2 associations			4	2	1	0/2	-
Total	32 associations			112	46	23	16/30	35

*Fraction of adult females pregnant or in estrus.

Table 1-3. Body and major organ weights of individual wolves, organized by geographic area.

						(Grams)					
				Body wt. (kg)					Kidneys		
Pack	Number	Sex	Age	Whole	Skinned	Heart	Liver	Spleen	Right	Left	$\overline{X}$
Flats - East											
A	61348	M	4	41	34	430	815	102.3	117.6	120.0	118.8
B	61389	M	3	44	38	422	975	70	132.8	*135.5	*
A	61350	F	2	39	32	440	*715	62.0	100.7	112.8	106.8
B	61387	F	5	44	-	389	1270	85	150.0	156.8	153.4
Fairbanks											
C	61357	M	6	41	35	409	1440	85.2	*138.4	*147.7	*
C	61358	M	4	51	41	554	1095	91	152.5	156.0	154.3
C	61365	M	3	50	43	469	1125	74.5	120	140	130
C	61376	M	4	52	44	441	1165	70.8	*139.0	137.8	*
20B	61401	M	5	-	33	441	810	63.5	155.5	145.0	150.3
RC	61402	F	3	-	31	404	910	65.6	106.9	107.5	107.2
RC	61403	F	5	-	35	431	910	94.5	120.4	*124.6	*
EI	61409	F	AD	-	(29)	338	790	79	93.7	112.7	103.2
RC	61400	F	PUP	-	20	224	526	+39	73.2	70.0	71.6
Flats - Buttes											
	61353	M	5	53	43	506	+980	101.8	165.8	*128.0	*
	61355	M	4	40	34	373	+740	76.5	101	103	102
D	61364	M	4	39	34	332	725	60.3	92.5	87.3	89.9
D	61391	M	4	47	41	467	1240	98	+126.9	(134.3)	126.9
D	61354	M	5	35	29	284	+720	66	100	106	103
RL	61396	M	PUP	-	19	216	595	+40.5	77.2	89.2	83.2
RL	61398	M	PUP	-	19	200	570	+43.5	63.2	74.5	68.9
D	61366	F	5	39	33	401	+1135	53	*125	*130	*
RL	61397	F	5	-	30	378	690	+48	89.5	96.4	93.0
RL	61407	F	3	-	(25)	275	810	54.5	85.2	94.5	89.9
RL	61408	F	PUP	-	(23)	230	495	59.7	+77.5	+78.3	77.9
Flats - Westcentral											
E	61352	M	3	50	43	451	1055	78.0	190.1	173.1	181.6
E	61356	M	4	48	-	486	870	72.7	+167	132	149.5
F	61359	M	4	51	43	454	1550	53	187	195	191
F	61360	M	2	47	41	445	1035	89.5	125	129	127
F	61361	M	2	50	41	351	1005	73.1	124.1	130.3	127.2
F	61377	M	4	41	41	454	880	70.5	*112.3	+148.3	*
G	61381	M	3	36	30	394	740	*91	112.5	137.8	125.2
F	61362	M	PUP	41	36	353	875	54.5	103.5	110.5	107.0
G	61382	F	3	35	-	314	550	67.5	*93.0	99.0	*
G	61383	F	PUP	35	30	278	510	58	82.3	87.1	84.7
F	61368	F	2	41	33	406	780	58.5	108.0	109.0	108.5

Table 1-3. (Continued).

				Body wt. (kg)		(Grams)					
									Kidneys		
Pack	Number	Sex	Age	Whole	Skinned	Heart	Liver	Spleen	Right	Left	$\overline{X}$
Foothills - East											
V	61367	M	4	39	34	293	890	58.5	93.2	96.4	94.8
V	61368	M	3	43	36	408	830	77.8	107.9	109.4	108.7
V	61404	M	3	43	37	409	1195	85	123.0	146.0	134.5
V	61406	M	4	38	33	+414	795	56	93.8	98.2	96.0
V	61369	F	2	36	30	286	830	67.2	*96.8	97.5	*
V	61388	F	7	39	33	374	725	57	*93.4	95.4	*
V	61390	F	5	44	37	383	810	64	125.4	*110.3	*
V	61405	F	3	41	36	431	740	67	98.8	101.2	100.0
Foothills - Little Delta											
T	61370	M	5	45	40	476	700	86	117.4	125.6	121.5
T	61374	M	4	36	30	310	+640	54	94.8	90.3	92.6
U	61378	M	3	39	32	342	770	40.5	106.6	102.6	104.6
U	61379	M	6	45	39	435	820	100.5	143.0	*148.5	*
U	61351	M	PUP	30	25	251	*690	34.6	85.5	84.0	84.8
T	61375	F	6	43	39	407	650	85.2	101	106	103.5
T	61372	F	3	34	27	+348	505	74.3	74.8	82.6	78.7
T	61371	F	PUP	30	24	270	+445	48.9	66.4	64.6	65.5
T	61373	F	PUP	30	-	226	+475	50.8	68.8	71.8	70.3
U	61349	F	PUP	25	19	193	(420)	-	83.0	80.5	81.8
Foothills - Central											
W	61332	M	3	47	42	-	+–	-	149.1	-	149.1
W	61333	M	2	50	43	-	+–	-	185	-	185
GK	61410	M	4	-	(25)	*345	1215	54	+106.0	+117.5	111.8
X	61336	M	2	41	35	-	-	-	+140.0	-	140.0
X	61337	M	3	49	40	-	-	-	122.7	-	122.7
X	61339	M	3	45	39	-	+–	-	124.8	138.3	131.6
X	61340	M	2	48	40	-	+–	-	128.2	*123.7	*
X	61338	M	PUP	39	30	-	-	-	104.5	-	104.5
X	61342	M	PUP	36	(30)	-	-	-	90.2	-	90.2
W	61331	M	PUP	45	40	-	-	-	129	127	128
W	61334	M	PUP	45	38	-	+–	+–	116.8	131.5	124.2
X	61341	F	2	38	32	-	-	-	81.9	-	81.9
W	61346	F	2	40	32	380	+1260	48.3	106.8	103.8	105.3
W	61347	F	4	38	28	332	(420)	48.0	91.0	-	91.0
X	61335	F	PUP	32	26	-	+–	-	91.7	-	91.7
Foothills - West											
Z	61384	M	5	50	43	416	775	100.5	129.7	137.1	133.4
Y	61395	M	4	52	47	376	975	87.0	149.7	151.6	150.7
Z	61385	M	PUP	38	32	312	680	45.0	72.6	73.8	73.2

Table 1-3. (Continued).

						(Grams)					
				Body wt. (kg)					Kidneys		
Pack	Number	Sex	Age	Whole	Skinned	Heart	Liver	Spleen	Right	Left	$\bar{X}$
Foothills - West (cont.)											
Y	61392	M	PUP	42	36	346	925	60	106.1	108.0	107.1
Y	61386	F	3	43	40	349	855	65	112.1	+106.4	109.3
Y	61393	F	5	44	40	356	880	74	105.5	110.7	108.1
Y	61394	F	3	44	38	340	790	68	100.6	101.5	101.1
Delta Pack											
DLP	61326	M	PUP	24	(16)	-	-	-	-	-	-
DLP	61327	F	PUP	(23)	15	-	-	-	-	-	-
Maclaren Pack											
MLP	61302	M	PUP	43	38	-	-	-	111.6	-	111.6
MLP	61303	M	PUP	43	37	-	-	-	99.2	-	99.2
Brushkana - Butte Area											
BBK	61304	M	4	46	41	-	-	-	144.0	-	144.0
BBK	61305	M	3	45	40	430	-	-	155	185	170
BBK	61311	M	2	48	43	-	-	-	160	160	160
BK	61309	M	PUP	36	32	-	-	-	100	105	102.5
BBK	61313	M	PUP	33	29	-	-	-	135	140	137.5
BBK	61307	F	4	46	38	-	-	-	*120	115	*
BBK	61314	F	5	45	40	-	-	-	130	150	140
BBK	61306	F	PUP	32	28	-	-	-	90	100	95
BBK	61308	F	PUP	35	30	258	-	-	-	-	-
BBK	61310	F	PUP	28	25	-	-	-	85	105	95
BBK	61312	F	2	48	37	-	-	-	105	130	117.5
BBK	61315	F	PUP	35	30	-	-	-	-	110	110
Deadman Pack											
DDP	61317	M	3	45	-	526	965	106.5	123.8	152.7	138.3
DDP	61300	M	PUP	41	37	-	-	-	100.0	-	100.0
DDP	61301	M	PUP	43	37	-	-	-	110	-	110
DDP	61318	F	4	43	-	367	775	114	96.8	-	96.8
DDP	61316	F	PUP	35	30	-	-	-	120	120	120
Oshetna Pack											
OHP	61319	M	AD	-	44	-	-	-	-	-	-
OHP	61320	M	AD	-	41	-	-	-	-	-	-
OHP	61321	M	3	-	43	470	845	79	146.0	142.5	142.5
OHP	61324	M	3	46	34	367	710	74.2	110.2	115.2	112.7
OHP	61323	F	AD	35	-	447	845	68	99.0	106.2	102.6
OHP	61322	F	2	35	29	399	585	87	89.1	94.5	91.8

Table 1-3. (Continued).

				Body wt. (kg)		(Grams)					
									Kidneys		
Pack	Number	Sex	Age	Whole	Skinned	Heart	Liver	Spleen	Right	Left	$\overline{X}$
Gulkana Area											
13A	61325	M	PUP	(27)	19	240	835	51	70.3	109.6	90.0
13C	61431	M	PUP	-	(33)	330	910	65	120.8	121.7	121.3
13C	61433	M	PUP	-	(23)	244	960	39.5	71.0	74.8	72.9
13C	61328	F	3	32	26	-	-	-	-	-	-
Copper Area											
13D	61432	M	5	-	(30)	469	1055	105	-	119.3	119.3
13D	61399	M	PUP	-	15	195	675	40	67.1	68.5	67.8
Yakutat: Unit 5											
-	61345	M	AD	32	-	365	880	103.5	102.5	104.5	103.5
-	61343	M	3	40	-	400	900	67	107.9	111.8	109.4
-	61344	F	PUP	-	25	(272)	-	66.7	75.7	78.6	77.2
Toolik: Unit 26											
-	61380	F	4	33	27	380	800	+45.4	87.0	*83.8	*

Table 1-4. Whole body weights of wolves (in kilograms), analyzed by sex and age categories ($\overline{x}$ = averaged weight, kilograms).

	Males			Females			Both sexes		
	n	$\overline{x}$	Range	n	$\overline{x}$	Range	n	$\overline{x}$	Range
Pup	15	39	24-45	10	32	25-35	25	36	24-45
2 yr.	6	47	41-50	7	39	35-42	13	43	35-50
3 yr.	14	44	36-50	6	38	32-44	20	43	32-50
Subtotal	20	45	36-50	13	39	32-44	33	43	32-50
4 yr.	14	44	36-52	4	40	33-44	18	43	33-52
5 yr.	4	46	35-53	5	43	39-45	9	44	35-53
6 yr.	2	43	41, 45	1	(43)	43	3	(43)	41-45
7 yr.	-	-	-	1	(39)	39	1	(39)	39
Subtotal	20	44	35-53	11	41	33-45	31	44	33-53
"Adult"*	1	(32)	32	1	(35)	35	2	34	32, 35
Total Adult	41	44	35-53	25	40	32-45	66	43	32-53

*Adults for which ages are not available.

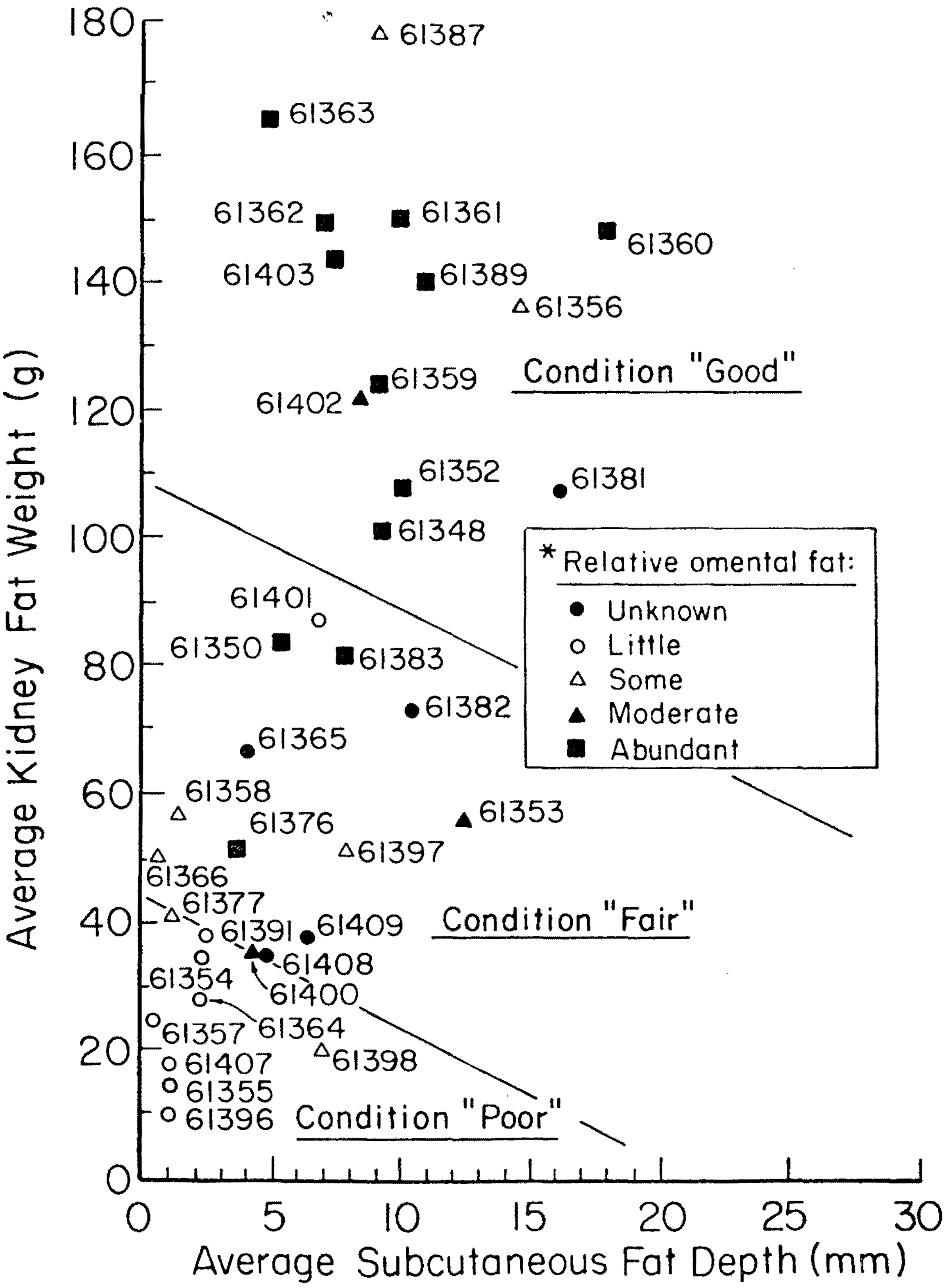

Fig. 1-3. Average kidney capsular fat weight (g) plotted as a function of average subcutaneous fat depth (mm) as measured at the sternum, flank, and rump, with relative amount of omental fat indicated*: 36 wolves from Unit 20A, Flats areas.

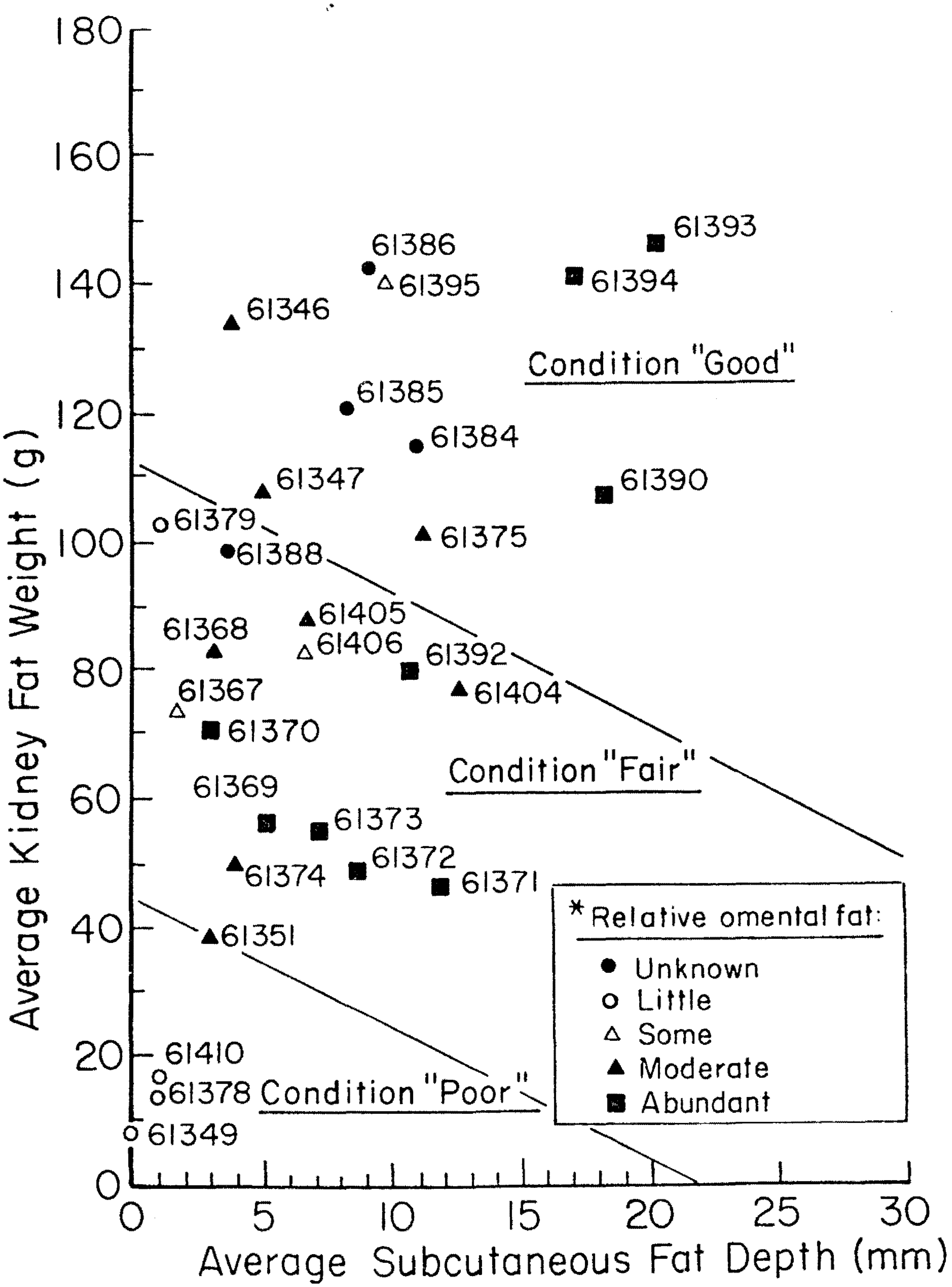

Fig. 1-4. Average kidney capsular fat weight (g) plotted as a function of average subcutaneous fat depth (mm) as measured at the sternum, flank and rump. With relative amount of omental fat indicated*: 28 wolves from Unit 20A, Foothills areas.

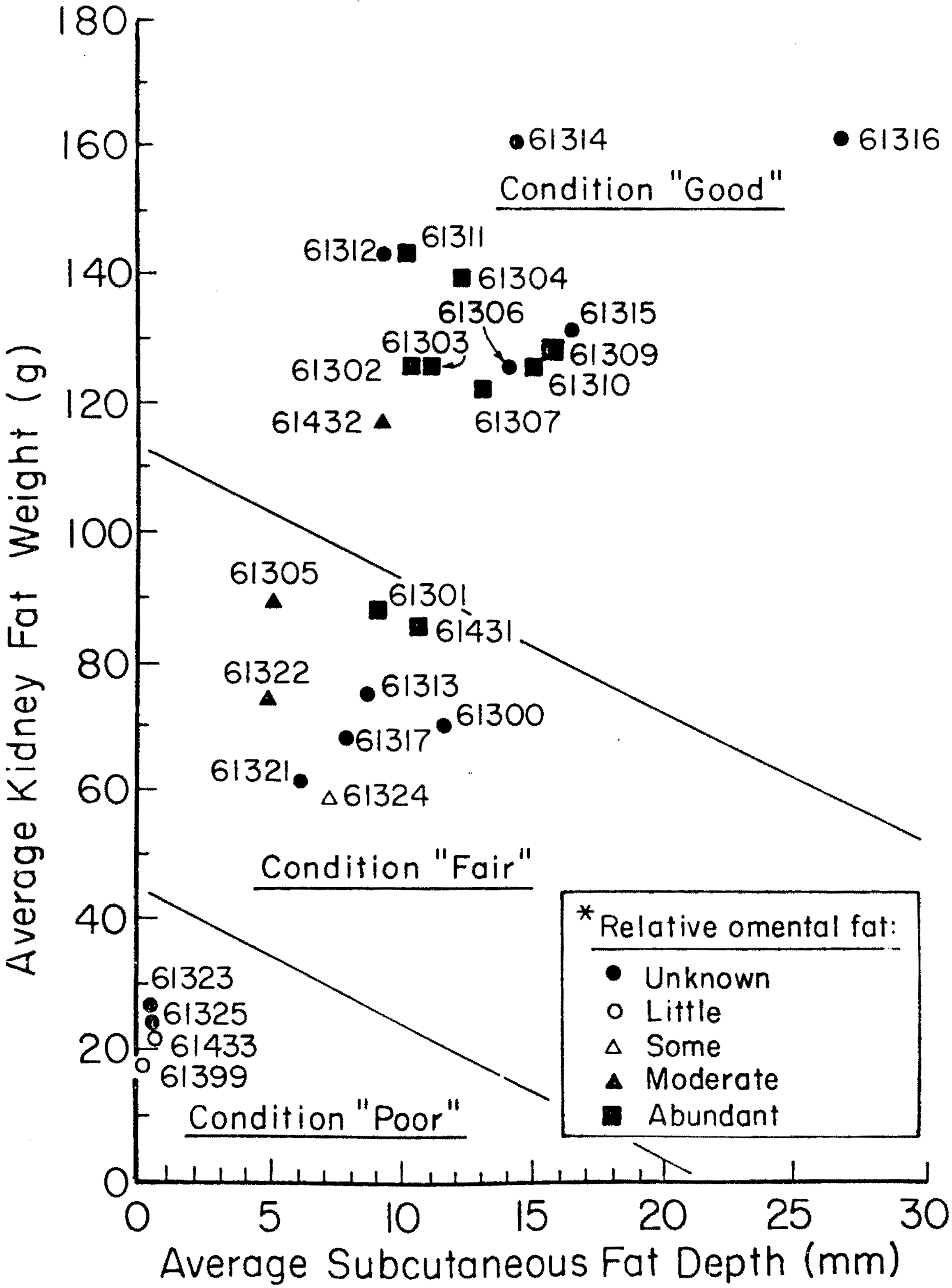

Fig. 1-5. Average kidney capsular fat weight (g) plotted as a function of average subcutaneous fat depth (mm) as measured at the sternum, flank and rump, with relative amount of omental fat indicated*: 27 wolves from Unit 13 areas.

had an average kidney capsular fat weight of less than 45 g, an average subcutaneous fat depth of less than 2.5 mm, and minimal or no omental fat. Those individuals in the "fair" category had amounts of fat between these extremes. In a few cases the relative amount of omental fat present was not consistent with nutritional status level as determined by the kidney capsular and subcutaneous fat levels. These particular individuals are marked with an asterisk in Table 1-1. Recent marked changes in the individual's plane of nutrition may have caused the inconsistency observed, and such phenomena are of obvious interest when evidence of recent injury or pathological conditions are encountered. Other biological implications of the apparent variation in nutritional status with respect to sex, area, and pack identity are discussed elsewhere (Stephenson, in prep.).

B. Major organ weights

Considerable variation was observed in the weights of the major organs: heart, liver, and kidney (Table 1-3). This variability was examined with respect both to geographical areas and to various age categories for both sexes. "Adults" were all animals age 2-years or more (with subcategories (1) age 2 and 3 years, and (2) age 4-7 years, while "pups" were approximately age 10-months at the time of collection. The weights of a few hearts, livers and kidneys displaying possible pathologic changes or unusual features (to be discussed in subsequent reports) were omitted as noted below.

Heart weights are presented in Table 1-3 and summarized in Table 1-5. Heart weights were available for 78 wolves: Unit 20A, 62 wolves; Unit 13, 13 wolves; Unit 5, 2 wolves; and Unit 26, 1 wolf. The average heart weight for male adults was 419 g (n = 36, range 284 - 554 g), for female adults 360 g (n = 25, range 275 - 447 g), and for pups 278 g (n = 17, range 193 - 367 g). Table 1-6 presents the distribution of heart weights observed in pups of each sex and in adults of different age and sex categories. In all cases hearts of females weighed less than those of males. Average heart weight in the older adult (age 4-7 years) category exceeded that in the younger adult (age 2 and 3 years) category for females but not for males. The weight of a single additional heart displaying possible pathological changes was omitted from these calculations (four-year-old male #61410, 345 g).

Liver weights, also presented in Table 1-3, are summarized by areas in Table 1-7. Liver weights were available for 73 wolves: Unit 20A, 59 wolves; Unit 13, 11 wolves; Unit 5, 2 wolves; and Unit 26, 1 wolf. Liver weights varied more widely among individuals than did heart weights. Average liver weight for male adults was 942 g (n = 36, range 640 - 1550 g), for female adults was 822 g (n = 23, range 505 - 1270 g), and for pups was 677 g (n = 14, range 445 - 960 g). Table 1-5 presents the distribution of liver weights among pups of both sexes and adults of different sexes and ages. Average liver weight increases directly with age for both sexes. However, as observed for heart weights, the average liver weights of females remain consistently below those of males in all age categories. This sex differential is less noticeable in the older age class. (Liver weight as a percentage of whole body weight is discussed in Report 4;

Table 1-5. Distribution of heart weights (grams) for wolves in different geographic areas.

	Adult						Pup			
	Male			Female						
	n	$\bar{x}$	range	n	$\bar{x}$	range	n	$\bar{x}$	range	Total individual
1. Flats - East	2	426	422-430	2	415	389-440	-			4
2. Fairbanks	5	463	409-554	3	391	338-431	1	224	224	9
3. Flats - Buttes	5	392	284-506	3	351	275-401	3	215	200-230	11
4. Flats - Westcentral	7	434	351-486	2	360	314-406	2	316	278-353	11
5. Foothills - East	4	381	293-414	4	369	286-431	-			8
6. Foothills-L. Delta	4	391	310-476	2	378	348-407	4	235	193-270	10
7. Foothills - Central	-			2	356	332-380	-			2
8. Foothills - West	2	396	376-416	3	348	340-356	2	329	312-346	7
9. Delta & Maclaren	-			-			-			-
10. Brushkana - Butte	1	430	430	-			1	258	258	2
11. Deadman	1	526	526	1			-	367	367	2
12. Oshetna	2	419	367-470	2	423	399-447	-			4
13. Gulkana, Copper	1	469	469	-			4	252	195-330	5
14. Yakutat, Toolik	2	383	365-400	1	380	380	-			3
	36	419	284-554	25	374	275-447	17	257	193-353	78

Table 1-6. Distribution of major organ weights (grams) for wolves of different sex and age categories.

		Heart Weight			Liver Weight			Average Kidney Weight		
		Males	Females	Both Sexes	Males	Females	Both Sexes	Males	Females	Both Sexes
Pups	n	10	7	17	9	5	14	20	12	32
	$\bar{x}$	269	240	257	781	490	677	99	87	95
	Range	195-353	193-278	193-353	570-960	445-526	445-960	67.8-137.5	65.5-120	65.5-137.5
2&3yrs	n	14	12	26	13	11	24	19	12	31
	$\bar{x}$	422	364	394	935	783	865	137	100	123
	Range	342-526	275-440	275-526	710-1195	505-1260	505-1260	104.6-185	78.7-117.5	78.7-185
4-7yrs	n	21	11	32	22	10	32	18	7	25
	$\bar{x}$	420	382	407	950	865	923	125	112	121
	Range	284-554	332-431	284-554	640-1440	650-1270	640-1440	92.6-191	91.0-153.4	91.0-191
Adults (age?)	n	1	2	3	1	2	3	1	2	3
	Range	365	338-447	338-447	880	790-845	790-880	103.5	102.6-103.2	102.6-103.5
Total Adults	n	36	25	61	36	23	59	38	21	59
	$\bar{x}$	419	374	400	942	822	895	130	104	121
	Range	284-554	275-447	230-554	640-1440	505-1270	505-1440	92.6-191	78.7-153.4	78.7-191

Table 1-7. Distribution of liver weights (in (grams) for wolves of different geographic areas.

	Adult						Pup			
	Male			Female						
	n	$\bar{x}$	range	n	$\bar{x}$	range	n	$\bar{x}$	range	Total individuals
1. Flats - East	2	895	815-975	1	1270	1270	-			3
2. Fairbanks	5	1127	810-1440	3	870	790-910	1	526	526	9
3. Flats - Buttes	5	881	720-1240	3	878	690-1135	3	553	495-595	11
4. Flats - Westcentral	7	1019	740-1550	2	665	550-780	2	693	510-875	11
5. Foothills - East	4	928	795-1195	4	776	725-830	-			8
6. Foothills-L. Delta	4	733	640-820	2	578	505-650	2	460	445-475	8
7. Foothills - Central	1	1215	1215	1	1260	1260	-			2
8. Foothills - West	2	875	775-975	3	842	790-880	2	803	680-925	7
9. Delta & Maclaren	-			-			-			-
10. Brushkana - Butte	-			-			-			-
11. Deadman	1	965	965	1	775	775	-			2
12. Oshetna	2	778	710-845	2	715	585-845				4
13. Gulkana, Copper	1	1055	1055	-			4	845	675-960	5
14. Yakutat, Toolik	2	890	880-900	1	800	800	-	8966	11740	3
	36	942	640-1550	23	822	505-1270	14	677	445-960	73

see also Table 4-1.) Eight livers displayed minor anomalies and their weights were included in the calculations, but the weights of two additional livers (female adult #61350, 715 g, and male pup #61351, 690 g) were omitted because of more significant pathological changes.

Although weights of the spleen are presented for 76 wolves in Table 1-3, the values were undoubtedly affected by the circumstances surrounding the individual's death, since there were considerable variations in the amount and duration of ante mortem hemorrhaging among individual wolves. This is reflected in the wide ranges of weights encountered: male adults from 40.5 to 103.5 g (n = 35), female adults from 45.4 to 94.5 g (n = 26) and pups from 34.6 to 65.0 (n = 15). Average spleen weights were not calculated. A single spleen was excluded from consideration because of possible pathological changes (male adult #61381, 91 g).

Kidney weights are presented in Table 1-3 and summarized in Table 1-8. The weights of both kidneys were available for 73 wolves and the average weight of the pair (listed in Table 1-3) was used in calculations. (Omitted entirely from consideration were 13 wolves with significant renal pathology in one kidney and the other apparently normal because of the possibility of compensatory hypertrophy, and 2 wolves with pathological changes in both kidneys.) Single kidney weights only were available for an additional 18 wolves, and this value was used in place of the "average" kidney weight for the purposes of calculation. Thus, kidney weights (averaged or single) were available from 91 wolves: Unit 20A, 62 wolves; Unit 13, 26 wolves; and Unit 5, 3 wolves. The average kidney weight for male adults was 130 g (n = 38, range 92.6 - 191 g), for female adults was 104 g (n = 21, range 78.7 - 153.4 g), and for pups was 95 g (n = 32, range 65.5 - 137.5 g).

Table 1-6 presents the variation of (average) kidney weights observed in different age and sex classes. Again, the average weights for females are less than those for males in the corresponding age category. As observed with heart weight, the average kidney weight of older females (age 4-7 years) exceeds that of younger females (age 2 and 3 years), but this adult age difference was not seen in males.

C. Endocrine organ weights

Two major endocrine organs, the thyroid and adrenal glands, were weighed. In both cases each of the paired organs (in this report each lobe of the thyroid was considered as a separate gland) was weighed and the average weight of the pair was used for calculations. In a few cases only a single organ of a pair was available, and its weight was of necessity used in place of the average. The few cases in which weights of members of a pair differed sharply or in which one member displayed pathological changes are omitted from the calculations and discussed in a subsequent section.

Thyroid weights were available from 72 individuals (Table 1-9), with both organs presented for 65 wolves and 1 only for 7. Table 1-10 summarizes the average thyroid weights for the 72 wolves by area (61 wolves from Unit 20A, 7 wolves from Unit 13, 3 wolves from Unit 5, and one wolf from Unit 26) and Table 1-11 presents these weights for pups of

Table 1-8. Distribution of $\overline{K}$, the average kidney weights (grams)*, for wolves in different geographic areas.

	Adult						Pups				
	Male			Female							
	n	$\bar{x}$	range	n	$\bar{x}$	range	n	$\bar{x}$	range	$\overline{K}$ total	n
1. Flats - East	1	118.8	118.8	2	130.1	106.8-153.4	-			379.0	3
2. Fairbanks	3	145	130-154.3	2	105.2	103.2-107.2	1	71.6	71.6	716.6	6
3. Flats - Buttes	4	106	89.9-126.9	2	91.5	89.9-93.0	3	76.7	68.9-83.2	834.7	9
4. Flats - Westcentral	6	150	125.2-191	1	108.5	108.5	2	95.9	84.7-107.0	1201.7	9
5. Foothills - East	4	108.5	94.8-134.5	1	100.0	100.0	-			534.0	5
6. Foothills-L. Delta	3	106.2	92.6-121.5	2	91.1	78.7-103.5	4	75.6	65.5-84.8	803.3	9
7. Foothills - Central	6	140	111.8-185	3	92.7	81.9-105.3	5	108	90.2-128	1657.0	14
8. Foothills - West	2	142.1	133.4-150.7	3	106.2	101.1-109.3	2	90.2	73.2-107.1	782.9	
9. Delta & Maclaren	-			-			2	105.4	99.2-111.6	210.8	2
10. Brushkana - Butte	3	158	144.0-170	2	129	117.5-140	5	108	95-137.5	1271.5	10
11. Deadman	1	138.3	138.3	1	96.8	96.8	3	110	100-120	565.1	5
12. Oshetna	2	127.6	112.7-142.5	2	97.2	91.8-107.6	-			449.6	4
13. Gulkana, Copper	1	119.3	119.3	-			4	88.0	67.8-121.3	471.3	5
14. Yakutat, Toolik	2	106.5	103.5-109.4	-			1	77.2	77.2	290.1	3
	38	130	92.6-191	21	104	77.7-153.4	32	95	65.5-137.5	10167.6	91

* $\overline{K} = \frac{K_r + K_l}{2}$, see Table 1-1.

Table 1-9. Distribution of adrenal and thyroid weights (grams), and thymus involution status*, for wolves in different geographic areas.

				Adrenals			Thyroids			
Pack	Number	Sex	Age (yrs.)	rt.	lft.	$\bar{A}$	rt.	lft.	$\bar{T}$	Thymus category*
Flats - East										
A	61348	M	4	1.3	1.2	1.3	*2.1	1.4	*	-
B	61389	M	3	1.4	1.6	1.5	3.0	3.1	3.2	1
A	61350	F	2	1.5	1.7	1.6	-	1.5	1.5	12
B	61387	F	5	-	1.7	1.7	3.3	2.9	3.1	2
n = 4										
Fairbanks										
C	61357	M	6	2.0	1.6	1.8	2.9	3.3	3.1	13
C	61358	M	4	2.3	2.2	2.3	2.7	3.0	2.9	13
C	61365	M	3	1.1	1.1	1.1	2.7	-	2.7	-
C	61376	M	4	1.6	1.5	1.6	1.8	2.1	2.0	10
20B	61401	M	5	1.5	1.5	1.5	1.2	1.2	1.2	13
RC	61402	F	3	1.7	1.6	1.7	1.7	1.8	1.8	13
RC	61403	F	5	1.4	1.1	1.3	1.6	1.8	1.7	13
EI	61409	F	AD	1.6	1.3	1.5	3.0	3.0	3.0	fz.
RC	61400	F	PUP	0.6	0.6	0.6	1.2	1.6	1.4	13
n = 9										
Flats - Buttes										
L	61353	M	5	1.9	1.9	1.9	3.7	3.4	3.6	13
D	61355	M	4	1.6	1.6	1.6	1.4	1.5	1.5	13
D	61364	M	4	1.8	1.5	1.7	2.4	2.6	2.5	10
D	61391	M	4	3.3	2.0	*	2.2	2.1	2.2	12
D	61354	M	5	1.7	1.2	1.5	1.3	0.9	1.1	10
RL	61396	M	PUP	1.8	1.8	1.8	0.7	1.1	0.9	-
RL	61398	M	PUP	1.4	1.5	1.5	1.2	2.1	*	fz.
D	61366	F	5	1.8	1.8	1.8	1.9	2.1	2.0	13
RL	61397	F	5	1.1	1.4	1.3	1.8	2.2	2.0	-
RL	61407	F	3	2.0	2.1	2.1	1.2	1.4	1.3	13
RL	61408	F	PUP	1.4	0.9	1.2	0.9	1.2	1.1	fz.
n = 11										
Flats - Westcentral										
E	61352	M	3	1.7	1.4	1.6	3.6	3.6	3.6	13
E	61356	M	4	1.1	1.3	1.2	3.1	3.6	3.4	13
F	61359	M	4	2.0	3.3	*	3.9	4.1	4.0	13
F	61360	M	2	1.7	1.7	1.7	3.0	3.4	3.2	12
F	61361	M	2	1.9	2.2	2.1	4.8	4.6	4.7	5
F	61377	M	4	1.3	1.4	1.4	3.2	2.5	2.9	8
G	61381	M	3	0.9	0.6	0.8	2.4	2.6	2.5	13
F	61362	M	PUP	1.7	1.5	1.6	1.9	-	1.9	1
G	**61382**	**F**	**3**	1.1	**1.4**	**1.3**	2.6	2.2	2.4	-
G	61383	F	PUP	1.1	1.0	1.1	1.1	1.2	1.2	11
F	61363	F	2	1.3	1.3	1.3	1.5	1.7	1.6	1
n = 11										

Table 1-9. (Continued).

				Adrenals			Thyroids			
Pack	Number	Sex	Age (yrs.)	rt.	lft.	$\bar{A}$	rt.	lft.	$\bar{T}$	Thymus category*
Foothills - East										
V	61367	M	4	1.1	1.2	1.2	(0.1)	1.0	1.0	4
V	61368	M	3	1.1	1.1	1.1	1.0	1.2	1.1	7
V	61404	M	3	1.7	1.6	1.7	1.5	1.9	1.7	6
V	61406	M	4	(1.0)	1.8	1.8	-	2.4	2.4	1
V	61369	F	2	0.8	0.7	0.8	1.1	1.2	1.2	1
V	61388	F	7	1.3	1.4	1.4	1.6	-	1.6	-
V	61390	F	5	1.6	2.0	1.8	1.2	1.2	1.2	13
V	61405	F	3	1.0	1.6	1.3	1.2	1.2	1.2	6
	n = 8									
Foothills - Little Delta										
T	61370	M	5	2.0	2.0	2.0	1.6	2.0	1.8	-
T	61374	M	4	1.4	1.4	1.4	1.2	0.9	1.1	2
U	61378	M	3	1.1	-	1.1	1.4	1.7	1.6	12
U	61379	M	6	2.1	-	2.1	4.3	4.1	4.2	13
U	61351	M	PUP	1.2	1.2	1.2	-	1.4	1.4	7
T	61375	F	6	2.1	2.1	2.1	1.2	1.4	1.3	12
T	61372	F	3	1.0	1.0	1.0	0.8	1.0	0.9	2
T	61371	F	PUP	1.0	1.3	1.2	0.9	1.1	1.0	2
T	61373	F	PUP	1.2	1.2	1.2	1.2	1.2	1.2	1
U	61349	F	PUP	1.2	1.8	1.5	1.2	-	1.2	13
	n = 10									
Foothills - Central										
W	61332	M	3	-	-	-	-	-	-	-
W	61333	M	2	-	-	-	-	-	-	-
GK	61410	M	4	2.0	1.8	1.9	2.1	2.9	2.5	13
X	61336	M	2	2.1	-	2.1	-	-	-	-
X	61337	M	3	1.8	-	1.8	-	-	-	"present"
X	61339	M	3	0.8	-	0.8	-	-	-	-
X	61340	M	2	0.9	-	0.9	-	-	-	-
X	61338	M	PUP	1.4	1.8	1.6	-	-	-	-
X	61342	M	PUP	1.2	-	1.2	-	-	-	"present"
W	61331	M	PUP	1.3	0.7	1.0	-	-	-	-
W	61334	M	PUP	-	0.5	0.5	-	-	-	-
X	61341	F	2	1.2	-	1.2	-	-	-	-
W	61346	F	2	1.5	1.6	1.6	0.8	0.8	0.8	2
W	61347	F	4	2.0	2.2	2.1	1.3	1.5	1.4	13
X	61335	F	PUP	1.5	1.3	1.4	-	-	-	-
	n = 15									

Table 1-9. (Continued).

				Adrenals			Thyroids			
Pack	Number	Sex	Age (yrs.)	rt.	lft.	$\bar{A}$	rt.	lft.	$\bar{T}$	Thymus category*
Foothills - West										
Z	61384	M	5	2.1	1.9	2.0	2.7	2.3	2.5	-
Y	61395	M	4	1.9	1.8	1.9	3.0	2.6	2.8	13
Z	61385	M	PUP	1.1	1.0	1.1	2.1	1.8	2.0	9
Y	61392	M	PUP	1.3	1.4	1.4	2.2	2.5	2.4	1
Y	61386	F	3	1.5	1.6	1.6	1.8	2.2	2.0	-
Y	61393	F	5	2.0	1.8	1.9	2.5	2.5	2.5	12
Y	61394	F	3	1.9	-	1.9	3.6	3.8	3.7	2
	n = 7									
Delta Pack										
DLP	61326	M	PUP	-	-	-	-	-	-	-
DLP	61327	F	PUP	-	-	-	-	-	-	-
	n = 2									
Maclaren Pack										
MLP	61302	M	PUP	2.9		2.9	-	-	-	-
MLP	61303	M	PUP	2.2		2.2	-	-	-	-
	n = 2									
Brushkana - Butte Pack										
BBK	61304	M	4	1.4		1.4	-	-	-	-
BBK	61305	M	3	-	-	-	-	-	-	-
BBK	61311	M	2	-	-	-	-	-	-	-
BBK	61309	M	PUP	-	-	-	-	-	-	-
BBK	61313	M	PUP	-	-	-	-	-	-	-
BBK	61307	F	4	-	-	-	-	-	-	-
BBK	61314	F	5	-	-	-	-	-	-	-
BBK	61306	F	PUP	-	-	-	-	-	-	-
BBK	61308	F	PUP	-	-	-	-	-	-	-
BBK	61310	F	PUP	-	-	-	-	-	-	-
BBK	61312	F	2	-	-	-	-	-	-	-
BBK	61315	F	PUP	-	-	-	-	-	-	-
	n = 12									
Deadman Pack										
DDP	61317	M	3	2.8	1.3	*	1.6	1.6	1.6	-
DDP	61300	M	PUP	1.5		1.5	-	-	-	-
DDP	61301	M	PUP	-	-	-	-	-	-	-
DDP	61318	F	4	1.6	1.6	1.6	-	-	-	-
DDP	61316	F	PUP	-	-	-	-	-	-	-
	n = 5									

Table 1-9. (Continued).

				Adrenals			Thyroids			
Pack	Number	Sex	Age (yrs.)	rt.	lft.	$\bar{A}$	rt.	lft.	$\bar{T}$	Thymus category*
Oshetna Pack										
OHP	61319	M	AD	-	-	-	-	-	-	-
OHP	61320	M	AD	-	-	-	-	-	-	-
OHP	61321	M	3	1.0	1.3	1.2	-	-	-	-
OHP	61324	M	3	1.0	1.2	1.1	0.9	0.9	0.9	-
OHP	61323	F	AD	1.8	1.9	1.9	1.4	1.5	1.5	-
OHP	61322	F	2	1.1	0.8	1.0	1.4	1.1	1.3	-
n = 6										
Gulkana Area										
EWA	61325	M	PUP	-	1.1	1.1	-	-	-	fz.
HOG	61431	M	PUP	1.4	1.0	1.2	1.6	1.0	1.3	fz.
TOK	61433	M	PUP	0.8	0.9	0.9	2.0	1.8	1.9	fz.
TOK	61328	F	3	-	-	-	-	-	-	-
n = 4										
Copper Area										
RUN	61432	M	5	-	1.5	1.5	2.1	1.6	1.9	-
CAS	61399	M	PUP	1.2	0.9	1.1	-	-	-	-
n = 2										
Yakutat: Unit 5										
Y3	61345	M	AD	1.1	1.0	1.1	0.8	1.0	0.9	fz.
Y1	61343	M	3	1.4	1.3	1.4	1.2	1.6	1.4	4
Y2	61344	F	PUP	1.3	1.4	1.4	0.8	1.2	1.0	2
n = 3										
Toolik: Unit 26										
TOO	61380	F	4	1.1	1.1	1.1	1.0	1.0	1.0	-
n = 1										

*See text, Report 2, and Table 2-2, for explanation of categories; fz: frozen specimen.

Table 1-10. Distribution of $\overline{T}$, the average thyroid weight* (grams) for wolves in different geographic areas.

	Adult						Pup				
	Male			Female						Total	
	n	$\bar{x}$	range	n	$\bar{x}$	range	n	$\bar{x}$	range	n	$\bar{x}$
1. Flats - East	1	3.2	3.2	2	2.3	1.5-3.1	-			3	7.8
2. Fairbanks	5	2.4	1.2-3.1	3	2.2	1.7-3.0	1	1.4	1.4	9	19.8
3. Flats - Buttes	5	2.2	1.1-3.6	3	1.7	1.3-2.0	2	1.0	0.9-1.1	10	18.2
4. Flats - Westcentral	7	3.5	2.5-4.7	2	2.0	1.6-2.4	2	1.6	1.2-1.9	11	31.4
5. Foothills - East	4	1.6	1.0-2.4	4	1.3	1.2-1.6	-			8	11.4
6. Foothills - L. Delta	4	2.2	1.1-4.2	2	1.1	0.9-1.3	4	1.2	1.0-1.4	10	15.7
7. Foothills - Central	1	2.5	2.5	2	1.1	0.8-1.4	-			3	4.7
8. Foothills - West	2	2.7	2.5-2.8	3	2.7	2.0-3.7	2	2.2	2.0-2.4	7	17.9
9. Delta & Maclaren	-			-			-			-	
10. Brushkana - Butte	-			-			-			-	
11. Deadman	1	1.6	1.6	-			-			1	1.6
12. Oshetna	1	0.9	0.9	2	1.4	1.2-1.5	-			3	3.7
13. Gulkana, Copper	1	1.9	1.9	-			2	1.6	1.3-1.9	3	5.1
14. Yakutat, Toolik	2	1.2	0.9-1.4	1	1.0	1.0	1	1.0	1.0	4	4.3
	34	2.3	0.9-4.7	24	1.8	0.8-3.7	14	1.4	0.9-2.4	72	141.6

* $\overline{T} = \dfrac{T_r + T_l}{2}$, see Table 1-9; $\bar{x} = \dfrac{\text{sum of area } \overline{T}}{n}$

Table 1-11. Distribution of average adrenal and thyroid weights* (grams) in wolves of different sex and age categories.

		Average thyroid weight (g)			Average adrenal weight (g)		
		Males	Females	Both sexes	Males	Females	Both sexes
PUPS	n	7	7	14	17	8	25
	$\bar{x}$	1.7	1.1	1.4	1.4	1.2	1.3
	Range	0.9-2.4	1.0-1.4	0.9-2.4	0.5-2.9	0.6-1.5	0.5-2.9
ADULTS							
2&3yrs	n	12	12	24	16	13	29
	$\bar{x}$	2.4	1.6	2.0	1.4	1.4	1.4
	Range	0.9-4.7	0.8-2.1	0.8-4.7	0.8-2.1	0.8-2.1	0.8-2.1
4-7yrs	n	21	10	31	21	11	32
	$\bar{x}$	2.4	1.8	2.2	1.7	1.7	1.7
	Range	1.0-4.0	1.0-3.1	1.0-4.0	1.2-2.3	1.1-2.1	1.1-2.3
Age unknown	n	1	2	3	1	2	3
	Range	0.9	1.5-3.0	0.9-3.0	1.1	1.5-1.9	1.1-1.9
Total	n	34	24	58	38	26	64
	$\bar{x}$	2.3	1.8	2.1	1.5	1.5	1.5
	Range	0.9-4.7	0.8-3.1	0.8-4.7	0.8-2.3	0.8-2.1	0.8-2.3

* $\bar{A} = \frac{A_r + A_l}{2}$, $\bar{T} = \frac{T_r + T_l}{2}$, see Table 1-9.

each sex and adults of different age and sex categories. There was a relatively broad range of (average) thyroid weights, with 5 (7%) either 0.8 or 0.9 g, 37 (51.5%) between 1.0 and 1.9 g, 18 (25%) between 2.0 and 2.9 g, 9 (12.5%) between 3.0 and 3.9 g, and 3 (4%) between 4.0 and 4.7 g. Thyroids of adult animals were generally heavier than those of younger animals, with those of male adults averaging 2.3 g (n = 34, range 0.9 - 4.7 g) and of female adults averaging 1.8 g (n = 24, range 0.8 - 3.1 g). Average thyroid weight of pups was 1.4 g (n = 14, range 0.9 - 2.4 g). Average thyroid weight of older adults (age 4-7 years) exceeded that of the younger adults (age 2 and 3 years) for females but not for males (Table 1-11).

There were unusually large differences between the weights of the right and left thyroids in two males (adult #61348 and pup #61398). The values for these individuals are omitted from the calculations above and are considered in Report 5.

Adrenal weights were available from 89 wolves (Table 1-9); both adrenals were available from 71 animals but 1 only for 18. Table 1-12 summarizes the average adrenal weights for Unit 20A's 71 wolves, Unit 13's 14 wolves, Unit 5's 3 wolves, and Unit 26's 1 wolf by unit area and by wolf age class. The range of (average) adrenal weights observed was relatively narrow, with 7 (8%) between 0.5 and 0.9 g, 71 (80%) between 1.0 and 1.9 g, and 11 (11%) between 2.0 and 2.9 g. Average adrenal weights of adult males and females were the same: male adults 1.5 g (n = 38, range 0.8 - 2.3 g), and female adults 1.5 g (n = 26, range 0.8 - 2.1 g). Adrenals from pups averaged 1.3 g (n = 25, range 0.5 - 2.9 g). Table 1-11 presents the distribution of (average) adrenal weights for pups of both sexes and for adults of different sexes and ages. Although average adrenal weights were identical for both males and females in the two adult age classes, the average adrenal weight of male pups exceeded that of female pups. The range of adrenal weights observed among male pups was particularly broad and seemed to have no clear relationship to body weight (for example, male pup #61334, body weight 99 lbs., adrenal weight 0.5g; male pup #61302, body weight 95 lbs., adrenal weight 2.9 g).

Although adrenal weight variability among different sex and age classes was relatively minor, even small differences may have considerable physiological implications (Robbins 1974). Nevertheless, no apparent relationship could be found between average adrenal weights of wolves from different areas (Table 1-11) and general nutritional status (present and possible immediate past, Table 1-2). The characteristics of individuals with either larger than average or smaller than average adrenal weights revealed no particular consistencies. Since the various zones of the adrenal cortex are affected in different ways by a variety of biological and pathological phenomena (Bloom 1968a, Robbins 1974), further discussion of variations in this gland awaits histological examination of the preserved material.

Three male adults (#61317, 61359 and 61391) displayed large differences between the weights of the right and the left adrenal glands. The values for these wolves were omitted in the calculation of averages above, and they are considered in Report 5.

Table 1-12. Distribution of average adrenal weights $\overline{A}$* (grams) for wolves in different geographic areas.

	Adult						Pup				
	Male			Female							
	n	$\bar{x}$	range of $\overline{A}$	n	$\bar{x}$	range of $\overline{A}$	n	$\bar{x}$	range of $\overline{A}$	n	Area $\bar{x}$
1. Flats - East	2	1.4	1.3-1.5	2	1.7	1.6-1.7	-			4	1.5
2. Fairbanks	5	1.7	1.1-2.3	3	1.5	1.3-1.7	1	0.6	0.6	9	1.5
3. Flats - Buttes	4	1.7	1.5-1.9	3	1.7	1.3-2.1	3	1.5	1.2-1.8	10	1.6
4. Flats - Westcentral	6	1.5	0.8-2.1	2	1.3	1.3	2	1.4	1.1-1.6	10	1.4
5. Foothills - East	4	1.5	1.2-1.8	4	1.3	0.8-1.8	-			8	1.4
6. Foothills - L. Delta	4	1.7	1.1-2.1	2	1.6	1.0-2.1	4	1.3	1.2-1.5	10	1.5
7. Foothills - Central	5	1.5	0.8-2.1	3	1.6	1.2-2.1	5	1.1	0.5-1.6	13	1.4
8. Foothills - West	2	2.0	1.9-2.0	3	1.8	1.6-1.9	2	1.3	1.1-1.4	7	1.7
9. Delta & Maclaren	-			-			2	2.6	2.2-2.9	2	2.6
10. Brushkana - Butte	1	1.4	1.4	-			-			1	1.4
11. Deadman	-			1	1.6	1.6	1	1.5	1.5	2	1.6
12. Oshetna	2	1.2	1.1-1.2	2	1.5	1.0-1.9	-			4	1.3
13. Gulkana, Copper	1	1.5	1.5	-			4	1.1	0.9-1.2	5	1.2
14. Yakutat, Toolik	2	1.3	1.1-1.4	1	1.1	1.1	1	1.4	1.4	4	1.3
	38	1.5	0.8-2.3	26	1.5	0.8-2.1	25	1.3	0.5-2.9	89	

* $\overline{A} = \frac{A_r + A_1}{2}$, see Table 1-9; $\overline{X} = \frac{\text{sum of area } \overline{A}}{n}$

Comparison of particular adrenal and thyroid weights which were markedly above or below average did not reveal consistent direct or inverse relationships between weights of these two glands in individuals. Only three animals, all large adult males, had both adrenal and thyroid weights considerably above normal: #61361, average adrenal weight 2.1 g, average thyroid weight 4.7 g; #61379, average adrenal weight 2.1 g, average thyroid weight 4.2 g; #61359, adrenal weights 2.0 and 3.3 g (an unusual difference), average thyroid weight 4.0 g. (Average male adult adrenal weight was 1.5 g; average male adult thyroid weight was 2.3 g.)

Discussion: Organ weights

Age and sex related differences in body weights were reflected in similar differentials of organ weights. As might be expected, considerable correlation was observed between the whole body weight of an individual and the weights of the heart, liver, kidneys and thyroid. Because body weight was shown to be a function of age and sex, organ weight differentials cannot be analyzed independently of the associated age and sex categories. Adult males, the heaviest class of individuals, had average heart, liver, kidney and thyroid weights exceeding those of adult females. However, this sex differential was less marked in the older (4-7 years) age category.

Female adults in the age 4-7 years category showed increases over those in the age 2 and 3 years category for weights of the body, liver, kidney and thyroid. This suggests continuing growth of both body and organs for females (n = 25 adults, 12 pups). A similar increase in organ weight between the two age categories was not observed for males, with the exception of the liver. Apparently, growth of both body and organs (excepting the liver) is completed within the first two years of life for males (n = 38 adults, 20 pups). Liver weight as a percentage of whole body weight is discussed below (Report 4).

This apparent sex differential in growth was not observed for the adrenal gland. Adrenal weights averaged exactly the same for both sexes after the first year of life (n = 38 male and 26 female adults). The average 1.5 g observed for adult wolves of both sexes compares to the "approximately 0.5 g" (Venzke 1975) adrenal weight of domestic dogs (body weights not given). No clear relationships were noted between adrenal weight variations and nutritional status.

In contrast, the thyroid increased with body weight and age, with the sex differential as discussed above. This is in apparent contrast to domestic dogs, among which proportionally larger thyroids are found in younger individuals (Smithcors 1964). Seal et al. (1975) have discussed the implications of various thyroxine levels in wolf pups in Minnesota and have suggested the possibility of hyperthyroidism in association with possible iodine deficiencies (increasing with body weight) in that state's population. Fox (1923) reported a case of exophthalmic goiter in a captive wolf. Iodine deficiencies are also a possibility in the wolf populations of Units 20A, 13 and 26 but are unlikely in the maritime Unit 5 (Yakutat) animals. It is interesting that the thyroid weights for the three Yakutat wolves (Table 1-9) were considerably less than those observed elsewhere, particularly for the adult animals (average male adult thyroid weight, 2.3 g, vs. Yakutat male adult thyroid weights, 0.9 and 1.4 g; average female pup thyroid weight, 1.1 g, vs. Yakutat female pup thyroid weight, 1.0 g). Further discussion of relative thyroid size and its biological implications awaits histological examination of the preserved materials.

Also remaining to be examined and possibly related to variations in relevant organ weights are the levels of various serum constituents (hormones, minerals, etc.), histological observations, food habits differences, and various other aspects of wolf biology (Stephenson, in prep., Holleman and Stephenson, in prep.).

Report 2. Relative size and involution of the thymus

The size and condition of the thymus gland were evaluated for 62 of the 112 wolves collected in spring 1976. Thymus specimens were not available from the remaining wolves because the anterior mediastinum and thoracic inlet area were macerated and/or obscured by hemorrhage in these individuals. For 9 of the 62 animals which had been frozen before examination, the presence of the thymic tissue was noted in a general way and the tissue was refrozen and shipped for histochemical analysis without further evaluation (Table 2-1). For the remaining 53 wolves, 51 from the Unit 20A collection and 2 from Yakutat, the anterior mediastinum was examined and possible thymic tissue was preserved in buffered 10 percent formalin from 44 individuals (Unit 20A, 42; Yakutat, 2). Thymic tissue was clearly lacking in nine wolves, and no materials were preserved from them. Thus, all thymuses available for detailed examination were from the Unit 20A collection.

Direct weighing of the anterior mediastinum provided no information about the amount of thymic tissue present, since the area frequently serves as a fat depot. In addition, the normal process of involution of this organ involves the replacing of lymphocytic and epithelial thymic tissue by an increasing number of adipose cells in the interlobular septae. These depots of fat complicate the process of evaluating the size of the thymus. However, it was found in the present study that thymic tissue could be clearly distinguished when preserved because it appears grey in contrast to the adipose tissue which remains yellow-white. Thus the condition of the thymus could be visually evaluated, taking both the processes of involution (shrinkage) and interstitial fat deposition (replacement) into account.

Involution was evaluated by direct examination of the preserved mediastina, and when the thymus was a coherent mass of tissue its dimensions were measured. Sizes ranged from "big" (approximately 7-25 cm^3) and "moderate" (2-5 cm^3) to "small" (0.5-2 cm^3). Where fat in the interlobular septae exceeded the amount of thymic tissue present, the classifications "remnant" (several islands of tissue each 1 cm^3 or less) and "residual" (one or two islands of tissue 0.5 cm^3 or less) were used. In a number of cases mediastina were saved in which thymic tissue was

Table 2-1. Wolves from which thymuses were noted or collected but not examined in detail (i.e. not preserved in formalin).

Wolf				Disposition of thymus specimen
Unit	Number	Pack	Area	
Unit 20A				
	61337	X	Foothills - central	Noted, discarded
	61342	X	Foothills - central	Noted, discarded
	61398	RL	Fairbanks	Frozen
Unit 13				
	61325	EWA	Gulkana, Copper	Frozen
	61431	HOG	Gulkana, Copper	Frozen
	61433	TOK	Gulkana, Copper	Frozen
	61408	BBP	Brushkana - Butte	Frozen
	61409	BBP	Brushkana - Butte	Frozen
Unit 5				
	61345	Y3	Yakutat	Frozen

TOTAL:
Unit 20A - 3
Unit 13 - 5
Yakutat - 1
9

suspected but, upon examination of the formalin-fixed materials, was found to be clearly absent (i.e. no grey thymic tissue was apparent within the adipose tissue).

Interlobular fat replacement was easily evaluated in the preserved material because of the apparent color differential between adipose and thymic tissue. Replacement was rated on an arbitrary scale of one to four, with (+) = little or no adipose tissue apparent in the connective tissue dividing thymic lobules, (++) = a moderate amount of fat, (+++) = a substantial amount of fat in the interstitium (but the lobules still clearly differentiated), and (++++) = abundant adipose tissue interspersed with thymic tissue so that the interstitium (lobular arrangement) was obscured, or, in some cases, so that the thymic tissue appeared as islands among the fat.

To evaluate both the processes of involution and fat replacement, 21 possible categories are obtained when thymus size and relative amount of interlobular fat are considered to vary independently (Table 2-2A). Thus, as thymus size varies (in five arbitrary steps) from "big," through "moderate" etc. to "residual," the relative amount of interlobular fat may vary (in four arbitrary steps) from (+) to (+++), yielding (4 x 5 =) 20 possible categories. The twenty-first category, with the size of "none" can, of course, only have an "all fat" designation.

The observed thymuses occupied only 13 of the possible 21 categories (Table 2-2B). There is clearly an inverse relationship between thymus size (involution) and the amount of interlobular fat present due to the replacement phenomenon. Most thymuses observed in these wolves were either; (a) large or moderate in size without lobules obscured by fat (categories 1 through 6, n = 17 or 33%) or (b) remnant/absent (categories 10 through 13, n = 30 or 59%), with few in the intermediate stages of involution (categories 7, 8, 9, n = 4 or 8%), as summarized in Table 2-2 and detailed in Table 2-3.

There are numerous biological factors influencing the size and involution of the thymus; the primary ones are age, pregnancy, nutrition and stress (Andersen 1932, Dougherty 1952). Although the primary function of the thymus is the production or influencing of thymocytes (T-lymphocytes) involved in cellular type immunity, this formation or influencing appears to be completed in late fetal and juvenile life (Latimer 1954, Arnason et al 1962, Osoba 1968, Eisen 1974). After reaching its maximal size at puberty, the thymus begins to involute, a process which is apparently hastened by disease, pathological conditions and other aspects of "stress" (Dougherty 1952). Involution proceeds to either partial or total atrophy and fat replacement in a variety of mammalian species studied (Andersen 1932, Bloom 1968a, b).

For the wolves examined in the present study, information on (a) age, (b) sex and (for females) reproductive state, and (c) nutritional condition (as reflected in body fat) was available and is discussed below. However, correlation of thymus state with physiological stress and pathological history was more limited because information on these two factors was available only as reflected in the carcass at necropsy

Table 2-2. Categories of thymus condition: thymus size and amount of fat replacement.

A. Number of wolves with thymus in condition indicated.

Size	Relative amount of fat replacement					Involution
Thymus	+	++	+++	++++	(all fat)	subtotal
Big	6	7	1	–	0	14
Moderate	2	1	2	–	0	5
Small	–	2	1	–	0	3
Remnant	1	–	–	3	0	4
Residual	–	1	–	6	0	7
None	0	0	0	0	20	20
Replacement subtotal	9	1	4	9	20	53 wolves total

B. Resultant categories describing thymus conditions actually observed among wolves in this study.

Category No.	Size/Replacement	Number of wolves in category
1	Big +	6
2	Big ++	7
3	Big +++	1
4	Moderate +	2
5	Moderate ++	1
6	Moderate +++	2
7	Small ++	2
8	Small +++	1
9	Remnant +	1
10	Remnant ++++	3
11	Residual ++	1
12	Residual ++++	6
13	None	20

Table 2-3. Individual wolves, listed by the thymic condition category in which their thymuses were observed.

	Wolf				
Thymus category	Pack	Accession number	Sex	Age	Nutritional condition
1) Big +	B	61389	M	3	Good
	F	61362	M	Pup	Good
	F	61363	F	2	Good
	V	61369	F	2	Fair
	T	61373	F	Pup	Fair
	Y	61392	M	Pup	Fair
2) Big ++	B	61387	F	5	Good
	W	61346	F	2	Good
	Y	61394	F	3	Good
	T	61374	M	4	Fair
	T	61372	F	3	Fair
	T	61371	F	Pup	Fair
	Y2	61344	F	Pup	Good
3) Big +++	V	61406	M	4	Fair
4) Moderate +	V	61367	M	4	Fair
	Y1	61343	M	3	Good
5) Moderate ++	F	61361	M	2	Good
6) Moderate +++	V	61404	M	3	Fair
	V	61405	F	3	Fair
7) Small ++	V	61368	M	3	Fair
	U	61351	M	Pup	Poor
8) Small +++	F	61377	M	4	Fair
9) Remn. +	Z	61385	M	Pup	Good
Not actively resorbing although fat present elsewhere in body.					
10) Remn. ++++	C	61376	M	4	Fair
	D	61364	M	4	Poor
	D	61354	M	5	Poor
11) Residual ++	G	61383	F	Pup	Fair
12) Residual++++	F	61360	M	2	Good
	T	61375	F	6	Good
	Y	61393	F	5	Good
	A	61350	F	2	Fair
	D	61391	M	4	Poor
	U	61378	M	3	Poor

Table 2-3. (Continued).

Thymus category	Wolf				
	Pack	Accession number	Sex	Age	Nutritional condition
13) None	RC	61402	F	3	Good
	RC	61403	F	5	Good
	E	61352	M	3	Good
	E	61356	M	4	Good
	F	61359	M	4	Good
	G	61381	M	3	Good
	V	61390	F	5	Good
	W	61347	F	4	Good
	Y	61395	M	4	Good
	C	61358	M	4	Fair
	20B	61401	M	5	Fair
	RL	61353	M	5	Fair
	U	61379	M	6	Fair
	C	61357	M	6	Poor
	RC	61400	F	Pup	Poor
	D	61355	M	4	Poor
	D	61366	F	5	Poor
	RL	61407	F	3	Poor
	U	61349	F	Pup	Poor
	GK	61410	M	4	Poor

and in properties of the serum. Since serum studies were incomplete as of this writing, only physiological stress as suggested by (d) adrenal weights and (e) traumatic injuries is considered here.

A. Age

The relationship between age of the individual and observed thymus size (and fat replacement) is presented in Table 2-4, with Table 2-4A listing observations for the 31 males, 2-4B listing observations for the 22 females, 2-4C listing the summation for both sexes, and 2-4D summarizing the data for both sexes and presenting them as a percentage of the total per age class. Age was known for all of the 53 wolves with examined thymuses: 10 pups, 18 two- and three-year-olds and 25 four- through seven-year-olds (both sexes included).

Considerable variation in thymus status was observed among pups (Tables 2-4C and 2-4D). Half the pups had large thymuses (accounting for nearly half of the "big" thymuses observed in all age classes), and half had small, remnant or no thymuses. Both pups with no thymus tissue were females (Table 2-4B).

Even more variation was observed among the 18 two- and three-year-old wolves. More than half of these had big or moderate-sized thymuses with a wide range of fat replacement progress, and nearly all of the remaining half had either residual or no thymus tissue (Tables 2-4C and 2-4D). In this age class females (n = 9) had most of the big thymuses observed, while male thymuses (n = 9) were widely distributed in size and replacement state.

Among the 25 four- through seven-year-olds for which the thymus was examined, the organ was remnant or lacking in 80 percent of the individuals (Tables 2-4C and 2-4D). The number of females in this age class (n = 7) was rather small relative to the number of males (n = 18) for comparisons between the sexes. Nevertheless, three individuals in this older age class (2 males age 4-years and 1 female age 5-years) had big thymuses, although some fat replacement was evident in all three cases.

The above data indicate an inverse relationship between wolf age and thymus weight, a phenomenon observed for domestic dogs (Miller et al 1964, Bloom 1968a, b) and for many other mammalian species (Andersen 1932). However, the relationship is not strictly age-dependent because 5 (9%) of the total 53 individuals were either pups with <u>no</u> observable thymic tissue (2) or older adults with substantial thymic tissue present (3) (Table 2-4C).

B. Reproductive history of females

Sex can influence thymic condition in a variety of ways, including social dominance, and other factors which can relate to physiological stress. In the present study sex will be considered only in terms of pregnancy, which is known to induce thymic involution (by unknown but presumably hormonal and physiological means) in mammals (Andersen 1932, Dougherty 1952, Shields 1972).

Table 2-4. Relationship of thymus condition to age of the individual wolf: number of individuals of different ages with thymus category indicated.

Table 2-4A. Thymus categories for males of different ages.

Category	Pups (total)	Adults							Total adults
		age (years)					subtotal 2 & 3	subtotal 4-7	
		2	3	4	5	6			
1) Big +	2	–	1	–	–	–	1	–	1
2) Big ++	–	–	–	1	–	–	–	1	1
3) Big +++	–	–	–	1	–	–	–	1	1
4) Moderate +	–	–	1	1	–	–	1	1	2
5) Moderate ++	–	1	–	–	–	–	1	–	1
6) Moderate +++	–	–	1	–	–	–	1	–	1
7) Small ++	1	–	1	–	–	–	1	–	1
8) Small +++	–	–	–	1	–	–	–	1	1
9) Remnant +	1	–	–	–	–	–	–	–	–
10) Remnant ++++	–	–	–	2	1	–	–	3	3
11) Residual ++	–	–	–	–	–	–	–	–	–
12) Residual ++++	–	1	1	1	–	–	2	1	3
13) None	–	–	2	6	2	2	2	10	12
Age totals, males	4	2	7	13	3	2	9	18	27

Table 2-4B. Thymus categories for females of different ages.

Category	Pups (total)	Adults							Total adults
		age (years)					subtotal 2 & 3	subtotal 4-7	
		2	3	4	5	6			
1) Big +	1	2	–	–	–	–	2	–	2
2) Big ++	2	1	2	–	1	–	3	1	4
3) Big +++	–	–	–	–	–	–	–	–	–
4) Moderate +	–	–	–	–	–	–	–	–	–
5) Moderate ++	–	–	–	–	–	–	–	–	–
6) Moderate +++	–	–		–	–	–	1	–	1
7) Small ++	–	–	–	–	–	–	–	–	–
8) Small +++	–	–	–	–	–	–	–	–	–
9) Remnant +	–	–	–	–	–	–	–	–	–
10) Remnant ++++	–	–	–	–	–	–	–	–	–
11) Residual ++	1	–	–	–	–	–	–	–	–
12) Residual ++++	–	1	–	–	1	1	1	2	3
13) None	2	–	2	1	3	–	2	4	6
Age totals, females	6	4	5	1	5	1	9	7	16

Table 2-4. (Continued).

Table 2-4C. Thymus categories for wolves of both sexes of different ages.

	Pups	Adults							
	(total)	age (years)					subtotal	subtotal	Total
Category		2	3	4	5	6	2 & 3	4-7	adults
1) Big +	3	2	1	-	-	-	3	-	3
2) Big ++	2	1	2	1	1	-	3	2	5
3) Big +++	-	-	-	1	-	-	-	1	1
4) Moderate +	-	-	1	1	-	-	1	1	2
5) Moderate ++	-	1	-	-	-	-	1	-	1
6) Moderate +++	-	-	2	-	-	-	2	-	2
7) Small ++	1	-	1	-	-	-	1	-	1
8) Small +++	-	-	-	1	-	-	1	-	1
9) Remnant +	1	-	-	-	-	-	-	-	-
10) Remnant ++++	-	-	-	2	1	-	-	3	3
11) Residual ++	1	-	-	-	-	-	-	-	-
12) Residual ++++	-	2	1	1	1	1	3	3	6
13) None	2	-	4	7	5	2	4	14	18
Age totals, both sexes	10	6	12	14	8	3	18	25	43

Table 2-4D. Thymus categories (grouped) for wolves of both sexes of different age classes with wolf numbers in the grouped categories expressed as a percentage of the total individuals in that age class.

Thymus categories (grouped)	Age class		
	Pups	2&3 yrs.	4-7 yrs.
1 - 3 (Big)	50	33	12
4 - 6 (Moderate)	-	22	4
7 - 9 (Small & Remnant)	20	6	4
10 - 12(Remnant & Residual	10	17	24
13 (None)	20	22	56
Total in age class	10	18	25

Of the 22 female wolves for which thymuses could be studied, 8 had histories of at least one previous pregnancy and 8 (plus 6 pups) had apparently never been pregnant (Table 2-5). Among those eight adult females which had never been pregnant, five had big thymuses and three had no thymic tissue. Among the eight adult females which had a history of pregnancy, however, only two had big or moderate thymuses and six had residual or no thymic tissue. Thus there may be an age-independent relationship between history of pregnancy and thymic involution in females age 2-years and older.

Of the six female pups for which thymuses were available, three had big thymuses and three had residual or no thymic tissue. Only two of the pups (#61344 and 61383) were in the early stages of their first estrus at the time of collection (there is some doubt about the age of these individuals: see Stephenson, in prep.).

C. Nutritional condition

Starvation or malnutrition have long been understood to contribute to involution of the thymus in mammals (Andersen 1932, Dougherty 1952, Latimer 1954, Bloom 1968a, Shields 1972). An evaluation of current nutritional condition and possible condition history of the wolves examined in the present study has been presented (Report 1, Table 1-1). Table 2-6 presents the conditions of the thymus associated with the three nutritional states, and Table 2-7 presents the same information in detail for each individual examined.

Among the individuals in good nutritional condition and the 19 in fair condition, there was a wide range of thymus sizes and fat replacement (Table 2-6). However, 11 of the 12 individuals in poor condition had residual or no thymic tissue. The lone wolf with a small thymus was a pup, #61351; the two other pups in poor condition lacked thymic tissue entirely. Thus an inverse relationship is indicated between thymus size and nutritional condition: thymuses tend to be small or absent in wolves in poor condition at the time of collection. The wide range of thymus sizes observed among wolves in good or fair condition may be related to their conditional history, since involution, once initiated, may slow or stop but is never reversible.

D. Adrenal weight

Various kinds of stress, in addition to malnutrition and pregnancy, have been correlated with reduction in thymus size in dogs and other mammals (Andersen 1932, Bloom 1968, Shields 1972) and have been attributed at least in part to hormonal influence (Dougherty 1952). But because "stress" is a condition difficult to define and to evaluate physically, and because information on the basic physiology of wolves is limited, it is difficult to evaluate stress at necropsy. The behavioral, physiological and nutritional components of stres probably all contribute to any physical manifestations and are inseparably intertwined. The nutritional aspect as evidenced by body fat reserves has been discussed above. Dougherty (1952) has discussed the delicate balance of hormonal influences.

Table 2-5. Thymus condition as a function of the reproductive history* of the individual female wolf.

	Wolf			Reproductive history	
Thymus category	Pack	No.	Age (yrs)	Past	At necropsy
1) Big +	F	61363	2	never pregnant	first estrus (pregnant?)
	V	61369	2	never pregnant	not in estrus
	T	61373	pup	never pregnant	not in estrus
2) Big ++	B	61387	5	pregnant once (?)	in estrus (pregnant?)
	W	61346	2	never pregnant	not in estrus
	Y	61394	3	never pregnant	pregnant
	T	61372	3	never pregnant	not in estrus
	T	61371	pup	never pregnant	not in estrus
	Y2	61344	pup	never pregnant	early first estrus
6) Moderate +++	V	61405	3	estrus (pregnant?) once	pregnant
11) Residual ++	G	61383	pup	never pregnant	early first estrus
12) Residual++++	T	61375	6	never pregnant(?)	in estrus
	Y	61393	5	pregnant once (?)	pregnant
	A	61350	2	pregnant once (?)	in second estrus
13) None ++++	RC	61402	3	never pregnant	in first estrus
	RC	61403	5	two pregnancies(?)	not in estrus
	V	61390	5	at least two pregnancies	not in estrus
	W	61347	4	never pregnant	not in estrus
	RC	61400	pup	never pregnant	not in estrus
	D	61366	5	two pregnancies(?)	pregnant
	RL	61407	3	two pregnancies(?)	not in estrus
	U	61349	pup	never pregnant	not in estrus

Total: 22 females - 6 pups, 9 two- and three-year-olds, 7 four- through seven-year-olds

Total pregnancy history:
14 - never pregnant
4 - pregnant or in estrus once
4 - pregnant twice

*Reproductive history evaluated by Jean Ernest and Robert Stephenson (see Stephenson, in prep.)

Table 2-6. Thymus condition as a function of nutritional status: number of individual wolves of different nutritional status in the various thymus categories.

Thymus category	Nutritional status of wolf			Category subtotal
	Good	Fair	Poor	
1) Big +	3	3	-	6
2) Big ++	4	3	-	7
3) Big +++	-	1	-	1
4) Moderate +	1	1	-	2
5) Moderate ++	1	-	-	1
6) Moderate +++	-	2	-	2
7) Small ++	-	1	1	2
8) Small ++++	-	1	-	1
9) Remnant +	1	-	-	1
10) Remnant ++++	-	1	2	3
11) Residual ++	-	1	-	1
12) Residual++++	3	1	2	6
13) None	9	4	7	20
Status subtotal	22	19	12	Total 53 wolves

Table 2-7. Thymus size (approximate dimensions of coherent thymic tissue) in individual wolves, listed according to both body condition and thymus category, with n = number of individuals in each group.

Area/Pack	No.	Sex	Age (yrs)	Thymus size*	Interstitial fat replacement	Thymus condition
Condition: Good, Thymus Small, Moderate, Large (n = 9):						
1) Flats - East						
B	61389	M	3	Big (25cm^3)	+	1
B	61387	F	5	Big (7cm^3)	++	2
4) Flats - Westcentral						
F	61361	M	2	Modr. (2cm^3)	++	5
F	61362	M	pup	Big (12cm^3)	+	1
F	61363	F	2	Big (12cm^3)	+	1
7) Foothills - Central						
W	61346	F	2	Big (8cm^3)	++	2
8) Foothills - West						
Y	61394	F	3	Big (9cm^3)	++	2
14) Yakutat						
Y1	61343	M	3	Modr. (5cm^3)	+	4
Y2	61344	F	pup	Big (20cm^3)	++	2
Condition: Good, Thymus Involuting/Absent (n = 13):						
2) Fairbanks						
RC	61402	F	3	None	-	13
RC	61403	F	5	None	-	13
3) Flats - Westcentral						
E	61352	M	3	None	-	13
E	61356	M	4	None	-	13
F	61359	M	4	None	-	13
F	61360	M	2	Residual	++++	12
G	61381	M	3	None	-	13
5) Foothills - East						
V	61390	F	5	None	-	13
6) Foothills - Little Delta						
T	61375	F	6	Residual	++++	12
7) Foothills - Central						
W	61347	F	4	None	-	13

*Approximate dimensions of coherent thymic tissue given in parentheses.

Table 2-7. (Continued).

Area/Pack	No.	Sex	Age (yrs)	Thymus size*	Interstitial fat replacement	Thymus condition
8) Foothills - West						
Y	61395	M	4	None	-	13
Z	61385	M	pup	Remnant	+	9
Y	61393	F	5	Residual	++++	12
Condition: Fair, Thymus Small, Moderate, Large (n = 12 & 2):						
4) Flats - Westcentral						
F	61377	M	4	Small (0.5cm^3)	+++	8
5) Foothills - East						
V	61367	M	4	Modr. (3cm^3)	+	4
V	61368	M	3	Small (2cm^3)	++	7
V	61404	M	3	Modr.	+++	6
V	61406	M	4	Big (8cm^3)	+++	3
V	61369	F	2	Big (15cm^3)	+	1
V	61405	F	3	Modr.	+++	6
6) Foothills - Little Delta						
T	61374	M	4	Big (14cm^3)	++	2
T	61372	F	3	Big (28cm^3)	++	2
T	61371	F	pup	Big (22cm^3)	++	2
T	61373	F	pup	Big (15cm^3)	+	1
7) Foothills - Central						
X	61337	M	3	"Present"	?	
X	61342	M	pup	"Present"	?	
8) Foothills - West						
Y	61392	M	pup	Big (12cm^3)	+	1
Condition: Fair, Thymus Involuting/Absent (n = 7):						
1) Flats - East						
A	61350	F	2	Residual	++++	12
2) Fairbanks						
C	61358	M	4	None	-	13
C	61376	M	4	Remnant	-	10
20B	61401	M	5	None	-	13

Table 2-7. (Continued).

Area/Pack	No.	Sex	Age (yrs)	Thymus size*	Interstitial fat replacement	Thymus condition
3) Flats - Buttes						
RL	61353	M	5	None	-	13
4) Flats - Westcentral						
G	61383	F	pup	Residual	++	11
6) Foothills - Little Delta						
U	61379	M	6	None	-	13
Condition: Poor, Thymus Small, Moderate, Large (n = 1):						
6) Foothills - Little Delta						
U	61351	M	pup	Small (2cm^3)	++	7
Condition: Poor, Thymus Involuting/Absent (n = 11):						
2) Fairbanks						
C	61357	M	6	None	-	13
RC	61400	F	pup	None	-	13
3) Flats - Buttes						
D	61355	M	4	None	-	13
D	61364	M	4	Remnant	++++	10
D	61391	M	4	Residual	++++	12
D	61354	M	5	Remnant	++++	10
D	61366	F	5	None	-	13
RL	61407	F	3	None	-	13
6) Foothills - Little Delta						
U	61378	M	3	Residual	++++	12
U	61349	F	pup	None	-	13
7) Foothills - Central						
GR	61410	M	4	None	-	13

The other best-known manifestation of generalized stress is adrenal hyperplasia. Adrenal weights for each animal have been presented and discussed above (Report 1, part C; see Table 1-9). Although these weights varied within a limited range ($\bar{x}$ = 1.5, range 0.8-2.3, n = 64) they had no apparent relationship to the widely varying condition of the thymus as observed in the 53 individuals examined. For example, wolves with no thymic tissue (category 13) had adrenal weights varying from 0.8 (three-year-old male #61381) to 2.3 g (four-year-old male #61358), while wolves with "big" thymuses and little fat replacement (categories 1 and 2) had adrenal weights varying from 0.8 to 1.6 g (two-year-old females #61369 and #61346, respectively).

E. Traumatic injuries

A variety of pathological conditions were observed at necropsy in 53 wolves whose thymuses were examined. Most of these conditions (to be discussed in the following reports) occurred with very low frequency and were of questionable significance to the individual. However, two pathological features were noted with greater frequency and might be examined relative to thymic involution.

Renal cortical scarring was observed in a considerable number of wolves. Analysis of the occurrence of this lesion in Report 6 indicated a direct relationship with age. Since involution of the thymus was shown above (this Report, section A) to also be somewhat related to age, the relationship between thymic involution and kidney lesions cannot be independently evaluated.

A considerable number of wolves also displayed evidence of recent traumatic injuries, as discussed in detail in Report 7. Among the 53 individuals whose thymuses were examined, 34 (64%) had at least one injury in the various sites examined. Injuries included fractures of the skull, ribs or long bones, damage to the teeth, abrasions of the skin, abscesses, and damage to the appendages (ears, toes). A total of 458 sites were examined in these 53 wolves and 57 (12%) of the sites (in 34 injured wolves) were damaged. Several individuals had more than one injury. Table 2-8 presents the distribution of thymus categories observed relative to the number of associated injury sites.

There is some indication that involution of the thymus is related to the occurrence of traumatic injuries. Table 2-8 presents the percentages of examined individuals and sites which showed evidence of traumatic injury in each thymus category. Somewhat greater percentages of injured individuals were noted in the small and residual thymus categories (7 through 13: 75%, 70%, 75%) than in the large thymus category (1 through 6: 50%, 40%). When injuries were expressed in terms of percentages of sites examined, however, there was less variation (8-19%) among the associated thymus categories.

Conversely, Table 2-8 also evaluates the comparative distribution of thymus categories observed for all individuals (or sites) vs. that for injured individuals (or sites). A slightly greater percentage of the 34

Table 2-8. Distribution of thymus conditions associated with the number and percentages of examined individuals, and number and percentage of anatomical sites within them, which displayed traumatic injuries.

	Individuals					Anatomical sites in these individuals				
	examined		injured		% of examined indiv. injured	examined		injured		% of examined sites injured
	n	% of 53	n	% of 34		n	% of 458	n	% of 57	
1 - 3 (Big)	14	26	7	21	50	123	27	11	20	10
4 - 6 (Moderate)	5	9	2	6	40	45	10	3	5	8
7 - 9 (Small)	4	8	3	9	75	36	8	4	7	11
10 - 12 (Residual)	10	19	7	21	70	88	19	7	12	9
13 (None)	20	38	15	44	75	166	36	32	56	19
Total	53	100	34	101	64	458	100	57	100	12

injured individuals (44%) than of all 53 individuals together (38%) lacked thymic tissue entirely, and fewer injured wolves (21%) than expected (26%) had big thymuses. The disparity was slightly more evident in the differential distribution of examined sites, where more injured sites (56%) than total sites examined (36%) were associated with no thymic tissue, and fewer injured sites (20%) than total sites (27%) were associated with big thymuses.

The possibility that involution of the thymus is enhanced by traumatic injury is consistent with the similar apparent effect of poor nutritional condition (above, section C), since traumatic injury can often be associated with lower nutritional status. Examination of six individuals noteworthy for multiple traumatic injuries in Report 7 (#61357, 61353, 61359, 61369, 61379 and 61384) indicated that this is often, but not inevitably, the case. The thymuses of five of these six wolves was available for examination. Four (#61357, 61353, 61359, and 61379) were in fair or poor nutritional condition and lacked thymic tissue entirely (category 13). The fifth (#61369) was in good nutritional condition and had a big thymus (category 1).

It is also possible that traumatic injury is only indirectly linked to thymic involution via nutritional status, since individuals in poor condition may be more likely to sustain traumatic injuries than well-nourished individuals. In this case, thymic involution may have been somehow initiated by the poor nutritional state before the injury even occurred.

Discussion: Thymus

Among the wolves in this study, the thymus gland was encountered in a variety of states, ranging from large to completely involuted. Several obvious parameters were found to vary in a way that suggested they had some relationship to thymus size. Age of the individual was associated inversely with thymus size in many instances, as observed in domestic canids and other mammalian species (Andersen 1932, Miller et al 1964, Eisen 1974). However, there were enough exceptions among both young and old wolves to indicate that age is not the only factor influencing thymus size. Persistent thymuses are occasionally encountered in normal dogs age 3-10 years, and hyperplastic or edematic thymuses may be associated with various canine disorders (Bloom 1968a, b).

High levels of adrenal corticosteroids have also been associated with rapid involution of the thymus, but no apparent relationship was encountered in the present study between adrenal weight and thymus size. However, the hormonal and physiological effects of pregnancy which have been related to thymic involution in other mammals (Andersen 1932, Dougherty 1952, Shields 1972) were indicated in the present study. Females older than two years of age with a history of pregnancy appeared to show age-independent thymic involution.

There were indications as well that occurrence of traumatic injuries hastened thymic involution, although variations in nutritional condition complicate this possible relationship. Bloom (1968a) found that trauma, poisoning and infections induce rapid atrophy of the thymus in domestic dogs. Severe or chronic illness in animals (Jubb and Kennedy 1970) and trauma and infections in humans (Eisen 1974) has been associated with thymic involution. Unfortunately, data on possible diseases of wolves in this study are not yet available.

Nutritional condition as indicated by body fat reserves seems to be the parameter most closely correlated to thymus size. When individual wolves are examined by category of thymic involution (Table 2-9), nutritional status appears to be the single common factor among a number of animals of different ages and sexes from a variety of different locations. This is consistent with some of the very earliest studies of the mammalian thymus which found the organ to be "...a barometer of nutrition and a very delicate one" (Simon 1845 as quoted by Latimer 1954).

In sum, the numerous factors influencing thymic condition are so interrelated that the effects of any one are difficult to discern. Since thymic involution is not well understood even in the intensively studied species, including humans and domestic dogs (Robbins 1974), it is unlikely that the implications of this phenomenon in the little-studied wolf can be immediately explained. Nevertheless, a tie between thymic involution and previous nutritional condition is suggested by the results presented here. The possibility of distinguishing histologically between natural involution and "acute" involution occasioned by infection (Andersen 1932) would be of particular potential value. Histopathological studies on the thymuses collected in this study remain to be done. Such correlations could provide an important addition to information found both at necropsy and in the serum for understanding the otherwise unattainable clinical history of an individual wolf.

Report 3. Pathology of the cardiovascular and respiratory systems

A. Heart

The heart and pericardium were examined macroscopically at necropsy. Few abnormalities, as discussed below, were noted and nearly all hearts exhibited at least a minimal coronary band of fat. Heart weight has been evaluated previously (see Report 1).

The parietal and visceral surfaces of the pericardium were examined for 94 wolves (43 adult males, 26 adult females, 25 pups) as enumerated in Table 3-1. Only a single pericardial abnormality was noted: #61372 (an adult female with heart weight near normal) had a small adhesion between the pericardium and the epicardium near the ventral midline of the left ventricle. The adhesion was 2 mm wide and 10 mm long and consisted of smooth, translucent fibrous tissue similar in texture and appearance to the pericardium itself, with which it was continuous. There were no other macroscopic signs of scarring, inflammation, pericarditis, etc., and it is probable the tissue represented a residual embryonic connection and had no further significance. Histopathological examination of the connection and associated cardiac wall remains to be done.

Table 3-1. Individual wolves, listed by area, for which the heart (including valves and pericardium) and lungs (including trachea and bronchi) were examined at necropsy, with N = normal (no macroscopic pathological changes apparent).

Wolf				Heart			Lungs,
pack	number	sex	age	gross	valves	pericardium	t & b*
1.	Flats - East						
A	61348	M	4	N	N	N	N
B	61384	M	3	N	N	N	N
A	61350	F	2	N	N	N	N
B	61387	F	5	N	N	N	N
	n = 4						
2.	Fairbanks						
C	61357	M	6	N	N	N	N
C	61358	M	4	N	N	N	N
C	61365	M	3	N	N	N	N
C	61376	M	4	N	N	N	N
20B	61401	M	5	N	N	N	N
RC	61402	F	3	N	N	N	N
RC	61403	F	5	N	N	N	N
EI	61409	F	AD	N	N	N	N
RC	61400	F	PUP	N	N	N	N
	n = 9						
3.	Flats - Buttes						
L	61353	M	5	N	N	N	N
D	61355	M	4	N	N	N	N
D	61364	M	4	N	N	N	N
D	61391	M	4	N	N	N	N
D	61354	M	5	N	N	N	N
RL	61396	M	PUP	N	N	N	N
RL	61398	M	PUP	N	N	N	N
D	61366	F	5	N	N	N	N
RL	61397	F	5	N	N	N	N
RL	61407	F	3	N	N	N	N
RL	61408	F	PUP	N	N	N	N
	n = 11						
4.	Flats - Westcentral						
E	61352	M	3	N	N	N	N
E	61356	M	4	N	N	N	N
F	61359	M	4	N	N	N	N
F	61360	M	2	N	N	N	N
F	61361	M	2	N	N	N	N
F	61377	M	4	N	N	N	bullae
G	61381	M	3	N	N	N	N

Table 3-1. (Cont.)

Wolf				Heart			Lungs,
pack	number	sex	age	gross	valves	pericardium	t & b*
F	61362	M	PUP	N	N	N	N
G	61382	F	3	N	N	N	N
G	61383	F	PUP	N	N	N	N
F	61363	F	2	N	N	N	N
	n = 11						
5. Foothills - East							
V	61367	M	4	N	N	N	N
V	61368	M	3	N	N	N	N
V	61404	M	3	N	N	N	N
V	61406	M	4	N	aorta:nodules	N	N
V	61369	F	2	N	N	N	N
V	61388	F	7	N	N	N	N
V	61390	F	5	N	N	N	N
V	61405	F	3	N	N	N	N
	n = 8						
6. Foothills - Little Delta							
T	61370	M	5	N	N	N	N
T	61374	M	4	N	N	N	N
U	61378	M	3	N	N	N	N
U	61379	M	6	N	N	N	N
U	61351	M	PUP	N	N	N	N
T	61375	F	6	N	N	N	N
T	61372	F	3	N	N	adhesion to epicardium	N
T	61371	F	PUP	N	N	N	N
T	61373	F	PUP	N	N	N	N
U	61349	F	PUP	N	N	N	N
	n = 10						
7. Foothills - Central							
W	61332	M	3	N	N	N	N
W	61333	M	2	N	N	N	N
GK	61410	M	4	thin area in wall	N	N	N
X	61337	M	2	N	N	N	N
X	61339	M	3	N	N	N	N
X	61340	M	2	N	N	N	adhesion
X	61338	M	PUP	N	N	N	N
X	61342	M	PUP	N	N	N	N
W	61331	M	PUP	N	N	N	N
W	61334	M	PUP	N	N	N	N
X	61341	F	2	N	N	N	N
W	61346	F	2	N	N	N	N
W	61347	F	4	N	N	N	N
X	61335	F	PUP	N	N	N	N
	n = 15						

Table 3-1. (Cont.)

Wolf				Heart			Lungs,
pack	number	sex	age	gross	valves	pericardium	t & b*
8. Foothills - West							
Z	61384	M	5	N	N	N	N
Y	61395	M	4	N	N	N	N
Z	61385	M	PUP	N	N	N	N
Y	61392	M	PUP	N	N	N	N
Y	61386	F	3	N	N	N	N
Y	61393	F	5	N	N	N	N
Y	61394	F	3	N	N	N	N
	n = 7						
9. Delta and Maclaren							
DLP	61326	M	PUP	N	-	-	-
DLP	61327	F	PUP	N	-	-	-
MLP	61302	M	PUP	N	N	N	N
MLP	61303	M	PUP	N	N	N	-
	n = 4						
10. Brushkana-Butte							
BBK	61304	M	4	N	N	N	N
BBK	61305	M	3	N	-	-	-
BBK	61311	M	2	N	-	-	-
BBK	61309	M	PUP	-	-	-	-
BBK	61313	M	PUP	-	-	-	-
BBK	61307	F	4	N	-	-	-
BBK	61314	F	5	-	-	-	-
BBK	61306	F	PUP	-	-	-	-
BBK	61308	F	PUP	-	-	-	-
BBK	61310	F	PUP	N	-	-	-
BBK	61312	F	2	N	-	-	-
BBK	61315	F	PUP	-	-	-	-
	n = 12						
11. Deadman							
DDP	61317	M	3	N	N	N	N
DDP	61300	M	PUP	N	N	N	N
DDP	61301	M	PUP	-	-	-	-
DDP	61318	F	4	N	N	N	N
DDP	61316	F	PUP	-	-	-	-
	n = 5						
12. Oshetna							
OHP	61319	M	AD	-	-	-	-
OHP	61320	M	AD	-	-	-	-
OHP	61321	M	3	N	N	N	N
OHP	61324	M	3	N	N	N	N
OHP	61323	F	AD	N	N	N	N
OHP	61322	F	2	N	N	N	N
	n = 6						

Table 3-1. (Cont.)

Wolf				Heart			Lungs,
pack	number	sex	age	gross	valves	pericardium	t & b*
13.	Gulkana, Copper						
EWA	61325	M	PUP	N	N	N	N
HOG	61431	M	PUP	N	N	N	N
TOK	61433	M	PUP	N	N	N	N
TOK	61328	F	3	-	-	-	-
RUN	61432	M	5	N	N	N	N
CAS	61399	M	PUP	N	N	N	N
	n = 6						
14.	Yakutat and Toolik						
Y3	61345	M	AD	N	N	N	N
Y1	61343	M	3	N	N	N	N
Y2	61344	F	PUP	N	N	N	N
50	61380	F	4	N	N	N	N
	n = 4						
	Total Examined:			101	94	94	93

The heart itself was examined macroscopically both externally and internally for 101 wolves (45 adult males, 28 adult females, and 28 pups) as detailed in Table 3-1. For 94 of these individuals (43 adult males, 26 adult females, and 25 pups) careful note was taken of the atrioventricular, pulmonary and aortic valves and associated proximal vessels as well. Only two individuals displayed unusual cardiac features. One, four-year-old male #61406 (heart weight near normal), had two tiny ridges of hard, cartilaginous material each measuring 1 x 1 x 5 mm. These were located 10 mm into the proximal ascending aorta, with their long axes perpendicular to that of the vessel, just at the distal borders of the right and left (but not the dorsal) semilunar cusps when the latter were fully opened. The ridge of tissue on the left side was immediately above the ostium of the left coronary artery. No other cardiac or proximal vascular abnormalities were noted in this individual. The second wolf, four-year-old male #61410 (trapped; heart weight below normal) had an unusually thin area approximately 10 mm^2 in the wall of the left ventricle near the apex. When viewed from the lumenal aspect this small area was markedly depressed below the average level of the surrounding muscular wall, measuring a scant 4 mm thick, while the thickness elsewhere at the ventricular apex was between 10 and 15 mm. There was some macroscopic indication of fibrous scarring in the muscle beneath the contracted area. No other unusual features were noted in the heart. This section of ventricular wall and the aortic ridges described above await histopathological examination.

Because of the left ventricular wall feature noted in wolf #61410, wall thicknesses in the left apical area were measured for comparison in eight other individuals (as presented in Table 3-2). A moderate amount of variation was found, but the average thickness was about 19 mm (range 10 to 30 mm). All of the measurements but one (#61409) were made at least 24 hours post mortem, beyond rigor. Number 61409 was necropsied four hours post mortem, but rigor had apparently also passed by that time in this individual.

B. Vascular system

Aside from the ascending aorta and proximal pulmonary artery, little of the blood vascular system was examined. The descending/thoracic aorta was opened and the intima macroscopically examined to the level of the diaphragm in approximately 20 wolves. No intimal fibrous plaques, nodular thickenings, or other unusual features were noted, nor were fat deposits apparent.

C. Respiratory system

Although in many cases the lungs were damaged during collection, there seemed to be few pathological signs in the material suitable for study. The lungs of 93 wolves (Unit 20A, 75; Unit 13, 14; Units 5 and 26, 4) were examined. These included organs from 43 adult males, 26 adult females, and 24 pups. The trachea was opened and examined internally from the thoracic inlet to its bifurcation and beyond, through the primary and secondary bronchi. No abnormalities or parasites were noted.

Table 3-2. Left ventricular wall thickness in nine wolves.

Area	Wolf				LV wall
	Pack	No.	Sex	Age	thickness (mm)
Unit 20A					
Fairbanks	C	61358	M	4	20
	EI	61409	F	4	17
Flats-Buttes	L	61353	M	5	30
	RL	61408	F	pup	15
Foothills-Central	GK	61410	M	4	10-15 (& thin area)
Unit 13					
Oshetna	OHP	61322	F	2	20-23
Gulkana-Copper	HOG	61431	M	pup	17
	TOK	61433	M	pup	15-16
	RUN	61432	M	5	15-17

Total individuals examined:	4 male adults	average left
	2 female adults	ventricular
	3 pups	wall thickness = 19 mm

The parenchyma of both lungs was then palpated and macroscopically examined (lungs were not weighed because of variable hermorrhagic content). Only 2 of the 93 wolves had pathological pulmonary features. The first, male adult #61339, had an adhesion between the anterolateral diaphragmatic lobe of the right lung and the adjacent parietal pleura. The contact surface of the adhesion with the parietal pleura measured approximately 4 by 7 cm. Directly external to this adhesion was a healing fracture of the eighth rib approximately 5 cm ventral to the spine. The involved lung parenchyma was compressed and atelectic, but not necrotic. The adhesion was probably incidental to the rib fracture and perhaps may have been able to heal uneventfully with parenchymal reinflation and negligible permanent damage (Jubb and Kennedy 1970).

The second pathological pulmonary feature was noted in male adult #61377 and appeared to be slightly more serious. On the lateral subpleura of the right cardiac lobe were three large, round emphysematous-type bullae in close proximity to one another. When fully inflated the entire three-part structure measured approximately 7 cm in diameter. Internal diameter of the three bullae ranged from 15 to 35 mm and they had smooth, moist lumenal surfaces of tough, translucent connective tissue (compressed alveolar tissue?). No adhesions or other pleural abnormalities were noted, no necrotic tissue was evident, and the remainder of the right lung, left lung, trachea, bronchi and associated bronchioles were not remarkable. A possible cause of this lesion was a well-healed fracture of a rib (the eighth) adjacent to the site, 20 cm ventral to the spine. Perhaps the bullae represented a site of former adhesion between the visceral pleura and fracture-damaged parietal pleura. At the time of collection the bullae appeared to be well established. Although Jubb and Kennedy (1970) related subpleural bullae to various pathological processes, they stated that such bullae are not significant clinically and are occasional incidental findings at necropsy. Of some interest was the fair-to-poor condition, however, of the individual in this case, in sharp contrast to the good-to-excellent condition of the other 10 wolves collected in the same area (5 in the same pack as the above individual). This lesion and the adhesion described above await histopathological examination.

Discussion: Cardiovascular system

Minor anomalies were noted in 2 of 94 hearts examined but appeared to be of little consequence. Similar incidental findings were evident in 2 of 93 lung pairs; in both cases the minor respiratory lesions may have been related to healed costal fractures. Evidence of cardiovascular or respiratory disease processes was not encountered. Mech (1970) listed several references to such diseases, but these were apparently encountered only in aged captive wolves.

Report 4. Pathology of the hepatobiliary system and the spleen

A. Liver

Liver weights were available for 73 wolves. These are presented in Tables 1-3 and 1-5, and have been discussed previously (Report 1). However, since liver weight is frequently presented and evaluated for canids as percentage of total body weight, appropriate percentages for the 59 wolves in the present study for which both body and liver weights were available are presented in Table 4-1 and summarized in Table 4-2.

When these liver weight percentages for different sex and age classes are compared (Table 2-4A), the consistencies observed are similar to those seen (Report 1, part B) for liver weight as an absolute value. Thus, a sexual disparity in liver weights expressed as percentages of whole body weights is evident among pups, for which the average is 2.12 percent (n = 4, range 1.77-2.34%) for male pups and 1.60 percent (n = 4, range 1.48-1.71%) for female pups. The same disparity was apparent in the younger adult age classes, in which the average male percentage still exceeded that of the female. However, an increase in the older adult age class compared to the younger adult class was evident only for the liver weight percentages of females. For both sexes and all age classes combined, the liver averaged 2.07 percent (n = 59, range 1.48-3.52%) of wolf body weight.

Liver weight as a percentage of body weight was less than 1.60 percent in nine wolves, including three male adults #61370 (1.54%), #61384 (1.55%) and #61324 (1.53%), three female adults #61382 (1.57%), #61375 (1.51%) and #61372 (1.48%), and three pups #61371 (1.51%), #61373 (1.56%) and #61383 (1.48%). The nutritional condition of these individuals was fair for seven wolves and good for two. Liver weight as a percentage of body weight was more than 2.50 percent in eight wolves, including five male adults #61357 (3.52%), #61359 (3.02%), #61391 (2.62%), #61404 (2.80%) and #61345 (2.77%) and three female adults #61366 (2.94%), #61387 (2.88%), and #61346 (3.19%). The nutritional condition of these individuals was good for four wolves, fair for one, and poor for three. These figures therefore fail to indicate a correlation between liver weight and nutritional condition. Nor was a correlation apparent when liver weight percentages of groups of wolves from different geographic areas with contrasting nutritional conditions (refer to Table 1-2) were evaluated (Table 2-4B).

Besides variations in liver weight, more direct pathological indications were investigated by macroscopic examination of both aspects of the organ at necropsy, including internal observation of the parenchyma (by slicing) of both major lobes for 94 wolves in the present collection. These included 75 animals from Unit 20A, 15 from Unit 13, and 4 from Units 5 and 26 (Table 4-1). An additional eight animals, all from Unit 13, were examined superficially. Unfortunately the general condition of most of the livers at necropsy ranged from mildly to severely autolytic. This was due to the prolonged maintenance of high body temperature for hours after death because of the insulating property of the hides

Table 4-1. Liver weights of individual wolves, expressed as percentages of whole body weight, and results of necropsy examination of the hepatobiliary system and spleen. N = normal (no macroscopic changes apparent). Wolves are listed by geographic area.

Wolf				Weight (kg)			Apparent pathology of		
Pack	Number	Sex	Age (yrs)	Whole body	Liver	Liver % of whole	liver,	gall bladder,	spleen
1. Flats - East									
A	61348	M	4	40.8	0.82	2.00	N	N	N
B	61389	M	3	43.5	0.98	2.24	N	N	N
A	61350	F	2	38.6	0.72	1.85	streaks	N	N
B	61387	F	2	44.0	1.27	2.88	N	N	N
n = 4									
2. Fairbanks									
C	61357	M	6	40.8	1.44	3.52	N	N	N
C	61358	M	4	51.2	1.10	2.14	N	N	N
C	61365	M	3	49.9	1.13	2.25	N	N	N
C	61376	M	4	52.2	1.17	2.23	N	nodules	N
20B	61401	M	5	n/a	0.81	-	N	N	N
RC	61402	F	3	n/a	0.91	-	N	N	N
RC	61403	F	5	n/a	0.91	-	N	N	N
EI	61409	F	adult	n/a	0.79	-	N	N	N
RC	61400	F	pup	n/a	0.53	-	N	N	pale; black
n = 9									
3. Flats - Buttes									
L	61353	M	5	53.1	0.98	1.85	fibrous patch	nodules	N
D	61355	M	4	39.5	0.74	1.87	pale area	N	N
D	61364	M	4	38.6	0.73	1.88	N	N	N
D	61391	M	4	47.2	1.24	2.62	N	N	N
D	61354	M	5	34.9	0.72	2.06	N	-	N
RL	61396	M	pup	n/a	0.60	-	N	N	pale areas
RL	61398	M	pup	n/a	0.57	-	N	N	pale areas
D	61366	F	5	38.5	1.14	2.94	fibrous scar	N	N
RL	61397	F	5	n/a	0.69	-	N	N	pale areas
RL	61407	F	3	n/a	0.81	-	N	N	N
RL	61408	F	pup	n/a	0.50	-	N	N	N
n = 11									
4. Flats - Westcentral									
E	61352	M	3	49.9	1.06	2.11	N	N	N
E	61356	M	4	47.6	0.87	1.83	N	N	N
F	61359	M	4	51.2	1.55	3.02	N	N	N
F	61360	M	2	47.2	1.04	2.19	N	N	N
F	61361	M	2	49.4	1.01	2.03	N	N	N
F	61377	M	4	40.8	0.88	2.15	N	N	N

Table 4-1. (Cont.)

Wolf				Weight (kg)			Apparent pathology of		
Pack	Number	Sex	Age (yrs)	whole body	Liver	Liver % of whole	liver,	gall bladder,	spleen
G	61381	M	3	35.8	0.74	2.06	N	N	scar
F	61362	M	pup	40.8	0.88	2.14	N	N	N
G	61382	F	3	34.9	0.55	1.57	N	N	N
G	61383	F	pup	34.5	0.51	1.48	N	N	N
F	61363	F	2	40.8	0.78	1.91	N	N	N
	n = 11								
6. Foothills - East									
V	61367	M	4	39.0	0.89	2.28	N	N	N
V	61368	M	3	43.1	0.83	1.92	N	N	N
V	61404	M	3	42.6	1.20	2.80	N	N	N
V	61406	M	4	38.1	0.80	2.08	N	N	N
V	61369	F	2	36.3	0.83	2.29	N	N	N
V	61388	F	7	39.0	0.73	1.86	N	N	N
V	61390	F	5	43.9	0.81	1.84	N	N	hilar black
V	61405	F	3	41.3	0.74	1.79	bile stasis	N	N
	n = 8								
6. Foothills - Little Delta									
T	61370	M	5	45.4	0.70	1.54	N	N	N
T	61374	M	4	36.3	0.64	1.76	pale areas	N	N
U	61378	M	3	39.0	0.77	1.97	N	N	N
U	61379	M	6	45.4	0.82	1.81	N	N	N
U	61351	M	pup	29.5	0.69	2.34	pale areas	N	N
T	61375	F	6	43.1	0.65	1.51	N	N	N
T	61372	F	3	34.0	0.51	1.48	N	N	N
T	61371	F	pup	29.5	0.45	1.51	pale areas	N	N
T	61373	F	pup	30.4	0.48	1.56	pale areas	N	N
U	61349	F	pup	24.5	0.42	1.71	N	N	N
	n = 10								
7. Foothills - Central									
W	61332	M	3	46.7	n/a	-	white foci	N	N
W	61333	M	2	49.9	n/a	-	calc. foci	-	N
GK	61410	M	4	n/a	1.22	-	N	N	N
X	61336	M	2	40.8	n/a	-	N	N	N
X	61337	M	3	49.4	n/a	-	N	N	N
X	61339	M	3	45.3	n/a	-	white foci	N	N
X	61340	M	2	47.6	n/a	-	white foci	N	N
X	61338	M	pup	39.0	n/a	-	N	N	N
X	61342	M	pup	36.3	n/a	-	N	N	N
W	61331	M	pup	45.4	n/a	-	N	-	N
W	61334	M	pup	44.9	n/a	-	white foci	-	pale areas
X	61341	F	2	38.1	n/a	-	N	N	N

Table 4-1. (Cont.)

Wolf				Weight (kg)			Apparent pathology of		
Pack	Number	Sex	Age (yrs)	whole body	Liver	Liver % of whole	liver,	gall bladder,	spleen
W	61346	F	2	39.5	1.26	3.19	white foci	N	N
W	61347	F	4	37.6	n/a	-	N	N	N
X	61335	F	pup	31.8	n/a	-	white foci	N	N
	n = 15								
8. Foothills - West									
Z	61384	M	5	49.9	0.78	1.55	N	-	N
Y	61395	M	4	52.2	0.98	1.87	N	N	N
Z	61385	M	pup	38.1	0.68	1.77	N	N	N
Y	61392	M	pup	41.7	0.93	2.21	N	N	N
Y	61386	F	3	43.1	0.86	1.98	N	-	N
Y	61393	F	5	44.0	0.88	2.00	N	N	N
Y	61394	F	3	43.5	0.79	1.81	N	N	N
	n = 7								
9. Delta and Maclaren									
DLP	61326	M	pup	24.0	n/a	-	-	-	-
DLP	61327	F	pup	n/a	n/a	-	-	-	-
MLP	61302	M	pup	43.1	n/a	-	N	-	N
MLP	61303	M	pup	43.1	n/a	-	N	-	N
	n = 4								
10. Brushkana-Butte									
BBK	61304	M	4	46.3	n/a	-	N	-	N
BBK	61305	M	3	45.4	n/a	-	N	-	-
BBK	61311	M	2	48.1	n/a	-	-	-	-
BBK	61309	M	pup	35.8	n/a	-	N	-	-
BBK	61313	M	pup	32.6	n/a	-	N	-	-
BBK	61307	F	4	45.5	n/a	-	N	-	-
BBK	61314	F	5	45.4	n/a	-	-	-	-
BBK	61306	F	pup	32.2	n/a	-	N	-	-
BBK	61308	F	pup	35.4	n/a	-	-	-	-
BBK	61310	F	pup	28.1	n/a	-	N	-	-
BBK	61312	F	2	48.2	n/a	-	N	-	-
BBK	61315	F	pup	34.5	n/a	-	-	-	-
	n = 12								
11. Deadman									
DDP	61317	M	3	45.4	0.97	2.13	N	N	N
DDP	61300	M	pup	40.8	n/a	-	N	-	pale areas
DDP	61301	M	pup	43.1	n/a	-	-	-	-
DDP	61318	F	4	43.1	0.78	1.80	N	N	N
DDP	61316	F	pup	35.4	n/a	-	N	N	-
	n = 5								

Table 4-1. (Cont.)

Wolf				Weight (kg)			Apparent pathology of		
Pack	Number	Sex	Age (yrs)	whole body	Liver	Liver % of whole	liver,	gall bladder,	spleen
12.	Oshetna								
OHP	61319	M	adult	n/a	n/a	-	-	-	-
OHP	61320	M	adult	n/a	n/a	-	-	-	-
OHP	61321	M	3	n/a	0.85	-	N	N	N
OHP	61324	M	3	46.3	0.71	1.53	N	N	N
OHP	61323	F	adult	35.4	0.85	2.39	N	N	N
OHP	61322	F	2	35.4	0.59	1.65	N	N	N
	n = 6								
13.	Gulkana, Copper								
EWA	61325	M	pup	n/a	0.84	-	N	N	N
HOG	61431	M	pup	n/a	0.91	-	N	N	N
TOK	61433	M	pup	n/a	0.96	-	N	N	pale areas
TOK	61328	F	2	31.7	n/a	-	-	-	-
RUN	61432	M	5	n/a	1.06	-	N	N	N
CAS	61399	M	pup	n/a	0.68	-	N	N	N
	n = 6								
14.	Yakutat and Toolik								
Y3	61345	M	adult	31.7	0.88	2.77	N	N	N
Y1	61343	M	3	39.5	0.90	2.28	N	N	N
Y2	61344	F	pup	n/a	n/a	-	N	N	N
TOO	61380	F	4	33.1	0.80	2.41	N	N	N
	n = 4								
	Total			91	76	59			

Table 4-2. Comparison of liver weights (expressed as a percentage of whole body weight*) for wolves of different sex and age categories and for different geographic areas.

A. Distribution of average liver weight percentages $(\bar{x})$ by wolf sex and age, with n = number of wolves examined in category.

	Males			Females			Both sexes		
Age class	n	$\bar{x}$	range	n	$\bar{x}$	range	n	$\bar{x}$	range
pups	4	2.12	1.77-2.34	4	1.60	1.48-1.71	8	1.84	1.48-2.34
adults									
2-3 years	12	2.13	1.53-2.80	10	1.95	1.48-2.29	22	2.05	1.48-2.80
4-7 years	19	2.11	1.54-3.52	8	2.16	1.51-2.94	27	2.12	1.51-3.52
other (age?)	1	2.77	2.77	1	2.39	2.39	2	2.58	2.39-2.77
Total adults	32	2.14	1.53-3.52	19	2.06	1.48-2.94	51	2.11	1.48-3.52
both pups and adults, total	36	2.13	1.53-3.52	23	1.97	1.48-2.94	59	2.07	1.48-3.52

B. Distribution of average liver weight percentages $(\bar{x})$ among wolves from different geographic areas, with n = number of wolves examined from that area.

Geographic area	n	$\bar{x}$	range
Unit 20A			
Flats-East	4	2.24	1.85-2.24
Fairbanks	4	2.54	2.14-3.52
Flats-Buttes	6	2.20	1.85-2.94
Flats-Westcentral	11	2.05	1.83-3.02
Foothills-East	8	2.11	1.79-2.80
Foothills-Little Delta	10	1.72	1.48-2.34
Foothills-Central	1	3.19	3.18
Foothills-West	7	1.88	1.55-2.21
Unit 13			
Delta-Maclaren	-	-	-
Brushkana-Butte	-	-	-
Deadman	2	1.97	1.80-2.13
Oshetna	3	1.86	1.53-2.39
Gulkana, Copper	-	-	-
Units 5, 26			
Yakutat, Toolik	3	2.49	2.28-2.77
Age Class Total	59	2.07	1.48-3.52

* Both liver and whole body weights expressed in grams for the percentage determination, see Table 4-1.

in combination with the logistic problems associated with collection and transport. Changes observed and ascribed to post mortem processes included gas bubbles beneath the capsule and within the parenchyma, superficial pigmentation changes and mottling, and recumbency stasis and pooling. In several cases in which it was difficult to differentiate possible infarcts or fatty areas from autolytic pigmentation changes (Jubb and Kennedy 1970) the tissue was considered pathological and as such is discussed below.

Apparent pathological changes were observed in 16 (15.7%) of the 102 livers examined. These findings are presented for individual wolves in Table 4-1 and are summarized in Table 4-3. All 16 of the changes observed occurred in Unit 20A animals, 9 in males and 7 in females. Table 4-3 gives the pathological changes observed as percentages of the total livers examined for different age and area categories. Particular kinds of changes tended to occur in wolves from certain areas. Six kinds of "apparent pathological changes" were macroscopically recognized at necropsy and are indicated in Table 4-3 by the numerals I through VI. One of the most common changes, accounting for 6 of the 16 observed, were focal white areas 1-3 mm in diameter (I). Two of the individuals involved were pups and the remaining four were males age 2 and 3 years. In five cases several foci (less than 5) were observed on the liver surface, all on the diaphragmatic aspect. In one of these individuals (two-year-old male #61333), the foci were hard, gritty, and apparently calcified. The sixth, three-year-old male #61339, had more abundant (noncalcified) foci on the surfaces of both the diaphragmatic and visceral aspects of the major lobes, and some of the larger (3 mm) foci extended approximately 5 mm into the parenchyma. All six of the wolves exhibiting this kind of hepatic change were from the foothills-central area, with three in pack W and three in pack X.

The second condition, also accounting for 6 of the 16 observed hepatic pathological changes, was presence of large pale areas apparent on the surface of both aspects and in the parenchyma (Table 4-3, III). These areas consisted of parenchyma of normal texture which was sharply delimited from surrounding areas by its pale, grey-pink color resembling recent infarcts; they did not have the yellowish, greasy macroscopic appearance associated with fatty infiltration. As discussed above, these areas could possibly represent ante mortem hemorrhagic or post mortem changes, but their relative rarity among the large number of livers from wolves collected under similar circumstances casts doubt upon this possibility. Histopathological examination should clarify the question.

The liver of four-year-old male #61355 exhibited a single such pale area measuring 3 x 5 mm just below the surface of the diaphragmatic aspect of the left lobe. This may in fact be an "intermediate lesion" between the superficial foci described previously and the larger pale areas seen below. Two-year-old female #61346 had two pale areas measuring 10 x 10 mm just under the surface (aspect and lobe not noted), with one extending 5 mm into the parenchyma. The remaining four wolves, three pups (#61351, 61371 and 61373) and one male age 4 years (#61374), exhibited an abundance of irregular pale areas measuring up to 15 mm in diameter throughout the parenchyma of all lobes. In one case (#61351)

Table 4-3. Number of wolf livers examined, and number and percentage of those exhibiting pathological changes. Kinds of apparent pathological changes observed are indicated.* Wolves are listed by geographic area.

Geographic area	Adults						Pups			Total		
	Males			Females								
	No. Exam.	No. Path.	Path. Changes*	No. Exam.	No. Path.	Path. Changes	No. Exam.	No. Path.	Path. Changes	No. Exam.	No. Path.	% Path.
Unit 20A												
Flats-East	2	–	–	2	1	IV	–	–	–	4	1	25.0
Fairbanks	5	–	–	3	–	–	1	–	–	9	–	–
Flats-Buttes	5	3	II,III	3	1	II	3	–	–	11	3	27.3
Flats-Westcentral	7	–	–	2	–	–	2	–	–	11	–	–
Foothills-East	4	–	–	4	1	V	–	–	–	8	1	12.5
Foothills-L. Delta	4	1	III	2	–	–	4	3	III	10	4	40.0
Foothills-Central	7	4	I	3	1	III	5	2	I	15	7	46.7
Foothills-West	2	–	–	3	–	–	2	–	–	7	–	
Unit 13												
Delta-Maclaren	1	–	–	–	–	–	1	–	–	2	–	–
Brushkana-Butte	2	–	–	2	–	–	4	–	–	8	–	–
Deadman	1	–	–	1	–	–	2	–	–	4	–	–
Oshetna	2	–	–	2	–	–	–	–	–	4	–	–
ana, Copper	1	–	–	–	–	–	4	–	–	5	–	–
Units 5, 26												
Yakutat, Toolik	2	–	–	1	–	–	1	–		4	–	
Area subtotals	45	8	17.8	28	4	14.3	29	5	17.2	102	16	15.7

*Pathological changes observed (See text Report 4 for details):

I. White or calcified surface foci
II. Fibrous scars on surface
III. Pale areas of parencityma
IV. Yellow foci and streaks on surface
V. Apparent bile stasis throughout parenchyma

the pale areas were more abundantly distributed toward the periphery of the liver. In several cases more typical post mortem mottling changes were also noted, and the pale areas appeared to represent a different phenomenon.

An additional two (of the 16 observed) apparent pathological changes in the liver were also white but appeared macroscopically to consist of fibrous connective tissue which may have been scars (Table 4-3, II). In one case (five-year-old male #61353) a diffuse patch of fibrous tissue 20 by 8 mm was observed just beneath the capsule 30 mm from the margin of the left lobe on the diaphragmatic aspect. In the other case (five-year-old female #61366) the form was more definite: a thin branching scar approximately 25 mm long and 2 mm wide was confined to the surface of the left lobe on the visceral aspect.

Two other apparent pathological changes were noted. Two-year-old female #61350 had a small number of yellow foci and streaks (2 by 5 mm) on the visceral surface of both the quadrate and caudate lobes near the porta (Table 4-3, IV). Three-year-old female #61405 had numerous small, round, yellow areas throughout the parenchyma, reminiscent of biliary stasis (Table 4-3, V). Numerous autolytic gas bubbles were also observed in the liver of this latter individual, and since she remained intact (with hide) a number of hours before necropsy it is possible the changes observed were entirely post mortem.

All of the above 16 cases of apparent pathological changes in the liver remain to be examined histologically and compared with other liver specimens thought to represent autolytic change. There is some possibility that focal and/or fibrous areas are remnants of parasitic larval migrans.

B. Gallbladder

The gallbladders of 85 wolves (69 from Unit 20A, 12 from Unit 13 and 4 from Units 5 and 26) were examined at necropsy (Table 4-4). The organ was incised, and its wall thickness and mucosal lining were noted macroscopically. Careful examination of the bile contents for trematodes and other helminths was not done, although no larger helminths were noted upon casual observation. Rausch and Williamson (1959) failed to find bile duct trematodes in their study of Interior Alaskan wolves, and Babero and Rausch (1952) found only one of 520 Alaskan canids examined, an Eskimo dog, to be infected with bile duct helminths (in that case, the trematode *Metorchis albidus*).

Table 4-4 summarizes the area and age class distribution of the 51 male and 34 female wolves whose gall bladders were examined. Only two individuals, male adults #61353 (age 5 years) and #61376 (age 4 years) displayed apparent pathological changes, both involving the gallbladder mucosa. The gallbladder mucosa of wolf #61353 had approximately six small (2mm diameter) nodules protruding from the mucosa into the lumen. All of the nodules were located in the fundus. Wolf #61376 had similar but more abundant mucosal nodules in an approximately 10 mm^2 area of the

Table 4-4. Number of wolves (n) of different age and sex categories, listed by geographic aea, for which gallbladders were examined. The two gallbladders showing possible pathological changes are indicated.*

Geographic area	Adults Male n	Adults Female n	Pups n	Total
Unit 20A				
Flats-East	2	2	-	4
Fairbanks	5*	3	1	9
Flats-Buttes	5*	3	3	11
Flats-Westcentral	7	2	2	11
Foothills-East	3	3	-	8
Foothills-L. Delta	4	2	4	10
Foothills-Central	5	-	3	11
Foothills-West	1	2	2	5
Unit 13				
Delta-Maclaren	-	-	-	-
Brushkana-Butte	-	-	-	-
Deadman	1	1	1	3
Oshetna	2	2	-	4
Gulkana, Copper	1	-	4	5
Units 5 and 26				
Yakutat, Toolik	2	1	1	4
Age/sex class subtotals	39	25	21	85 wolves

*One in each area showing possible pathological changes.

gallbladder fundus; these were red against a bile-stained background of bright yellow mucosa and might have resulted from autolytic change. In neither case were the nodules associated with macroscopically apparent inflammatory responses, nor were calculi present in these or in any of the other gallbladders examined. Histopathological examination should clarify the possibility of autolytic causation of the nodules. It is of interest that one of the individuals displaying nodules in the gallbladder (#61353) had the large diffuse patch of fibrous tissue on the liver surface, as discussed above. The liver of the second individual (#61376) was normal.

C. Spleen

The spleen was macroscopically examined on both its parietal and visceral aspects, and the parenchyma was observed by several longitudinal slices nearly through the organ. Spleens from 94 wolves were examined, including 75 from Unit 20A, 15 from Unit 13, 3 from Unit 5 and 1 from Unit 26 (Table 4-1). Sixty of the wolves were males and 34 were females; Table 4-5 lists the animals examined by age class and area.

Possible pathological changes were encountered in 9 (9.6%) of the 94 spleens examined. Seven of these nine spleens exhibited irregular areas of pale parenchyma. In three cases the areas were small and poorly defined: male pup #61396 had approximately 10 such areas 2 to 5 mm in diameter on the viseral aspect only, extending no more than 3 mm into the parenchyma, and male pups #61334 and #61398 had similar-sized areas which occurred throughout the parenchyma. Male pup #61300 had somewhat larger areas 5 to 10 mm in diameter, also poorly defined and also occurring throughout the parenchyma. In the remaining three spleens, from five-year-old adult female #61397 and pups #61433 and #61400, the pale areas were ill-defined and abundant throughout the parenchyma. These pale areas resembled perimortem infarcts, as did the pale areas occasionally encountered in the liver (see above). However, none of the wolves with pale areas in the spleen had similar areas in the liver. The pale areas in the spleen may be related to ante mortem hemorrhage. Also of possible significance was the fact that six of the seven spleens affected had suffered autolytic change; all seven were from carcasses that had been frozen and thawed at least once before necropsy. Five of the seven wolves had been trapped, a factor which increased the opportunity for additional freezing-thawing cycles and consequent autolytic changes. However, 12 other wolves which had been trapped and the carcasses treated similarly, had apparently normal-appearing spleens. Histopathological examination of the preserved tissue should clarify possible causative relationships.

The second type of apparent pathological change, encountered in two of the examined spleens, consisted of specks of black, metallic-like material in the adventia and the immediately adjacent tissue of blood vessels along the hilus. The black areas were minute, or clustered irregularly into foci, and might possibly represent deposits of hemosiderin pigment (Jubb and Kennedy 1970). They were not found in the parenchyma

Table 4-5. Number of wolf spleens examined, and number and percentage of those exhibiting pathological changes. Kinds of apparent pathological changes observed are indicated.* Wolves are listed by geographic area.

Geographic area	Adults						Pups			Total		
	Males			Females								
	No. Exam.	No. Path.	Path. Changes*	No. Exam.	No. Path.	Path. Changes	No. Exam.	No. Path.	Path. Changes	No. Exam.	No. Path.	% Path.
Unit 20A												
Flats-East	2	-		2	-		-	-		4	-	-
Fairbanks	5	-		3	-		1	1	I,II	9	1	11.1
Flats-Buttes	5	-		3	1		3	2	I	11	3	27.3
Flats-Westcentral	7	1	III	2	-		2	-		11	1	9.1
Foothills-East	4	-		4	1	II	-	-		8	1	12.5
Foothills-L. Delta	4	-		2	-		4	-		10	-	-
Foothills-Central	7	-		3	-		5	1	I	15	1	6.7
Foothills-West	2	-		3	-		2	-		7	-	-
Unit 13												
Delta-Maclaren	-	-		-	-		2	-		2	-	-
Brushkana-Butte	1	-		-	-		-	-		1	-	-
Deadman	1	-		1	-		1	1	I	3	1	33.3
etna	2	-		2	-		-	-		4	-	-
kana, Copper	1	-		-	-		4	1	I	5	1	20.0
Units 5 & 26												
Yakutat, Toolik	2	-		1	-		1	-		4	-	-
Area subtotals	43	1	(2.3%)	26	2	(7.7%)	25	6	(24.0%)	94	9	9.6

*Pathological changes observed (see text Report 4 for details):
I. Irregular areas of pale parenchyma
II. Black material in vascular adventitia near hilus
III. Fibrous tissue (scar?) on surface

and were observed only in association with the major (macroscopic) vessels all along the hilus. When preserved in 10 percent buffered formalin the black specks appeared to change to a bright yellow-brown. Aside from these black specks, female pup #61400 (trapped) had no other splenic changes, but five-year-old female #61390 had areas of pale parenchyma in the spleen (described above) in addition to the black hilar material.

The third type of apparent pathological change was observed in a single spleen, that of three-year-old male #61381. A small area (3 by 5 mm) of white tissue, which appeared macroscopically to be fibrous, slightly puckered the capsule near the cranial edge (dorsal or ventral aspect not noted) of the organ. The area resembled a healed scar, perhaps of an old traumatic wound to the spleen. Histopathological examination of this specimen, as well as of those exhibiting pale areas and hilar black material, remains to be completed.

Discussion: Hepatobiliary system and spleen

Liver weight as a percentage of whole body weight averaged 2.11 percent for 51 adult wolves. This compares to 3.38 percent found by Miller et al (1964) for 91 adult mongrel dogs. They also found that mongrel pups had relatively heavier livers than the adult dogs. However, the livers of eight wolf pups in the present study averaged a smaller percentage of body weight (1.84%) than those of adult wolves (2.11%). Body morphology and other specific differences between wolves and domestic dogs may also be significant. An additional important factor, however, may be individual nutritional history. Malnutrition can cause a decrease in liver weight (Jubb and Kennedy 1970). Although seasonal malnutrition is a fact of life for wolves in a natural setting, it is unlikely that the dogs Miller et al (1964) observed were subjected to periodic nutritional deprivation.

Considerable variation was encountered between relative liver weight (expressed as a percentage of body weight) averages for different age and sex classes. An increase in relative liver weight with age was seen in females but not in males. Among pups and young adults, the relative liver weight was greater for males than for females. Reasons for this dichotomy are not obvious and have apparently not been investigated. However, the age-related change observed only in females may in fact be a reflection of the smaller body weight of young females found both in this study and elsewhere (Van Ballenberghe and Mech 1975). Whole body weight, important as the denominator of the liver percentage calculation, is influenced by nutritional effects during growth and development. Individuals which are poorly nourished in their early years might develop a smaller adult stature. When these individuals are better nourished as adults, their livers may show percentage increases relative to body weight that is not as apparent in larger-statured individuals. The evaluation and implications of body weights for these wolves is presented elsewhere (Stephenson, in prep.).

Although no clear relationship was apparent between nutritional status at the time of collection and the liver weight percentage variations observed, these two factors do not vary independently. Any decrease in liver weight which might be expected from poor nutritional condition can be masked by concurrent decreases in body weight due to loss of fat and, ultimately, of protein. Thus, a starving wolf collected in early 1977 (not a part of the present study) had a relative liver weight percentage of 1.59 percent, which is rather low but not dramatically so. Although this liver was small with acute margins indicating that the organ had shrunk considerably, and the individual's stature was very large; the extreme emaciation of the entire body had offset to some extent the weight loss of the liver.

No relationships were discovered between liver weight percentages averaged by area and the nutritional condition prevalent among wolves in each area. However, a somewhat surprising inverse relationship was encountered between average liver weight percentages of wolves from various areas and the estimated relative amount of caribou in their diets. Any investigation of this possible connection awaits the results of a separate study on the use of the caribou by wolves from different areas (Holleman and Stephenson, in prep.).

Of particular importance in the present discussion is the close relationship between liver weight and disease or pathological conditions. Significant temporary changes in the size and weight of the organ accompanied numerous important viral and bacteriological infections, including infectious canine hepatitis and leptospirosis (Jubb and Kennedy 1970, Smith et al. 1974, Bruner and Gillespie 1973). Unfortunately, hepatic enlargement (or shrinkage) is a very nonspecific "lesion" and the post-infection persistence of hyperplasia or edema is ill defined. It is therefore impossible to draw conclusions from variations in liver weight with regard to either disease or to any of the other factors mentioned above until the serum is evaluated for the presence and levels of a variety of antibodies (Jubb and Kennedy 1970). Mr. D. G. Ritter of the Alaska Department of Health and Social Services, and Dr. B. L. Deo of the National Animal Disease Laboratory are currently involved in such evaluations. Also of potential significance to understanding liver weight variations are a variety of biochemical tests on samples of liver tissue from 78 of the wolves in the present study. The tests are being conducted by Dr. U. S. Seal and his colleagues at the Veterans Administration Hospital, Minneapolis.

Possible pathological changes were encountered in 16 of the 94 wolf livers examined. These changes included white foci, large pale areas, possible connective tissue scars, yellow streaks, and apparent bile stasis. Some of the changes may be merely autolytic, and others may relate to parasitic larval migrans. Since the gastrointestinal tracts were not opened and examined for parasites, this latter possibility cannot be substantiated for the immediate past; however, previous studies of gastrointestinal helminths of wolves from Interior Alaska have indicated the ubiquitous nature of certain infestations (Rausch and Williamson 1959). These changes might also be associated with bacterial or viral infections of a chronic or an acute nature. Serum analysis is required to demonstrate the occurrence of such infections. This is of particular interest because area differences encountered for several of the pathological changes noted (Table 4-3) might be related to differences in the distribution of certain infections.

Incidental abnormalities were encountered in 2 of 85 gallbladders and 9 of 94 spleens. Included were nodules on the gallbladder mucosa and pale areas, black foci and a connective tissue scar in the spleen.

Many of the changes observed in the liver, gallbladder and spleen were discussed above as being "apparently pathological" when they may in fact only represent perimortem or autolytic changes. They may also, however, be relatively normal changes related to aging, periodic malnutrition, or other biological processes in this particular species. Because little comparative pathological material has been presented for this species in the literature, it is difficult to evaluate the significance (if any) of these changes in terms of the individual's health and clinical history, particularly since data from other studies of these wolves are lacking.

Report 5. Pathology of the endocrine system: adrenal and thyroid

A. Adrenal

Both of the paired adrenals were available for 74 animals and one only for 18. Table 1-12 lists the distribution of adrenal weights observed by geographic area (73 wolves from Unit 20A, 15 wolves from Unit 13, 3 wolves from Unit 5, and one wolf from Unit 26) and Table 1-11 compares the averaged adrenal weights by wolf sex and age class. As discussed in Report 7 (part C), adrenal weight varied within only a limited range.

Three male adults, three-year-old #61317, and four-year-olds #61359 and 61391, displayed large differences between the weights of the right and left adrenal glands. These differences were (2.8 minus 1.3 =) 1.5 g, (3.3 minus 2.0 =) 1.3 g, and (3.3 minus 2.0 =) 1.3 g, respectively. These equaled variations of 107 percent and 76 percent from the average adrenal weights for male adults of the same age classes (i.e. males age 2-3 years : 1.4 g, males age 4-7 years : 1.7 g). The larger member of all three unusual pairs exceeded the adrenal weight ranges observed for other wolves of that age class, but the smaller member fell within the normal range in all three cases (cf. Table 7-11). No abnormal features were noted in these three adrenal pairs other than the differential hyperplasia. Hormonal disorders in domestic canines are not known to differentially influence one adrenal over the other (Bloom 1968a). Since the three affected individuals were in fair, good and poor nutritional condition, respectively, the nutritional factor had no apparent relationship to the phenomenon.

All adrenals examined were in their usual position anterior to and slightly medial of the associated kidney. All were shaped like a stout "L" or boomerang, and all were embedded in varying amounts (often abundant) of perirenal fat. Possible pathologic change was noted in the adrenals of only one individual: adult male #61357 had faint petechiae on the external surfaces of both adrenals. Although this change is sometimes seen in association with traumatic death (Jubb and Kennedy 1970) such as had occurred in this individual, it was not noted in any of the 91 other wolves examined which had met similar fates. Infectious canine hepatitis and certain other infections are also associated with focal hemorrhages (Bloom 1968a); however, most pathological changes described for the adrenal gland can be recognized and interpreted only macroscopically. Histopathological and biochemical analyses of the adrenals collected in this study remain to be done.

B. Thyroid

Thyroids of 74 wolves, including both of the paired organs for 67 animals and one only for 7, were examined macroscopically. Table 1-10 lists the various thyroid weights observed by area (Unit 20A, 63 wolves; Unit 13, 7; Unit 5, 3; Unit 26, 1), and Table 1-11 summarizes average thyroid weights by age and sex classes. As discussed in Report 1 (part C), a relatively broad range of (average) thyroid weights, correlated with various sex and age classes, was observed. The right and left lobes of the thyroid were entirely separate (no isthmus present) in all individuals examined and are therefore discussed here as "paired organs." Unusually large differences between the right vs. the left thyroid lobes were noted in only two individuals. Both were males, one a pup, #61398, and one age 4 years, #61348. The differences were (2.1 minus 1.4 =) 0.7 g and (2.1 minus 1.2 =) 0.9 g, respectively. Variations as great as 50 percent are occasionally encountered between the thyroid pair weights of domestic dogs and are not considered significant (Smithcors 1964).

Each thyroid lobe is an elongated, slightly flattened ellipsoid, often tapered toward its anterior pole. In some individuals one or both lobes were more difficult to examine macroscopically because of exterior staining by cervical perimortem hemorrhaging and pooling. The parathyroid was present as a single, flattened, 4 mm ovoid body subcapsullarly located at the medioventral center of each thyroid lobe. Parathyroids were particularly clear in some individuals (ex. #61357, #61368, #61373) but were difficult to distinguish in others.

Only two individuals displayed possible macroscopic pathological changes of the thyroid. In male adult #69348 the right lobe weighed 2.1 g (the left, 1.4 g) and had a somewhat unusual appearance. A central stricture, evident internally as a shallow infolding of the capsule and associated connective tissue, partially divided the anterior and posterior halves. The posterior portion had parenchyma of normal color and texture, but in the anterior portion a number of small, diffuse pale areas with a softer, less dense texture than the surrounding normal-appearing parenchyma were evident. These unusual areas were macroscopically reminiscent of adrenal medullary tissue and perhaps contained lipid material. Since the wolf in question was approximately four years old, it seems unlikely that the phenomenon represented a senile change. The abnormal tissue may be an adenoma (Jubb and Kennedy 1970). More precise definition and determination of possible causation await histopathological examination.

The second individual displaying possible pathological change in the thyroid was the above male's associate, adult female #61350. The weight of this individual's right thyroid was not available, but the left weighed 1.5 g. On the center of the lateral edge of the left thyroid a dark bulge was evident beneath the capsule. Oval, measuring approximately 3 by 6 mm, it was entirely surrounded by connective tissue and may simply represent a subcapsular hemorrhage. The remainder of the lobe was macroscopically normal. Histopathological examination remains to be done on this thyroid as well as on the others described above.

Discussion: Adrenal and thyroid

Several unusual features were noted among the adrenals and thyroids examined. Substantial weight differences between the right and the left thyroid lobes were observed in 2 of 67 cases. Similar differences are not unusual among domestic dogs (Smithcors, 1964). However, substantial weight differences between the right and the left adrenal glands are more unusual and were observed in 3 of 74 individuals. Histopathological examination of these three and of the single pair of adrenals showing surface petechiation would allow better interpretation of these unusual findings. This is of particular interest because infectious canine hepatitis has been associated with focal adrenal hemorrhages (Bloom 1968a) and the adrenals of domestic carnivores can display inflammation during histoplasmosis and toxoplasmosis infections (Jubb and Kennedy 1970).

The thyroids of 2 of the 74 wolves examined were found to exhibit unusual features. In one case a possible adenoma was found, while the other had an apparent subcapsular hemorrhage. Thyroid carcinomas and hyperplasia have been reported previously in captive wolves (Lucas 1923, Fox 1923 and 1926), so histopathological examination of these specimens will be of particular interest. Microscopic changes may also be found in other thyroid specimens and may be related to acute or chronic diseases or to deficiency states. Serum antibody analyses should be related to the investigation as well. Possible iodine deficiency and calcium superabundance have been mentioned in Report 1, part C and discussed above. Intrafollicular hemorrhages are often associated with canine leptospirosis, particularly in young animals (Jubb and Kennedy 1970). The degree of hyperplasia or hypoplasia and various other features of the major endocrine organs provide a number of important clues to the physiological state and clinical history of the individual.

Report 6. Pathology of the urinary system: the kidney and bladder

A. Kidney

Kidneys were examined from 106 of the 112 wolves collected. Both of the paired organs were examined for 102 individuals and one only for four individuals (#61301, #61308, #61347 and #61432). For the remaining six wolves, all from Unit 13, damage to both kidneys (#61302, #61303, #61308, #61328) or unavailability of the viscera (#61319, #61320) precluded examination of either organ. Table 6-1 lists the area distribution of individuals for which one or both kidneys were examined. Weights of the right and left kidneys and the averaged weight of both (when both organs were normal) were presented for these 106 individuals in Table 1-3 (Report 1).

Results of the macroscopic kidney examinations, with pathological changes noted, are presented in Table 6-2. Apparent pathological features were noted in the kidneys of 26 individuals: in 8 cases both organs of the same individual were involved, and in 18 cases (in each of which both kidneys were available) the change was observed in only one organ. These apparent lesions or peculiarities are analyzed with respect to age, sex and geographic distribution of the affected wolves in Table 6-3. Specific ages were not available for three individuals: adult female #61409 from the Fairbanks area (both kidneys normal), adult male #61345 from Yakutat (both kidneys normal), and adult female #61323 from the Oshetna pack (one kidney displaying a small hilar cyst and the other kidney normal).

Percentage of individuals with apparent changes in one or both kidneys ranged from 18 to 38 percent in the different geographic areas, averaging 32 percent of all animals examined. Changes were observed in one kidney in 16 percent of the cases and in both kidneys in 8 percent. There was some indication that packs consisting of larger numbers of individuals that were older than age 4 years (notably, those from the Fairbanks area) had a greater frequency of kidney lesions, while packs with many animals age 3 years or less (notably, those from the foothills-central area) had a smaller frequency of renal changes. When the data are evaluated by age class (regardless of area), only 2 (6%) of 33 pups displayed changes in either kidney, but 9 (26%) of 35 animals age 2-3 years and 14 (40%) age 4-7 years displayed changes (Table 6-3). In addition, both kidneys were more frequently affected (17%) in the age group 4-7 years than in the younger classes (3%). These data indicate age-related etiologies, such as periodic acute disease, physiological disturbances, chronic illness, or exposure to pathogens.

Age is an important factor in the occurrence of kidney lesions in domestic dogs. Approximately 80 percent of dogs older than age 8 years are affected by the focal lesions of chronic interstitial nephritis, often the result of repeated episodes of progressive viral or bacterial inflammation (Bloom 1968b). Leptospirosis is the causative agent of at least

Table 6-1. Numbers of wolves, listed by geographic area, for which both kidneys or only one kidney were examined. Numbers of these wolves for which age was also available is indicated.

Geographic area	Wolves with kidney specimens available							Other wolves	
	Sex		Age		Total individuals for which kidney(s) examined	Pair members examined		Individuals for which kidneys not examined	Total wolves in area
	M	F	available	not available		both	one		
1. Flats-East	2	2	4	–	4	4	–	–	4
2. Fairbanks	5	3	8	1	9	9	–	–	9
3. Flats-Buttes	7	4	11	–	11	11	–	–	11
4. Flats Westcentral	8	3	11	–	11	11	–	–	11
5. Foothills-East	4	4	8	–	8	8	–	–	8
6. Foothills-Little Delta	5	5	10	–	10	10	–	–	10
7. Foothills-Central	11	4	15	–	15	14	1	–	15
8. Foothills-West	4	3	7	–	7	7	–	–	7
Unit 20A Subtotal	46	28	74	1	75	74	1	–	75
9. Delta & Maclaren	2	–	2	–	2	2	–	2	4
10.Brushkana-Butte	5	6	11	–	11	11	–	1	12
11.Deadman	3	2	5	–	5	3	2	–	5
12.Oshetna	2	1	3	1	4	4	–	2	6
13.Gulkana-Copper	5	–	5	–	5	4	1	1	6
Unit 13 Subtotal	17	9	26	1	27	24	3	6	33
Units 5 & 26 Yakutat & Toolik	1	2	3	1	4	4	–	–	4
Total	64	39	103	3	106	102	4	6	112

Table 6-2. Results of gross pathological examination of the kidneys and bladders of individual wolves, listed by geographic area. Two kinds of changes were observed in kidneys: fibrous foci and streak scars.* Bladder observations included the unstretched wall thickness and the mucosa. N = normal, no apparent pathological changes noted, - = not available for examination.

Individual				Right Kidney					Left Kidney					Bladder		
				Fibrous foci*		Scars, streaks*		Other	Fibrous foci		Scars, streaks		Other	Wall thickness (mm)	Mucosa	Other
Pack	No.	Sex	Age (yr.)	cap	cor	cor	med		cap	cor	cor	med				
Unit 20A																
1. Flats - East																
A	61348	M	4					N					N		-	-
B	61389	M	3					N			X	X	Shrunken	3	Blotches	Calculi
A	61350	F	2					N					N		-	-
B	61387	F	5					N					N		-	-
2. Fairbanks																
C	61357	M	6			X	X	Retraction	X		X	X	-	4	N	-
C	61358	M	4					N					N	7	N	-
C	61365	M	3					N					N		-	-
C	61376	M	4	X			X	-	X				-	-	N	-
20B	61401	M	5					N					N	2-3	N	Distended
RC	61402	F	3					N					N	4	N	-
RC	61403	F	5					N					Shrunken	Thin	N	-
EI	61409	F	adult					N					N		-	-
RC	61400	F	pup					N					N		N	-
3. Flats - Buttes																
L	61353	M	5					N	X	X	X	X	Reduced	-	N	-
D	61355	M	4					N					N	10	Thick	-
D	61364	M	4					N					N		-	-
D	61391	M	4	X	X			-					N		-	-
D	61354	M	5					N					N		-	-
RL	61396	M	pup					N					N	3-6	N	-
RL	61398	M	pup					N					N	2-3	N	-
D	61366	F	pup	X			X	Yellow st.	X			X	Yellow st.		-	-
RL	61397	F	5					N					N	4-5	N	-
RL	61407	F	3					N					N		N	-
RL	61408	F	pup					Semi-form					Semi-form		N	-

Table 6-2. (Cont.)

Individual				Right Kidney					Left Kidney					Bladder		
				Fibrous foci*		Scars, streaks*		Other	Fibrous foci		Scars, streaks		Other	Wall thickness (mm)	Mucosa	Other
Pack	No.	Sex	Age (yr.)	cap	cor	cor	med		cap	cor	cor	med				
4. Flats - Westcentral																
E	61352	M	3					N					N		–	–
E	61356	M	4					Semi-form					Semi-form	2-3	Blotches	N
F	61359	M	4					N					N	1	N	–
F	61360	M	2					N					N		–	–
F	61361	M	2					N					N		–	–
F	61377	M	4			X	X	Shrunken					Cyst	1-2	N	–
G	61381	M	3				X	Reduced					N	8	N	–
F	61362	M	pup					N					N		–	–
G	61382	F	3			X	X	Retraction					N		–	–
G	61383	F	pup					N					N		–	–
F	61363	F	2	X				–			X	X	–	Thin	N	–
5. Foothills - East																
V	61367	M	4					N					N		–	–
V	61368	M	3					N					N		–	–
V	61404	M	3					N					N		N	–
V	61406	M	4					N					N		N	–
V	61369	F	2					N			X	X	–		–	–
V	61388	F	7	X	X			–	X	X	X		–	8	N	–
V	61390	F	5					N	X	X	X	X		2-3	N	–
V	61405	F	3					N					N		N	–
6. Foothills - Little Delta																
T	61370	M	5					N					N		–	–
T	61374	M	4					N					N		–	–
U	61378	M	3					N					N	1-4	N	–
U	61379	M	6					Calculi					Calculi	2	N	–
U	61351	M	pup					N					N		–	–
T	61375	F	6					N			X	X	–		N	–
T	61372	F	3					N					N		–	–
T	61371	F	pup					N					N		–	–
T	61373	F	pup					N					N		–	–
U	61349	F	pup					N					N		–	–

Table 6-2. (Cont.)

				Right Kidney					Left Kidney					Bladder		
Individual				Fibrous foci*		Scars, streaks*		Other	Fibrous foci		Scars, streaks		Other	Wall thickness (mm)	Mucosa	Other
Pack	No.	Sex	Age (yr.)	cap	cor	cor	med		cap	cor	cor	med				
7. Foothills-Central																
W	61332	M	3					N					N		-	-
W	61333	M	2					N					N		-	-
GK	61410	M	4	X				-	X				-		N	-
X	61336	M	2	X				-					N		-	-
X	61337	M	3					N					N		-	-
X	61339	M	3					N					N		-	-
X	61340	M	2					Calculi					N		-	-
X	61338	M	pup					N					N		-	-
X	61342	M	pup					N					N		-	-
W	61331	M	pup					N					N		-	-
W	61334	M	pup					N					N		-	-
X	61341	F	2					N					N		-	-
W	61346	F	2					N					N		-	-
W	61347	F	4					N					-		-	-
X	61335	F	pup					N					N		-	-
8. Foothills-West																
Z	61384	M	5					N	X			X	-		-	-
Y	61395	M	4					N					N	2-3,5	Blotches	Calculi
Z	61385	M	pup					N					N		-	-
Y	61392	M	pup					N					N	2-3	N	-
Y	61386	F	3					N	X				-		-	-
Y	61393	F	5					N					N	2-3	Blotches	N
Y	61394	F	3					N					N	2-3,5	N	-
Unit 13																
9. Delta & Maclaren																
DLP	61326	M	pup					-					-		-	-
DLP	61327	F	pup					-					-		-	-
MLP	61302	M	pup					N					N		-	-
MLP	61303	M	pup					N					N		-	-

Table 6-2. (Cont.)

Individual				Right Kidney					Left Kidney					Bladder		
				Fibrous foci*		Scars, streaks*		Other	Fibrous foci		Scars, streaks		Other	Wall thickness (mm)	Mucosa	Other
Pack	No.	Sex	Age (yr.)	cap	cor	cor	med		cap	cor	cor	med				
10.Brushkana - Butte																
BBK	61304	M	4					N					N		-	-
BBK	61305	M	3					N					N		N	-
BBK	61311	M	2					N					N		N	-
BBK	61309	M	pup					N					N		-	-
BBK	61313	M	pup					N					N		-	-
BBK	61307	F	4				X	-					N			
BBK	61314	F	5					N					N		-	-
BBK	61306	F	pup				X	-					N		N	-
BBK	61308	F	pup					-					-		N	-
BBK	61310	F	pup					N					N		-	-
BBK	61312	F	2					N					N		N	-
BBK	61315	F	pup					N					N		-	-
11.Deadman																
DDP	61317	M	3					N					N	Thin	N	Distended
DDP	61300	M	pup					N					N		-	-
DDP	61301	M	pup					N					-		-	-
DDP	61318	F	4					N					-	Thin	N	-
DDP	61316	F	pup					N					N		N	-
12.Oshetna																
OHP	61319	M	adult					n/a					n/a		-	-
OHP	61320	M	adult					n/a					n/a		-	-
OHP	61321	M	3					N					N		-	-
OHP	61324	M	3					N					N	Thin	N	Distended
OHP	61323	F	adult		X			Cyst					N	2-3	N	-
OHP	61322	F	2					Shrunken					N		N	-

Table 6-2. (Cont.)

Individual				Right Kidney					Left Kidney					Bladder		
Pack	No.	Sex	Age (yr.)	Fibrous foci*		Scars, streaks*		Other	Fibrous foci		Scars, streaks		Other	Wall thickness (mm)	Mucosa	Other
				cap	cor	cor	med		cap	cor	cor	med				
13.Gulkana, Copper																
EWA	61325	M	pup					N					N		-	-
HOG	61431	M	pup					N					N	Thin	N	-
TOK	61433	M	pup					N					N		N	-
TOK	61328	F	3					n/a					n/a		-	-
RUN	61432	M	5					n/a					N		N	-
CAS	61399	M	pup					N					N	2	N	-
<u>Units 5 and 26</u>																
14.Yakutat, Toolik																
Y3	61345	M	adult					N					N		-	-
Y1	61343	M	3					N					N		-	-
Y2	61344	F	pup					N					N		-	-
TOO	61380	F	4					N			X	X	Shrunken		-	-

*Apparent pathological changes observed in kidneys:

(1) Fibrous foci
    cap = foci confined to capsule (dimples)
    cor = foci extending as small scar into cortex

(2) Streak scars
    cor = streaks extending through the cortex
    med = fibrous retractions extending from the capsule through the cortex into the medulla

Table 6-3. Relative occurrence of individuals with kidneys displaying possible pathological changes, organized by sex, age class, and geographic area. Denominator: number of kidney pairs examined; numbertor: number of kidney pairs with both normal (2N), one of pair normal and one with pathological changes (1N, 1P), or both with pathological changes (2P).

	Males												Females												Total									
	Pups			2-3 yr.			4-7 yr.			Subtotal			Pups			2-3 yr.			4-7 yr.			Subtotal			Pups			2-3 yr.			4-7 yr.			Total
Geographic area	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N	1N 1P	2P	2N
1. Flats-East				-	1	-	1	-	-	1	1	-				1	-	-	1	-	-	2	-	-				1	1	-	2	-	-	3
					1			1			2						1			1			2						2			2		
2. Fairbanks				1	-	-	2	-	2	3	-	2	1	-	-	1	-	-	-	1	-	2	1	-	1	-	-	2	-	-	2	1	2	5
					1			4			5			1			1			1			3			1			2			5		
3. Flats-Buttes	2	-	-				3	2	-	5	2	-	1	-	1	1	-	-	1	-	-	3	-	1	3	-	1	1	-	-	4	2	-	8
		2						5			7			2			1			1			4			4			1			6		
4. Flats-Westcentral	1	-	-	3	1	-	2	-	1	6	1	1	1	-	-	-	1	1				1	1	1	2	-	-	3	2	1	2	-	1	7
		1			4			3			8			1			2						3			2			6			3		
5. Foothills-East				2	-	-	2	-	-	4	-	-				1	1	-	-	1	1	1	2	1				3	1	-	2	1	1	5
					2			2			4						2			2			4						4			4		
6. Foothills-Little Delta	1	-	-	1	-	-	2	-	1	4	-	1	3	-	-	1	-	-	-	1	-	4	1	-	4	-	-	2	-	-	2	1	1	8
		1			1			3			5			3			1			1			5			4			2			4		
7. Foothills-Central	4	-	-	4	2	-	-	-	1	8	2	1	1	-	-	2	-	-	1	-	-	4	-	-	5	-	-	6	2	-	1	-	1	12
		4			6			1			11			1			2			1			4			5			8			2		
8. Foothills-West	2	-	-				1	1	-	3	1	-				1	1	-	1	-	-	2	1	-	2	-	-	1	1	-	2	1	-	5
		2						2			4						2			1			3			2			2			3		
Subtotal Unit 20A	10	-	-	11	4	-	13	3	5	34	7	5	7	-	1	8	3	1	4	3	1	19	6	3	17	-	1	19	7	1	17	6	6	53
		10			15			21			46			8			12			8			28			18			27			29		

Table 6-3. (Cont.)

	Males												Females												Total									
	Pups			2-3 yr.			4-7 yr.			Subtotal			Pups			2-3 yr.			4-7 yr.			Subtotal			Pups			2-3 yr.			4-7 yr.			Total
		IN			IN			IN			IN			IN			IN			IN			IN			IN			IN			IN		
Geographic area	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N	1P	2P	2N
9. Delta & Maclaren	2	-	-							2	-	-										-	-	-	2	-	-							2
		2									2															2								
10. Brushkana-Butte	2	-	-	2	-	-	1	-	-	5	-	-	2	1	-	1	-	-	1	1	-	4	2	-	4	1	-	3	-	-	2	1	-	9
		2			2			1			5			3			1			2			6			5			3			3		
11. Deadman	2	-	-	1	-	-				3	-	-	1	-	-				1	-	-	2	-	-	3	-	-	1	-	-	1	-	-	5
		2			1						3			1						1			2			3			1			1		
12. Oshetna				2	-	-				2	-	-				-	1	-				-	1	-				2	1	-				2
					2						2						1						1						3					
13. Gulkana-Copper	4	-	-				1	-	-	5	-	-													4	-	-				1	-	-	5
		4						1			5															4						1		
Subtotal Unit 13	10	-	-	5	-	-	2	-	-	17	-	-	3	1	-	1	1	-	2	1	-	6	3	-	13	1	-	6	1	-	4	1	-	23
		10			5			2			17			4			2			3			9			14			7			5		
14. Yakutat & Toolik				1	-	-				1	-	-	1	-	-				-	1	-	1	1	-	1	-	-	1	-	-	-	1	-	2
					1						1			1						1			2			1			1			1		
Total, all areas	20	-	-	17	4	-	15	3	5	52	7	5	11	1	1	9	4	1	6	5	1	26	10	3	31	1	1	26	8	1	21	8	6	78
		20			21			23			64			13			14			12			39			33			35			35		

some damage, possibly that of the initial lesions (McIntyre and Montgomery 1952, Monlux 1953, Taylor et al. 1970), but other organisms can cause similar scars (Kirk et al. 1968, Smith et al. 1974). The renal scars encountered in wolves in the present study were of generally lesser severity than is often seen in aged domestic canines and probably had little clinical significance at the time of collection.

Of the 26 wolves with lesions or unusual features in their kidneys, 19 (73%) had pathological changes similar to those attributed to interstitial nephritis in domestic dogs. The changes seen in these individuals were foci, streaks or wedges of dense, grey-white material resembling fibrous scar tissue. There was evidence of the repeated, progressive inflammation noted above in that the observed range of abundance and extent of these scars appeared to represent a continuum of severity and involvement. Seven major stages of severity were recognized in wolves and are detailed below.

(1) Least in apparent severity were focal white and/or dimpled areas in the capsule with slight local narrowing of the cortex immediately beneath the focus as the only macroscopically evident changes. This was observed in four individuals: pup #61306, one focus on one kidney; two-year-old male #61336, two foci in one kidney only; four-year-old male #61391, two foci on one kidney only; and four-year-old male #61410, two foci on one kidney and one focus on the other.

(2) Next in apparent severity were narrow fibrous streaks radiating from the capsule (often in conjunction with external capsular foci) toward the hilus but penetrating only the corticomedullary boundary or the area shortly beyond. Four individuals, all females, exhibited this change in only one kidney, with the other kidney macroscopically normal: two-two-year-old #61369, six-year-old #61375, five-year-old #61384 and four-year-old #61307.

(3) This category is characterized by more extensive development of the fibrous scars described in (1) and (2), with the depressed foci or streaks apparent in the capsule communicating with more extensive fibrous scarring observed in the cortex. Cortical scars were often broadened into pyramidal wedge-shaped infarcts with bases in the (depressed) capsule. In both individuals exhibiting lesions of this severity in one kidney, two-year-old female #61363 and four-year-old male #61376, the other kidney had several lesions (foci, narrow streaks) of lesser severity confined to the capsule.

(4) The narrow streaks in the cortex apparently broadened into wedge-shaped infarct-type cortical scars. These were pyramidal with apeces at the corticomedullary boundary and bases (measuring about 3 mm) along the capsule, retracting it into a "trough" apparent on the surface. Two individuals displayed lesions of thistype. In seven-year-old female #61388 (the oldest wolf collected) the depressed trough-like capsular scar measured 2 by 5 mm, and in five-year-old female #61390 it measured 8 by 22 mm. The former wolf had in addition several smaller focal capsular and streak cortical scars on and

in both kidneys, while the latter wolf had such scars on only the left kidney (the right kidney was macroscopically normal both externally and internally).

(5) In two individuals cortical scars attained even larger dimensions to form larger fibrous channels or troughs on the capsular surface with partial concomitant retraction of the cortex beneath. Three-year-old female #61382 displayed such a scar across the entire ventral aspect of the right kidney from hilus to lateral edge, measuring 8 by 50 mm and extending from 2 to 5 mm deep into the cortex. The left kidney was normal. Six-year-old male #61357 displayed a similar channel on the ventral kidney surface, branching from the hilus in a Y-shape approximately 60 mm long with width varying from several to about 10 mm. Numerous smaller fibrous seams were evident on the dorsal surface and radial scars were noted internally extending from the cortex through the medulla. The right kidney of this individual also exhibited capsular and cortical scars to a lesser extent.

(6) In several kidneys examined irregular retraction of parts of the organ parenchyma had occurred. In two cases, the shrinkage was not associated with macroscopically evident scars. Female pup (age uncertain) #61403 had a slight local indentation at the posterior third of the lateral surface of the left kidney; the right kidney was normal. Two-year-old female #61322 had a similar indentation together with general shrinkage of the entire posterior third of the right kidney; the left kidney was normal. It is possible that both of these cases represented congenital morphological variations of no pathological significance.

(7) However, in four other individuals, retraction of the renal parenchyma was associated with fibrous scarring of the type described above (categories 2 through 5). In two cases the entire kidney was uniformly reduced in size in comparison with the other normal kidney. Three-year-old male #61381's right kidney, displaying a cortical wedge-shaped scar, weighed 112.5 g in contrast to the 137.8 g of the normal left kidney. Five-year-old male #61353's left kidney showed considerable capsular scarring as well as several radial streak scars which extended into the cortex and, in two instances, through the medulla into the pelvis. The weight of this affected kidney was 128.0 g, in contrast to the 165.8 g of the normal (right) kidney. In the remaining two wolves, four-year-old female #61380 and three-year-old male #61389, the shrinkage involved only the posterior third of one kidney. This area displayed large, grey-white, wedge-shaped scars extending from the cortex through the medulla, retracting the cortex inward and distorting the shape of the entire organ. In all of these four cases the remaining kidney of the pair was unscarred and displayed normal morphology.

This series of categories (1 through 7) describes 19 (73%) of the 26 cases of renal change observed in wolves. Although it seems to represent a continuum of severity that is indicative of a progressive pathological process (Jubb and Kennedy 1970, Robbins 1974), the actual extent of the lesion type is not clearly associated with age. Thus the average age of the nine individuals in the first three categories was 3.7 years, compared to 4.0 years for the eight individuals in the last three categories (omitting category 6). However, the frequency of the lesion type itself was clearly greater in the older adult age class.

The remaining 7 (27%) of the 26 individuals exhibited pathological features in their kidneys that were apparently unrelated to the fibrous-scarring categories detailed above. Four basic kinds of unusual features were observed.

First, two individuals displayed shrinkage of the posterior third of a kidney, as seen in category 7 above, but without evidence of fibrous scarring. In this sense they were similar to the kidneys observed in category 6. However, an additional feature was apparent in these two wolves' kidneys. Thin walled cystic structures were present in the medulla in these cases and could have represented local dilations of the minor calyces. Three-year-old female #61323 had such a cyst in the slightly shrunken posterior third of her right kidney (99.0 g), while her left kidney (106.2 g) was apparently normal (although shot-damaged). Four-year-old male #61377 had a similar cyst measuring 5 by 10 mm in the right kidney (112.3 g) as well as a fibrous scar on the adjacent capsule. However, the left kidney (137.8 g) of this individual also had a cyst which, although it appeared to extend toward the renal pelvis and may have communicated with it, seemed less likely to represent a dilation of the calyces. The cyst was located in the cortex just anterior to the hilus, with its anterior part bulging slightly medially from the renal margin. Measuring 10 by 15 mm, it was slightly constricted centrally and was filled with fluid. Christensen (1965) observed that renal cysts are not uncommon in domestic canines and are of little clinical significance although bilateral cystic kidneys (such as observed in #61377) may lead to uremia.

The second type of change was noted in a single individual. Five-year-old female #61366 had several focal depressed fibrous scars on the capsular surfaces, as well as a few narrow scars radiating from the cortex through to the medullary-pelvic boundary in both kidneys, as in category 3, above. However, the internal streaks were a distinctive yellow color in this individual, macroscopically reminiscent of uric acid precipitation in the collecting tubules.

The third type of change observed was the presence of numerous small (1 to 3 mm diameter) calculi, smooth and irregular in shapeand located in the renal pelves of two individuals. The calculi were most apparent in the right kidney of two-year-old male #61340, where the renal pelvis was somewhat enlarged and the medulla concomitantly reduced. The left kidney of this individual was normal. Similar calculi from focal to 2 mm in diameter were also noted in the renal pelvis (left kidney only) of six-year-old male #61379. Unfortunately shot damage to the organ precluded careful examination. In both individuals the calculi were grey-white, soft and friable, and of a chalky consistency which could be easily crushed, thus corresponding closely to descriptions of phosphate calculi. There is some possibility, however, that the "calculi" were in fact artefactual, resulting from post mortem autolysis and rendering of the renal pelvic adipose tissue, although it seems odd this change would occur in only 2 of 106 individuals examined.

The fourth type of unusual feature was an apparent persistence of fetal lobation, with the affected kidney being semi-divided in half in the anterior-posterior plane at the hilus, with partial fusion of the cortex, medulla and renal pelvis. The semi-division was externally apparent as a shallow depression encircling the kidney at the level of the hilus. This feature was more apparent in the left kidney than in the right in both of the individuals affected, female pup #61408 and four-year-old male #61356. These two wolves were not geographically associated. Persistent fetal lobulation has no functional significance (Christensen 1965, Jubb and Kennedy 1970).

B. Bladder

The bladder, which was incised and examined internally for 44 wolves, was the only portion of the lower urinary tract observed in detail at necropsy. These 44 wolves included 29 individuals from Unit 20A and 15 from Unit 13 (see Table 6-2). Both kidneys were also examined for 42 of the 44 individuals, while one kidney only was examined for one individual, and in the remaining case neither kidney was available for examination.

In several cases changes were observed in the bladder which were apparently the result of post mortem autolysis rather than pathological processes. These included (1) extreme distention of the bladder, and (2) irregular areas of vascular engorgement on the mucosal surface. Three individuals, all males, displayed the first apparently autolytic change; extreme distention of the bladder. These were three-year-old wolves #61317 and #61324, and five-year-old wolf #61401. The lengths and girths of these bladders were 15 cm and 25 cm (#61317), 11 cm and 11 cm (#61324), and 10 cm and 12.5 cm (#61401). Urine volumes measured 400 ml, 80 ml and 60 ml, respectively. In two cases the mucosal lining appeared normal, while in the third case (#61401) apparent post mortem bacterial action had resulted in 2 mm diameter yellow foci on both the external and internal faces of the organ. In all three cases the carcasses had been frozen and thawed several times before examination.

The second kind of apparently autolytic change in the bladder was the appearance of irregular reddish blotches on the mucosal surface in several individuals. This was particularly noticeable in four-year-old male #61356 and five-year-old female #61393. Closer macroscopic examination revealed that the blotched appearance was due to localized superficial patterns of engorged vessels in the mucosa. No other changes were macroscopically evident in the bladders of these individuals, but all three cases of possible bladder lesions encountered (discussed below) displayed similar blotches. The significance of the blotches unaccompanied by other unusual features is therefore unclear. Although the blotches may represent post mortem vascular imbibition, microscopic changes or inflammation may also have been involved (see below).

Macroscopic pathological changes were noted in only 3 (7%) of the 44 wolf bladders examined. Two kinds of changes were observed: (1) thickening of the mucosal wall and (2) cystic calculi. The first change was of a somewhat vague nature, occurring in only a single individual. Measurement of the unstretched walls of 22 normal bladders (Table 6-2) produced an average mid-lateral wall thickness of about 3 mm (range 2 to 5 mm), with occasional individuals having somewhat thicker (7 or 8 mm) walls. The individual mentioned above, however, four-year-old male #61355, had a bladder wall measuring 10 mm in thickness, with the mucosa appearing somewhat edematous and marked by irregular blotches (as described above, possible post mortem change). (This individual was necropsied less than 24 hours post mortem.) Chronic cystitis may have been present in this individual, causing connective-tissue thickening of the submucosa and hypertrophy of the muscularis. Histopathology would reveal this, as well as an associated infiltration of mononuclear cells. Irregular reddening of the mucosa may also be attributed to chronic cystitis, and histopathological examination might reveal the mucosal blotches described above to be associated with inflammation. Changes in urine pH and composition as well as renal or cystic calculi have been associated with chronic cystitis in domestic dogs (Jubb and Kennedy 1970). All three of the wolves possibly affected, however, had normal kidneys with no calculi apparent in either location.

Calculi were macroscopically apparent in the urinary bladders of two wolves: three-year-old male #61389, and four-year-old male #61395. In both cases the calculi were bright yellow, indicating a possible uric acid composition. In this they were reminiscent of the yellow streaks observed in the cortex and medulla of both kidneys of wolf #61366, although no calculi were observed in the bladder of the latter individual. Male #61355 had from 20 to 50 calculi, all 1 mm diameter or less in size. Male #61389, in contrast, had approximately 10 calculi, a large one about 3 mm in diameter with an irregular shape, rough pitted surface and very hard consistency; 2 calculi about 1 mm in diameter; and about 6 tiny calculi (less than 1 mm in diameter) all of the same color and hardness. The bladder walls of both individuals were of normal thickness, but the mucosal surfaces of both bladders were marked by the irregular red blotches described above as possible post mortem changes. (Both individuals were necropsied within 48 hours of collection.) Both kidneys of #61355 were normal, while #61389 had one normal kidney and one marked by scarring and size reduction (category 7, above).

Of the 43 wolves for which both kidneys and bladders were examined, 15 individuals exhibited pathological changes in at least one kidney yet had normal-appearing bladders (Table 6-2). Neither of the two wolves displaying calculi in the renal pelvis had apparent bladder calculi.

Discussion: Urinary system

Although changes were frequently observed in the kidneys, they were relatively nonspecific. The radial- and wedged-shaped cortical scars encountered most often could have been caused by at least three physiological processes. The first is acute or chronic interstitial nephritis of a mild nature, such as often occurs in domestic canines as a result of *Leptospira* infections (McIntyre and Montgomery 1952, Monlux 1953, Kirk et al. 1968, Taylor et al. 1970). This has been reported previously in captive wolves (Fox 1926, Hamerton 1931, 1932). Second, general pyelonephritis could also explain the wedge-shaped scars seen, particularly those extending into the medulla, as well as the frequently observed asymmetrical nature of the changes (Jubb and Kennedy 1970). Kirk et al (1968) noted, however, that pyelonephritis rarely occurs independently of other diseases or conditions in domestic canines and is seen more often in bitches (which was not the case in the present study). Third, glomerulonephritis could also account for the changes seen, although capsular adhesion to the scars, which was not noticeable in any of the affected kidneys, might be expected in that case (Jubb and Kennedy 1970). This condition is rare in dogs (Kirk et al. 1968). Histopathological examination should clarify which pathological process or processes were involved.

Also noted among wolves was the presence of renal pelvic and cystic (bladder) calculi. Phosphate calculi appeared to be involved in the former location and uric acid calculi in the latter. In addition, the bright yellow streaks in the renal cortex and medulla of wolf #61366 also might be considered manifestations of uric acid precipitation (Sandritter and Thomas 1972). Phosphate precipitation occurs only at alkaline pHs and thus is rare in the usually acid urine of carnivores. Infection, however, can cause the urine to become alkaline because the pathogenic bacteria can split urea inti amonia, thereby decreasing the solubility of the urinary calcium and magnesium phosphates which would appear in high concentrations after protein-rich meals. Bacterial infections could also favor the formation of calculi in the renal pelvis and bladder by: (1) inducing tissue - destructive inflammation and consequent sloughing, with the detritus providing nidi of mineralization, and (2) decreasing urine passage rate, with any stagnation also favoring crystallization of minerals (Jubb and Kennedy 1970, Smith et al. 1974, Robbins 1974). In captive wolves the occurrence of haemorrhagic cystitis and bladder stones has been reported (Plimmer 1916, Hamerton 1945).

Bright yellow, uric acid-type crystals, however, occur primarily in acid urine and are usually not associated with infections of the urinary tract. Stagnation, habitual intake of mineralized water, or various metabolic disorders can bring about crystallization of uric acid even in urine of a normal pH (Jubb and Kennedy 1970). Genetic variation in some individuals also could cause higher than normal levels of uric acid to appear and precipitate in the kidney tubules or bladder (Lehninger 1975), an aberration common in some breeds of dogs (Smith et al. 1974).

Of interest, however, is the fact that damage to the renal tubules can bring about the formation of either type of calculus given the proper conditions. Since kidney scarring was encountered with some frequency, a disease process might explain both the cortical scarring as well as the much rarer calculi even if both phenomena were rarely manifested in the same individual. For this reason, the renal tubules of the two individuals with possible renal pelvic calculi, the single individual with apparent cortical-medullary uric acid precipitation, and both individuals with cystic calculi should be histologically examined with particular care to detect signs of recent damage, inflammation, or perhaps concurrent bacterial infection.

The urinary tract lesions encountered were of a uniformly mild nature compared to those observed in aged domestic canines (Bloom 1968b), and probably had little clinical significance for the wolves, at least at the time of collection. However, progressive renal lesions of the same type could contribute to morbidity. Lodging of renal pelvic or cystic calculi in the urethra of males might occasionally cause debility and inflammation. The ubiquity of kidney lesions of an apparently progressive nature as encountered among the wolves of this collection suggests that renal problems may play a role in natural selection.

Report 7. Traumatic injuries

All 112 wolves collected were examined to varying extents for evidence of traumatic injury. The examination covered a total of 9 sites, with the ribs, each humerus, each tibia-fibula, and one femur superficially observed for fractures at the necropsy of 110 animals. The condition of the hide, associated subcutaneous tissue, and appendages was noted during the skinning of 82 of these animals. The skulls, teeth and one radius-ulna were examined after cleaning and boiling, so that small fractures and abnormalities were made readily apparent on these particular specimens. Since all 9 sites were not available for examination in each wolf, only 901 sites were examined rather than the (112 x 9 =) 1008 potentially available in 112 individuals. The 901 sites included 634 sites for 75 wolves from Unit 20A, 238 sites for 33 wolves from Unit 13, and 29 sites for 4 wolves from Units 5 and 26 (Table 7-1). For two individuals, male pup #61326 and female pup #61327 from Unit 13, only the skulls (and teeth) were available for examination. These individuals are thus often omitted from the discussion below. Accordingly, 110 wolves were examined comprehensively for evidence of traumatic damage.

Evidence of traumatic injury was observed in 56 (50.9%) of the 110 wolves examined (Table 7-2A) or in 85 (9.4%) of the 901 sites examined (Table 7-2B). Fractures and other bone injuries, often associated with injuries received in hunting large ungulates (Stephenson, in prep.), were observed in 43 (39.1%) of 110 individuals, or in 55 (8.7%) of the total 633 sites examined. Chipped teeth, hide lesions and damage to appendages were observed in 23 (28.1%) of the 82 animals examined, or 30 (11.2%) of 268 sites.

Interesting differences were observed in the occurrence of traumatic injuries in different age classes of wolves. Wolves age 4 and 5 years were most frequently injured (84.2 and 69.2% of 19 and 13 wolves, respectively). Lower percentages of injured individuals were encountered among wolves age 5, 2, and 3 years, respectively (Table 7-2A). Wolves age 4 and 5 years also had a greater number of injured. Among the potential injury sites examined, wolves age 4 and 5 years displayed the greatest frequency of damage (15.5 and 13.5% of 168 and 104 potential sites, respectively; Table 7-2B). Pups were the least frequently

Table 7-1. Individual wolves, listed by geographic area, examined at various anatomical sites for evidence of traumatic injury. N = normal, no injuries apparent; X = traumatic injury apparent at that site, - = site not available for examination.

Individual				Fractures of							Damage to					
				Skull	Ribs	Long bones				Total frac. sites*	Teeth	Hide		Appendages		Total damage sites*
Pack	No.	Sex	Age (yrs)			Humerus	Radius-Ulna	Femur	Tibia-Fibula			Abrasions	Abscesses	Ears	Toes	
Unit 20A																
1. Flats - East																
A	61348	M	4	X	N	N	N	N	N	1	N		abscess	N		1
B	61389	M	3	N	X	N	N	N	N	1	N		abscess	N		1
A	61350	F	2	N	N	N	N	X	N	1	N	N		N		0
B	61387	F	5	X	N	N	N	N	N	1	N	N		N		0
2. Fairbanks																
C	61357	M	6	X	X	N	N	N	N	2	N		abscess	ear		2
C	61358	M	4	N	N	N	N	N	N	0	N		abscess	N		1
C	61365	M	3	N	N	N	N	N	N	0	N	N		N		0
C	61376	M	4	N	N	N	N	N	N	0	N	N		N		0
20B	61401	M	5	N	N	N	-	N	N	0(5)	N	-		-		0(1)
RC	61402	F	3	N	N	N	N	N	N	0	N	-		-		0(1)
RC	61403	F	5	X	N	N	N	N	N	1	X	-		-		1(1)
El	61409	F	AD	-	N	N	N	N	N	0(5)	-	-		-		-
RC	61400	F	PUP	N	N	N	N	N	N	0	N	-		-		0(1)
3. Flats - Buttes																
LO	61353	M	5	N	X	N	N	N	N	1	X	N		ear		2
D	61355	M	4	N	X	N	N	N	N	1	X	N			toe	2
D	61364	M	4	X	N	N	N	N	N	1	N	N		N		0
D	61391	M	4	N	N	N	N	N	N	0	N	N			toe	1
D	61354	M	5	N	N	N	N	N	N	0	N	abrasion		N		1
RL	61396	M	PUP	N	N	N	N	N	N	0	N	-		-		0(1)
RL	61398	M	PUP	-	N	N	N	N	N	0(5)	-	-		-		-
D	61366	F	5	N	N	N	N	N	N	0	N	N		N		0
RL	61397	F	5	N	N	N	N	N	N	0	X	-		-		1(1)
RL	61407	F	3	N	N	N	N	N	N	0	X	-		-		1(1)
RL	61408	F	PUP	N	N	N	N	N	N	0	N	-		-		0(1)

Table 7-1. (Cont.)

Individual				Fractures of							Damage to					
				Skull	Ribs	Long bones				Total						Total
			Age				Radius-		Tibia-	frac.	Teeth	Hide		Appendages		damage
Pack	No.	Sex	(yrs)			Humerus	Ulna	Femur	Fibula	sites*		Abrasions	Abscesses	Ears	Toes	sites*
4. Flats - Westcentral																
E	61352	M	3	X	N	N	N	N	N	1	N	abrasion		N		1
E	61356	M	4	N	N	N	N	X	N	1	N	N		N		0
F	61359	M	4	X	X	N	X	N	N	3	N	N		N		0
F	61360	M	2	X	N	N	N	N	N	1	N	N		N		0
F	61361	M	2	N	N	N	N	N	N	0	N	N		N		0
F	61377	M	4	N	X	N	N	N	N	1	N	abrasion		N		1
G	61381	M	3	N	N	N	N	N	N	0	N	N		N		0
F	61362	M	PUP	N	N	N	N	N	N	0	N	N		N		0
G	61382	F	3	N	N	N	N	N	N	0	N	N		N		0
G	61383	F	PUP	–	N	N	N	N	N	0(5)	–	N		N		0(2)
F	61363	F	2	N	N	N	N	N	N	0	N	N		N		0
5. Foothills - East																
V	61367	M	4	N	N	N	N	N	N	0	X	N		N		1
V	61368	M	3	N	X	N	N	N	N	1	N	N		N		0
V	61404	M	3	N	N	N	N	N	N	0	N	N		N		0
V	61406	M	4	N	N	N	N	N	N	0	N	N		N		0
V	61369	F	2	X	N	N	X	N	N	2	N	N		toe		1
V	61388	F	7	X	N	N	N	N	N	1	N	N		N		0
V	61390	F	5	N	N	N	N	N	N	0	X	N		N		1
V	61405	F	3	N	N	N	N	N	N	0	N	N		N		0
6. Foothills - Little Delta																
T	61370	M	5	N	N	N	N	N	N	0	N	abrasion		N		1
T	61374	M	4	X	N	X	N	N	N	2	N	N		N		0
U	61378	M	3	N	N	N	N	N	N	0	N	N		N		0
U	61379	M	6	X	X	N	N	N	X	3	N	abrasion		N		1
U	61351	M	PUP	X	N	N	N	N	N	1	N	N		N		0
T	61375	F	6	N	N	N	N	N	N	0	N	N		N		0
T	61372	F	3	X	N	N	N	N	N	1	N	N		N		0
T	61371	F	PUP	N	N	N	N	N	N	0	N	N		N		0
T	61373	F	PUP	N	N	N	N	N	N	0	N	N		N		0
U	61349	F	PUP	X	N	N	N	N	N	1	N	abrasion		N		1

Table 7-1. (Cont.)

				Fractures of							Damage to					
Individual				Skull	Ribs	Long bones				Total frac. sites*	Teeth	Hide		Appendages		Total damage sites*
Pack	No.	Sex	Age (yrs)			Humerus	Radius-Ulna	Femur	Tibia-Fibula			Abrasions	Abscesses	Ears	Toes	
7. Foothills - Central																
W	61332	M	3	N	-	N	X	-	N	1(4)	N	N		N		1
W	61333	M	2	N	-	N	N	-	N	0(4)	N	N		N		0
GK	61410	M	4	X	X	N	-	N	N	2(5)	N	-		-		0(1)
X	61336	M	2	X	-	N	N	N	N	1(5)	N	N		N		0
X	61337	M	3	N	-	N	N	N	N	0(5)	N	N		N		0
X	61339	M	3	N	X	N	N	N	N	1	N	N		N		0
X	61340	M	2	N	N	N	N	N	N	0	N	N		N		0
X	61338	M	PUP	N	-	N	N	N	N	0(5)	N	N		N		0
X	61342	M	PUP	N	N	N	N	N	N	0	N	N		N		0
W	61331	M	PUP	N	-	N	N	N	N	0(5)	N	N		N		0
W	61334	M	PUP	N	-	N	N	-	N	0(4)	N	N		N		0
X	61341	F	2	N	N	N	N	N	N	0	N	N		N		0
W	61346	F	2	X	N	N	N	N	N	1	N	N		N		0
W	61347	F	4	N	N	N	N	N	N	0	X	N		N		1
X	61335	F	PUP	N	-	N	N	N	N	0(5)	N	N		N		0
8. Foothills - West																
Z	61384	M	5	X	N	N	N	N	X	2	X	N		N		1
Y	61395	M	4	X	N	N	N	N	N	1	N	N		N		0
Z	61385	M	PUP	N	X	N	N	N	N	1	N	N		N		0
Y	61392	M	PUP	N	N	N	N	N	N	0	N	N		N		0
Y	61386	F	3	N	N	N	N	N	N	0	N	N		ear		1
Y	61393	F	5	X	N	N	N	N	N	1	N	N		N		0
Y	61394	F	3	N	X	N	N	N	N	1	N	N		N		0
Unit 13																
9. Delta & Maclaren																
DLP	61326	M	PUP	N	-	-	-	-	-	0(1)	N	-				0(1)
DLP	61327	F	PUP	N	-	-	-	-	-	0(1)	N	-				0(1)
MLP	61302	M	PUP	N	-	N	N	X	N	1(5)	N	N		N		0
MLP	61303	M	PUP	N	-	N	N	N	N	0(5)	N	N		N		0

Table 7-1. (Cont.)

				Fractures of							Damage to					
Individual				Skull	Ribs	Long bones				Total frac. sites*	Teeth	Hide		Appendages		Total damage sites*
Pack	No.	Sex	Age (yrs)			Humerus	Radius-Ulna	Femur	Tibia-Fibula			Abrasions	Abscesses	Ears	Toes	
10.Brushkana-Butte																
BBK	61304	M	4	X	N	N	X	N	N	2	N	N		N		0
BBK	61305	M	3	N	N	N	N	N	N	0	N	N		N		0
BBK	61311	M	2	N	N	N	N	N	N	0	X	N		N		1
BBK	61309	M	PUP	N	N	N	N	N	N	0	N	N		N		0
BBK	61313	M	PUP	N	N	N	N	N	N	0	N	N		N		0
BBK	61307	F	4	N	N	N	N	N	N	0	N	N		N		0
BBK	61314	F	5	N	N	N	N	N	N	0	N	–		–		0(1)
BBK	61306	F	PUP	N	N	N	N	N	N	0	N	N		N		0
BBK	61308	F	PUP	N	N	N	N	N	N	0	N	N		N		0
BBK	61310	F	PUP	X	N	N	N	N	N	1	N	–		–		0(1)
BBK	61312	F	2	N	X	N	N	N	N	1	N	–		–		0(1)
BBK	61315	F	PUP	–	N	N	–	–	N	0(3)	–	N		N		0(2)
11.Deadman																
DDP	61317	M	3	X	X	N	N	N	N	2	N	N		N		0
DDP	61300	M	PUP	N	–	N	N	N	N	0(5)	N	–		–		0(1)
DDP	61301	M	PUP	N	–	N	N	N	N	0(5)	N	–		–		0(1)
DDP	61318	F	4	N	N	N	N	N	N	0	N	abrasion		N		1
DDP	61316	F	PUP	N	N	N	N	N	N	0	N	–		–		0(1)
12.Oshetna																
OHP	61319	M	AD	N	N	N	N	N	N	0	N	–		–		0(1)
OHP	61320	M	AD	X	N	N	N	N	N	1	N	–		–		0(1)
OHP	61321	M	3	X	X	N	N	N	N	2	N	N		N		0
OHP	61324	M	3	N	X	N	N	N	N	1	N	N		N		0
OHP	61323	F	AD	N	N	N	N	N	N	0	N	–		–		0(1)
OHP	61322	F	2	X	N	N	N	N	N	1	N	–		–		0(1)

Table 7-1. (Cont.)

Individual				Fractures of							Damage to					
				Skull	Ribs	Long bones				Total	Teeth	Hide		Appendages		Total
			Age				Radius-		Tibia-	frac.						damage
Pack	No.	Sex	(yrs)			Humerus	Ulna	Femur	Fibula	sites*		Abrasions	Abscesses	Ears	Toes	sites*
13.Gulkana, Copper																
EWA	61325	M	PUP	N	N	N	N	N	N	0	N	–		–		0(1)
HOG	61431	M	PUP	N	N	N	N	N	N	0	N	–		–		0(1)
TOK	61433	M	PUP	N	N	N	–	N	N	0(5)	N	–		–		0(1)
TOK	61328	F	3	X	N	N	–	N	N	1(5)	X	–		–		1(1)
RUN	61432	M	5	N	N	N	–	–	N	0(4)	N	–		–		0(1)
CAS	61399	M	PUP	N	N	N	N	N	N	0	–	–		–		–
<u>Units 5 & 26</u>																
14.Yakutat, Toolik																
Y3	61345	M	AD	–	N	N	N	N	N	0(5)	–	–		–		–
Y1	61343	M	3	N	N	N	N	N	N	0	X	abrasion		N		2
Y2	61344	F	PUP	N	N	N	–	N	N	0(5)	N	–		–		0(1)
TOO	61380	F	4	X	N	N	N	N	N	1	X	N		N		1
Total, all units:																
no. injured :				29	16	1	4	3	2	55	13	12		5		85
no. examined :				107	98	110	103	105	110	633	106	81		81		901

*Number in parenthesis indicates number of relevant anatomical sites examined <u>only</u> if not all were examined.

Table 7-2. Prevalence of traumatic injuries in different age and sex categories, expressed as (7-2A) percentage of examined individuals and (7-2B) percentage of examined anatomical sites.

Table 7-2A. Prevalence of traumatic injuries expressed as a percentage of individuals in different age and sex categories.*

Age Class	Male						Female						Both Sexes					
	Fractures*		Other Damages		Total		Fractures		Other Damages		Total		Fractures		Other Damages		Total	
Pups	3/20	15.0	0/12	0	3/20	15.0	2/13	15.4	1/8	12.5	2/13	15.4	5/33	15.2	1/20	5.0	5/33	15.2
2 yr.	2/6	33.3	1/6	16.7	3/6	50.0	5/7	71.4	1/5	20.0	5/7	71.4	7/13	53.9	2/11	18.2	8/13	61.5
3 yrs.	8/15	53.3	3/15	20.0	9/15	60.0	3/8	37.5	1/5	20.0	5/8	62.5	11/23	47.8	4/20	20.0	14/23	60.9
4 yrs.	10/15	66.7	6/15	40.0	13/15	86.7	1/4	-	3/4	-	3/4	-	12/19	63.2	9/19	47.4	16/19	8[illegible]
5 yrs.	2/6	33.3	4/4	-	4/6	66.7	3/7	42.9	1/4	-	5/7	71.4	5/13	38.5	5/8	62.5	9/13	69.2
6 yrs.	2/2	-	2/2	-	2/2	-	0/1	-	0/1	-	0/1	-	2/3	-	2/3	-	2/3	-
7 yrs.	0/0	-	0/0	-	0/0	-	1/1	-	0/1	-	1/1	-	1/1	-	0/1	-	1/1	-
Other Adults (Age Unknown)	1/3	-	0/0	-	1/3	-	0/2	-	0/0	-	0/2	-	1/5	20.0	0/0	-	1/5	20.0
Total	28/67	41.8	16/54	29.6	35/67	52.2	15/43	34.9	7/28	25.0	21/43	48.9	44/110	40.0	23/82	28.3	56/110	50.9

*First number is a fraction showing number of injured individuals (numerator) over total number of individuals examined in that class (denominator); second number is the resultant percentage of individuals injured in that class. Percentages are omitted for classes containing less than five individuals.

e 7-2. (Cont.)

Table 7-2B. Prevalence of traumatic injuries expressed as a percentage of the total anatomical sites examined in wolves of different age and sex categories.**

	Male			Female			Both Sexes		
Age Class	Fractures	Other Damages	Total	Fractures	Other Damages	Total	Fractures	Other Damages	Total
Pups	2.7	0	2.0	2.7	3.6	3.0	2.7	1.4	2.4
2 yrs.	6.1	5.6	5.9	14.3	5.9	11.9	10.7	5.7	9.1
3 yrs.	11.5	8.9	10.6	6.4	16.7	9.2	9.7	11.1	10.2
4 yrs.	16.9	16.3	16.7	(4.2)	(25.0)	(11.1)	14.2	18.2	15.5
5 yrs.	9.1	(35.7)	17.0	7.1	(20.0)	10.5	8.0	27.6	13.5
6 yrs.	(41.7)	(50.0)	(44.4)	(0)	(0)	(0)	(27.8)	(33.3)	(29.6)
7 yrs.	-	-	-	(16.7)	(0)	(11.1)	(16.7)	(0)	(11.1)
Adults (Age Unknown)	(5.9)	(0)	(5.3)	(0)	(0)	(0)	(3.6)	(0)	(3.2)
Total	10.2	11.7	10.7	6.4	12.3	7.8	8.7	11.6	9.3

rcentages are given in parenthesis for classes containing less than five individuals.

injured of any age class: 15.2 percent of 33 pups displayed injuries. Only 2.4 percent of the 255 potential sites examined in pups were damaged. Unfortunately, the number of individuals age 6-7 years was inadequate for comparisons.

Table 7-3 compares the prevalence of various traumatic injuries in different geographic areas. Injuries were observed with greater frequency among the Unit 20A wolves (42 of 75, or 56.0%) in comparison to the Unit 13 wolves (12 of 33, or 36.4%). Fractures in particular were more frequent among individuals of the former group (43.7%) than the latter (32.3%). Although the Unit 13 injury data might be somewhat inaccurate because many of these wolves were necropsied under less favorable conditions, it is possible that the relative scarcity of large ungulate prey in Unit 13 (McKnight 1976a, b) resulted in fewer opportunities for hunting-associated injuries there.

Within Unit 20A the percentage of examined individuals showing evidence of fractures was greatest in the flats-east (100% of 4) and foothills-west (71.4% of 7) areas, followed by the foothills-Little Delta (50.0% of 10) and flats-westcentral (45.5% of 11) areas. Percentages in the remaining four areas were similar and relatively low: foothills-east (37.5% of 8), foothills-central (33.3% of 15), Fairbanks (28.3% of 9) and flats-buttes (27.3% of 11). Whether these findings imply that wolves in the latter four areas prey upon large ungulates less frequently than those in the former four areas is considered elsewhere (Stephenson, in prep.). Complicating the comparison is the fact that the different areas had unequal distribution of pups (which were shown above to have fewer injuries) vs. older adults (which have had greater temporal opportunity for injuries).

Male wolves showed evidence of traumatic injury slightly more frequently than did female wolves: 52.2 percent of males (n = 67) and 48.9 percent of females (n = 43). Percentages of individuals suffering fractures and other damages were also similar (Table 7-2A). A slightly larger percentage of injury sites were in males (10.4% of 553 sites) than in females (7.8% of 348 sites). A large percentage (86.7%) of injuries was apparent among the 15 four-year-old males examined, including fractures of the ribs (4), humerus (1), radius-ulna (2), and femur (1), and skull damage (7), tooth damage (2), and injuries to the hide (3) and appendages (2). Although moderate percentages of females were injured, these injuries seemed to be more evenly distributed among the different age classes.

One complication in evaluating the prevalence of injuries in different age classes was the difficulty of determining the amount of time since the initial injury. While costal fractures probably heal quickly (within weeks), malpositioned fractures of the long bones subjected to constant stress may become chronically inflamed and thus are evident for years. Discussions of the appearance and location of different fractures and other injuries are detailed below.

Table 7-3. Prevalence* of wolves showing evidence of traumatic injuries compared to the total number of wolves examined from the same geographic area.

		Fractures		Other Damages		Total Traumatic Injury	
Unit	Area	Prevalence*	%	Prevalence*	%	Prevalence*	%
20A	(1) Flats-East	$\frac{4}{4}$	100.0	$\frac{2}{4}$	50.0	$\frac{4}{4}$	100.0
	(2) Fairbanks	$\frac{2}{9}$	28.3	$\frac{2}{4}$	50.0	$\frac{3}{9}$	33.3
	(3) Flats-Buttes	$\frac{3}{11}$	27.3	$\frac{5}{6}$	83.3	$\frac{7}{11}$	63.6
	(4) Flats-Westcentral	$\frac{5}{11}$	45.5	$\frac{2}{11}$	18.2	$\frac{5}{11}$	45.5
	(5) Foothills-East	$\frac{3}{8}$	37.5	$\frac{3}{8}$	37.5	$\frac{5}{8}$	62.5
	(6) Foothills-L. Delta	$\frac{5}{10}$	50.0	$\frac{3}{16}$	30.0	$\frac{6}{10}$	60.0
	(7) Foothills-Central	$\frac{5}{15}$	33.3	$\frac{1}{15}$	6.7	$\frac{6}{15}$	40.0
	(8) Foothills-West	$\frac{5}{7}$	71.4	$\frac{2}{7}$	28.6	$\frac{6}{7}$	85.7
	20A Subtotal	$\frac{32}{75}$	43.7	$\frac{20}{65}$	31.8	$\frac{42}{75}$	56.0
13	(9) Delta & Maclaren	$\frac{1}{2}$	50.0	$\frac{0}{2}$	0	$\frac{1}{4}$	25.0
	(10) Brushkana-Butte	$\frac{3}{12}$	25.0	$\frac{1}{9}$	11.1	$\frac{4}{12}$	33.3
	(11) Deadman	$\frac{1}{5}$	20.0	$\frac{1}{2}$	50.0	$\frac{2}{5}$	40.0
	(12) Oshetna	$\frac{4}{6}$	66.7	$\frac{0}{2}$	0	$\frac{4}{6}$	66.7
	(13) Gulkana, Copper	$\frac{1}{}$	16.7	-	-	$\frac{1}{}$	16.7
	13 Subtotal	$\frac{10}{31}$	32.3	$\frac{2}{15}$	13.3	$\frac{12}{33}$	36.4

Table 7-3. (Cont.)

Unit	Area	Fractures Prevalence*	Fractures %	Other Damages Prevalence*	Other Damages %	Total Traumatic Injury Prevalence*	Total Traumatic Injury %
5 & 26 (14)	Yakutat, Toolik	1/4	25.0	2/2	100.0	2/4	50.0
Total		43/110	40.1	24/82	30.3	56/112	50.0

*Prevalence is given as number of individuals showing evidence of traumatic injury type (numerator) over total number of individuals examined from that area (denominator).

A. Skull injuries

More than half (52.7%) of the 55 fractures and other bone injuries (observed in 43 individuals) involved the skull. Damage was evident in 29 (27.1%) of 107 individuals for which the cleaned, boiled skull (and teeth) were available. Frequency of damage evidence increased directly with age, with only 3 (9.4%) of 32 pups showing injuries, while 10 (27.8%) of 36 wolves age 2-3 years and 16 wolves (41.7%) age 4-7 years showed healed or healing injuries. Table 7-4 presents a description of the injuries observed. In 15 cases these were on the right side of the skull, in 10 cases they were on the left, and in 4 cases they were medially located. After dividing the skull into anterior and posterior halves (by an imaginary line through the center of the orbit), slightly more of the skull injuries were observed in the anterior part (17) than in the posterior part (18). Most were observed in the vicinity of the orbit (10) or on the extreme postero-dorsal part (9). Healed dents were the most frequently observed injury (10), followed by small osteophytic growths marking the site of localized trauma (Jubb and Kennedy 1970) on more exposed locations (6) and flattening of the posterior sagittal crest (5). Each of four individuals displayed fairly deep, regular, penetrating "hole" injuries, occurring near the mouth in two (#61369, 61349), near the orbit in one (#61388), and near the anterior sagittal crest in one (#61310). the latter injury, in female pup #61310, differed somewhat in conformation from the others, with the hole shallow and conically shaped. Although the trajectory of the first three holes appeared to be at or slightly below the level of the animals' heads, the fourth had penetrated from the dorsal surface. Some or all of these injuries may represent healed bite wounds.

B. Costal fractures

The ribs were the second most frequent fracture site after the skull: costal fractures accounted for 29.1 percent of the total 55 fractures observed. Evidence of costal fractures was present in 16 (16.3%) of the 98 wolves examined. Surprisingly, 14 of the 16 individuals were males, with 10 in the age 3-4 years class. The injured individuals were fairly evenly distributed among the different packs and geographic areas.

Table 7-5 presents a description of the costal fractures observed. In two cases fractures were evident on both sides of the body, in nine cases only the right side was involved and in five cases only the left. The proximal shaft (just ventral to the angle) of those ribs on the latero-dorsal body immediately posterior to the scapula (numbers six and seven) evidently received traumatic injury with the greatest frequency. Of the 23 total ribs broken (in 16 individuals), 13 (56.5%) were ribs numbers six and seven together, 3 (13.0%) were rib number six only, 3 (13.0%) were rib number eleven, 2 (8.7%) were rib number ten, one (4.4%) was rib number nine and one (4.4%) was rib number twelve (Table 7-5). Most of the fractures were located within 25 cm of the spine, with seven from 5 to 9 cm, four from 10 to 14 cm, four from 15 to 19 cm, and one each at 20 and 22 cm.

Table 7-4. Wolves, listed by geographic area, showing evidence of skull injuries of various kinds, with a description of the character, dimensions and anatomical location of each skull injury observed (X marks the general anatomical site).

							Injury location						Injury associated with
							General location				Specific location		
Geographic area	Pack	Wolf			Injury character		Front		Back		Bone	Locale	
		No.	Sex	Age	Character	Dimen. (mm)	Side	Top	Side	Top			
Unit 20A													
Flats-East	A	61348	M	4	Dent	15 x 15		X			Frontal	Right Anterior	Orbit
	B	61387	F	5	Dent	45 x 20	X				Maxilla	Right Posterior	Muzzle
Fairbanks	C	61357	M	6	Dent & Crack	20 x 20 x 5	X				Maxilla	Left Posterior	Orbit
	RC	61403	F	5	Flatten	-				X	Occipital	Post. Sagittal Cr.	-
Flats-Buttes	D	61364	M	4	Flatten	-				X	Occipital	Post. Sagittal Cr.	-
Flats-West-central	E	61352	M	3	Dent	8 x 10	X	X			Frontal & Zygomatic	Left Anterior	Orbit
	F	61359	M	4	Ophyt.	10 x 10				X	Frontal	Right Tip Zygo. P.	Orbit
	F	61360	M	2	Dent	35 x 15		X			Frontal	Left Anterior	Forehead
Foothills-East	V	61369	F	2	Hole	8 x 8					Palatine	Right Medial	Mouth
	V	61388	F	7	Hole	6 x 6	X				Frontal	Right Anterior	Orbit
Foothills-Little Delta	T	61374	M	4	Flatten	-				X	Occipital	Right Medial Cr.	-
	U	61379	M	6	Porous	40 x 30	X				Maxilla	Right Anterior	Canine
	U	61351	M	PUP	Ophyt.	40 x 25				X	Parietal	Right Anterior Cr.	-
	T	61372	F	3	Ophyt.	8 x 20				X	Parietal	Right Posterior	-
					Ophyt.	5 x 8	X				Zygomatic	Right Anterior	Orbit
	U	61349	F	PUP	Hole, Porous	13 x 8 40 x 25	X				Mandible	Right Lateral	Mouth
Foothills-Central	GK	61410	M	4	Dent	25 x 40 x 8	X				Maxilla	Left Posterior	Orbit
	X	61336	M	2	Dent	10 x 15		X			Nasal & Incisive	Left Anterior	Nose
	W	61346	F	2	Cracks	6 x 26		X			Nasal & Incisive	Left Anterior	Nose
Foothills-West	Z	61384	M	5	Dent	30 x 35 x 10	X				Maxilla	Left Posterior	Orbit
	Y	61395	M	4	Flatten	-				X	Parietal	Right-Medial Cr.	-
	Y	61393	F	5	Dent	10 x 5		X			Frontal	Left Anterior	Forehead

Table 7-4.. (Cont.)

Geographic area	Pack	Wolf			Injury character		Injury location						Injury associated with
							General location				Specific location		
							Front		Back		Bone	Locale	
		No.	Sex	Age	Character	Dimen. (mm)	Side	Top	Side	Top			
Unit 13													
Brushkana-Butte	BBK	61304	M	4	Dent	30 x 15	X				Maxilla	Left Posterior	Orbit
	BBK	61310	F	PUP	Hole	11 x 5 x 1				X	Parietal	Right Anterior Cr.	-
Deadman	DDP	61317	M	3	Cracks			X			Nasal & Incisive	Medial	Nose
Oshetna	OHP	61320	M	AD	Ophyt.	-				X	Occipital	Right Post. Cr.	-
	OHP	61321	M	3	Flatten	-				X	Occipital	Medial Cr.	-
	OHP	61322	F	2	Ophyt.	-			X		Zygomatic	Left Anterior Th.	Orbit
Gulkana, Tok Copper		61328	F	3	Dent Porous	50 x 30	X				Maxilla	Anterior Right	Canine
Units 5 & 26													
Yakutat & Toolik	TOO	61380	F	4	Flatten Ophyt.	-				X	Occipital	Posterior Cr.	-

Table 7-5. Wolves, listed by geographic area, showing evidence of costal fractures, with the involved rib listed and the anatomical location and character of the fracture noted. N = normal, no injuries apparent.

	Wolf				Right Ribs			Left Ribs		
Geographic area	Pack	No.	Sex	Age	rib number(s)	cm from spine	comment	rib number(s)	cm from spine	comments
Unit 20A										
Flats-East	B	61389	M	3				7	17	Lump
Fairbanks	C	61357	M	6	7	12	Lump	7	8	Lump
Flats-Buttes	LON	61353	M	5	11, 12	5	Lumps	7	15	Lumps
	D	61355	M	4	8	15	Lump			N
Flats-West-central	F	61359	M	4	10	15	Lump			N
	F	61377	M	4	8	20	Sm. Lump Well Healed			N
Foothills-East	V	61368	M	3			N	6	8	Lump
Foothills-Little Delta	U	61379	M	6	10	8	Sm. Well Healed			N
Foothills-Central	GK	61410	M	4	7	22	Large Lump			N
	X	61339	M	3	8	6	Callus			N
Foothills-West	Z	61385	M	PUP			N	6, 7, 8	10	very soft callus
	Y	61394	F	3			N	7, 8, 9	7	Callus
Unit 13										
Brushkana-Butte	BBK	61312	F	2	11	?	Lump			N
Deadman	DDP	61317	M	3	11	10	Well-Healed			N
Oshetna	OHP	61321	M	3				6	6	Lump
	OHP	61324	M	3	8	13	Callus			N

Total: 16 individuals 14M
2F Right only: 9 Left only: 5 Both sides: 2

The costal fractures were observed in a variety of healing stages. The only evidence of a possible fracture in three-year-old male #61317 was a slight disorientation of the distal section with respect to the proximal. Other well-oriented fractures healed to this extent may have been overlooked at necropsy. In two individuals (#61377 and 61379) a small, hard lump at the fracture site was the only evidence of previous damage. In eight wolves a more sizeable hard lump, with a maximal width from a quarter to a third greater than the remainder of the rib, probably marked the site of a more recent fracture. Two wolves (#61410 and 61324) had somewhat more recent fractures, judging from the plasticity of the calluses (Jubb and Kennedy 1970), which had widths about half again greater than those of the undamaged shafts. Finally, two wolves displayed very soft calluses from which the broken ends of the rib shaft spontaneously separated as the ribs were disarticulated and removed from the carcass. Both of these cases involved adjacent fractures of three ribs: ribs six, seven and eight in male pup #61385, and ribs seven, eight and nine in three-year-old female #61394. In the latter individual the break site in rib seven was marked by the largest callus and in rib nine by the smallest callus (perhaps marking only an incomplete fracture), with rib eight displaying a callus of intermediate size. Interestingly, these two wolves were both collected in the foothills-west area of Unit 20A, although they were apparently members of different packs.

One additional individual, three-year-old male #61339, displayed an apparently recent incomplete fracture. Trauma to the centerline of the shaft of rib eight (right) had resulted in a splitting of the rib as well as a lateral break, so that in the proximal segment the two longitudinally broken parts of the shaft diverged in a V-shape as they approached the site of the lateral fracture. The distal segment of the lateral fracture was nearly a single head, with only a small longitudinal splinter protruding posteriad. When observed at necropsy these four segments were joined by a large, soft callus. Apposition of the larger proximal and distal splinters was not favorable, and the fracture might ultimately have healed as a permanent pseudoarthrosis (Robbins 1974).

C. Foreleg fractures and bone abnormalities

Evidence of traumatic injury to the major bones of the foreleg accounted for 9.1 percent of the total fracture-type injuries observed. These injuries were observed in 5 (4.6%) of the 110 individuals examined.

The humeri were noted only superficially at necropsy, and a single healing fracture was discovered. The affected animal was four-year-old male #61374 from the foothills-Little Delta area (pack T) of Unit 20A. The right humerus had apparently been broken in mid-shaft, and the two broken ends had slipped past each other to rest side-by-side, thus shortening the length of the bone to 22 cm. The left humerus, undamaged, measured 26 cm in length. A callus of firm cartilaginous material immobilized the ends of the fracture. The callus measured 20 cm in diameter and was apparent externally as a large lump. The firmness of the callus indicated the fracture was not recent, but the presence of inflammatory material and fistulae indicated the presence of chronic infection (Jubb and Kennedy 1970). No other evidence of traumatic injury was apparent in this individual.

The radii and ulnas were also noted superficially at necropsy for 110 individuals, but a single radius-ulna unit was saved, cleaned and available for more detailed examination from each of 103 wolves. Evidence of traumatic injuries was apparent in four animals, with one showing evidence of bilateral foreleg injury. This individual, four-year-old male #61359 from the flats-westcentral area (pack F) of Unit 20A, had a large callus associated with a fracture of both the right radius and ulna just below the elbow joint. The primary damage seemed to be on the lateral surfaces, but the entire joint (i.e. the distal head of the humerus and the proximal heads of the affected radius and ulna) appeared noticeably enlarged. A careful examination of the radius and ulna from the left side revealed an additional feature of interest: a sizeable eroded groove across the posterior third of the proximal articular surface of the left radius, perpendicular to the direction of joint motion. The irregular groove measured approximately 4 x 15 mm, and was from 1 to 1.5 mm deep. The etiology of this lesion was not immediately apparent, although unusual stress on the joint because of the corresponding right joint injury, or even an autoimmune mechanism, may have been involved (Jubb and Kennedy 1970, Robbins 1974). This same individual displayed a healing costal fracture on the right side (see above, part B, and below, part H).

A second wolf had foreleg injuries which were apparent at necropsy. Two-year-old female #61369 from the foothills-east area of Unit 20A (pack V) had a small lump in the right radius at mid-shaft. No shortening of this bone was evident when compared with the normal left radius.

The remaining two wolves had foreleg injuries which were only apparent upon detailed examination of the cleaned bones. Three-year-old male #61332 (from the foothills-central area of Unit 20A, pack W) displayed a large bony proliferation (osteophyte) 8 x 12 x 23 mm, extending medially from the distal articular surface of the right radius. Four-year-old male #61304 (from the Brushkana-Butte Creek area of Unit 13, Brushkana pack) had small, irregular bony osteophytes on both the distal radius and ulna at the articular surfaces of the ulnar notch. Both of these proliferative bone lesions were probably the result of localized trauma to the foreleg (Jubb and Kennedy 1970). The former lesion probably had more debilitating, painful effects than the latter (J. C. Beckley, pers. comm.).

An incidental finding was the occurrence of a small, narrow ridge on the posterior edge of the ulna in 9 (8.7%) of the 103 specimens which were cleaned and examined. The ridge was located between 67 and 72 mm from the distal end of the ulna in eight of these individuals, and 38 mm from the distal end in the ninth. The length of the ridge varied from 8 to 20 mm and the maximum height from 1 to 4 mm. Apparently the ridge serves as a tendinous attachment site, although the detailed anatomy of the domestic dog ulna by Miller et al (1964) mentions no such site. There appeared to be no correlations between the occurrence of the ridge and pack association, geographic area, sex, age, or traumatic injuries.

D. Hindleg fractures

Hindleg injuries were observed in five wolves, and accounted for 9.1 percent of the total fractures observed. The tibia and fibula were examined superficially at the necropsy of 110 individuals, and the femur of 105 animals was noted more carefully as it was removed and partially cleaned.

Three femur injuries (2.9% of the total examined) were noted. Male pup #61302 (Unit 13, Maclaren pack) and two-year-old female #61350 (Unit 20A, flats-east area, pack A) both displayed healing incomplete fractures which were in the form of a splinter along the distal part of the posterior midline of the shaft, i.e. along the popliteal surface. Highly vascularized cartilaginous material joined the splinter to the femur shaft in both cases, so both injuries appeared to be recent. Neither individual displayed other evidences of traumatic injuries.

Another femur injury, apparent in four-year-old male #61356 (from Unit 20A, flats-westcentral area, pack E), involved the distal third of the shaft. The fracture site appeared as a hard, well-healed lump extending 11 cm dorsad from the condyles. The affected left femur was 24 cm long in comparison to the normal right femur's 26 cm. It is possible that the two ends of a simple fracture near the condyles had slipped past one another to lie side-by-side, as in the humerus described above (#61374), thus shortening the femur. No other evidence of traumatic injuries was apparent.

Two individuals displayed healing fractures of the tibia and fibula with inflammatory material and fistulae formation indicating the presence of chronic infection: these were six-year-old male #61379 (Unit 20A, foothills-Little Delta area, pack U) and five-year-old male #61384 (Unit 20A, foothills-west area, pack Z). In both cases a fracture of the left tibia and fibula had resulted not only in the shortening of these bones, but also in torsion of the entire limb. A large chronic callus (girth 15 cm in #61379 and 18 cm in #61384) involved both the tibia and fibula in each individual. The callus was 15 cm in girth and 8 cm long and located just above the distal (hock) joint in #61379. In #61384 the chronic callus was 18 cm in girth and located 12 cm above the distal joint. The tibia-fibula were shortened by 2 cm in #61379 and 8 cm in #61384, and in both cases the limb had rotated laterally so that the left foot pointed about 10^{o} outward. Apparently the outward rotation of the limb was even apparent from the animals' tracks in the snow (Shepherd, pers. comm.), and both animals would have presumably had a limping gait. In addition, both individuals displayed evidence of skull injuries (Table 7-4) and #61379 had costal fractures as well (Table 7-5).

E. Traumatic injuries to teeth

Skulls and mandibles (with associated teeth) of 106 wolves were cleaned, boiled and examined. In many cases the incisors, premolars and occasionally the canines were loosened by boiling, but most teeth were in place. Thirteen (12.3%) of the 106 specimens showed evidence of traumatic injury to the mouth as evidenced by broken (11 cases) or completely missing teeth (2 cases). Table 7-6 presents these findings. Six males and 7 females displayed apparently traumatic dental injuries; 9 of the 13 individuals were age 4 or 5 years, and 4 of the 13 were from the flats-buttes area of Unit 20A.

Four of the 13 wolves with injured teeth displayed evidence of other traumatic injuries to the skull (#61403, 61384, 61328 and 61380; see Table 7-4), but in only one case, which is discussed in detail below (#61328), did the skull injuries appear to be directly associated with the dental damage. The prominent canine teeth were broken most frequently (11 cases), while the large, shearing carnassials were chipped on their more exposed buccal aspect in two cases. Premolars I and II were missing from the left maxilla of #61347, and the alveolar bone had healed over entirely.

In three cases inflammation of the alveolar bone at the roots of a missing (#61328) or broken canine (#61353 and #61403) had apparently lead to necrosis of the associated maxilla (Severin 1968; see Table 7-6). The largest maxillary area involved was that of three-year-old female #61328, which also had a small dent in the maxilla directly above the root of the broken canine. Over what was apparently at least a moderate period of time the inflammation associated with the injuries in this individual had caused an osseous resorption and proliferation resulting in irregular cracks, lumps and ridges over an area of 30 x 50 mm, or most of the anterior half of the right maxilla.

F. Traumatic injuries of the skin

The condition of the skin and subcutaneous tissue of 81 wolves was noted during the skinning procedure, and 12 (14.8%) had abrasions or abcesses, apparently the results of recent traumatic injuries (Table 7-7). Ten (18.9%) of the 53 males examined had skin damage in comparison to only 2 (7.1%) of 28 females examined. All of the injured males were age 3 years or older. There seemed to be a greater incidence of skin injuries among wolves from the flats area (7, or 28.0%, of 25 examined) than among those from the foothills area (3, or 7.7%, of 39 examined) of Unit 20A or those from Unit 13 (1, or 6.7%, of 15 examined).

The most common skin injury observed was abrasions. As indicated in Table 7-7, 8 of the 12 injured individuals displayed abrasions of the head area (#61349), foreleg (#61379, 61343), dorsum (#61352), or hindleg (#61389, 61357, 61377, 61370). In five cases the abrasion was nearly healed and appeared as an area of sparse or unusually short hair (#61389, 61352, 61377, 61370, 61379), in two cases scabs still covered part of the abrasion (#61349, 61343), and in two cases abscesses were encountered in association with abrasions (#61389, 61357). An additional individual (#61377) displayed signs of a recent bruise with localized hemosiderosis and edema, but no external abrasions were evident.

Small, round wounds such as might have been made by buckshot or by the canine teeth of another wolf were observed in two individuals. In

Table 7-6. Wolves, listed by geographic area, showing evidence of traumatic injuries to the teeth as described.

Geographic area	Wolf				Evidence of traumatic injury to teeth
	Pack	No.	Sex	Age	
Unit 20A					
Fairbanks	RC	61403	F	5	Left upper and right lower canines broken off, porous bone and cavity beneath right lower canine
Flats-Buttes	L	61353	M	5	Left lower canine front aspect broken off and porous bone at base, left upper carnassial buccal aspect broken off
	D	61355	M	4	Right upper canine broken off
	RL	61397	F	5	Right upper and lower canines chipped
	RL	61407	F	3	Left upper canine broken off
Foothills-East	V	61367	M	4	Right upper canine chipped
	V	61390	F	5	Left upper and lower canines broken off
Foothills-Central	W	61347	F	4	Left upper premolars I and II missing and healed over
Foothills-West	Z	61384	M	5	Left upper and lower carnassials chipped on buccal surfaces
Unit 13					
Brushkana-Butte Creek	BBK	61311	M	2	Left upper canine broken off
Gulkana, Copper	TOK	61328	F	3	Right upper canine completely broken off and healed over, porous bone and proliferation at base (anteroventral maxilla)
Units 5 & 26					
Yakutat,	Y1	61343	M	3	One lower canine broken off (other lower canine not available for study)
Toolik	TOO	61380	F	4	Left upper canine broken off

Total: 13 wolves

Table 7-7. Wolves, listed by geographic area, showing evidence of traumatic injuries to the skin, or subcutaneous tissue as described, with dimensions and anatomical location noted for each.

Geographic area	Wolf				Surface dimensions of damage(mm)	Location of damage	Description of damage
	Pack	No.	Sex	Age			
Unit 20A							
Flats-East	A	61348	M	4	20 x 20	Right shoulder, cranial angle of scapula	Cystic structure with fistula (opening 2 mm)
	B	61389	M	3	5 x 5	Right gastrocnemius, posterior aspect	Healing skin abrasion
		61389			10 x 15	Left sartorius and postero-lateral abdomen	Healing abrasion and resolving subcutaneous abscess
Fairbanks	C	61357	M	6	20 x 50	Left popliteal	Healing abrasion and associated abscess
		61357			5, 5(dia)	Left popliteal	Two round holes covered by common scab, pockets of purulent exudate
	C	61358	M	4	20 x 20	Left dorsum, mid-body	Fluid-filled cystic structure with smooth (1-mm thick) wall
Flats-Buttes	D	61354	M	5	8 x 8	Near umbilicus	Herniation of ventral peritoneum and associated abdominal fat
Flats-West-central	E	61352	M	3	120 x 150	Anterior dorsum (central and posterior thoracic vertebrae)	Healed abrasion (?): hide area with short hairs, no guard hairs
	F	61377	M	4	25 x 50	Right popliteal	Abasion, no associated inflammation evident
					5 x 5	Left lateral hip (mid-ilium)	Recent bruise of cutaneous/subcutaneous tissue
Foothills-Little Delta	T	61370	M	5	25 x 90	Left mid-tibia/fibula	Healing abrasion
	U	61379	M	6	10 x 15	Left front foot: digit III	Small abrasion
	U	61349	F	PUP	30 x 50	Right maxilla	Healing abrasion with several small scabs
Unit 13							
Deadman	DDP	61318	F	4	8 x 8	Dorso-lateral thoracic	Two healed circular wounds (as from shotgun) with hair everted in center of each
Units 5 & 26							
Yakutat	Y1	61343	M	3	20 x 30	Latero-distal right ulna	Two healing abasions covered by separate scabs

six-year-old male #61357 there were two such wounds in the left popliteal area near an abrasion, with pockets of inflammatory exudate beneath the wounds. The location and spacing of these injuries were consistent with bite and slash wounds by another wolf. When collected this particular animal was part of pack C, from which three other individuals, all males, were also collected (four-year-olds #61358 and #61376, and three-year-old #61365). In the second individual, four-year-old female #61318, the small round wounds occurred on the dorso-lateral thoracic area and could have been buckshot wounds. In these cases the wounds were well healed in a rim around a central focus of inverted (internally directed) hair.

Rather unusual features were encountered in the skin of three individuals. In two wolves (#61348, 61358), moderate-sized cysts were encountered in the subcutaneous tissue of the back. The empty cystic structure appeared to communicate with the exterior via a small fistula in #61348, while in #61358 the cyst was filled with a clear fluid, had a thin fibrous wall, and lacked an external opening. In both cases the cyst-like structures were slightly encapsulated but no inflammation was apparent. The structures were considered to be remnants of resolved traumatic injuries for this discussion, but might also have been epidermal inclusion cysts resulting from the occulsion of the mouth of hair follicles (Smith et al. 1974). The third individual, five-year-old male #61354, had an apparent umbilical hernia consisting of a portion of parietal peritoneum and associated mesenteric adipose tissue protruding through the linea alba in the umbilical area and lying within the hypodermis. Although the actual size of the wall defect measured less than 3 by 8 mm the entire hernial sac was about 80 mm long. No portion of the intestine or major blood vessels was apparent in the sac, nor were there any apparent signs of necrosis, inflammation or encapsulation. These hernias occasionally are seen in domestic dogs as the result of slight damage to the abdominal wall of the newborn pup when the bitch bites off the umbilical cord (J. C. Beckley, pers. comm.).

G. Damage to minor appendages

Six (7.4%) of 81 wolves examined during skinning and hide preparation had damage to their minor appendages. All six were from Unit 20A, with three from a single area near Fairbanks, the flats-buttes area, which supports a considerable number of traplines.

Three individuals were missing a digit (including phalanges): four-year-old male #61355 lacked one from the right hind foot, four-year-old male #61391 lacked digit III from the right front foot, and two-year-old female #61369 lacked both digits II and III from the right front foot. The first two individuals were collected from an intensively trapped area and may have each lost a digit in a trap. The third individual (#61369) had a healing fracture of the right radius (discussed above, section C) which may have been associated with the foot injury.

Three individuals had damaged ears. Five-year-old male #61353 lacked the distal third of the left pinna, and six-year-old male

#61357 and three-year-old female #61386 each had a deep (3.5 cm) notch in the distal left pinna. The wounds were well healed in all three cases.

H. Multiple traumatic injuries

As might be expected from both the mode of life of the wolf and the primary method of collection (i.e. moving groups of wolves were sighted from aircraft), all animals taken were in generally fit condition. Of particular interest, however, were six individuals which showed signs of having recovered from multiple traumatic injuries. All of these animals were collected in the Unit 20A aerial hunt, and five of the six were older males (age 4, 5 and 6 years).

Case 1. Six-year-old male #61357 (Fairbanks area) had recovered from a considerable dent of the right maxilla, two broken ribs (one on each side), and a notched ear pinna. A moderate abscess was healing on the left thigh as well. At the time of collection this individual was in relatively poor nutritional condition.

Case 2. Five-year-old male #61353 (flats-buttes area) had recovered from three broken ribs, had chipped and broken teeth, and was missing part of an ear pinna. Although this was the heaviest (53 kg) animal collected, it was in only fair nutritional condition and the quality of its hide was the poorest encountered.

Case 3. Four-year-old male #61359 (flats-westcentral area) had recovered from damage to the right frontal bone and to a right rib. A very large callus showing evidence of chronic inflammation was located at the right elbow where the radius and ulna had been broken, and an unusual groove in the articular surface of the left radius was also observed. This individual was in good nutritional condition, with abundant omental fat.

Case 4. Two-year-old female #61369 (flats-westcentral area) had an 8 mm hole penetrating the roof of the mouth, a fracture of the right radius and ulna, and had two missing front toes. This individual was in fair condition and was not pregnant or in estrus at the time of collection.

Case 5. Six-year-old male #61379 (foothills-Little Delta area) showed evidence of sustaining the most injuries of any wolf studied. A healed fracture of the left tibia and fibula had rotated the leg outward (as discussed above); there was a healed fracture of a right rib; the right maxilla showed evidence of inflammation in association with a missing right canine; and a middle digit on the left hind foot showed abrasions. Apparent phosphate calculi were observed in the left kidney. This individual was in fair to poor condition at the time of collection.

Case 6. Five-year-old male #61384 (foothills-west area) had recovered from a large dent to the left maxilla, had several chipped teeth, and had a very large callus at a fracture site of the left tibia and fibula which had considerably shortened and rotated the limb. This individual was in good nutritional condition at the time of collection.

Discussion: Traumatic injuries

Evidence of traumatic injury was encountered in the hide, subcutis or skeleton of 56 (50.9%) of 110 wolves. Injuries included dents in the skull, chipping and damage of the teeth, fractures of long bones and ribs, abrasions and abcesses of the hide and subcutis, and damaged or missing ears or toes. Of 901 sites inspected for injury in the 110 wolves, 85 (9.3%) displayed evidence of injury.

Wolves of ages 4 and 5 years were the most frequently injured of any age class, while pups were the least frequently injured. This is contrary to the expectations of Mech (1970), who believed that pups would be the most frequently injured members of the population. Fractures in particular were encountered most often in age classes 2 and 4 years (Table 7-2A, B). A possible explanation is that these age classes suffer a larger proportion of injuries while hunting large game. Older, more experienced animals may be better able to avoid injury, and pups might participate less fully in the kill and thus also have reduced risk. Stephenson and Ahgook (1975) observed that both pups and aged wolves rarely participate actively in killing large prey.

Less severe, non-fracture injuries were encountered most frequently in older wolves. Chipped teeth, hide lesions, and minor appendage damage are perhaps more often associated with intraspecific fighting, or with trapping injuries. The likelihood of accumulating these less debilitating injuries apparently increases directly with age.

Considerable variation in the percentages of injured individuals (or sites) was encountered in different areas. Fracture injuries in particular were relatively frequent in parts of Unit 20A, but were less frequent in other parts of that unit and in Unit 13. Fractures are most likely to be sustained while hunting, and the unequal distribution of large ungulate prey species capable of inflicting these injuries on wolves may be a cause of this differential (McKnight 1976a, b). Possible geographic variations are partially obscured by unequal distribution of pups vs. older age classes in the different areas.

Similar percentages of injuries were found in males and females, except that broken ribs were primarily found in males. Males, however, showed a sizeable percentage of injuries concentrated in the four-year-old age class, while the percentages among females were more evenly distributed in all adult age classes. While age-related differences in hunting behavior and, hence, risk of injury are recognized (Stephenson and Ahgook 1975), sex-related hunting roles are unknown. However, the lighter weight and greater agility of females (Stephenson, pers. comm.) may give them advantages in avoiding injury in many diverse situations.

Skull fractures were very common, occurring in 27 percent of 107 wolves examined and accounting for 53 percent of all fractures observed.

Frequency of skull damage increased with age. Because healed skull fractures were so often observed both in this study and elsewhere (Rausch 1966, Mech 1970), wolves are apparently able to recover from fairly severe head injuries. A recent example was four-year-old female #61380. This individual was struck in the evening by a vehicle and sustained, among other injuries, an extensive fracture in the right orbit area of the maxilla and frontal bones. Apparently a fracture of this severity was not immediately fatal, because she left the accident scene and apparently lived for several hours before being found dead the next morning some distance away. Necropsy revealed numerous visceral injuries and apparent death from internal hemorrhaging. This history, together with the sizeable extent of dent-shaped healed fractures in the skulls of several other individuals, suggest that wolves can frequently recover from severe injury to the skull if damage to the brain itself is avoided.

In his examination of 1250 Alaskan wolf skulls Rausch (1966) found numerous healing compression fractures involving the nasal and frontal bones that suggested heavy blows with a blunt object such as the hoof of a moose (*Alces alces*). He felt that similar blows delivered a few centimeters higher on the skull would be sufficient to kill. A number of skulls examined in the present study displayed injuries to the parietal bone, but these all consisted of damage (primarily flattening) of the posterior saggital crest. The paucity of severe penetrating injuries to the area of the braincase is understandable, since this would undoubtedly result in immediate mortality. As Rausch (1966) noted, there is no way of determining the relative frequency of such mortalities. However, the actual area which is crucial for survival may be rather small, involving only the posterior half of the frontal bones, the parietals, and the dorsal half of the temporals. The ventral part of this particular area is well protected by the large temporalis muscle mass, and heavy fur on the posterior part of the head may also cushion blows.

A number of costal and limb fractures were observed in various stages of healing. Several poorly oriented costal fractures may have ultimately become pseudoarthroses, while several limbs fractured displayed fistulae and inflammatory material characteristic of chronicity (Jubb and Kennedy 1970). In four cases an entire injured limb was shortened relative to the normal member, and in two cases torsion of the affected limb was also observed. Mech (1970) related several occasions in which wolves sustained fractures of the limbs, pelvis, ribs and skull while hunting moose, and Cross (1940) postulated that arthritis seen in two Canadian wolves was the result of old costal, pelvic and limb fractures.

Tooth damage was most apparent among the canine and carnassial teeth. In several cases the damage had resulted in inflammation of the alveolar bone and the associated maxilla, a common cause of tooth loss among domestic canids (Severin 1968). Since the canine and carnassial teeth are the wolf's primary aggressive tools (Mech 1970), they are most subject to traumatic injury. Accordingly, most of these injuries were observed in older adults.

Older male adults displayed most of the skin and subcutis injuries observed, including abrasions, bruises, damaged ears, and apparent bite wounds. All of these might result from intraspecific aggression, but other injuries, including apparent buckshot wounds and missing digits, were man-related.

Six wolves were noteworthy for the multiple traumatic injuries they had sustained, yet five of these were in good or fair nutritional condition. Although traumatic injuries of varying severity are frequently encountered among wolves, the species apparently has substantial recovery abilities. This is necessitated by a mode of life demanding considerable mobility as well as adaptation to severe periodic physical stress and malnutrition. Social interactions may also encourage minimal display of and rapid recovery from traumatic injuries (Rausch 1966, 1967, Stephenson and Johnson 1973).

CONCLUSIONS

Sexual differences were encountered in the body and organ weights relative to growth of wolves, and these were dissimilar in many respects to those observed for domestic canids. Preliminary necropsy findings also included a number of apparent pathological changes, although many appeared to be of little clinical significance. But even moderately debilitating lesions would not be expected with frequency in a free-living wolf population.

The relatively high proportion of young wolves in this population, however, indicates that mortality factors are certainly operating on individuals older than five years (Stephenson, in prep.). lthough the preliminary necropsy findings did not make these factors readily apparent, several lesions encountered are of potential significance. In particular, the age-related (progressive?) renal cortical lesions of unknown etiology could exert direct detrimental effects differentially on older individuals. Kidney problems might also be exacerbated by interacting with seasonal or geographic variations in dietary intake (including vitamins and minerals) and drinking water. In addition, during starvation the renal cortex assumes an important role in vital gluconeogenesis and metabolic interactions (Lehninger 1975). Increased extensions in severity of renal lesions or of several of the other apparent pathological changes observed could result in mortality by acting: (1) in combination with one another, or (2) during periods of stress or malnutrition, or (3) when traumatic injuries are added to the burden.

Many of the apparent pathological changes observed were nonspecific and could easily be associated with a variety of pathogens that have been reported from wolves in Alaska and elsewhere (see Background). Any of these pathogens could markedly influence the dynamics of the population by acting differentially on either previously unexposed pups and juveniles or on older adults debilitated by traumatic injuries or other factors. Serological, histopathological, and endocrine studies planned for the future should, in combination with the preliminary necropsy information presented here, provide greater insight into the many health-related factors influencing a free-living wolf population.

RECOMMENDATIONS

The continuing presence and perhaps constantly varying character of health-related factors should always be considered in the management of Alaskan wolf populations. Even at low population densities, mortality due to traumatic injuries and perhaps progressive renal problems occurs continuously, and at high densities additional disease-related mortality might operate differentially on pups. Thus, health-related factors undoubtedly affect population dynamics and are in turn affected by them. Until such factors are better understood, important causes of wolf mortality remain unknown or poorly understood.

Further specialized investigations of health-related factors should continue. In future necropsies, several phenomena warrant special attention. Serum antibody titers to the significant diseases known to occur elsewhere in wolf populations should be analyzed. This would not only establish the presence of these potential mortality factors in the Alaskan wolf population but would also indicate the wolf's role in carrying and transmitting pathogens to other species in the ecosystem. In particular, the prevalence of renal cortical scarring in different populations and in different areas of the state should be evaluated for individuals of various ages. Those few wolves found dead or moribund in the wild should be carefully necropsied in as much detail as possible.

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