THE VANCOUVER ISLAND WOLF (*Canis lupus crassodon*), AN INITIAL STUDY OF FOOD HABITS AND SOCIAL ORGANIZATION

by

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ABSTRACT

The food habits and social organization of Vancouver Island wolves (_Canis lupus crassodon_ Hall) inhabiting an area on Northeastern Vancouver Island were studied from January, 1977 through January, 1979. During this period, two adjacent packs were studied in detail between March and November, 1978.

Three members of the Upper Adam pack, an adult male, adult female and yearling female, were captured, fitted with radio-transmitters and subsequently radio-tracked for five months (April to August, 1978). The same procedures were carried out on the adult male and female of the Lower Adam pack, who were radio-tracked for eight and five months respectively (April to November; April to August). A lone male was captured and tracked for eight months (November, 1978 to June, 1979).

Black-tailed deer (_Odocoileus hemionus columbianus_) were the major prey in the diet of both packs, while Roosevelt elk (_Cervus elaphus roosevelti_) and beaver (_Castor canadensis leucodontus_) were utilized as secondary food sources. Seasonal variation in the diet of the wolves was apparent, with deer fawns and elk calves constituting the bulk of the summer (June 1 to August 31) diet. Beaver were taken primarily during the winter months.

Individual packs showed different foraging patterns. The Lower pack depended less upon adult elk during the winter and more upon ungulate young during the summer, while the Upper pack utilized relatively more adult elk during the winter with more emphasis on adult deer as opposed to ungulate young during the summer.

The Upper pack consisted of ten individuals, two adult males, one adult female, one yearling femaling, two unknown, and four pups. The radio-collared members inhabited a 64 km^2 home range. Wolf density within their home range was one per 6.4 km^2.

The Lower pack consisted of five individuals including one adult male, one adult female, and three pups which ranged throughout a 75 km^2 area. Density within this area was one wolf per 15 km^2.

Den sites were situated within pristine coniferous timber where hollow logs, tree bases and root systems were utilized for denning purposes. Both packs occupied densites from late April until mid-July. During the post-denning period rendezvous sites were frequented, situated in open meadows bordering on timber stands or river side areas. Both types of sites were generally typified by a water source nearby, structural suitability giving a view of the surrounding area, activity and resting areas, and several well used trails.

Seasonal shifts in the use of core areas of home ranges were apparent for both packs, and den and rendezous sites were spatio-temporally distributed at significant distances from adjacent pack sites.

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1. INTRODUCTION

The wolf (*Canis lupus*) is a large canid widely distributed throughout the northern hemisphere. From the earliest times, it has held the interest of *Homo sapiens* and since the early 1940's has been the subject of numerous detailed studies both in North America (Murie, 1944; Mech, 1966; Pimlott *el al*., 1969; Carbyn, 1974; Haber, 1977) and Eurasia (Makridin, 1962; Pulliainen, 1965). Within its distribution the species is thought to be composed of 32 sub-species, 24 of these occurring in North America (Mech, 1970).

The Vancouver Island wolf (*Canis lupus crassodon* Hall) was described in 1932, and designated as a subspecies unique to the Island from its apparent distinct pelage colour and carnassial teeth characteristics (Hall, 1932). However, its taxonomic status is currently questionable, as adequate cranial samples were not available to Hall (1932), Joliceuer (1959) or Lawrence & Bossert (1967).

Although no accurate figures exist which deal with wolf numbers, it is believed that this race has gone through "violent fluctuations" and has been "virtually extirpated on either two or three occasions since the early 1920's" (Cowan, pers. comm.). Since the early 1970's there have been reports of an apparent increase in wolf numbers (Hebert, pers. comm.). Concurrently there has been increased access into remote areas of probable prime wolf habitat throughout the Island, to the extent that only one pristine watershed remains. Coupled with this increased access, an awareness of the wolf has developed in various segments of the human population. Without accurate data on the population dynamics of the wolf this apparent increase in numbers can only be speculative, and its management practically impossible.

This study was the first on Vancouver Island to investigate wolf behaviour and ecology. The major objectives were to provide baseline information dealing primarily with the food habits and social organization of two adjacent wolf packs. For the former objective the wolf's major food sources, the relative proportions of occurrence in their diet, and seasonal variation in prey species and age-class utilization were investigated. Aspects of social organization examined included wolf densities, pack distributions, pack sizes and compositions, home range sizes, den and rendezvous site characteristics and, daily and seasonal movements.

As there was substantial information on the ecology of the wolf in other regions with contrasting or similar habitats and prey complexes, certain predictions were made regarding the ecology of the Vancouver Island race. It was suggested that because elk, deer, and beaver are large mammalian prey species for wolves elsewhere, these species would also constitute the major portion of the diet for the Vancouver Island race. Seasonal variation in utilization of prey species and type was also predicted. Specifically that young ungulates would be used more frequently than adults early in the summer when they were vulnerable and abundant. Finally, steep watersheds, a common topographical feature in the study site, were expected to be influencial in limiting the activities of wolf packs to separate watersheds.

2. STUDY AREA

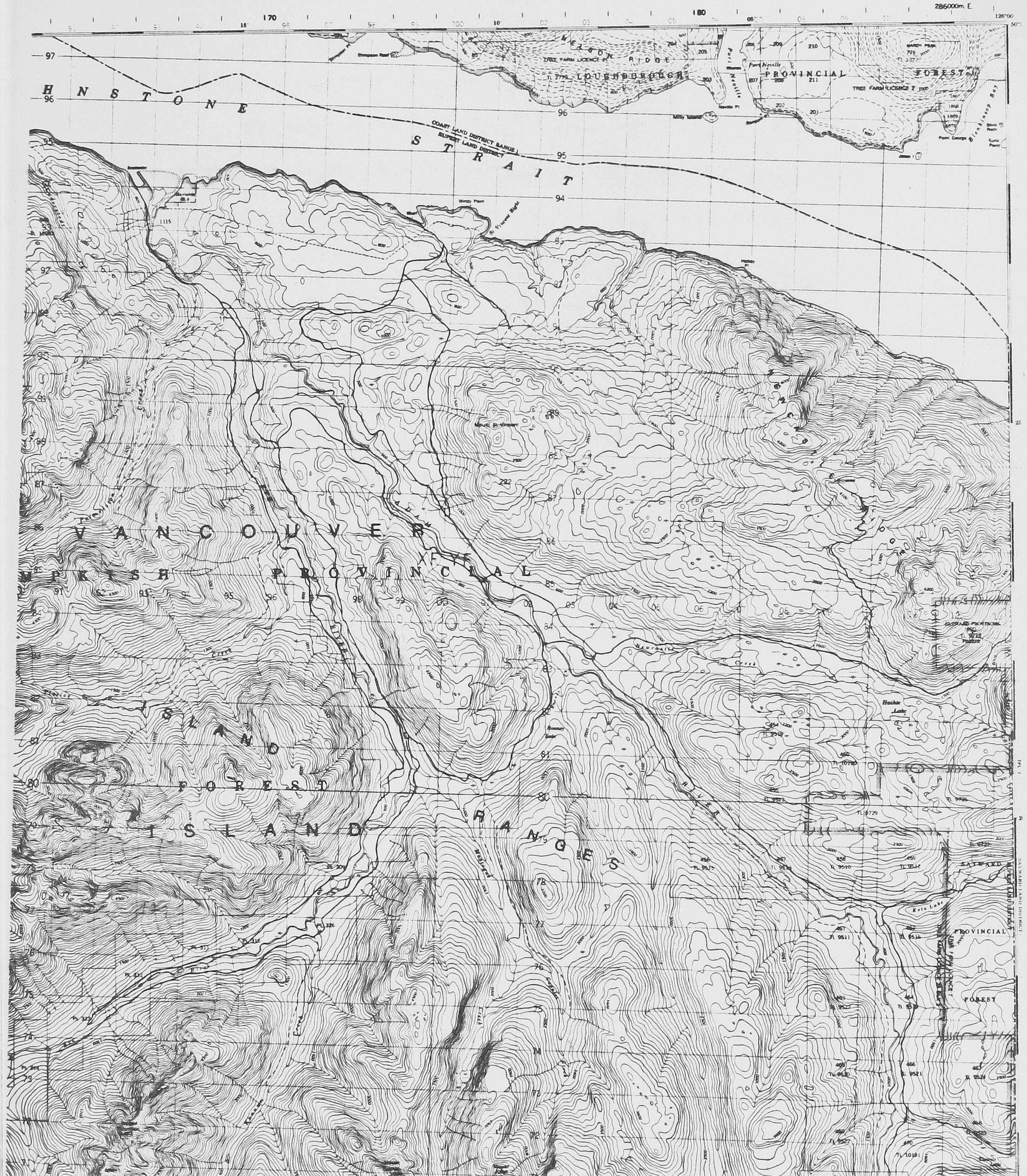
The study site (Figure 1) is situated on the northeast portion of Vancouver Island, 115 km southeast of Port Hardy and 80 km north of Campbell River, British Columbia (latitude 50°N, longitude 125° 15' W). The major watersheds are the Adam and Eve Rivers which flow in a north-northwesterly and northeast-northwesterly direction respectively through the area. They converge one kilometre from the ocean and ultimately drain into Johnstone Strait. The study site encompasses approximately 530 km^2.

Access to the site is afforded by logging roads. A major highway to Port Hardy, opened in 1979, traverses the area along valley floors. The terrain is characterized by steep and narrow valley systems ranging in elevation from sea level to 2,158 m.

Logging practices within the area have altered natural habitat types, resulting in clearcut and second growth zones in valley bottoms and side hills. Pristine habitat remains at river headwaters and upper reaches of side hills within watersheds. Habitat types within these areas include pristine forests, alpine, and high elevation wet meadows. The study site includes three biogeoclimatic zones - the subalpine mountain hemlock, coastal Douglas fir and coastal western hemlock zones (Krajina and Brooke, 1969-70).

Figure 1

Map of the study site



ADAM RIVER
BRITISH COLUMBIA
Scale 1:50,000 Échelle

Within the study site trees commonly form closed forest stands where mountain hemlock (*Tsuga mertensiana*), amabilis fir (*Abies amabilis*), yellow (*Chaemacyparis nootkatensis*) and red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) are the dominant species. Tree line occurs at 1373 m. The major faunal components are shown in Table 1.

Table 2 provides data on snowfall, precipitation and temperature recorded at sites near the study area. Precipitation and temperature data show general trends over a thirty year period.

Table 1. Major Mammal Species Inhabiting the Study Area (From Cowan & Guiguet, 1975).

Wolf	Canis lupus crassodon
Cougar	Felis concolor vancouverensis
Wolverine	Gulo luscus vancouverensis
Black bear	Ursus americanus vancouveri
Marten	Martes americana caurina
Racoon	Procyon lotor vancouverensis
Mink	Mustela vison evagor
Otter	Lutra canadensis pacifica
Black-tailed deer	Odocoileus hemionus columbianus
Roosevelt elk	Cervus elaphus roosevelti
Beaver	Castor canadensis leucodontus
Shrews	Sorex spp. (2)
Bats	Myotis spp. (4)
Marmot	Marmota caligata vancouverensis
Squirrel	Tamiasciurus hudsonicus lanuginosus
Mouse	Peromyscus maniculatus interdictus
Vole	Microtus townseudi laingi
Muskrat	Ondatra zibethica osoyoosensis
Weasel	Mustela erminea onguinae
Red Fox	Vulpes fulva

Table 2. Metereological Data from Two Stations in the Area Surrounding the Study Site. Data were Collected over the Period 1941 to 1970.

Chatham Point — *Latitude 50 20 N* *Longitude 125 26 W* *Elevation 65 ft. ASL*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean daily temperature (F°)	36.5	39.6	41.5	45.0	53.2	56.8	60.4	59.8	55.4	48.7	42.1	38.4
Mean daily maximum temperature	39.2	43.0	45.9	52.0	60.0	63.6	67.3	66.4	61.0	52.5	45.0	41.3
Mean daily minimum temperature	33.7	36.1	37.1	37.9	46.3	49.9	53.4	53.1	49.7	44.8	39.2	35.5
No. of days with frost	9	4	4	0	*	0	0	0	0	*	2	7
Mean rainfall (inches)	8.59	6.92	6.04	4.68	3.66	3.16	2.97	3.63	5.02	10.91	9.70	11.69
Mean snowfall	14.6	4.0	3.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	3.7	12.0
Mean total ppt.	10.05	7.32	6.39	4.71	3.66	3.16	2.97	3.63	5.02	10.91	10.07	12.89
No. of yrs. of record	12	12	12	12	12	12	13	13	13	13	13	13

Alert Bay — *Latitude 50 35 N* *Longitude 126 56 W* *Elevation 169 ft. ASL*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean daily temperature	37.4	40.6	41.4	45.4	50.7	54.6	57.4	57.9	54.8	49.0	42.4	39.2
Mean daily maximum temperature	40.7	44.7	46.8	51.7	58.1	61.4	64.2	64.6	60.9	53.7	46.0	42.4
Mean daily minimum temperature	34.1	36.4	35.9	38.9	43.2	47.7	50.6	51.2	48.7	44.3	38.8	36.0
No. of days with frost	10	6	6	1	*	0	0	0	0	*	3	7
Mean rainfall (inches)	6.45	4.47	4.98	3.31	2.15	2.09	2.06	2.49	4.44	8.44	7.76	7.99
Mean snowfall	10.3	3.8	2.1	0.1	0.0	0.0	0.0	0.0	0.0	1.7	5.0	23.0
Mean total ppt.	7.47	4.86	4.30	3.32	2.15	2.09	2.06	2.49	4.44	8.44	7.95	8.48
No. of yrs. of record	23	23	23	22	22	22	22	22	22	22	22	22

3. FOOD HABITS

3.1 Introduction

During the past four decades, a number of wildlife studies have focussed upon the relationships between wolves and their prey. In different geographical regions with varying habitats and prey species, the diet of the wolf has received much attention. Their food habits have been determined mainly by the analysis of scats, and also by direct observations of wolves interacting with and feeding upon their prey. Major studies in which the diet of the wolf has been investigated include those of Murie, 1944; Cowan, 1947; Thompson, 1952 ; Mech, 1966; Pimlott *et al*., 1969; Kuyt, 1971; Carbyn, 1974; Van Ballenberghe *et al*., 1975; and Haber, 1977.

These studies have shown that the wolf relies mainly upon ungulates for food. Depending upon the prey complex and habitat, general trends have been revealed regarding major versus minor prey, and seasonal variation in their utilization of prey species and type.

Murie, who was the first to do a detailed study on wolves, found that in Mt. McKinley National Park, Alaska, they preyed upon caribou (*Rangifer articus stonei*), Dall sheep (*Ovis dalli dalli*), ground squirrels (*Citellus parryii ablusus*), marmots (*Marmota caligata caligata*), and voles (Microtine spp.). The summer diet (May 1 to September 30) consisted mostly of calves and lambs, while adult animals were taken primarily during the winter (October 1 to April 30). Ungulates constituted approximately 60 per cent of the diet.

In the Rocky Mountain National Parks, Cowan showed that the winter diet was made up of 49, 15, 9, 6 and 6 per cent elk (Cervus canadensis), mule deer (Odocoileus hemionus), moose (Alces americana), bighorn sheep (Ovis canadensis), and caribou (Rangifer arcticus) respectively. Elk, deer, moose and bighorn occurred in 42, 14, 4, and 8 per cent respectively of the summer scats. Beaver were found in 17 per cent of the summer scats. Goat (Oreamnois americanus), horse (Equus caballus), rodents and other small mammals were taken in limited quantitites.

Thompson's (1952) work in northern Wisconsin demonstrated that over 90 per cent of the wolf's diet was made up of white-tailed deer (Odocoileus virginianus), while snowshoe hare (Lepus americanus), and voles (Microtus pennsylvanicus and Clethrioromys gapperi) served as secondary food sources. A shift in the diet occurred one summer and fall during an abundance of voles in the area. He thought that wolves preyed upon a higher proportion of fawns versus adults during the summer (May 21 - August 31). Thompson commented on the possible increased vulnerability of fawns after June 26 when they began to move about more, as opposed to their earlier period of life when they remained somewhat secluded.

Moose were the major prey species of wolves on Isle Royale National Park, Michigan. Mech (1966) found that they occurred in 76 per cent of the scats while beaver constituted most of the remainder of the diet.

Pimlott et al. (1969) working Algonquin Provincial Park, Ontario, reported that wolves relied principally upon white-tailed deer and utilized moose and beaver as secondary prey species (these occurred in the diet 80.5, 8.5, and 7.1 per cent respectively). Hares and rodents were taken in small numbers. In one area of the park where there was an overabundance of beaver, wolves relied mainly upon this species for that year. The summer diet (July 1 to September 30) consisted mostly of fawns (71% of all deer) and calves (88% of moose).

In the Thelon River area of the Northwest Territories, Kuyt (1971) showed that wolves relied almost exclusively upon caribou. Birds, microtines, and fish were occasionally taken, particularly during the summer when small animals became important in areas temporarily without caribou. The winter diet was much less varied.

Carbyn (1974), working in Jasper National Park, Alberta, found that elk, mule deer, moose, and sheep occurred in 46, 30, 8 and 2 per cent respectively of the summer scats (May 1 to September 30). During the winter (October 1 to April 30) the same species occurred in 11, 66, 8 and 4 per cent of the scats.

A study in northeastern Minnesota by Van Ballenberghe *et al*. (1975), revealed that white-tailed deer comprised the greater proportion (55%) of summer scats while moose and beaver constituted 13 and 10 per cent respectively of the diet. In winter deer and moose occurred in 66 and 21 per cent of the scats respectively.

Haber (1977) working in the same area as Murie (1944) found the summer diet of wolves to consist of caribou, moose, and sheep. Many of these animals were young of the year. During the winter wolves utilized primarily older animals of these species.

In the most recently published study of food habits, Theberge *et al*. (1978) observed that wolves in Algonquin Park, Ontario, have changed their food habits following a decline in deer (*O. virginianus*) and an increase in beaver. Changes in occurrence of these prey species followed their relative abundance. They also found differences among scat contents collected at rendezvous sites and in other areas, with respect to beaver, deer and moose, their major prey species.

In these studies the diet of the wolf has been estimated by calculating the percentage occurrence of various prey species in scats. However, this method is prone to error due to the varying surface: volume ratio of prey eaten, which tends to overestimate the proportions of smaller animals eaten and underestimate those of larger animals (Shelton, 1966; Mech, 1966, 1970; Kruuk, 1978; Carbyn, 1974). The results of a study performed on captive wolves (Floyd et al., 1978) make it possible to determine the relative total weight of prey species or type fed upon. This method is more meaningful in describing the quantitative relationship between wolves and their prey than the former. This is particularly evident for the summer diet of the wolf which often contains substantial proportions of young ungulates of varying sizes.

3.2 Methods

Fresh scats were collected along regular travel routes of wolf packs at intervals of five to seven days, and from den and rendezvous sites after packs had vacated them. A sample of each scat was collected and labelled with date and location. Samples were stored in plastic bags at outdoor temperatures and later frozen. A sample rather than the whole scat was collected because the remainder of the scat was used as an attractant for capture purposes. Although wolf scats commonly contain one prey item, this method may not detect minor prey items.

Scat samples were sterilized at 110°C for 3 hr. to kill the ova of Echinococcus granulosus (Bowen, 1978). To remove debris from hair shafts samples were moistened and then identified macroscopically on the basis of maximum diameter, length, colouration, and pigment banding of guard hairs. For comparison purposes a known collection of prey species hairs, including those of both adults and young, was prepared. More specifically, the criteria used to identify prey species' hairs are as follows:

Beaver: Hairs characteristically brown along the shaft with spatulate tips.

Deer: Adult hairs have a subterminal yellow or white band not exceeding 4 mm. in length. Fawn hairs have a maximum diameter less than 115 μ.

Elk: Adult hairs have a subterminal yellow or white band greater than 13 mm. Rump patch hairs have no subterminal band but may be easily distinguished from those of deer which do possess a subterminal band.
Calf hairs have a maximum diameter greater than 115 μ and less than 210 μ.

Food habits were analyzed by percentage occurrence of prey species or type in scats, and by relative total weight of prey type fed upon after the method of Floyd *et al.* (1978). The regression equation used for the latter method is as follows:

$$y = 0.38 + 0.02x$$

where y equals the kilograms of prey per collectable scat, and x the average weight (kg) of a given prey type. This method compensates for error in percentage occurrence calculations due to the varying surface:volume ratio of prey eaten which tends to overestimate proportions of smaller animals eaten and underestimate larger prey.

3.3 Results

Analysis of 616 scat samples combined from both packs for the total study period shows that the three major prey species were black-tailed deer, Roosevelt elk, and beaver (Table 3). Comparison of the relative weights of various ungulate age classes demonstrates that adult and calf elk replaced black-tailed deer fawns as the second most important food types (Table 3).

Figure 2 displays monthly diets calculated from the combined samples of the two packs. Young ungulates were the major food items in the summer diet (June 1 to

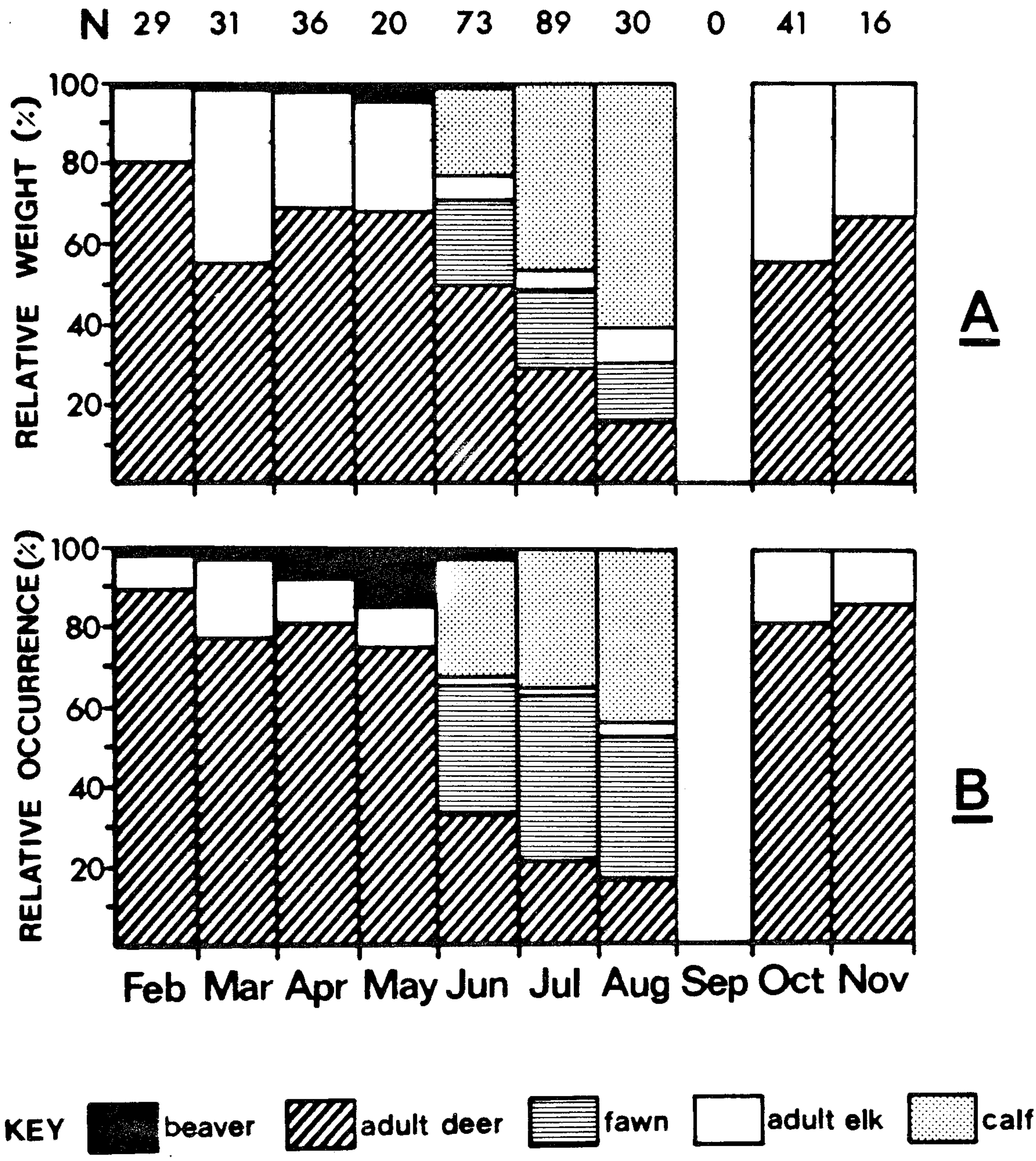
Table 3. The diet of Vancouver Island wolves (*Canis lupus crassodon*) determined by analysis of scats from two packs collected between February and November, 1979. Relative weights of prey were determined following Floyd *et al*. (1978).

SPECIES	N[1]	RELATIVE OCCURRENCE (%)	RELATIVE WEIGHT (%)
Beaver	13	2.1	0.7
Adult Deer	364	59.1	63.2
Deer Fawns	126	20.4	8.1
Adult Elk	27	4.4	14.1
Elk Calves	86	14.0	13.9

1 - Number of scats in which each species was found.

Figure 2

Seasonal changes in the diets of wolves obtained from combined samples from both packs, estimated by relative weight (A) and relative occurrence (B). No scat samples were obtained in September. N shows number of scats.


N 29 31 36 20 73 89 30 0 41 16
100
80
60
40
20
RELATIVE WEIGHT (%)
A
100
80
60
40
20
RELATIVE OCCURRENCE (%)
B
Feb Mar Apr May Jun Jul Aug Sep Oct Nov
KEY
beaver
adult deer
fawn
adult elk
calf

August 31). After this period it was not possible to determine how important the above age class was, due to the development of adult pelage characteristics. The decline in utilization of beaver occurred after July when young ungulates became available. Observations made in December, 1977 and January, 1978 showed that beaver are also utilized at this time.

Figure 3 shows scats collected at den and rendezvous sites. Both packs occuppied dens from early May until mid-July. The Upper Adam pack occupied a rendezvous site between mid-August to mid-October and was visited for scat collection after this time. The Lower Adam pack's rendezvous sites were not visited although attempts were made to find these sites. Scats from both types of homesite reveal a higher proportion of adult deer than those of monthly diets as shown in Figure 2. Beaver occurred only in den site scats, while a small proportion of adult elk occurred only at the Upper Adam rendezvous site.

The seasonal diets of each pack viewed separately, shows various differences (Table 4). Although the Upper Adam pack utilized adult elk from February to May, there was no detectable use of this species by the Lower Adam pack until June and July when use of adult and calf elk coincided. An increasing use of elk calves and fluctuating use of deer fawns is shown by both packs during the summer period.

Figure 3

Diets of wolves determined from scats collected at den (D-S) and rendezvous (R-S) sites. Den sites occupied from early May until mid-July and rendezvous sites mid-August to mid-October. The rendezvous site data is for the Upper Adam pack only, those for densite represent both packs. N. shows number of scats.

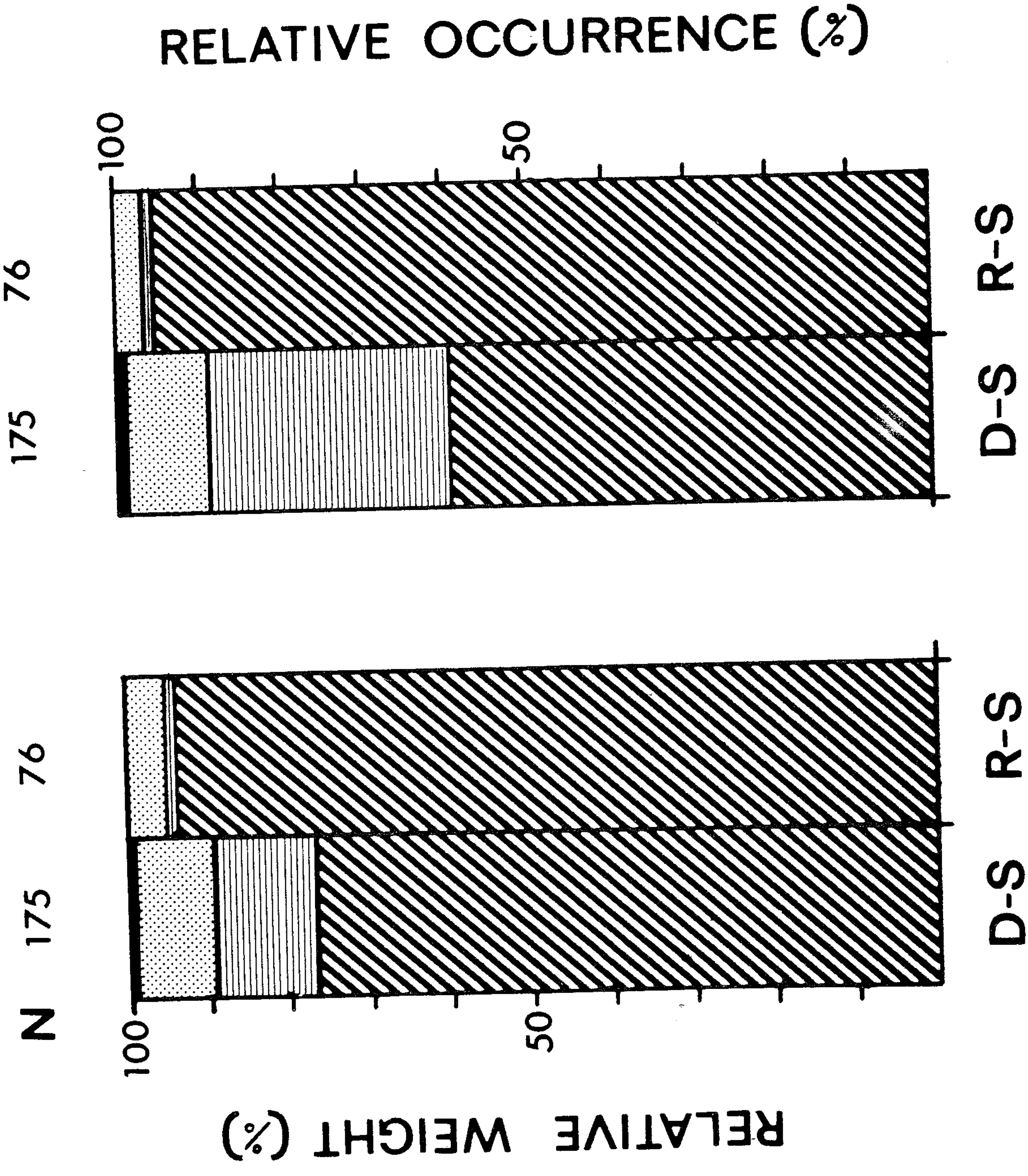

RELATIVE OCCURRENCE (%)
100
50
76
175
R-S
D-S
N
175
76
100
50
D-S
R-S
RELATIVE WEIGHT (%)

Table 4. Diets of the Upper and Lower Adam wolf packs, expressed in terms of the relative weights of each prey species in the scats (after Floyd et al. 1978). Scats from den sites represent the period of occupancy from early May to mid-July, 1978 and rendezvous site scats represent the period mid-August to mid-October, 1978.

SPECIES	PACK	RELATIVE WEIGHTS[1] OF EACH PREY SPECIES BY MONTH AND LOCATION										
		FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	OCT	NOV	DEN SITE	RENDEZVOUS SITE
Beaver	Upper Adam	0.9	0.8	0.9	2.2	-	0.8	-	-	-	1.5	-
	Lower Adam	-	-	7.5	8.5	1.9	-	-	-	-	-	-
Adult Deer	Upper Adam	80.5	49.7	63.2	55.9	51.5	50.0	-	-	-	85.1	94.4
	Lower Adam	-	100.0	92.5	91.5	48.4	-	36.6	58.0	66.7	72.1	-
Deer Fawns	Upper Adam	-	-	-	-	32.7	11.5	15.5	-	-	10.1	0.5
	Lower Adam	-	-	-	-	15.4	32.9	6.3	-	-	14.3	-
Adult Elk	Upper Adam	18.6	49.5	35.9	41.9	-	-	20.0	-	-	-	-
	Lower Adam	-	-	-	-	9.0	10.4	-	42.0	33.3	-	-
Elk Calves	Upper Adam	-	-	-	-	15.8	37.7	64.5	-	-	3.3	5.1
	Lower Adam	-	-	-	-	25.3	56.7	57.1	-	-	13.7	-
Number of Scats Collected	Upper Adam	29	25	26	11	20	46	18	-	-	57	76
	Lower Adam	-	6	10	9	53	43	12	41	16	125	-

1 - Relative weights expressed as percentages.

Although patterns of use did not coincide, adult deer utilization also seemed to fluctuate for both packs during this same period.

3.4 Discussion

The abundance, distribution, and seasonal availability of various prey species and age-classes appears to be reflected in the diet of the two packs studied. Another factor possibly contributing to dietary variations was the relative difference in pack size.

No accurate data were obtained on the density and distribution of deer, but the limited observations made on this species indicated that they were both highly abundant and widely distributed throughout the study site. The fact that they were the major prey of wolves may be attributed to these factors. The homogenous distribution of deer is in contrast to that of elk, which display a "clumped" or heterogeneous distribution. Elk were less important in the diet of wolves, except during the summer period when calves constitute a higher proportion of the herds. In addition to their clumped distribution, elk undergo long range seasonal migrations which often take them into adjacent wolf pack ranges. Due to these seasonal migrations and their clumped distribution, elk are probably taken opportunistically by wolves, particularly during the period when calves are not abundant.

Beaver illustrate a further type of distribution which may be described as fixed relative to ungulate species. They were least important in the wolves' diets. In contrast to other regions where they are preyed on mainly during the summer (Cowan, 1947; Pimlott *et al*., 1969; Van Ballenberghe *et al*., 1975; Theberge *et al*., 1978) beaver contributed to the diet of wolves in this study during the winter and spring period. This is likely related to the mild climate on Vancouver Island which leaves beaver habitat free from ice and snow, and thus the beaver vulnerable at this time.

When comparing the summer versus winter diet, it is apparent that the wolves in this study vary their use of prey species and age-classes on a seasonal basis. Deer fawns and elk calves constitute the bulk of their diet during the summer, at which time the occurrence of beaver as a food source is almost non-existent. This may reflect the higher proportion of young ungulates present during this season, and possibly their greater availability and vulnerability to wolves, due to their size and inexperience at either outrunning or warding off predators. Seasonal variation in prey species and age-class utilization is well documented in previous studies (Cowan, 1947; Thompson, 1952; Pimlott *et al*., 1969; Van Ballenberghe *et al*., 1975).

The diets of individual packs show distinctions particularly during the summer period. The larger, Upper Adam pack, preyed on a higher proportion of adult deer during the early summer while the smaller, Lower Adam pack, depended more upon young ungulates. This may be related to the larger pack being able to capture larger size prey as has been demonstrated with coyotes (Bowen, 1978). The high proportion of young ungulates in the smaller pack's diet may be reflecting the inability of fawns and calves to escape, as contrasted to adults which often succeed in outrunning wolves. The winter and spring diets showed a greater proportion of adult elk taken by the large pack particularly during March, April, and May, when there were no apparent occurrences of this species in the smaller pack's diet. Another possibility explaining these individual pack diet variations is a difference in prey base within each pack's home range. Sufficient information was not available to test this hypothesis.

Scat contents from den and rendezvous sites showed some differences in relative proportion and weights compared to scats collected from the rest of the home ranges. Comparable differences for rendezvous sites and other areas were shown for wolves in Algonquin Park (Theberge _et al._, 1978) where the higher proportion of beaver in rendezvous site scats was attributed to the fact that beaver colonies were adjacent to rendezvous sites. However, no comparable arguement can be made for the Vancouver Island scat results which showed much higher use of adult deer at the den and rendezvous sites compared to other areas.

In relation to other studies, the diet of the Vancouver Island race reveals both similarities and contrasts. Variations in diet between regions probably reflect the unique prey complexes the wolf deals with, and the distinct nature of the habitat which its activities and those of its prey are subjected to. In particular, the diet of the wolves studied resembles that of wolves in Ontario, Minnesota, and the Rocky Mountains.

The largest prey present within the study site is elk, a position held by moose in Ontario and Minnesota (Pimlott _et_ _al_., 1969; Van Ballenberghe _et_ _al_., 1975). Otherwise, the prey complex is the same and proportions of deer and beaver which occur in the wolf's diet in these areas are similar to those found in the Vancouver Island race's diet. Minor differences are shown by the presence of moose in both the summer and winter diet of Minnesota wolves (Van Ballenberghe _et_ _al_., 1975). This may be attributable to the unavailability of beaver during the winter when streams and ponds are frozen over. A further consideration is a difference in prey ecology. Elk herds undergoing seasonal migrations may be contrasted to moose which are mainly solitary non-migrators. This would tend to create a homogenous prey distribution in Ontario and Minnesota (Mech, pers. comm) as opposed to the partial heterogenous distribution on the island.

How the diet of the wolf is influenced by these factors is beyond the scope of this thesis but nevertheless noteworthy.

Carbyn's (1974) work showed that elk were taken in greater proportions during the summer and that male deer were the major food item in the wolves' diet. Cowan's (1947) data from the same region tend to conflict with Carbyn's showing instead elk as the major prey species. However, Cowan noted that elk were overabundant in the study site, so perhaps wolves were responding to this factor as has been demonstrated elsewhere (Thompson, 1952; Pimlott et al., 1969). Although the prey complex in the Rocky Mountains is vastly different to that on Vancouver Island, making comparisons difficult, it is significant that in one of the above studies male deer were the major food source for wolves, with elk secondary and taken in greater proportions during the summer.

If the diet of the two packs studied is representative of others throughout the island it appears that this race demonstrates foraging patterns which are consistent with those of other regions. The factors which contribute to variation between areas to be climatic differences and the unique ecology of prey species which inhabit distinct habitats.

4. SOCIAL ORGANIZATION

4.1 Introduction

The manner in which wolves are organized amongst themselves and in relation to their environment has been investigated by several researchers (Murie, 1944; Cowan, 1947; Mech, 1966; Pimlott *et al.*, 1969; Clark, 1971; Carbyn, 1974; Van Ballenberghe *et al.*, 1975; Haber, 1977). Aspects of their social organization which have been focussed upon include pack distributions and sizes, wolf densities, home range sizes, daily and seasonal movements, and homesite (den and rendezvous sites) characteristics. Data have been obtained by maintaining close contact with wolves in their natural environments, either by intensive ground work often with the aid of aircraft, or by radio-telemetry.

Table 5 summarizes the findings of several researchers on various aspects of wolf social organization in North America. It is quite apparent that estimates of home range size and wolf densities reported by those authors, vary considerably between different regions and even within areas.

Table 5. Summary of results from previous studies of the social organization of wolves in North America.

Reference	Location	Home Range Size[a]	Pack Size	Wolf Density[c]	Den Site Features
Murie, 1944	Mt. McKinley, Alaska	1800 [4662.0]	7A 5P[b]	1 per 138 [357.4]	Renovated fox dens formed in sandy or loamy soil. Within spruce and cotton wood stands or open riverside site entrances 15" x 20" to 16" x 25".
Cowan, 1947	Banff and Jasper Park, Alberta	50 [129.5]	4-5	1 per 10-12 [25.9-31.1]	Sandy knolls, old beaver houses, and rock over hangs.
Burkholder, 1959	Alaska	5000 [12950.0]	10	1 per 500 [1295.0]	Information not given.
Mech, 1966	Isle Royale, Michigan	205 [531.0]	2-3	1 per 35-53 [90.7-137.3]	South facing slope with entrance 17" x 28" and inside tunnels 12" in diameter.
		105 [272.0]	15-21	1 per 10-14 [25.9-36.3]	
Pimlott et al. 1969 Joslin, 1967	Algonquin Park, Ontario	40, 50, 60, 120 [103.6, 129.5, 155.4, 310.8]	7-8	1 per 6 [15.5]	Underground burrows, tree bases, hollow logs and rock caves.
Clark, 1971	Baffin Island, N.W.T.	1798.8 [4660]	15	1 per 120 [311]	Expanded fox dens in sandy soils, rock overhangs or crevices.
Carbyn, 1974	Jasper Park, Alberta	-	10-14	-	Within coniferous forests or mature aspen stands.
Van Ballenberghe et al. 1975	Minnesota	34.0-94.2 [88-244]	5-8	1 per 4.0-6.8 [10.4-17.6]	Sandy slopes, balsam and jack pine stands.
Haber, 1977	Mt. McKinley, Alaska	600-1000 [1554.0-2590.0]	12-15	1 per 40-66.6 [103.6-172.5]	Elevated areas within spruce or willows. Southerly aspects. Several main entrances, interconnecting tunnels and chambers 10-20'.

a - Areas of home ranges in mi^2 and [km^2]

b - "A": Adults of both sexes; "P": Pups, less than 12 months of age.

c - Densities in wolves per mi^2 and [per km^2]

4.2 Methods

4.2.1 Capture Procedures

Individuals were captured in steel-jawed traps (#4 Newhouse Woodstream Corporation) with attached steel chains and "drag logs". Sets were distributed over a wide area, buried in trails and road sides frequently used by wolves. Fresh wolf scats and urine were used as attractants. Traps were checked daily at dawn, on foot, snowshoe or with a 4-wheel drive vehicle.

Captured animals were immobilized with a mixture of phencyclidine hydrochloride (Sernylan, Parke, Davis and Co., 100 mg/ml) and promazine hydrochloride (Sparine, Wyeth Laboratories, 50 mg/ml), at a dosage rate of 1.0 mg/kg of estimated body weight for the former and an equal concentration of the latter. Drugs were administered intramuscularly to the upper hind leg region with a syringe on a pole.

Radio-transmitters, with frequencies in the 150 mH_Z range, were secured around the animals' necks by bolting collar ends together. Transmitters were equipped with activity switches, weighed 345 grams, and had a theoretical life expectancy of four years (Wildlife Materials, Carbondale, Illinois).

Weights of wolves were taken with a spring balance scale to the nearest pound and later converted to kilograms. Standard body measurements, including total length, tail length, heart girth and hind foot length were taken. Permanent upper and lower canine teeth lengths were measured from gumline to tip, along the labial midline with vernier calipers. Ages of wolves were estimated by tooth wear (Bowen, pers. comm.). Photographs of incisors and canines were taken for later comparison and checking age estimates. Colour coded ear tags (Ketchum Manufacturings Sales Ltd., Ottawa, Ontario) were inserted into individual's right ears and lip tattoos applied to both sides of the lower lip for permanent future identification.

Blood samples were drawn from the lateral saphenous vein in the hind-leg, or from the cephalic vein in the upper fore-leg. Between 10-40 cc of blood were taken, 5 cc for whole blood studies, 4 cc for cortisol, and the remainder centrifuged for serum. Samples were refrigerated, then flown to the Puget Sound Institute of Pathology in Seattle for analysis on the same or following day.

Blood samples were analyzed for the following constituents: hemoglobin (Hgb), number of red blood cells (RBC), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH), number of white blood cells (WBC), and concentrations of cholesterol, calcium (Ca), phosphorus (P), bilirubin, serum urea nitrogen (BUN), glucose, lactic dehydrogenase (LDH), alkline phosphotase, serum glutamic oxalacetic transaminase (SGOT), creatinine, tryglyceride, sodium (Na), postassium (K), chloride (Cl), carbon dioxide (CO_2), total protein, albumin, thyroxine, and cortisol. Blood smears were used for anti-distemper antibody analyses.

Rectal temperatures of immobilized animals were periodically monitored, their overall conditions noted, and 2-4 cc of penicillin administered intramuscularly as standard procedure. Once animals were "processed" they were placed out of sight in shade, and left to recover on their own once they began to show head movement.

4.2.2 Radio-Location Methods

Data on daily seasonal movements, temporal and spatial distribution of packs, home range sizes, and pack sizes and compositions, were obtained by radio-telemetry methods. Radio-tracking was performed from the ground and air. Telmetry equipment utilized, included a portable receiver (TRX-24, Cat. No. C1b), a three-element Yagi antenna (Cat. No. C7d. Wildlife Materials), two four-element Yagi antennae (Cushcraft Corporation, Mancester, New Hampshire), and a headset (Model H10-00, David Clark Company Inc., Worcester, Ma.).

Ground tracking involved taking several compass bearings from known map locations on each located individual. When animals were inactive and at a den or rendezvous site, three compass bearings were taken. When they were active or away from known activity areas, five to six bearings were taken. Date, time of day, and animal state (active/inactive) were noted along with compass bearings. Bearings were later plotted on 20 chain (1":1/4 mile; 1": 402 metres) company maps (MacMillan Bloedel) and each individual's location determined by triangulation. Polar co-ordinates of locations were then calculated, and punched onto computer cards for analysis.

For aerial tracking a Cessna-180 wheel or float plane was used. Initially, a single three-element antenna was used to locate wolves. To improve precision two four-element antennae were vertically mounted to wing struts, pointed slightly down relative to the wing's plane, and directed out under the wing. Antennae cables were fed through air vents and connected to a coaxial switch, receiver and headset. When the general location of a wolf was determined the plane was flown at an altitude ranging from 305 to 610 m. until transmitter signals were heard. The pilot was then directed to fly in that direction which yielded equal signal strength on each antenna. The area from which the loudest signal was received was flown over. Circling and simultaneous switching to alternate antennae enabled the tracker to determine whether the radioed animal was within the inner or outer circle flown by the plane. The animals' location was then determined to within a 200 m. radius by flying decreasing circles around it. Final locations were made as close to the ground as possible. When animals were not directly observed the date, time of day, animal state, habitat type and identification of monitored individuals were noted. For direct observations the same information was noted in addition to numbers of wolves observed, and activities at time of observation (interacting, resting, travelling).

When the general location of animals was unknown the plane was flown at altitudes of 2,743 to 3,048 m. until signals were heard. Once the animals' location was found the plane descended and the former method was followed. All aerial locations were plotted on 20 chain maps and handled the same as ground locations. On the few occasions that weather conditions prevented low altitude tracking, locations were then determined from higher altitudes (1,524 - 1,829 metres).

4.2.3 Den and Rendezvous Sites

Den and rendezvous sites were determined by repeated radio locations from these sites, and were examined after packs had moved to other areas. Descriptions were made of den interiors, site locations, activity areas, site trails, and habitat type and vegetation in the immediate vicinity. Site aspect, observations of other species and their signs, were also noted. Photographs were taken at each site, particularly of den interiors, activity areas, and site trails.

4.3 Results

4.3.1 Weights, Measurements and Metabolic Profiles

Weights and measurements of the nine wolves captured during this study are shown in Table 6. Adult males were heavier and larger in body dimensions than adult females.

Results of blood and serum analyses are shown in Tables 7, 8 and 9. Problems of haemolysis or inadequate sample size limited analyses for two individuals. No blood sample was collected from the small male pup.

4.3.2 Pack Sizes and Composition

The visual density of the habitats in the study area did not allow for many direct observations of packs. Therefore, information on pack sizes and composition is limited, and supplemented by indirect observations of radio-tagged individuals, animal tracks and sign, howling and signs of activity around den and rendezvous sites.

Table 6. Weights (kg) and measurements (mm) of nine Vancouver Island wolves (*Canis lupus crassodon*) captured between April 10 and November 1, 1978, near Kelsey Bay, British Columbia.

Pack and Wolf Identity	Sex	Age[1]	Total Weight	Total Length	Tail Length	Hind Foot Length	Heart Girth	Canine Length	
								Upper	Lower
Upper Adam (87)	M	A	38.6	1803	495	267	550	24.5	-
Lower Adam (86)	M	A	32.7	1800	483	241	787	28.3	25.1
Upper Adam[2]	M	A	36.7	1727	394	279	792	24.5	23.0
Lone Wolf	M	A	36.6	1780	460	300	770	26.0	23.5
Average	M	A	36.18	1777.5	458.0	271.8	752.3	25.83	23.87
Standard Deviation			2.484	35.18	45.07	24.62	62.21	1.795	1.097
Lower Adam	M	P[3]	10.0	1100	270	210	480	8.9	6.1
Lower Adam	F	P[4]	21.8	1490	380	250	610	19.2	19.3
Lower Adam (97)	F	A	31.8	1638	432	254	660	26.8	22.0
Upper Adam (90)	F	A	31.4	1715	432	264	729	23.0	18.5
Upper Adam (4)	F	Y	28.2	1638	392	254	711	22.8	19.7
Average	F	A/Y	30.47	1663.7	418.7	257.3	700.0	24.20	20.07
Standard Deviation			1.973	44.456	23.09	5.77	35.79	2.254	1.779

1 - Age classes: A - Adult, P - Pup of year, Y - Yearling.

2 - Animal died shortlv after handling.

3 - Estimated from denning period to be months old.

4 - Estimated to be months old.

Table 7. Haemotology of some Vancouver Island wolves.

WOLVES	Weight (kg)	Hgb (g %)	RBC ($10^6/mm^3$)	Hct (%)	MCV μ^3	MCHC (Vol %)	WBC $10^3/mm^3$
<u>Adult Males</u>							
Upper Adam (87)	38.6	17.4	7.22	60.2	84	28.8	12.9
Lower Adam (86)	32.7	20.4	8.27	62.9	76	33.1	15.1
Upper Adam*	36.7	12.7	5.52	38.2	69	32.8	9.1
Lone Wolf	36.7	15.6	6.64	47.2	71	33.3	23.0
<u>Female Pup</u>							
Lower Adam	21.8	14.9	6.37	47.8	75	31.4	11.2
<u>Adult/Yearling Females</u>							
Upper Adam (90)	31.4	12.5	5.52	38.2	69	32.8	12.9
Upper Adam (4)	28.2	16.1	6.35	49.4	72	32.9	17.8

* - This animal died shortly after handling.

Table 8. Serum chemistries of Vancouver Island wolves.

WOLVES	WEIGHT (kg)	CHOLESTEROL (mg %)	Ca (mg %)	P (mg %)	Bilirubin (mg %)	BUN (mg %)	Glucose (mg %)	LDH (IU/1)	ALK.PH. (IU/1)	SGOT (IU/1)	CREATININE (mg %)	TRIGLYCERIDE (mg %)
Adult Males												
Upper Adam (87)	38.6	280	10.8	4.4	0.8	32	140	240	72	140	QNS[1]	QNS
Lower Adam (86)	32.7	230	11.0	5.8	0.3	29	100	270	77	300^{+}	1.0	25
Upper Adam*	36.7	167	9.5	6.1	0.2	34	160	186	56	155	0.8	15
Lone Wolf	36.7	95	4.3	2.5	0.1	QNS	53	76	25	130	0.6	10
Adult/Yearling Females												
Upper Adam (90)	31.4	184	10.2	4.0	0.2	43	116	130	55	186	0.7	47
Lower Adam (4)	28.2	200	3.8	4.6	0.2	15	115	215	59	350^{+}	0.3	40

* - Animal died shortly after handling.

1 - Inadequate Sample.

Table 9. Serum proteins and hormones of Vancouver Island wolves.

WOLVES	WEIGHT (kg)	TOTAL (g %)	ALBUMIN (g %)	THYROXINE (g %)	CORTISOL (g %)
<u>Adult Males</u>					
Upper Adam (87)	38.6	8.0	4.4	1.9	QNS[1]
Lower Adam (87)	32.7	7.3	4.3	1.3	16.0
Upper Adam*	36.7	5.4	3.4	QNS	9.6
Lone Wolf	36.7	3.4	1.9	0.7	QNS
<u>Adult/Yearling Females</u>					
Upper Adam (90)	31.4	6.6	3.7	2.5	5.8
Upper Adam (4)	28.2	6.2	3.8	1.0	4.6

1 - Insufficient sample.

* - Animal died shortly after handling.

A. The Lower Adam pack was estimated to consist of an adult male, an adult female, and three pups (one female, one male and one unknown) which were born during May, 1978. Observations of this pack were as follows:

The adult male was captured on April 11, 1978, and recaptured on June 23, 1978. The adult female was captured on April 14, 1978.

The adult male was observed on May 24, 1978 at 09.50 hrs. in a clearcut adjacent to the denning area. At this time he moved off into the timber began to howl and was joined shortly by another wolf, thought to be the adult female.

On June 22, 1978 at 09.30 hrs. the adult male and female were observed travelling through a clearcut-second growth area approximately 1 km from their den.

On July 12, 1978 at 22.30 hrs. the adult female was radio-located in a small roadside timber stand close to the den. She responded to my howling with growls and "yippy" barks. Shortly after she howled a single animal, thought to be adult male, began howling from the densite, followed by howling of pups. When I returned to this area at 23.14 hrs. there were tracks of a single animal crossing the road towards the den.

A male pup was captured on July 28, 1978 and a female pup on October 29, 1978.

On August 29, 1978 at 17.00 hrs. the pack (adult male, adult female and three pups) was observed from the air on a small rock outcrop approximately 2 km from their den. The adults were resting, and the pups romping and playing among themselves.

On October 9, 1978, the adult male was observed from the air resting in an open area on the banks of the Eve River.

Members of the pack were not observed again until late November when the adult male was found shot in the field. The female pup could not be radio-located at this time and the radio on the adult female was no longer functioning. Tracks of two animals were consistently seen on snow covered roads in this pack's territory in January, 1979.

It is possible that this pack consisted of more than five animals, however, the above information led me to believe the pack was composed of two adults (the breeding pair) and three pups. The amount of sign seen within their territory and around their den would support this belief.

B. The Upper Adam pack was believed to have originally consisted of ten animals. An adult male from this pack died shortly after handling at the trapsite, leaving nine pack members. Obersvations of this pack were as follows:

An adult male was captured on April 10, 1978, an adult female on April 30, 1978 and yearling female on May 3, 1978.

On May 24, 1978 at 12.00 hrs. the yearling female was observed alone travelling through a clearcut area.

On July 24, 1978 at 07.00 hrs. the adult male was observed running down a grassy slope to cross a road. When he spotted my vehicle he turned and moved away from the road onto a small knoll and began to howl. Other pack members, including pups, responded from across the river. It was not possible to determine numbers on the basis of howling.

On September 3, 1978 nine members of this pack were aerially observed at a rendezvous site from 12.30-13.00 hrs. Some individuals were resting while others played. Individuals observed were thought to include five pups, one other adult/yearling and the three radio-tagged members.

On September 6, 1978 the two radio-tagged females could not be located and five individuals were aerially observed including three pups and two adult/yearlings. The radioed male was located approximately two kilometres from his rendezvous site but could no longer be located anywhere within the territory the following day.

On February 16, 1979 at 12.30 hrs. nine wolves were observed together in a gravel pit approximately 4 km. from their densite of 1978 (Marika van Alderwegen, pers. comm.).

On March 22, 1979 six members of this pack were aerially observed lying in the middle of a frozen lake (Keith McKillican, pers. comm.).

On the basis of these observations, the Upper Adam pack was believed to originally consist of two adult males, one adult female, one yearling female, two unknown and four pups. The aerial observation of September 3, 1978 is believed to be incorrect regarding pups versus adults, such that there were only 4 pups in this pack. The age classification of radio-tagged pack members is based upon weight and tooth wear (Don Bowen, pers. comm.).

4.3.3 Home Range Sizes and Distributions

The concept of territory is not used here because investigation of defense of an area by a pack was not part of this study. Home range is used instead to describe the areas used by the wolves of the two packs, as determined by radio telemetry locations. The definition of home range is that of Burt (1943): "... that area traversed by an individual(s) in its normal activities of food gathering, mating and caring for young." Home range sizes were calculated by the convex polygon method and plotted using a computer program developed by Harestad (1979). Home range areas were calculated for 100, 90, and 50 percent of the nearest locations.

If an animal does occupy a home range, a plot of home range area against the number of locations should asymptote. This is referred to as the "observation-area" curve (Odum and Kuenzler, 1955). Unfortunately, the time period covered in this study did not encompass an entire annual cycle, and animals of both packs did demonstrate seasonal shifts in spatial distribution, including their core areas (50 percent home ranges). The observation area curves shown in Figures 4 and 5 indicate that during the denning period an asymptote was reached for all individuals for their 100 per cent home range boundaries. Following denning, further increases in home range size and corresponding changes in the asymptote level occurred. These changes coincided for most animals, with shifts in core area use, and may also reflect a general increase in movements between rendezvous sites, as the pups became more mobile.

The observation-area curves for 90 per cent home range boundaries, show a different pattern (Figures 4 and

Figure 4

Observation area curves for Lower Adam adult male's (86) and adult female's (90) 100 and 90 per cent home ranges. Vertical broken lines separate denning and post-denning periods.

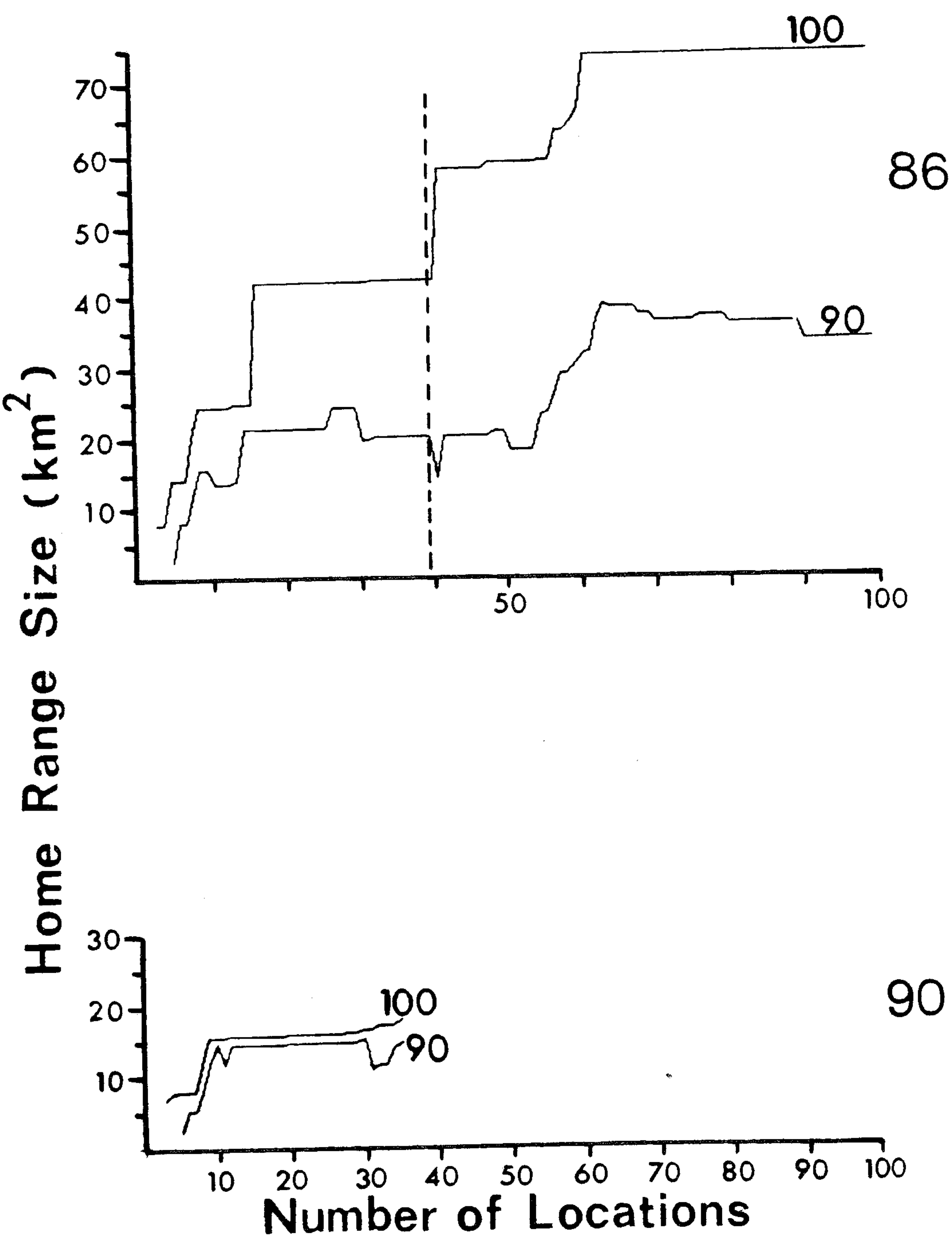
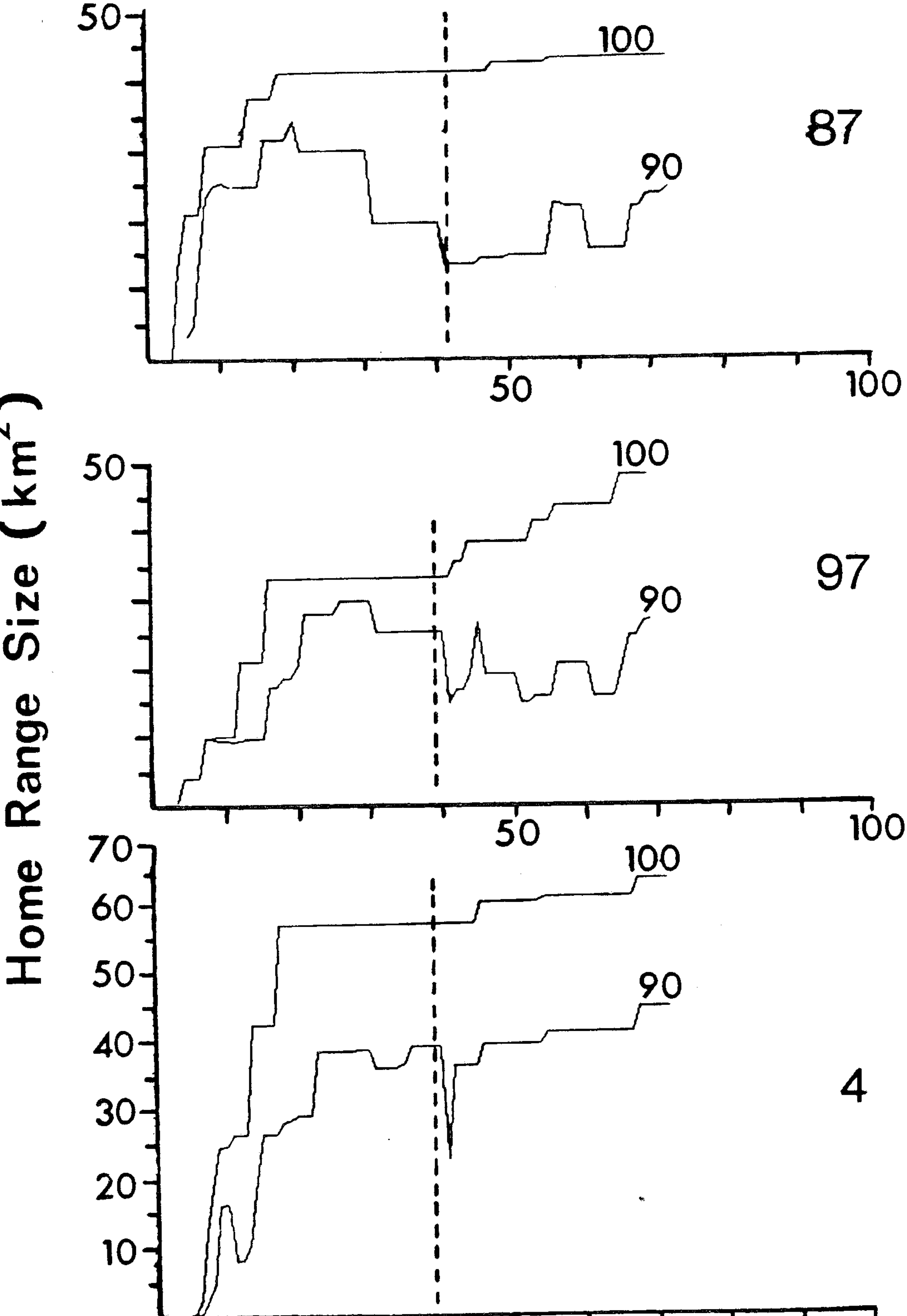

Home Range Size (km^2)
100
90
86
70
60
50
40
30
20
10
50
100
90
100
90
30
20
10
10
20
30
40
50
60
70
80
90
100
Number of Locations

Figure 5

Observation-area curves for Upper Adam adult male's (87), adult female's (97) and yearling female's (4) 100 and 90 per cent home ranges. Vertical broken lines separate denning and post-denning periods.


Home Range Size (km^2)
50
100
90
87
50
100
50
100
90
97
50
100
70
60
50
40
30
20
10
100
90
4
10 20 30 40 50 60 70 80 90 100

5), with a drop in area at or around the time the wolves vacated the den sites. This decrease in 90 per cent home range area indicates that during this shift from dens towards rendezvous sites, the wolves limited their movements within the previous 90 per cent areas, rather than travelling throughout the home range or moving into previously unoccupied areas.

The data in Figures 4 and 5, further indicate that the cumulative home ranges of both packs, considered from the aspect of the annual cycle, may not have reached their maximum size. Thus the home range sizes for the whole study period (Table 9) are likely underestimates of the annual home range areas used by each pack.

A. Lower Adam Pack

Home range sizes for the two adult wolves monitored in this pack are shown in Tables 10 and 11, and together with plots of home ranges (Figures 6, 7 and 8) suggest that the adult male (86) occupied a much larger area than did the female (90). Even though the radio transmitter of female 90 eventually malfunctioned, the denning period should be comparable for these two animals. The larger home range size of the male compared to the female may reflect the fact that as the only adult member of the pack, he had a large share of

Table 10. Individual and pack home range sizes (km^2) for the whole study period combined for two packs of Vancouver Island wolves.

WOLF AND PACK IDENTITY	PERIOD	NUMBER OF LOCATIONS	HOME RANGE SIZES		
			100%	90%	50%
Lower Adam:					
Adult Male (86)	Apr 11-Nov 20	100	75.0	33.8	3.3
Adult Female (90)	Apr 14-Aug 29	35	18.5	15.1	1.7
Pack	Apr 11-Nov 20	135	75.0	33.8	3.7
Upper Adam:					
Adult Male (87)	Apr 10-Sept 10	72	43.8	24.8	3.0
Adult Female (97)	Apr 30-Sept 3	69	47.8	26.3	2.8
Yearling Female (4)	May 3-Sept 3	72	63.0	45.0	3.9
Pack	Apr 10-Sept 10	213	64.0	43.6	3.9

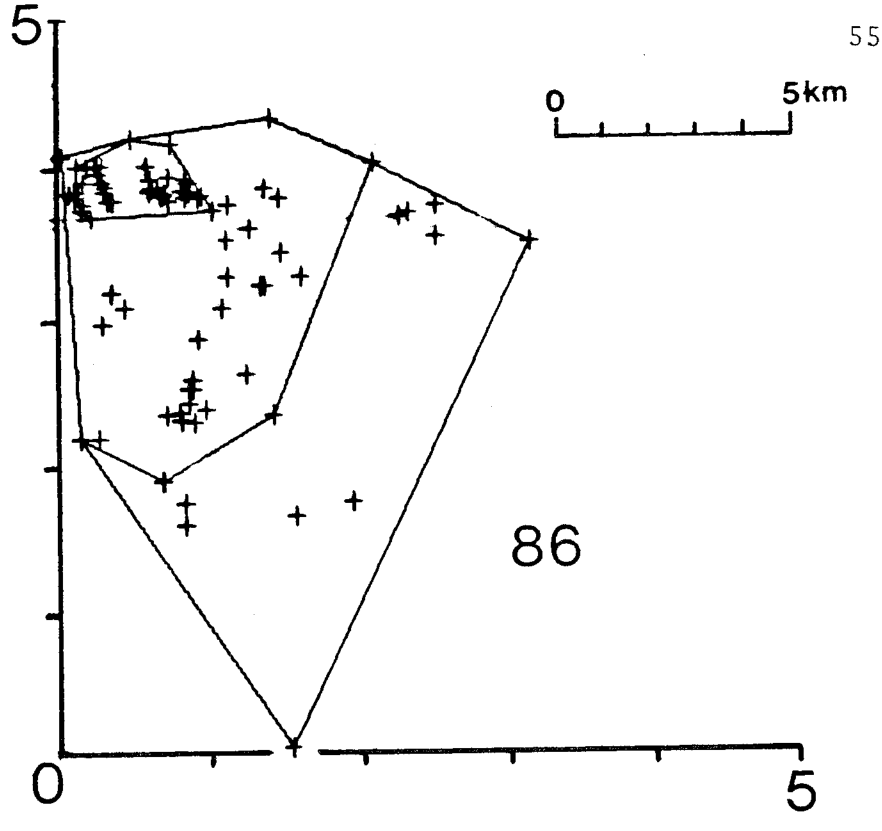
Table 11. Individual and pack home range sizes (km^2) shown for denning (April 11 to July 11) and post-denning periods of two packs of Vancouver Island wolves. (Lower Adam: July 12 to November 20; Upper Adam: July 12 to September 10).

WOLF AND PACK IDENTITY	DENNING PERIOD				POST-DENNING PERIOD			
	Number of Locations	Home Range Sizes 100%	90%	50%	Number of Locations	Home Range Sizes 100%	90%	50%
Lower Adam:								
Adult Male (86)	40	43.1	20.9	1.1	60	56.3	32.0	3.2
Adult Female (90)	25	16.4	15.1	0.3	10	10.5	2.5	0.1
Pack	65	43.2	25.3	0.7	70	56.3	29.0	3.3
Upper Adam:								
Adult Male (87)	43	42.1	20.9	1.6	29	20.7	15.5	0.9
Adult Female (97)	37	32.9	25.0	1.8	32	26.6	17.6	1.4
Yearling Female (4)	39	57.4	40.0	2.4	33	27.0	17.6	1.4
Pack	119	60.9	41.8	2.5	94	28.1	22.7	1.7

Figure 6

100, 90 and 50 per cent home ranges of the adult male (86) and the adult female (4) from the Lower Adam pack for the whole study period (86: April 11 - November 20; 4: April 14 - August 29, 1978).

Orientation of axesis arbitrary but allows direct comparisons between all home range plots.


5
0
5km
86
0
5

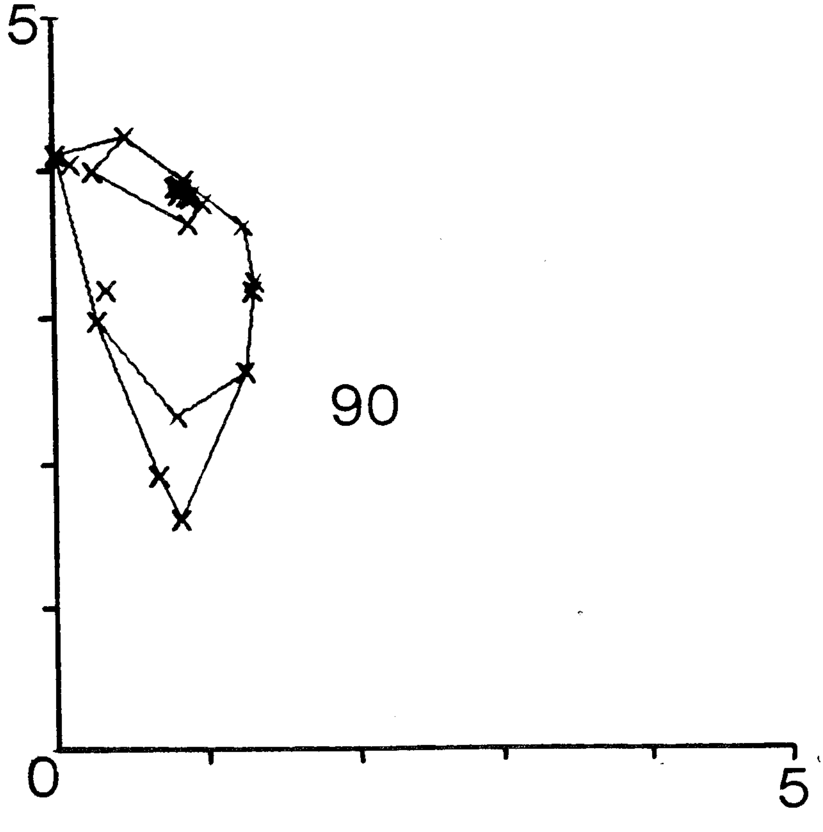
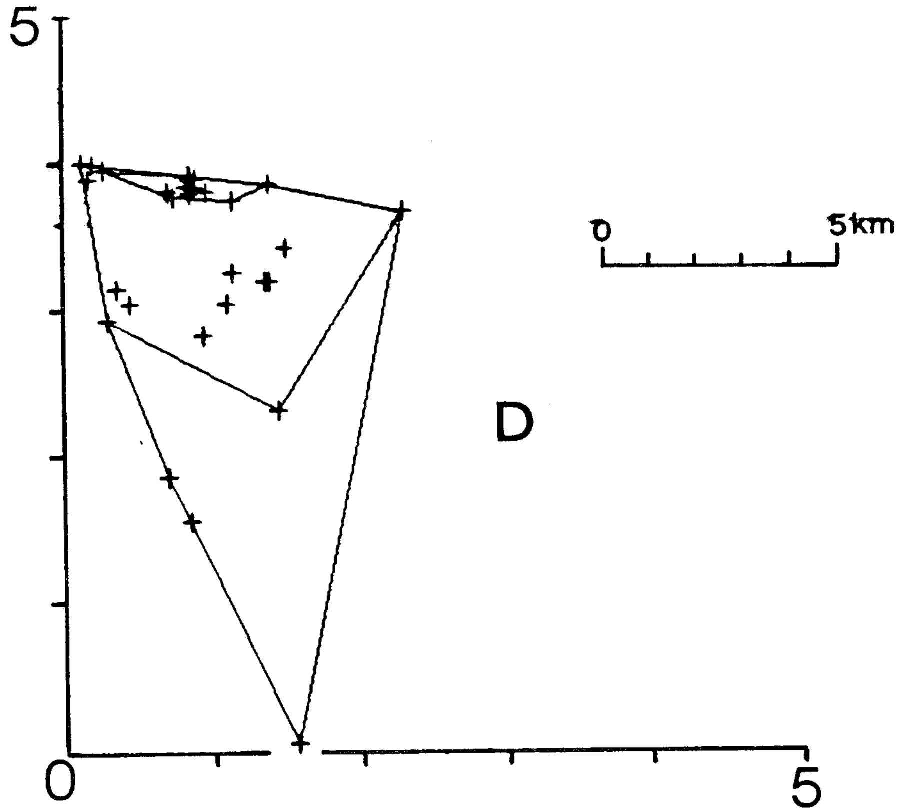

5
90
0
5

Figure 7

100, 90 and 50 per cent home ranges of the Lower Adam adult male during the denning (D) and post-denning (PD) periods (D: April - July; PD: August - November, 1978).


5
0
5km
D
0
5

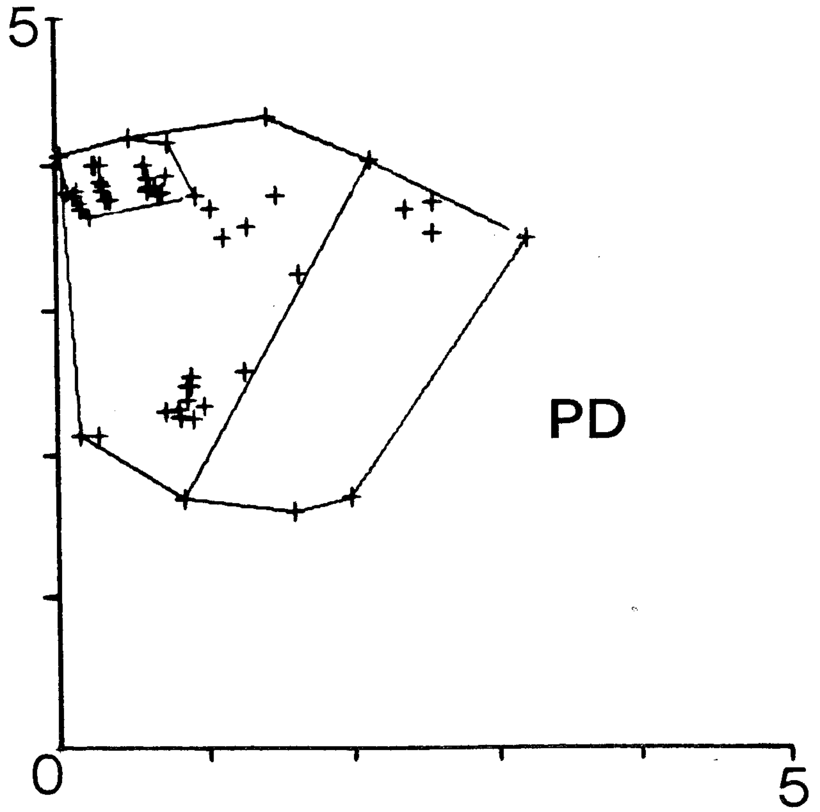
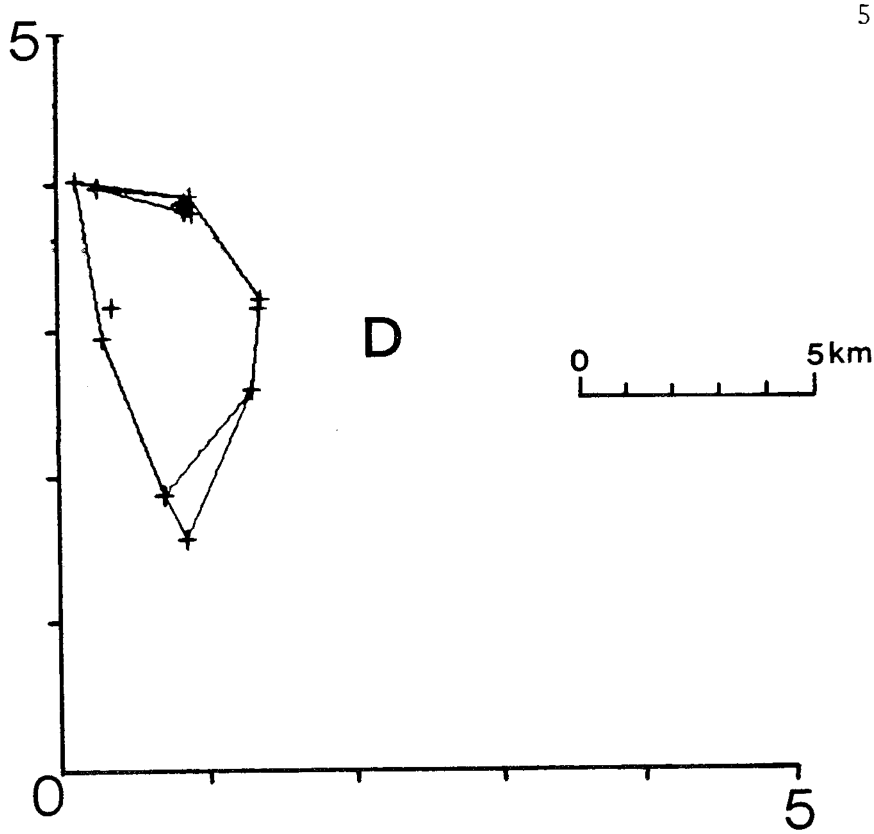
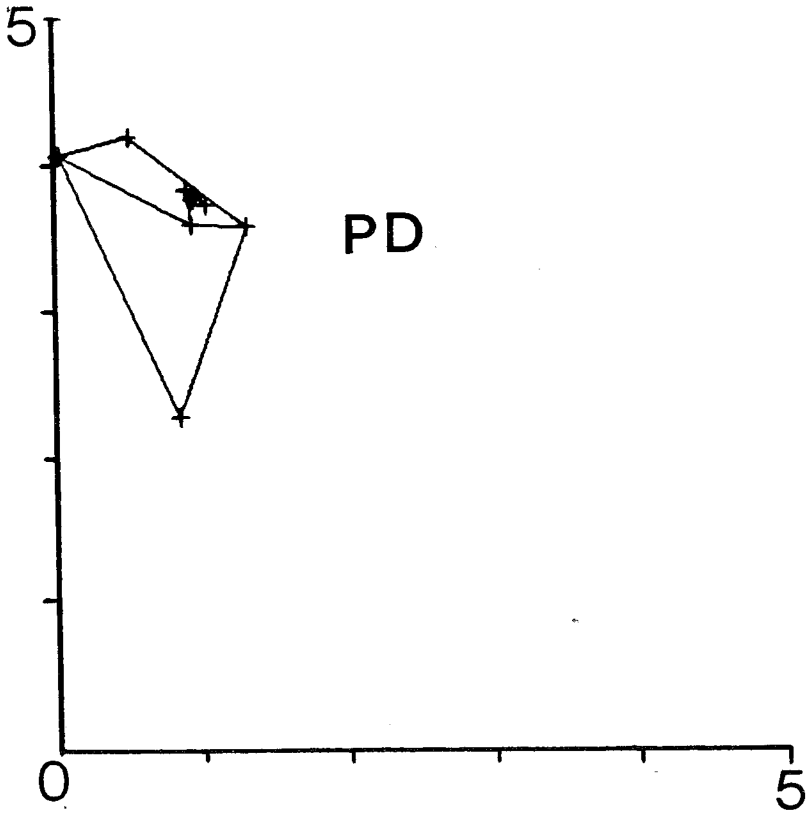

5
PD
0
5

Figure 8

100, 90 and 50 per cent home ranges of the Lower Adam adult female during the denning (D) and post-denning (PD) periods (D: April to July; PD: August, 1978).


5
D
0
5km
0
5


5
PD
0
5

hunting to provide food for the female who was restricted in her movements because of the young pups at the den. Concentrations of locations for both animals in the denning and post-denning periods (Figures 7 and 8) correspond to the den site and the rendezvous sites occupied by them (Figure 9).

B. Upper Adam Pack

Data on the sizes of home ranges (Tables 10 and 11) of the three animals monitored in this pack show that the yearling female (4) ranged through a larger home range area than either of the two adults, particularly during the denning period. All three wolves occupied similar sized home ranges in the post-denning period.

Home range plots for the three wolves of the Upper Adam pack are shown in Figures 10, 11, 12 and 13. The adult (97) and yearling (4) females have remarkably similar location plots, particularly for their 90 and 50 per cent home range locations. In fact during the post-denning period they had essentially identical distributions. They were actually located together on almost every occasion in the post-denning period and very frequently during the denning period.

The adult male (87) while generally similar in his distributions to the two females, was infrequently located with them. His 50 per cent boundaries

Figure 9

Home ranges (100, 90 and 50 per cent) of Lower Adam (LA) and Upper Adam (UA) packs for whole study period superimposed on topographic map. Den sites (◆) and rendezvous sites (■) are shown. Numbers by rendezvous sites indicate order of use during the post-denning period. For Lower Adam 1-2 denotes alternating use of these two sites. Rendezvous site 2 for Upper Adam was last site radio-collared wolves located, site 3 had tracks after wolves shot.

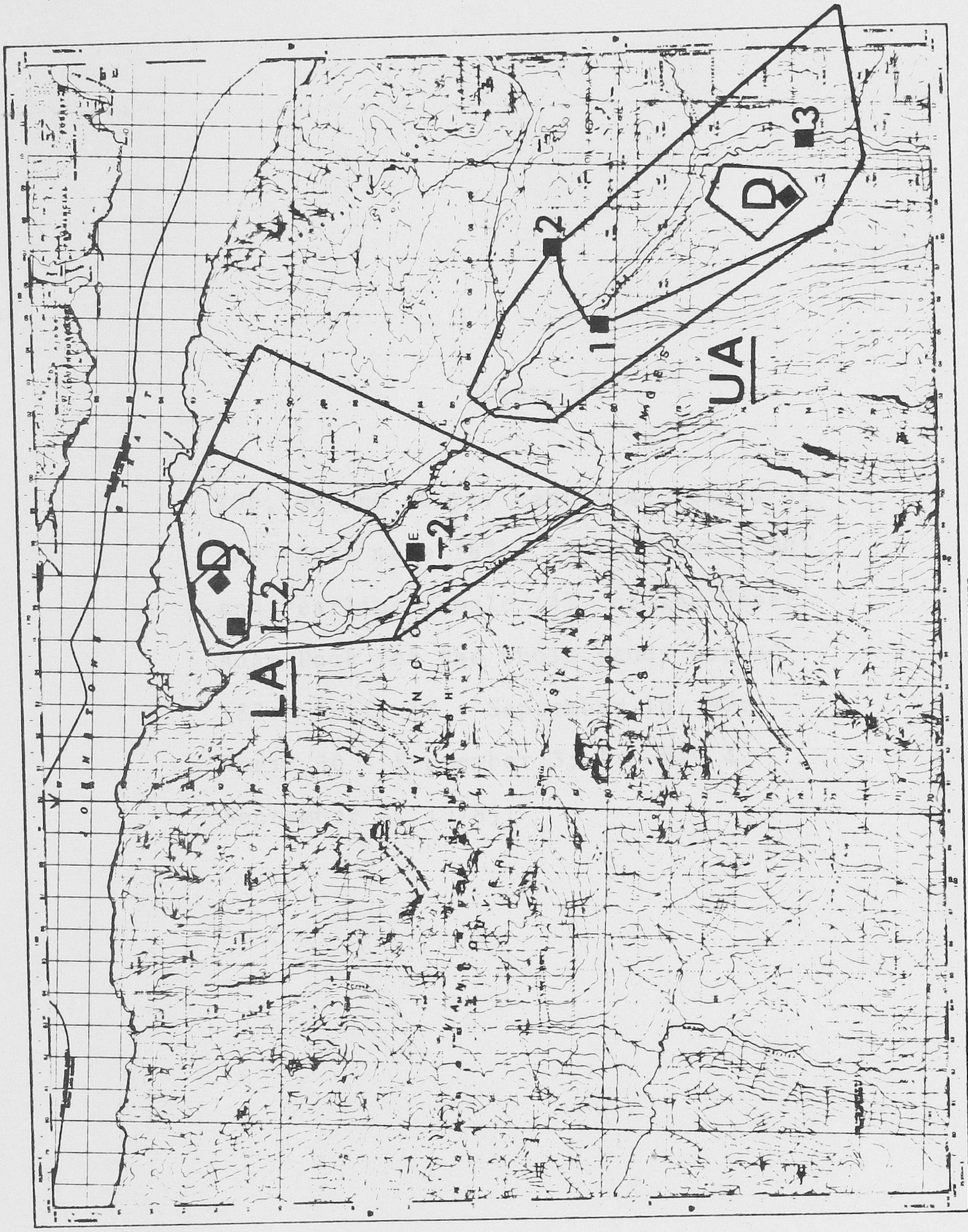

LA
UA
1-2
D
1
2
3
ADAM RIVER
BRITISH COLUMBIA

Figure 10

100, 90 and 50 per cent home ranges of the adult male (87), adult female (90), and yearling female (4), of the Upper Adam Pack for the whole study period (87: April 10 - September 10; 97: April 30 - September 3; 4: May 4 - September 3, 1978).

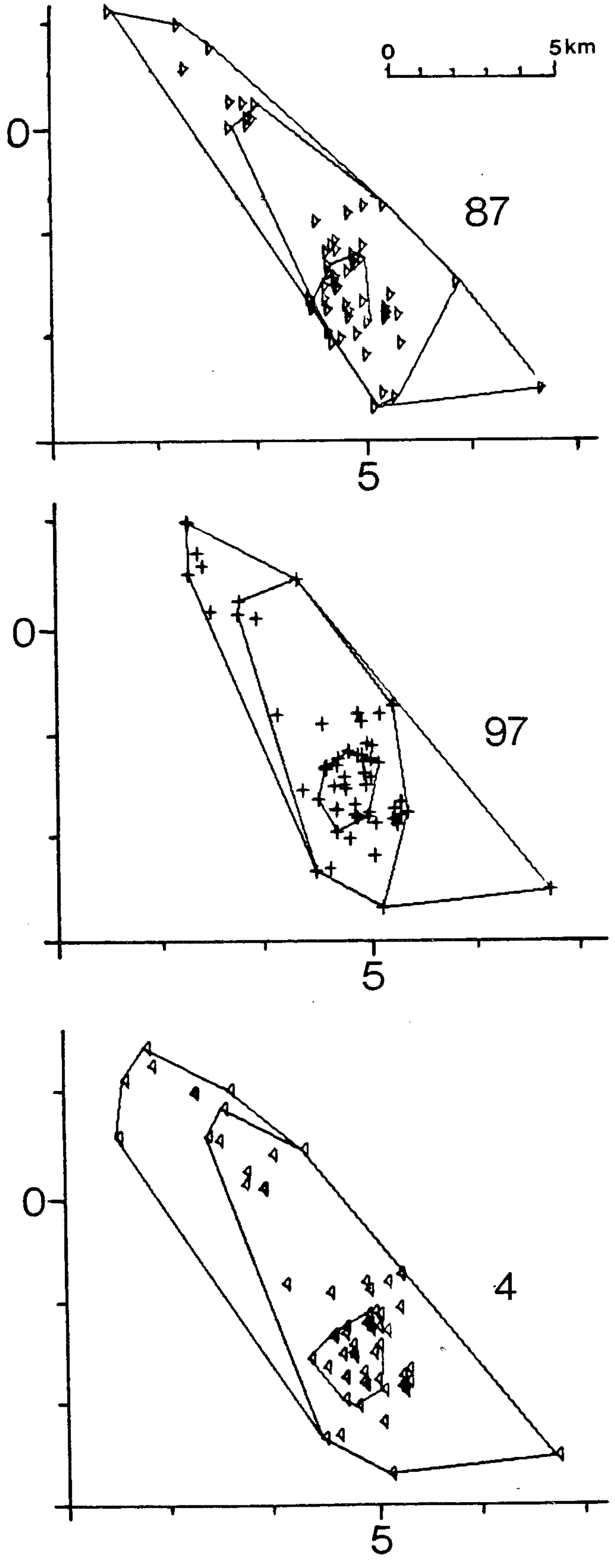
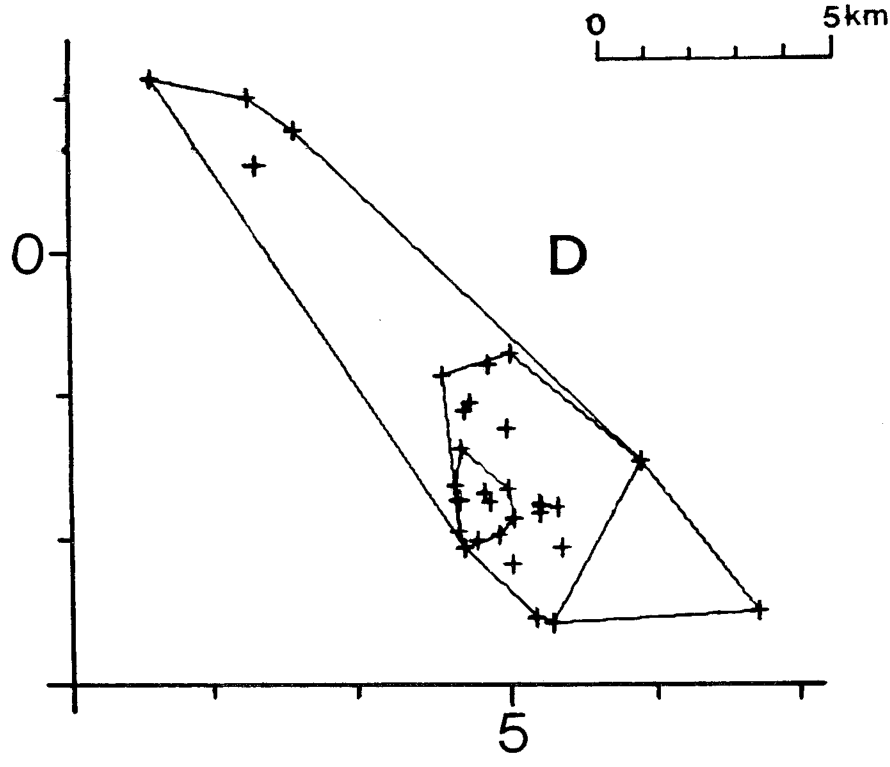

0
5km
0
87
5
0
97
5
0
4
5

Figure 11

100, 90 and 50 per cent home ranges of the Upper Adam adult male (87) for the denning (D) and post-denning (PD) periods (D: April - July; PD: August - September, 1978).


0
5km
0
D
5

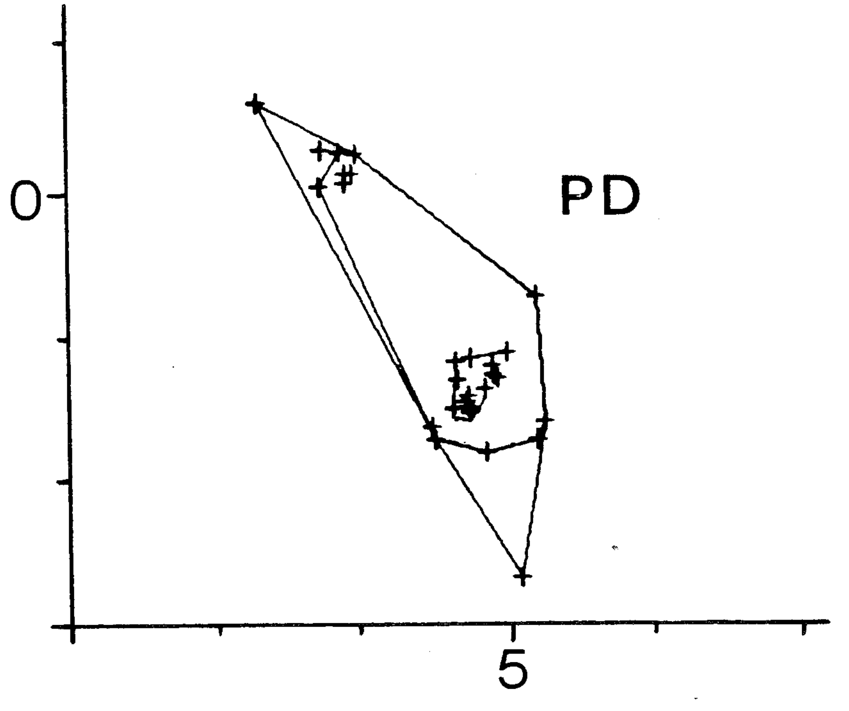
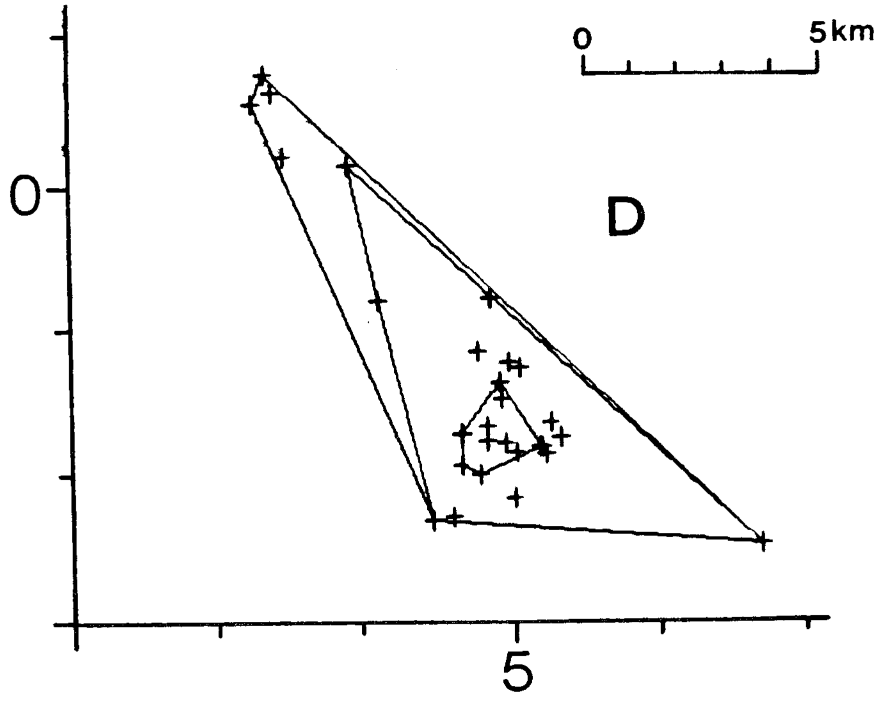

0
PD
5

Figure 12

100, 90 and 50 percent home ranges for the Upper Adam female (97) during the denning (D) and post-denning (PD) periods (D: April - July; PD: August - September, 1978).


0
5km
0
D
5

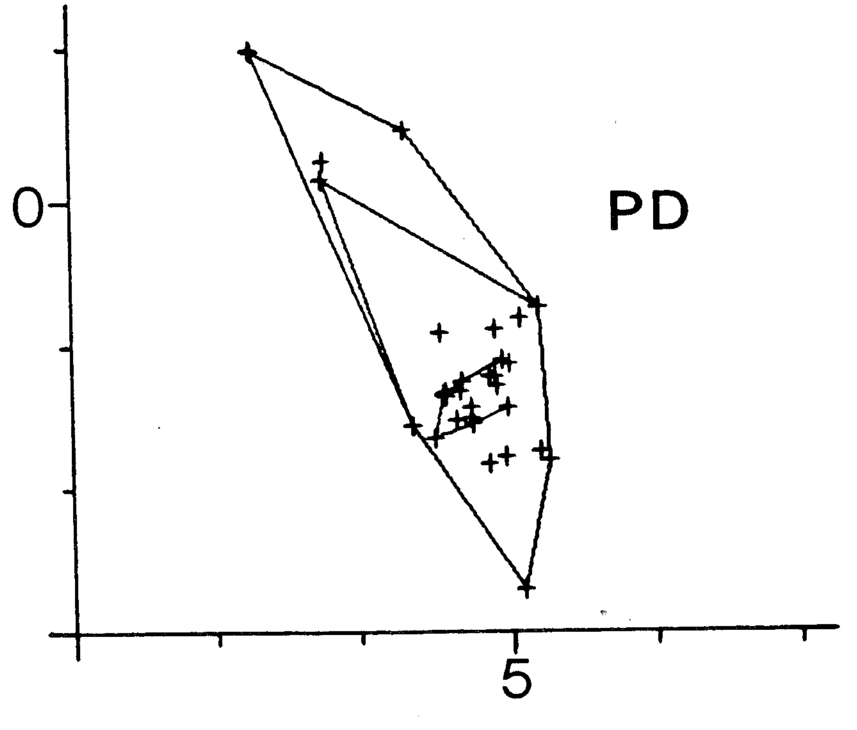
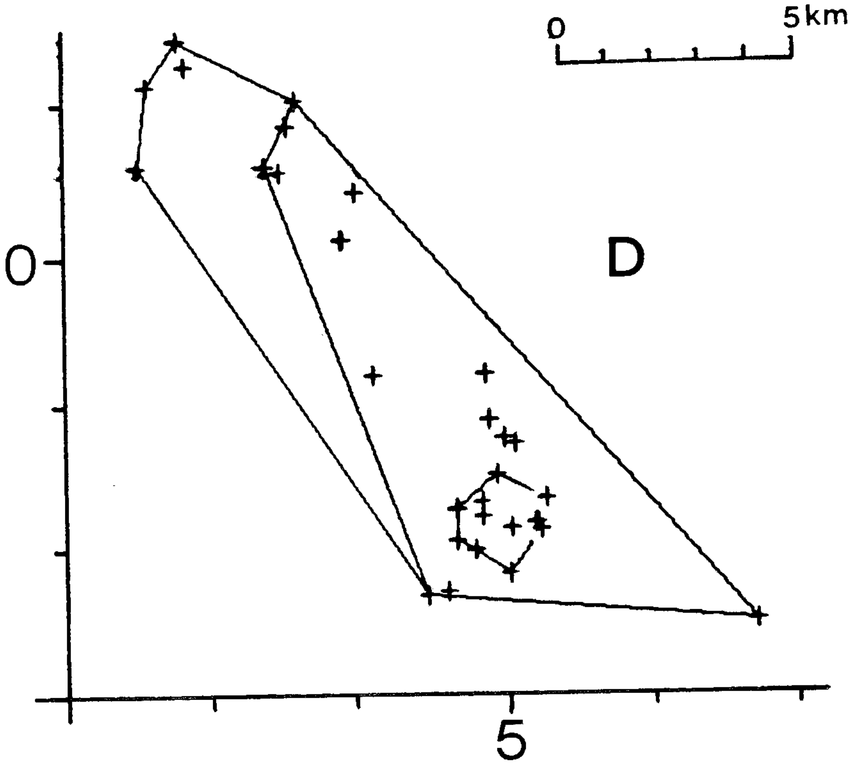
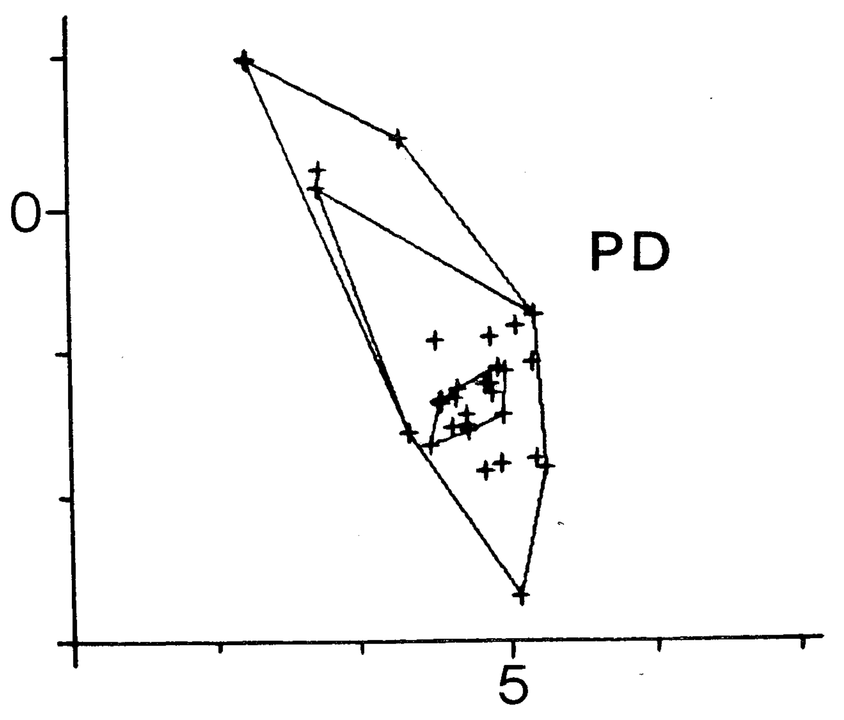

0
PD
5

Figure 13

100, 90 and 50 per cent home ranges of the Upper Adam yearling female (4) for the denning (D) and post-denning (PD) periods (D: April - July; PD: August - September, 1978).


0
5km
0
D
5


0
PD
5

did coincide with theirs, and locations throught the post-denning period were similar for all three animals. This similarity in distributions of the three pack members, together with the similar size of post-denning home ranges (Table 1) suggests a greater pack cohesion at this time compared to the previous denning period when pups would not be mobile. Den and rendezvous sites located on the ground (Figure 9), corresponded to the concentration s of locations shown in home range plots (Figures 10, 11, 12 and 13).

C. Both Packs

Home range sizes of the two packs differed, with the Lower Adam male (86) occupying a larger home range when the whole study period was considered (Table 10) and during the post-denning period (Table 11). However, observations of Lower Adam male (86) extended into November, while those for the Upper Adam pack were curtailed in September when animals were shot. And, although the observation-area plot for the Lower Adam male (86) had asymptoted during the post-denning period (Figure 4), those of the Upper Adam adult (97) and yearling (4) female appeared to be still increasing (Figure 5). The observation-area curve of the Upper Adam adult male (87) did suggest an asymptote had been reached, however, in the post-denning period.

The relative distributions of the home ranges occupied by the two packs during the whole study period are shown in Fig.14. Distances between pack home range boundaries were approximately 1, 9 and 19 km for the 100, 90 and 50 per cent home range plots respectively (Fig. 14). Similar or greater distances when denning (Fig. 15) and post-denning (Fig. 16) periods are considered separately. Thus it appears that, at least for the radio-collared individuals, the two packs held distinct, non-overlapping home ranges during the study period, the core areas (50 per cent plots) being the most separate. Whether this separation of core areas was by "design" or due to limitations of suitable home sites is unknown.

4.3.4 Wolf Densities

Wolf density within the study area, particularly within the Upper pack's home range is likely to be higher than actual figures for reasons which will be discussed later. On the basis of the available data the density within the Lower pack's range is one wolf per 15 km^2 and one per 6.4 km^2 within the Upper pack area.

4.3.5 Daily and Seasonal Movements

A. Lower Adam Pack

The two radio-tagged members of this pack were

Figure 14

100, 90 and 50 per cent home ranges of the Lower Adam pack (LA) and the Upper Adam pack (UA) for the whole study period (LA: April 11 - November 20; UA: April 10 - September 10, 1978).

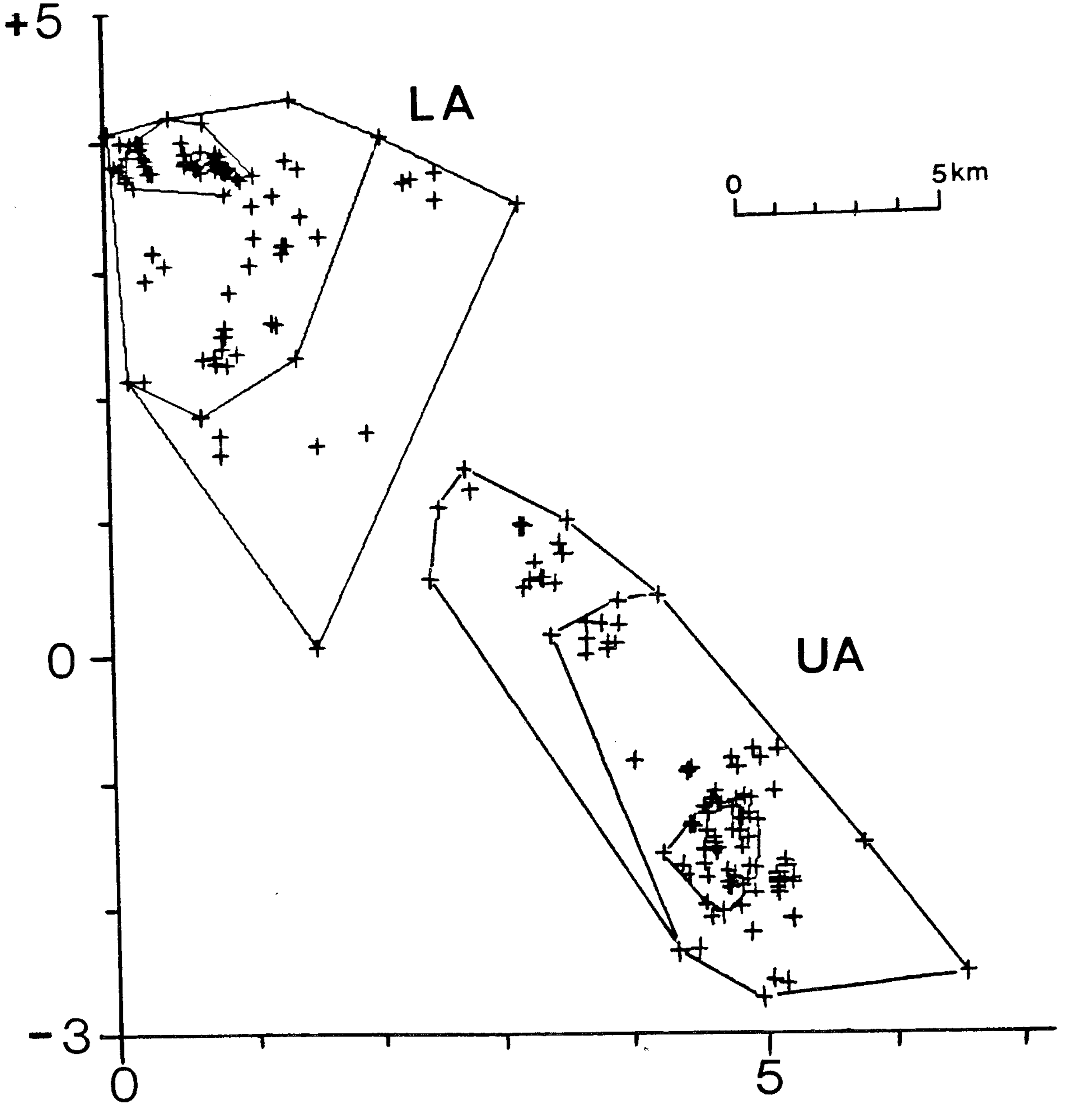

+5
LA
0
5km
0
UA
-3
0
5

Figure 15

100, 90 and 50 per cent home ranges of the Lower Adam (LA) and the Upper Adam (UA) packs during the denning period (April - July, 1978).

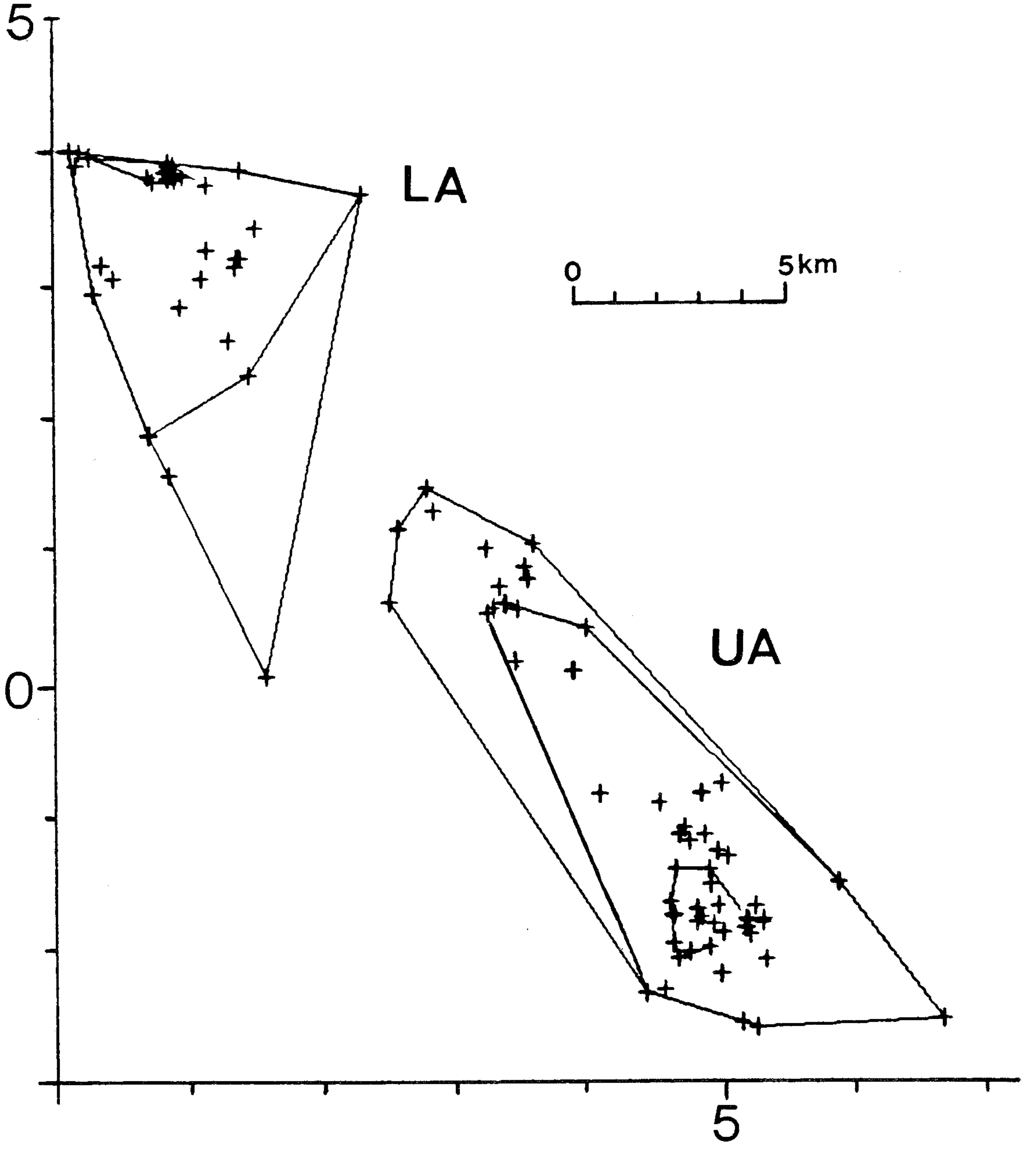
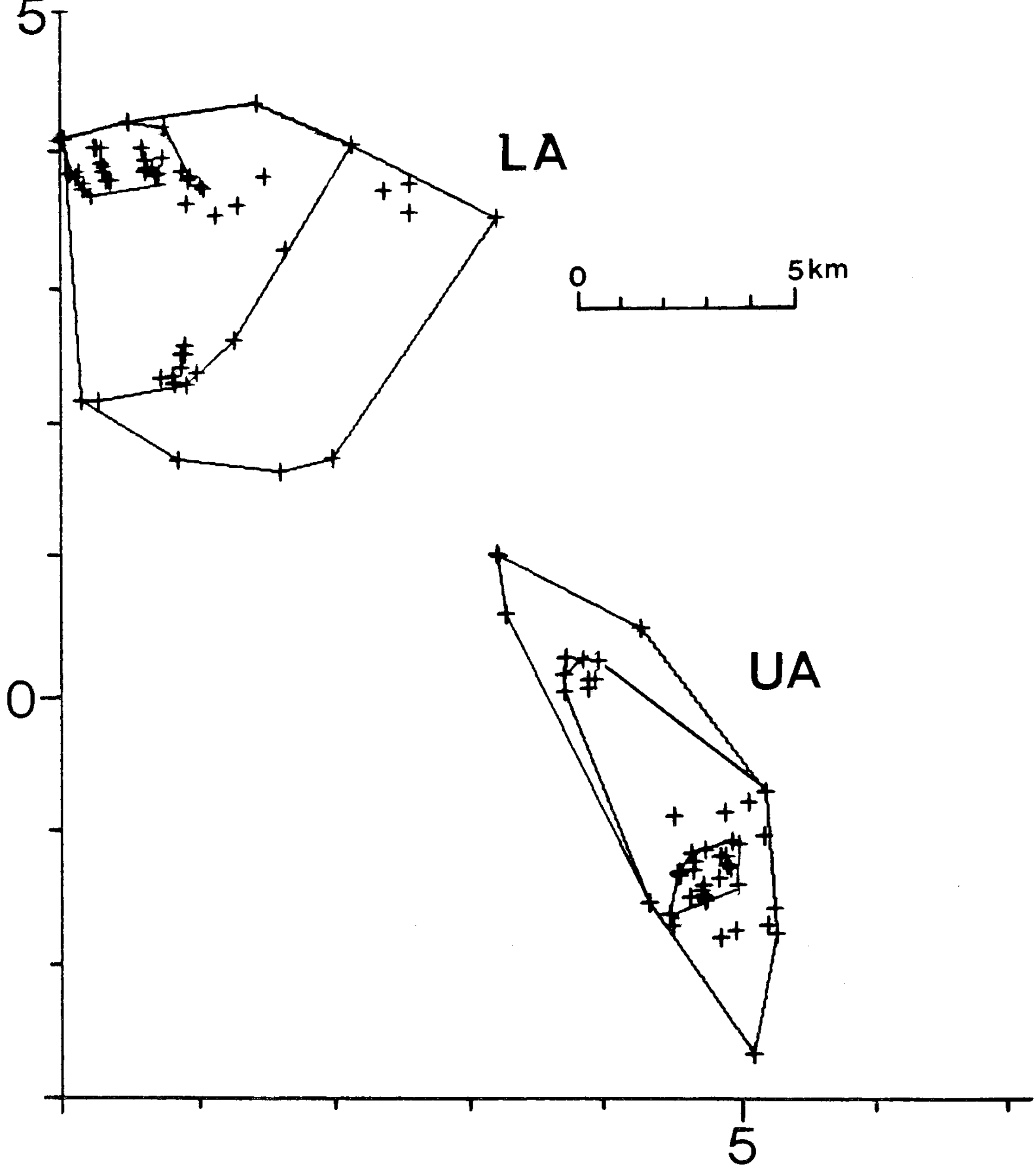

5
0
5
LA
UA
0
5km

Figure 16

100, 90 and 50 per cent home ranges of the Lower Adam (LA) and Upper Adam (UA) packs duri the post-denning period (LA: August-November; UA: August-September, 1978).


LA
UA
0
5km
5
0
5

together when located 68.6 per cent of the time (24 out of 35 locations).

To test the hypothesis that animal activity (active or inactive) was independent of time (day or night) a chi-squared value was calculated for both samples. For April through September 06.00 - 21.00 hrs. was described as day and 21.00 - 06.00 hrs. night. For October and November 08.00 - 18.00 hrs. was termed day and 18.00 - 08.00 hrs. night. The above hypothesis was rejected ($Chi^2 = 4.41$, df=1, $p < .05$); it appeared that animals were more active at night.

Shifts in the home range location of this pack were evident. During April until mid-July their activities were centered around the den with occasional forays into other areas of their range. During the post-denning period they alternated between two core areas; the first a site along the Eve River approximately 1.5 km from the den, and the other a higher elevation area 6 km from the den. The former site was characterized by coniferous and alder/willow stands and expansive sand/gravel bars along the river. The latter was within a pristine conifer stand at 1000 meters of elevation.

Unfortunately, logistical constraints allowed only two occasions during which the movements of a wolf were monitored continuously for an extended period of time. The adult male (86) was followed for 10 hours on September 14, and for 5 hours on September 15, 1978 (Fig. 17). During these times he covered approximately 1.7 km in the 10 hour period and approximately 2.4 km in the 5 hour period. These distances do support the differences in daytime versus nocturnal activity levels described above. The 5 hour period covered part of the night, during which the animal travelled more than it did in a 10 hour daylight period.

B. Upper Adam Pack

The three radio-tagged members of this pack were together when located 45 per cent of the time (31 out of 69 locations). The two females were together 88.4 per cent of the time (61 out of 69 locations).

The activity of animals in this pack was also dependent of time ($Chi^2 = 15.38$, $df = 1$, $p < .05$).

This pack centered their activities primarily around the den from April until mid-July although extensive movements away from this homesite were evident for all tagged members. After this time they moved to a riverside site 6 km from the den, then to a rendezvous site 3 km from the latter. The former area was located in a clearcut/second growth zone beside a creek flowing into the Adam river. The latter was a typical rendezvous

Figure 17

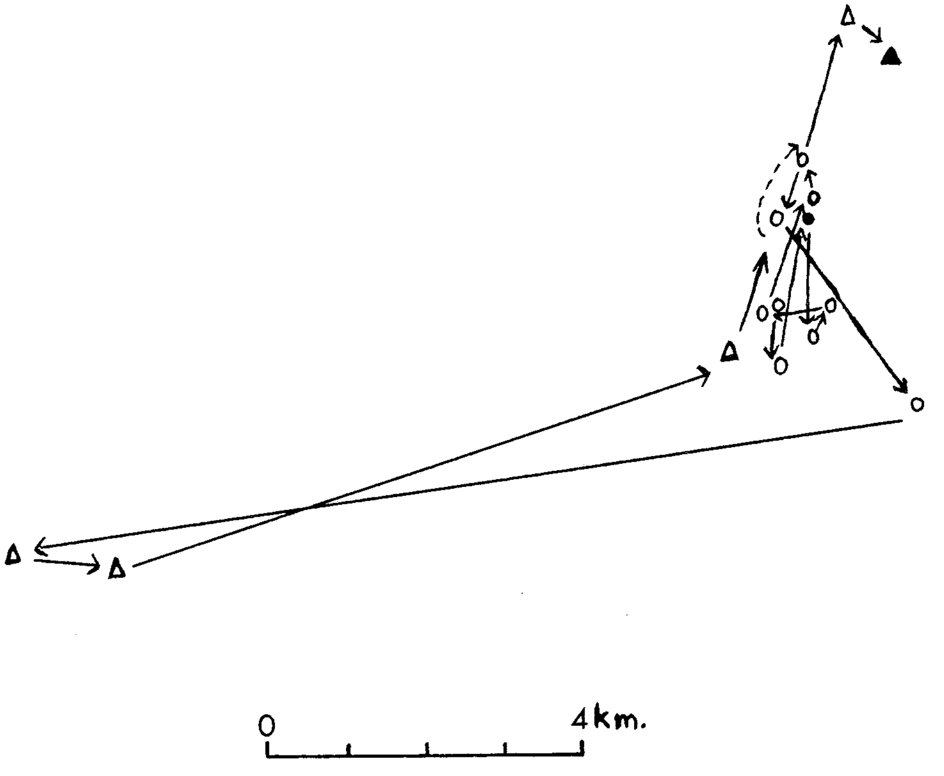
Movements of the adult male (86) from the Lower Adam pack during a 10-hour and 5-hour period

06.30 - 16.30 hrs (○) 14/9/78

18.30 - 23.00 hrs (△) 15/9/78

▲ - last fix

● - first fix


0
4 km.

site as described in the homesite section. Although not borne out by radio-location data, direct observations of individuals and their sign suggests that the remaining members of the pack moved to a rendezvous site located 2 km from the den sometime during December. Differenential utilization of the home range is also apparent for this pack.

4.3.6 Movements of a Lone Wolf

This animal, an adult male, moved over such a vast area of the Island that his movements and locations had to be obtained mainly from the air. His movements are displayed in Figure 18.

He was captured during the early winter (November 1978) in an area believed to be between the two resident packs' ranges. He remained in the general area for three days then moved into the northern section of the Upper Adam pack's range. They were still in the immediate area. A month later he was located in another watershed about 80 km directly southwest, and then a week later he had moved to the headwaters of the Adam river, a direct distance of 50 km. Three days later he was located in the Gold River valley 70 km to the south. His next move took him into the Salmon River 100 km from his last location.

Figure 18

Movements of a lone adult male wolf

(November 1, 1978 - June 1, 1979)

C.S. - capture site

BRITISH COLUMBIA
VANCOUVER ISLAND
Scale: 6 Miles to 1 Inch
REFERENCE
VICTORIA AND SAANICH PENINSULA
QUEEN CHARLOTTE STRAIT
JOHNSTONE STRA
COAST
MOUNTAINS
PACIFIC
OCEAN
VANCOUVER ISLAND
MOUNTAINS
STRATHCONA PARK
COURTENAY
CUMBERLAND
PORT ALBERNI
NANAIMO
QUALICUM BEACH
PARKSVILLE
STRAIT OF GEORGIA
GULF ISLANDS
DUNCAN
UCLUELET
NORTH VANCOUVER
VANCOUVER
VICTORIA
SAANICH
INLET
CENTRAL SAANICH
NORTH SAANICH
ROYAL ROADS
HARO STRAIT
JUAN DE FUCA STRAIT
NOOTKA ISLAND
POWELL RIVER
GARIBALDI PARK
30 4 79
1 6 79
85

It was possible to track him on the ground here, at which time tracks in the snow indicated that he had been following deer along an old logging grade. He remained in this watershed for at least two weeks, then moved 85 km farther south into the Campbell River watershed and stayed there for three weeks. In this area he was observed on the middle of a frozen lake feeding upon a deer (yearling - confirmed on ground), which he had just recently (fresh blood) chased onto the lake and killed. The throat of the deer was the first part to be fed upon. The snow cover on the lake was crusted allowing the wolf to run on top while the deer broke through. Initially as the plane circled above him, he did not appear disturbed, but after some time began to drag the carcass towards the lake's edge. He then abandoned it and wandered off to lie down in a sparsely treed area at the lake's edge. Sometime during the afternoon or evening he dragged the kill about .3 km into a thick alder stand 25 meters from the water. He was located resting a few meters from the carcass and occasionally chasing off ravens which continuously landed on and picked at the carcass. The night previous to the kill he was located in a patch of second growth, inactive, at the lake's edge.

After this time he moved in a southerly direction primarily along the east coast of Vancouver Island passing through several watersheds inland from the coastal towns. When last located he was in an area just outside of Victoria where he remained for at least a week.

When moving through mountainous terrain he seemed to travel the easiest route through mountain passes and along watersheds. He was often located near one of two major powerlines, which run from Campbell River to Victoria, and these would have afforded an easy travel route. Several sections of the line revealed other wolf sign and are probably used by them in a similar manner to logging roads and old grades.

4.3.7 Den Site Characteristics

A. Lower Adam Den

The den was located in the base of a western red cedar windfall which measured 24.5 meters in length. At its widest point the den entrance was 1.5 metres, separated into two passages by a central hump which extended 1.4 meters into the den. The left passage measured .98 meters and the right .56 meters into the den. The left passage measured .98 meters and the right .56 meters in height. Where the den floor levelled out, the single passage was .33 meters in height and .27 meters in width. Farther into the den the passage opened out being large enough for a human to sit with ample head and leg room. The immediate entrance floor was dry, but became increasingly damp farther into the den. Several pup scats were collected just inside the entrance and wolf hair was observed in several places inside the den.

At the entrance level the den floor was 6 meters from ground level. The outer circumference of the tree base measured approximately 11 meters. The den entrance aspect was 292° W.

The den site was located in a primary growth timber stand at 150 m. elevation which jutted out into clearcut and second growth hemlock zones. Dominant tree species were western hemlock and red cedar. Shrubs observed included red huckleberry and blueberry (*Vaccinium spp.*), salmonberry (*Rubus spectabilis*), devil's club (*Oplopanax horridus*), and skunk cabbage (*Lysichitum americanum*). The ferns noted were oak fern (*Gymnocarpium dryopteris*), sword fern (*Polystichum munitum*), deer fern (*Blechnum spicant*), and bracken (*Pteridium aquilinum*).

A small stream ran through the timber stand in which the densite was located. Numerous boggy sites were observed which would likely be ponds during the wetter months when the pack utilized the den. Another stream with nearby ponds ran through the clearcut adjacent to the timber stand. The nearest major river, the Eve, was approximately 2 km from the densite.

Four major trails led to and from the den. Two ran parallel to the denning log from behind the entrance, and two radiated in from the front at either side of the den entrance. These trails branched into many side trails throughout the forested site.

A total of 126 scats were collected in the immediate vicinity of the den. The remains of two deer (lower jaws and femurs) were gathered in the surrounding area.

Throughout the timber stand and near the den, were numerous squirrel chewings (hemlock cones), bear scats, and fresh deer tracks and pellets. Small "digs" at tree bases were observed possibly indicative of marten and squirrel. A marten was observed near the den. Fresh elk pellets were observed in the clearcut adjacent to the timber stand.

A well worn area forming a semi-circle of approximately 1 m. radius, suggestive of an activity site, was observed in front of the den. To one side of the den another windfall with well worn areas around and under it, was noted. It appeared to provide cover for at least two adult/yearling wolves. Several pup and adult/ yearling scats were collected around this windfall.

Adjacent to the den entrance was a lateral seepage site supporting skunk cabbage and devil's club. The ground sloped up with increasing distance from the den, the forest floor being rather soft and spongy underfoot with numerous windfalls throughout. Several of these windfalls were worn down on the top giving the impression they had been utilized as resting/travelling/vantage points. Throughout the surrounding area the tracks of pups and adults were observed, particularly under windfalls and in boggy sites. Scats of adults were often found on windfall tops, and those of pups on ground level.

B. Upper Adam Den

Due to the nature of the habitat and topography in the area, the denning area utilized by the Upper Adam pack was not examined until November 22, 1978. At that time snow cover precluded making the desired detailed observations.

The denning area was situated on a north facing ridge within an area of pristine timber at approximately 750 m altitude. Several excavated caves were found at the bases of red cedar and mountain hemlock (*Tsuga mertensiana*) trees. These caves measured on the average .4 meters in height and width. The ground was well worn around tree bases and wolf hairs were observed both inside and at cave entrances. Also noted were numerous areas around den entrances where wood had been chewed.

The densite was located within a primary growth timber stand approximately 2 km from logged areas. Dominant tree species included red cedar, western hemlock and amabilis fir. The major shrubs were Vaccinium spp. Ground cover consisted of mosses, and arboreal lichens were supported by dominant tree species. Grasses and sedges were the primary components in nearby high elevation wet meadows.

Three high elevation wet meadows were close to the denning area, and two streams flowed in a northeast direction to the Adam River approximately 3 km from the site.

One major trail ran up the ridge to and from the site and others radiated out into the timber. Adjacent to the high elevation wet meadow nearest to the denning area a small activity area was observed. Several scats were collected around the bases of trees where the ground had been worn from animal activity.

Fifty-four scats were collected at and around the site. Deer and elk remains were observed in the surrounding area while searching for the denning site.

Squirrel chewings were frequent about the site and fresh deer and old elk signs were observed in the surrounding area.

4.3.8 Rendezvous Site Characteristics

A. Lower Adam site

Although the rendezvous site of this pack was searched for, it was not found.

B. Upper Adam Site

Pack members were radio-located or aerially observed at this activity site from mid-August until mid-October, 1978.

The site was situated in a high elevation wet meadow surrounded by pristine timber at approximately 800 m. altitude. Numerous other meadows and bogs were situated nearby. The length of the meadow (90 m x 30 m) ran in a southeast-north-west direction. Several small creeks flowed southwest into the Adam River about 3 km from the site.

Trees common within the surrounding timber included mountain hemlock, amabilis fir, yellow cedar, western white pine and western yew. Arboreal lichens were supported by dominant trees. Major shrubs within the meadow were <u>Vaccinium</u> <u>spp</u>., and labrador tea.

Grass and sedge species were the dominant constituents of the meadow vegetation.

Pack members appeared to predominately utilize only a small corner of the site for activity purposes. The main activity area was hidden from view of the remainder of the meadow by several stunted trees and snags. In this corner the ground was well worn around a small raised mound (5 m x 3 m). Digging was noted around the mound and at the bases of numerous nearby trees. One major trail ran along the southwest edge of the meadow leading into the main activity area. Several trails radiated out from this area into the timber.

Sixty-two scats were collected around the site and the remains of some deer kills observed in the surrounding timber.

Observations around the site confirmed that both elk and deer were present near the site. Fresh tracks and pellets of both species were noted. Another examination of this site in mid-November confirmed that deer were again present.

Although contact with this pack was lost during September, 1978 it is known that they utilized another rendezvous site with similar features to the above during

December, 1978 through April, 1979. This site was close to their densite of 1978, therefore it appears they were again frequenting areas near to the denning area.

4.4 Discussion

Morphological data from the nine wolves captured in this study show that in comparison to similar data from other parts of North America, the adult Vancouver Island wolves of both sexes are heavier than those from Ontario (Pimlott et al., 1969; Kolenosky and Stanfield, 1975), Quebec (Huot et al., 1978) and northeastern Minnesota (Van Ballenberghe, 1975). And, while similar in weight to Stenlund's (1955) sample from northeastern Minnesota, are lighter than animals from Alaska (Rausch, 1967) and the orthwest Territories (Fuller and Novakowski, 1955; Kelsall, 1968). However, in terms of body dimensions the Vancouver Island wolves measured here, show larger total lengths and tail lengths than those reported by Van Ballenberghe (1975) for northeastern Minnesota, and by Fuller and Novakowski (1955) and by Kelsall (1968) for wolves from the Northwest Territories. Hind foot lengths and upper canine lengths are similar to those reported by Van Ballenberghe (1975), while hind food lengths appear smaller than data from the Northwest Territories (Fuller and

Novakowski 1955, Kelsall 1968).

Only one other published report presents data on metabolic profiles of wolves, and these are for pups (Seal et al., 1975). Changes with age in certain blood parameters have been reported for domestic dogs (Bulgin et al., 1970). If these are considered in comparisons with the data for wolf pups presented by Seal et al. (1975) and the adult Vancouver Island wolves studied here, it is apparent that the trends in total serum protein, serum albumin, haemoglobin concentration and RBC are comparable. Seal et al. (1975) suggested that relative levels of BUN and cholesterol between their samples for two years, indicated differences in nutritional state of their wolf pups. The adult Vancouver Island wolves had higher BUN values but lower cholesterol values than the wolf pups reported by Seal et al. (1975). Both these values for wolves are higher than those reported by Bulgin et al. (1970) for beagles.

Aspects of the social organization of the two wolf packs investigated in this study may be summarized as follows: The Lower Adam pack, consisting of five animals (including pups), utilized a 75 km^2 home range, with a resulting density of one wolf per 15 km^2. Within this home range they demonstrate seasonal shifts in core areas, which were related to activities around den and rendezvous sites. They denned in a red cedar windfall within pristine coniferous timber, and alternated their post-denning movements between two rendezvous sites, one a riverside site, the other at a higher elevation in coniferous timber. The larger Upper Adam pack, estimated to be composed of ten individuals (including pups), ranged within a 64 km^2 home range, with a density of one wolf per 6.4 km^2. The smaller home range size of the large pack, may be an underestimate, because the period over which they were followed was less than the period the small pack was monitored. Similarly, the lower calculated densities, may be due to the fact that only three of the large pack were radio-collared, and thus other adult members may have included other areas in their home ranges, thereby increasing the home range size estimates for the whole pack. Upper Adam wolves demonstrated similar seasonal shifts in home ranges, moving from a densite located within a primary stand of timber at high elevation, to rendezvous sites at other locations.

It was originally hypothesised that the topography within the study site would limit the distribution of packs to separate watersheds. The distributions of these two packs, together with incidental observations of other wolves in adjacent areas, suggest that this hypothesis is rejected in general, and applies only where valley systems have very steep sides. The two home ranges observed, occurred within the same general watershed, and also encompassed other tributary drainages. An alternative hypothesis to be tested in the future, is that the wolves are limited in their distributions by a combination of suitable home sites, and availability of food sources, particularly high densities of black-tailed deer.

In comparison to previously published studies of Nearctic wolves, those studied on Vancouver Island appear to hold smaller home ranges, and occur at higher densities (Table 5). However, the lack of year round observations on Vancouver Island due to the illegal shooting of the radio-collared wolves, probably resulted in an underestimate of annual home range size as presented here. The actual estimates did approach those reported for the mid-latitude forested regions (Mech, 1966; Pimlott et al., 1969,; Van Ballenberghe et al., 1975), but were vastly different from the large home ranges estimated for wolves inhabiting Alaska and the Northwest Territories (Murie, 1944; Burkholder, 1959; Clarke, 1971; Haber, 1977).

Pack sizes are somewhat difficult to compare between studies and between areas, as previously published studies have determined them using different methods. They are somewhat variable throughout North America

(Table 5) both between and within regions. Furthermore, the durations of the various studies also varies considerably. Data gathered over longer periods may be more accurate for estimating pack size, but significant fluctuations in pack numbers can vary over relatively short periods (Haber, 1977).

There appears to be a general trend for wolf densities to be higher in the mid-latitudes (Cowan, 1947; Mech, 1966; Pimlott _et al_., 1969; Van Ballenberghe _et al_, 1975) as compared to those of the arctic and subarctic zones (Murie, 1944; Burkholder, 1959; Clark, 1971; Haber, 1977). Some combinations of differences in the densities and seasonal availabilities of prey species, probably accounts for this variability (Mech, 1970). Although no adequate data are available from the Vancouver Island study area, it is hypothesised that the relatively small home ranges the two packs occupied, and their high densities compared to other studies, reflects a higher prey density, particularly with regard to the main prey black-tailed deer. Further studies of the Vancouver Island wolf at study sites varying in black-tailed deer densities, would be required to test this hypothesis of the influence of prey density on wolf home range size and density.

Homesites of both packs displayed good drainage, structural suitability, nearby water sources, and a clear view of the surrounding areas. Prominent trails, activity and resting sites, and animal signs (scats and tracks) were common features of homesites. They were generally situated towards the centre of home ranges, and spatially distributed several kilometers from the adjacent pack's sites. Characteristics of den sites vary in specific details among the various studies undertaken in North America. However, all generally display good drainage, structural suitability, a close source of water, and clear views of the surrounding areas (Murie, 1944; Cowan, 1947, Joslin, 1967; Pimlott *et al*., 1969; Mech, 1970; Clark, 1971; Carbyn, 1974; Haber, 1977). All these features were associated with the Vancouver Island wolves' den sites examined. In some studies, wolf dens were found to utilize previous dens of other species, and were sometimes re-excavated (Murie, 1944; Clarke, 1971; Haber, 1977).

It is suggested that pristine conifer stands covering suitable substrate, or with large windfalls, are important for successful denning by Vancouver Island wolves. Such areas are therefore necessary to preserve during forest cutting operations.

Rendezvous sites show common features throughout the literature. They are invariably situated in open meadows bordering timber stands, and have signs of activity and resting sites, together with other signs (Joslin 1967, Haber 1977). Utilization of more than one rendezvous site within a pack's home range, similar to those reported here were found by Joslin (1967) for Ontario wolves. However, these latter animals were found to move more frequently between rendezvous sites than the Vancouver Island wolves.

Observations of diurnal activity in the Vancouver Island wolves demonstrated that they were more often found resting during the daylight hours, but were significantly more active at night. This together with the limited observations collected during the two continuous monitoring periods, suggest that where studies involve only daylight observations or daylight radio telemetry locations, home range size and distribution may be significantly underestimated. More intensive work during the night period should provide a quite different picture from our present level of understanding, and have implications for theoretical considerations of home range sizes (Harestad and Bunnell, 1979).

The lone wolf captured and monitored during this study clearly does not fit the previous ideas about lone individuals (Mech, 1970). This animal was apparently alone throughout the period he was followed, and ranged over a large portion of Vancouver Island. Although his movements appeared in part related to the north-south oriented, cleared powerlines, major inter-valley movements were also apparent among his locations in the northern part of the Island.

The social organization of wolves appears to be dependent upon the nature of the areas they inhabitat and the ecology of the prey species within the particular region. Wolves inhabiting the mid-latitudes of North America demonstrate similarities in social organization, while those found in the higher latitudes depart from these patterns. The Vancouver Island race demonstrates patterns which are consistent with the habitat and prey base.

5. FINAL DISCUSSION

As man continues to alter the original state of his surroundings, the interrelationships between the environment and its wildlife inhabitants are receiving increasing attention. One area of particular concern has been the dynamics of predators and their prey. During the past two decades numerous field studies have focussed upon the behaviour and ecology of the large predators (Mech, 1966; Hornocker, 1970; Kruuk, 1972; Schaller, 1972; Haber, 1977). These studies and others have demonstrated that the foraging habits of predators are closely related to both their own and their prey species' social organization and behaviour. Diet and hunting technique have been shown to differ according to the environment and prey species in question (Schaller, 1972; Kruuk, 1975). In addition, the degree of sociality within certain carnivore species appears to be related to their exploitation of varying sized prey species (Schaller, 1972; Bowen, 1978).

Conclusive data are not available from this study to clearly demonstrate the above principles. However, to a minor degree certain suggestions can be made. Deer constitute the bulk of the wolves' diet on a yearly basis. This has been shown in other environments which support a similar prey complex (Pimlott *et al*., 1969; Carbyn, 1974; Van Ballenberghe *et al*., 1975; Theberge *et al*, 1978). The homogeneous distribution and high abundance of this prey species appears to be reflected in the wolves' diet as opposed to elk and beaver which are alternate and usually secondary food sources. Utilization of elk may be opportunistic, owing to their clumped distribution, relatively low abundance and hence lower predictability compared to deer. Beaver are predictably distributed but low in biomass and are preyed upon through the winter and spring months. It appears that beaver constitute a larger proportion of the diet during that time of year when ungulate young are not available. The occurrence of of this species in the diet of wolves during this period is likely reflecting the relatively mild climate on the Island. In more mountainous and eastern habitats this species is preyed upon during the summer.

The summer diet of wolves consists mainly of ungulate young. Seasonal variation in utilization of prey type and species is clearly demonstrated. Wolves are known to vary their diet on a seasonal basis in other environments which support both a similar and unique prey complex (Murie, 1944; Pimlott *et al*., 1969;

Kuyt, 1971; Clark, 1971; Van Ballenberghe et al., 1975; Theberge et al., 1978).

Differences in the diet of the two packs studied here suggests a relationship between larger group foraging efficiency and their greater ability to prey on larger prey species captured. This has been demonstrated for other carnivore species (Kruuk, 1972; Schaller, 1972; Bowen, 1978). Another possibility is a difference in the prey distributions in the two packs' home ranges. The diet of the larger, Upper Adam pack, showed a higher proportion of adult elk on a yearly basis, whereas the smaller, Lower Adam pack, showed occurrences of this species only during the summer. Furthermore, the larger pack preyed initially upon adult deer in the summer, while the smaller pack fed primarily upon ungulate young. The late summer diet of the larger pack consisted of fawns, calves, and adult elk while that of the smaller showed mainly fawns and adult deer. These findings suggest that the total prey complex could be taken by the larger pack throughout the year as a result of their greater numbers, while the smaller pack was restricted to a partial prey complex and was seasonally dependent upon the largest prey species, elk. Theberge et al. (1978) report changes in diet related to changes in prey species abundance in Ontario.

Judging from the howling of packs as they left their den sites, presumably for hunting purposes, individual were often separated and seemed to travel away from dens in a fanned-out formation. Once they had reached valley bottoms or a particular site, it appeared that they located one another by howling. This aspect of wolf social behaviour is thought to act in coordinating their social hunting activities (Theberge and Falls, 1967).

Both packs studied here displayed seasonal shifts within their total home ranges, and utilized core areas within these areas. With the exception of the Upper pack's denning area, both packs frequented rendezvous sites located at a higher elevation from sections of the home ranges used prior to this time. These movements may have been related to those of elk and deer. The seasonal migrations of the former are made to areas of higher elevation while deer appear to use forested areas bordering on clearcut zones at this time of year. Fresh sign of both prey species was noted around these rendezvous sites. However, there were no adequate data to demonstrate a direct relationship between the movements of wolves and their ungulate prey.

Data on home range sizes, pack sizes, and hence densities are limited by the lack of information, particularly

Mech, 1970). Previous researchers have thought that dens were selected on the basis of drainage, water supply, suitable digging structure, early disappearance of snow, and a view. Rendezvous sites are believed to be selected for similar reasons. I believe that site selection is mainly based upon the presence of an abundant and close food source. The other factors noted above may vary in importance within different habitats. For instance, wolves in higher latitudes which seem to hunt mostly by sight (Clark, 1971), appear to choose sites which provide a good view, an easily dug substrate, early disappearance of snow and a nearby water supply. In forested areas dens often lack such a view. This may be related to their hunting a great deal by smell (Mech, 1970). The elevated location of dens appears to be a common factor in choice, which may result from their desire to be on a raised area. This would naturally provide good drainage and hence a dry site, but does not necessarily imply that areas are selected for this reason. An adequate accessible water supply would also be necessary for the lactating female (Mech, 1970).

Wolves probably base their choice of site mainly upon food supply. Depending upon the habitat involved the other factors noted above are likely to influence their site choice secondarily. A further possiblity is that sites are chosen in areas that are spatio-temperally separated from those of adjacent packs. It would be advantageous if not crucial for packs to separate themselves and maintain their daily and seasonal patterns with the least amount of contact with neighbouring packs. Inter-specific strife often resulting in the death of animals is known to occur with wolves (Mech, 1977).

Throughout Vancouver Island and within the study site the habitat is constantly being altered by logging and and other practices to the extent that the total "landscape" of regions is changed by the formation of clearcut and second growth zones which replace pristine timber. The effects of these practices upon the dynamics of wolves and their prey are not definitely known. However, the vast clearcut areas provide additional forage for ungulate species which probably promote an increase in their numbers (Harestad, pers. comm.), and in turn also cause an increase in wolf numbers over time. In timbered areas where wolves formerly hunted by smell only they could now hunt by both sight and smell. Another equally important factor is the human hunting pressure upon deer in these open areas, which in combination with wolf and cougar predation may act to depress deer numbers. Furthermore, the occurrence of open (logged) areas may act against the wolf. Considering five out of the eight radioed wolves in this study "disappeared", mostly by shooting, during the deer hunting season, it appears that their chances of survival are not enhanced in accessible areas of altered habitat.

The interrelationships between the environment and its wildlife inhabitants are worthy of much attention. To successfully manage wildlife species it is necessary to determine the ecological needs of the predators and their prey species both in areas of altered habitat and those which remain in a pristine state.

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