TOPIC 2. EVALUATIONS OF SEASONAL ANIMAL RESPONSES

Animals maintain a dynamic energy balance through the annual cycle. This includes periods of both positive and negative balances for wild ruminants, with the positive energy balances during the productive summer period when females lactate and body growth and weight gains occur. The winter period is a time of negative energy balances when weight losses occur as a result of the breakdown of body tissue, especially fat, to meet metabolic demands.

Annual rhythms in body weights were discussed in CHAPTER 1, and body composition in CHAPTER 2. Annual rhythms in metabolism also occur, and were discussed in CHAPTER 7. Calculations of the amounts of forage necessary to meet seasonal metabolic requirements were discussed in CHAPTER 12.

The UNITS in this TOPIC include discussions of thermal energy balances. Thermal energy exchange is a constant process, and cold weather, thermal energy losses may exceed metabolic heat production, resulting in a negative thermal energy balance. In hot weather, heat production may exceed heat loss, which results in positive thermal energy balance, and a dangerous one.

Many factors affect thermal energy balances. Some of the physical atmospheric factors are solar and infrared radiation, wind speeds and turbulence levels, air temperatures, and vapor pressure deficits of the air. Some of the physical topographic factors are slope, aspect, and surface characteristics of the substrate (soil, vegetation, or snow). Some of the habitat factors are density of the cover as a barrier to wind, overhead density as a factor in radiation flux, overhead density for snow interception, life-forms of the plants and their leaves, and others. Some of the animal factors are size, weight, surface area, posture, orientation, piloerection, hair depth distribution, wetness of the hair coat, activities, metabolic rate, vasoconstriction and dilation, thermogenesis, fat quantity and distribution, and others. All of these are potential factors for affecting heat exchange. The large number of factors make the idea of "critical temperature," which is so entrenched in the literature, rather inadequate.

Critical temperatures are determined by placing an animal in a temperature-controlled metabolic chamber and raising and lowering chamber temperatures until a metabolic response is observed. The temperature at which the animal shows signs of heat stress is called the upper critical temperature, and the temperature at which the animal shows signs of cold stress, the lower critical temperature. It is my opinion, after reading the literature on this subject for a variety of species and observing deer in the pens at the Wildlife Ecology Laboratory and in the wild, that the temperatures at which responses occur are artifacts of the experimental conditions. A deer in a chamber is deprived of all of its behavioral options, and it is in an alien habitat not at all characteristic of the species' choice. It has little choice but to respond physiologically at some temperature.

Deer at the Wildlife Ecology Laboratory have not shown signs of cold stress at temperatures as low as -25°F (-32°C). Rather, they have shown reduced heart rates, respiration rates, and rumination rates. Piloerection occurs over parts of the body. Shivering may or may not occur.

Rainy days with freezing temperatures may result in signs of cold stress. The effects of water, with its heat capacity and evaporative cooling effect, may be critical. We humans are aware of the danger of becoming wet in cold temperatures. Thus temperature is simply not <u>the</u> critical one for free-ranging animals.

The concept of a critical thermal environment was published in Moen (1968), with several factors of thermal importance discussed, and any potential factor part of the concept. The <u>combinations</u> of factors that cause heat stress are called <u>critical hyperthermal environments</u>. The <u>combinations</u> of factors that cause cold stress are called <u>critical hypothermal environments</u>. Within these environments there could be critical wind velocities, critical postures, critical radiation fluxes, critical air temperatures, critical orientations, and so on. Any factor that could be altered to maintain an appropriate energy balance is a potential critical one, and many of these factors are behavioral options to be selected by the animal.

This discussion of the thermal environment precedes the UNITS because it applies to all of them. Keep this in mind when reading the literature on the effects of weather on wild ruminants. It is well to remember when considering thermal relationships and many other kinds of biological questions, especially ecological ones, that <u>there are no simple answers to complex questions</u>.

LITERATURE CITED

Moen, A. N. 1968. The critical thermal environment: A new look at an old concept. BioScience. 18(11):1041-1043.

UNIT 2.1: ANIMAL RESPONSES IN THE SPRING

Spring officially arrives on March 21, JDAY 80. Since weather conditions over most of the wild ruminant range are more like winter than summer at that time, the animals are faced with the problem of conserving heat energy to avoid hypothermia and yet meet the increasing metabolic costs associated with the annual metabolic cycle (See CHAPTER 7, UNIT 6.1).

Animals may or may not be on the winter range when spring officially arrives, depending on the weather and snow conditions in March. The most conspicuous animal response in the spring is that of movement from the winter range to the summer range. This involves dispersion from winter concentration areas, migrations to higher altitudes, and migrations to areas of traditional use, such as calving grounds.

Weather conditions may vary widely, from severe spring storms with deep snow to very warm and sunny days. The winter coat is retained through April and May, so heat loss is not necessarily more severe during cold, spring weather. Since the fat reserves are depleted and the available forage has the lowest nutritive quality of the year, severe spring storms cause more stress than similar conditions cause early in the winter (Moen 1976).

The significant physiological response to consider in the spring is the rise in metabolism. If winter weather conditions persist and the animals are forced to remain on low quality winter forage, the rise in metabolism places the animal in a lessl-favorable nutrient energy balance. This was discussed and illustrated in Moen (1978) for different times of arrival of spring. The basic relationship may be illustrated with the following numerical examples, using the formula discussed in CHAPTER 12, TOPIC 3. A gross energy of 4500 kcal per kg and a metabolic energy coefficient of 0.86 is used in the calculations below.

Ecological Metabolism		Forage Digestibility		Forage Required
2200	÷	[(4500) (0.40) (0.86)]	=	1.42
2400		0.40		1.55
2600		0.40		1.68
2800		0.40		1.81
3000		0.45		1.72
3200		0.50		1.65
3400		0.55		1.60

Note that as ecological metabolism increases, forage required increases as long as the forage digestibility remains the same. When digestibility increases, then the forage required decreases as the increase in digestibility compensates for the increase in ecological metabolism. The timing of the arrival of spring, the amelioration of cold weather, and the onset of the growing season are critical factors determining energy balance and hence productivity in wild ruminant populations.

Weather profiles were completed in WORKSHEETS at the end of each UNIT in the previous TOPIC. In this TOPIC, animal profiles are completed at the end of each UNIT, listing important weight, metabolism, and diet characteristics at 7-day intervals.

LITERATURE CITED

Moen, A. N. 1976. Energy conservation by white-tailed deer in the winter. Ecology. 57(1):192-198.

Moen, A. N. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. J. Wildl. Manage. 42(4):715-738.

REFERENCES, UNIT 2.1

ANIMAL RESPONSES IN THE SPRING

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	84--1	270	273	odvi	response to wisc wild fire	vogl,rj; beck, am	1970
CAFNA	90--2	123	136	odvi	distr, movs reln env fctrs	drolet,ca	1976
JANSA	45--2	365	376	odvi	nutritin thrghout the year	holter,jb; urba /	1977
JOMAA	39--2	309	311	odvi	aspects of blood chemistry	wilber,cg; robins	1958

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	19--3	358	364	odvi	rnge apprsl, missouri ozar	dunkeson,rl	1955
JWMAA	24--4	387	395	odvi	deer-for hab relnshps, ark	halls,lk; crawfor	1960
JWMAA	33--4	881	887	odvi	repro pattrns rel nutr pln	verme,lj	1969
JWMAA	35--1	37	46	odvi	eff fallng temp, heat prod	silver,h; holter/	1971
JWMAA	38--2	220	228	odvi	infl lt, weathr, obsrvblty	zagata,md; haugen	1974
JWMAA	41--2	315	317	odvi	seasnl chnge circad activ,	kammermeyer,ke; m	1977
JWMAA	42--4	715	738	odvi	seasnl chngs hrt rate, act	moen,an	1978
JWMAA	42--4	746	754	odvi	metab indictrs of hab difs	seal,us; nelson,/	1978
MGQPA	31...	62	74	odvi	spring ecolg, nc minnesota	pierce,de,jr	1971
NAWTA	24---	201	215	odvi	evergl hrd, rng cond, life	loveless,cm; liga	1959
NYCOA	14--2	30	31	odvi	big deer vs lit deer, food	severinghaus,cw;	1959
NYCOA	27--2	28	31	odvi	weather and the deer popul	severinghaus,cw	1972
NYCOA	29--4	18	20	odvi	advances, science deer mgt	severinghaus,cw	1975
RWLBA	6---2	327	385	odvi	wint, spr obsrv, adirndcks	spiker,cj	1933
SJAFD	1....	10	13	odvi	use of clear cuts, sw virg	blymyer,mj; mosby	1977
TISAA	63--2	198	201	odvi	deer trap corr weath fctrs	hawkins,re; klims	1970
WLSBA	6---2	88	90	odvi	the fat cycle in deer	mautz,ww	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	48--2	275	282	odhe	feed intake, heat producti	nordon,hc; cowan/	1970
ECMOA	2----	1	46	odhe	seasonal migratn of mule d	russell,cp	1932
JRMGA	15---	278	281	odhe	rng mgt, habitat, hrd prod	julander,o	1962
JRMGA	30--2	122	127	odhe	eval habita on nutri basis	wallmo,oc; carpe/	1977
JRMGA	31--3	192	199	odhe	spr forg selec, sagebr rng	willms,w; mclean,	1978
JWMAA	22--3	275	283	odhe	food hab, rang use, montan	lovaas,al	1958
JWMAA	29--2	352	366	odhe	stom cont anal rela condtn	anderson,ae; sny/	1965
JWMAA	31--4	651	656	odhe	char herds, range n e utah	richens,vb	1967
NAWTA	20---	568	588	odhe	factrs infl dee, ariz brsh	hanson,wr; mccull	1955
PMASA	19...	72	79	odhe	annu cycl of cond, montana	taber,rd; white,/	1959
WLMOA	20---	1	79	odhe	ceel, doca, rng ecol, mont	mackie,rj	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
EKPOA	17-22	381	389	ceel	repartitn of habita niches	dzieciolowski,r	1969
JOMAA	49--4	762	764	ceel	physiologi stud, rocky mts	herin,ra	1968
NCANA	101-3	505	516	ceel	shiras moos, rng reltnshps	stevens,dr	1974
NZJSA	36...	429	463	ceel	eval cond free-rng dee, nz	riney,t	1955
PZESA	14---	34	39	ceel	ruru, sensitv to temp fluc	christie,ahc	1967
XARRA	63---	1	7	ceel	od, doca, pondero pine use	reynolds,hg	1966
XARRA	66---	1	4	ceel	od, doca use of openings	reynolds,hg	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	24--1	52	60	alal	food comp, rng relns, hare	dodds,dg	1960
JWMAA	39--4	653	662	alal	odvi,relnshps on burn,minn	irwin,ll	1975
JWMAA	40--4	645	657	alal	odvi,habta use, sympt rng	kearney,sr; gilbe	1976
NCANA	101-1	417	436	alal	influence of snow,behavior	coady,jw	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CBPAB	60A-2	123	126	rata	seas change growth hormone	ringberg,t; jaco/	1978
CJZOA	38--4	679	688	rata	wind,moistr,heat loss,calf	lentz,cp; hart,js	1960
CJZOA	39--6	845	856	rata	clim,metb,thrml resp,infnt	hart,js; heroux,/	1961
UABPA	1----	414	419	rata	weath effct on behav, migr	gavin,a	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	87--4	433	454	ovca	chilcotin river bigh popul	demarchi,da; mitc	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATICA	27...	256	264	obmo	rata, northw territ, canad	kevan,pg	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMZOA	16--4	699	710	many	fat, energy, mammal surviv	young,ra	1976
JWMAA	43---	437	444	many	hab partitioni, fire, mont	singer,fj	1979
NCANA	103-3	153	167	many	resour div, commun lg herb	hudson,rj	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
RVTSA	7....	466	479	dosh	thermal reguln, two breeds	webster,ajf; blax	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	24--1	92	94	ungu	asses phys cond, field tch	riney,t	1960

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ANYAA	301..	110	127	----	influnc exrcise skin tempe	adams, wc	1977
BISNA	18-11	1041	1043	----	critical thermal environme	moen,an	1968
IJBMA	20--2	139	156	dome	signif,meteorol, anim prod	bianca,w	1976

CHAPTER 17, WORKSHEET 2.1a

Animal characteristics during the spring season

Animal characteristics for each of the JDAY's from March 26 (JDAY 85) through June 18 (JDAY 169) at 7-day intervals may be completed by referring to the equations below.

FEWK: See CHAPTER 1, WORKSHEET 1.1a
CLWK: See CHAPTER 1, WORKSHEET 1.2a
MBLM: See CHAPTER 7, WORKSHEET 1.1a
ELMD: See CHAPTER 7, WORKSHEET 6.1a, 6.1b
DIDI: See CHAPTER 11, WORKSHEET 3.3a
DWFK: See CHAPTER 12, WORKSHEET 3.1a

Complete the calculations using equations given in other PARTS or for animals in your local area and tabulate the results below. Many other parameters could be included, of course; the format on the next page may be used to tabulate your selections.

JDAY	AGDA	FEWK	CLWK	MBLM	ELMD	DIDI	DWFK
85	____	____	____	____	____	____	____
92	____	____	____	____	____	____	____
99	____	____	____	____	____	____	____
106	____	____	____	____	____	____	____
113	____	____	____	____	____	____	____
120	____	____	____	____	____	____	____
127	____	____	____	____	____	____	____
134	____	____	____	____	____	____	____
141	____	____	____	____	____	____	____
148	____	____	____	____	____	____	____
155	____	____	____	____	____	____	____
162	____	____	____	____	____	____	____
169	____	____	____	____	____	____	____

JDAY									
85									
92									
99									
106									
113									
120									
127									
134									
141									
148									
155									
162									
169									

JDAY									
85									
92									
99									
106									
113									
120									
127									
134									
141									
148									
155									
162									
169									

UNIT 2.2: ANIMAL RESPONSES IN THE SUMMER

Summer (June 21, JDAY 172, to September 20, JDAY 263) is a time when weather conditions are expected to offer the least stress of any time during the year. There are possibilities for unusual weather conditions, especially in late summer at high altitudes and in the extreme north.

The most common stress imposed by summer-like weather occurs in late spring and early summer when the neonates are not yet fully capable of regulating metabolism and behavior to meet transient conditions. Suppose, for example, that newborn fawns are exposed to a period of cool wet weather. If their weights are 4 kg, characteristics of a fawn a week or two old, their base-line metabolism is 198 kcal (CHAPTER 7, Page 2), and their ecological metabolism is about 3 times the base-line, or about 600 kcal. The surface area of a 4 kg fawn may be estimated with the equation in WORKSHEET 2.3b, CHAPTER 1, UNIT 2.3; TSAM = 0.34 sq meters, or 3400 sq centimeters. Suppose that half of this area, or 1700 sq cm, was exposed to cold rain, and that each sq cm of hair surface absorbed 100 milligrams of water. This results in 170 cubic centimeters of water being absorbed.

The heat of vaporization is about 600 cal per gram of water vaporized (see CHAPTER 15, UNIT 4.1). Multiplying 170 by 600 and dividing by 1000 to convert to kcal, the evaporation of this amount of water absorbed by the hair surface results in a loss of 102 kcal of heat energy, which is 20% of the 600 kcal of daily ecological metabolism of the 4 kg fawn. If rainy, cold weather persists and essentially all of the heat energy for evaporation must come from metabolic heat (a cold, saturated atmosphere provides no energy for surface evaporation), it is easy to see that the amount of heat energy lost could be substantial, resulting in mortality of the hypothermic fawn. There are many estimates in the example above, but none are unreasonable for a 24-hour period. Use your own estimates to repeat similar calculations for various combinations of factors in WORKSHEET 2.2b.

Ruminants use weather and thermal energy distribution to escape from insect harassments in the summer. Windy areas are selected as bed sites by deer because they are more free of biting insects. Snow patches on the tundra become favored bedding areas of caribou because they are more insect-free. These responses to weather and thermal conditions are indirect; it is the insect that is distributed as a direct result of weather effects and the deer and caribou as a direct result of insect distribution.

There has been some discussion in published literature about the role of velvet-covered antlers in heat dissipation. Heat energy is given off from the antlers as they feel warm to the touch, but analyses of the magnitude of heat loss from these organs in relation to total heat loss have not been made. Until that is done, any judgements of their significance are premature. They surely cannot be essential because female deer, elk, and moose do not have them. They are another avenue of heat loss in the males, supplementing other pathways such as the very vascular and essentially hairless ears, the thin-haired summer coat, and a variety of postures and thermoregulatory behaviors that can be employed.

It is important to note that replacement of the summer coat by the winter coat begins before the end of summer. There is a potential for heat stress then as sunny and warm late summer days provide a high energy input which, coupled with the effective insulation of the growing winter coat, may result in a critical hyperthermic environment and subsequent heat stress. This is discussed further in the next UNIT.

REFERENCES, UNIT 2.2

ANIMAL RESPONSES IN THE SUMMER

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	OEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	13--3	314	315	od--	deer forag observtns, utah	smith,jg	1949

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMNAA	84--1	270	273	odvi	response to wisc wild fire	vogl,rj; beck, am	1970
CAFNA	90--2	123	136	odvi	distr, movs reln env fctrs	drolet,ca	1976
JANSA	45--2	365	376	odvi	nutritin thrghout the year	holteer,jb; urba/	1977
JOMAA	39--2	309	311	odvi	aspects of blood chemistry	wilber,cg; robins	1958
JWMAA	19--3	358	364	odvi	rnge apprsl, missouri ozar	dunkeson,rl	1955
JWMAA	24--4	387	395	odvi	deer-for hab relnshps, ark	halls,lk; crawfor	1960
JWMAA	33--4	881	887	odvi	repro pattrns rel nutr pln	verme,lj	1969
JWMAA	35--1	37	46	odvi	eff fallng temp, heat prod	silver,h; holter/	1971
JWMAA	35--3	476	487	odvi	summer habitat, nc minneso	kohn,e; mooty,jj	1971
JWMAA	41--2	315	317	odvi	seasnl chnge circad activ,	kammermeyer,ke; m	1977
JWMAA	42--4	715	738	odvi	seasonl chngs hrtrate, act	moen,an	1978
NAWTA	24---	201	215	odvi	evergl hrd, rng cond, life	loveless,cm; liga	1959
NYCOA	14--2	30	31	odvi	big deer vs lit deer, food	severinghaus,cw;/	1959
NYCOA	29--4	18	20	odvi	advances, science deer mgt	severinghaus,cw	1975
SJAFD	1....	10	13	odvi	use of clear cuts, sw virg	blymyer,mj; mosby	1977
WLSBA	6---2	88	90	odvi	the fat cycle in deer	mautz,ww	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	48--2	275	282	odhe	feed intake, heat producti	nordon,hc; cowan/	1970
ECMOA	2----	1	46	odhe	seasonal migratn of mule d	russell,cp	1932
JRMGA	15---	278	281	odhe	rng mgt, habitat,herd prod	julander,o	1962
JRMGA	30--2	122	127	odhe	eval habita on nutri basis	wallmo,oc; carpe/	1977
JWMAA	22--3	275	283	odhe	food hab, rang use, montan	lovaas,al	1958
JWMAA	25--1	54	60	odhe	rel sum rng cond, hrd prod	julander,oj; rob/	1961
JWMAA	29--2	352	366	odhe	stom cont anal rel to cond	anderson,ae; sny/	1965
JWMAA	34--4	852	862	odhe	resp to mgt sum rnge, kaib	hungerford,cr	1970
JWMAA	39--3	605	616	odhe	doca, rng relns, prair hab	dusek,gl	1975
NAWTA	20---	568	588	odhe	factrs infl dee, ariz brsh	hanson,wr; mccull	1955
PMASA	19...	72	79	odhe	annu cycl of cond, montana	taber,rd; white,/	1959
WLMOA	20---	1	79	odhe	ceel, doca, rnge ecol, mon	mackie,rj	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
EKPOA	17-22	381	389	ceel	repartitn of habita niches	dzieciolowski,r	1969
JOMAA	49--4	762	764	ceel	physiologi stud, rocky mts	herin,ra	1968
NCANA	101-3	505	516	ceel	shiras moos, rng reltnshps	stevens,dr	1974
NZJSA	36...	429	463	ceel	eval cond free-rng dee, nz	riney,t	1955
PZESA	14---	34	39	ceel	ruru, sensitv, temp fluctu	christie,ahc	1967
XARRA	63---	1	7	ceel	od, doca, pondero pine use	reynolds,hg	1966
XARRA	66---	1	4	ceel	od, doca, use of openings	reynolds,hg	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	16--5	227	231	alal	apprais moose rang, montan	peek,jm	1963
JWMAA	24--1	52	60	alal	food comp, rng relns, hare	dodds,dg	1960
JWMAA	39--4	653	662	alal	odvi,relatns on burn, minn	irwin,ll	1975
JWMAA	40--4	645	657	alal	odvi, habita use, symp rng	kearney,sr; gilbe	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CBPAB	60A-2	123	126	rata	seas change growth hormone	ringberg,t; jaco/	1978
CJZOA	38--4	679	688	rata	wind,moistr,heat loss,calf	lentz,cp; hart,js	1960
CJZOA	39--6	845	856	rata	metbl, therml respns,infnt	hart,js; heroux,/	1961
IJBMA	12--1	21	27	rata	wint activ, reltn sno, ice	henshaw,j	1968
NJZOA	23--1	93	95	rata	growing antlers, heat loss	wika,m; krog,j; /	1975
RIJUA	30---	289	293	rata	intractins w/ habita, alas	klein,dr	1970
UABPA	1----	360	367	rata	responses to heat stress	yousef,mk; luick,	1975
XFWWA	43---	1	48	rata	st matthew isl reind range	klein,dr	1959

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NAWTA	15---	627	644	anam	rng ecol, wichita mts refu	buechner,hk	1950

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	87--4	433	454	ovca	chilcotin river bigh popul	demarchi,da; mitc	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	23--1	8	14	obmo	rata,tndra n of boreal for	klein,dr	1970
JWMAA	40--1	151	162	obmo	rata, summ rnge relns, nwt	wilkinson,pf; sh/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMZOA	16--4	699	710	many	fat, energy, mammal surviv	young,ra	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AJAEA	24--5	775	782	doca	heat toleranc, exposre sun	moran,jb	1973
AJAEA	26--3	615	622	doca	eff heat stres on grth,met	kellaway,rc; cold	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AJAEA	11...	402	407	dosh	regul bod temp, hot envirn	brook,ah; short,b	1960
AJAEA	13--1	122	143	dosh	temp reg, new-brn, hot env	alexander,g; will	1962
RVTSA	7....	466	479	dosh	thermal regula, two breeds	webster,ajf; blax	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ANYAA	301..	110	127	----	influnc exrcise skin tempe	adams,wc	1977
BISNA	18-11	1041	1043	----	critical therml environmnt	moen,an	1968
IJBMA	20--2	139	156	dome	signif, meterol, anim prod	bianca,w	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AJPHA	219-4	1131	1135	ungu	temp regulat, evap, ea afr	taylor,cr	1970
AJPHA	222-6	1374	1379	ungu	thermoregulat, heat balanc	finch,va	1972
CBCPA	38...	525	534	ungu	thermoregul, water, ea afr	maloiy,gmo; hopc/	1971
JSAVA	41...	17	24	ungu	adapt sol rad, afric herbi	harthoorn,am; fi/	1970
JWMAA	24--1	92	94	ungu	asses phys cond, field tch	riney,t	1960
SZSLA	31---	315	326	ungu	enrgy exchang ea afr antel	finch,va	1972

CHAPTER 17, WORKSHEET 2.2a

Animal characteristics during the summer season

Animal characteristics for each of the JDAY's from June 25 (JDAY 176) through September 17 (JDAY 260) at 7-day intervals may be completed by referring to the equations below.

CLWK: See CHAPTER 1, WORKSHEET 1.2a
MBLM: See CHAPTER 7, WORKSHEET 1.1a
ELMD: See CHAPTER 7, WORKSHEET 6.1a, 6.1b
DIDI: See CHAPTER 11, WORKSHEET 3.3a
DWFK: See CHAPTER 12, WORKSHEET 3.1a

Complete the calculations using equations given in other PARTS or for animals in your local area and tabulate the results below. Many other parameters could be included, of course; the format on the next page may be used to tabulate your selections.

JDAY	AGDA	CLWK	MBLM	ELMD	DIDI	DWFK
176	____	____	____	____	____	____
183	____	____	____	____	____	____
190	____	____	____	____	____	____
197	____	____	____	____	____	____
204	____	____	____	____	____	____
211	____	____	____	____	____	____
218	____	____	____	____	____	____
225	____	____	____	____	____	____
232	____	____	____	____	____	____
239	____	____	____	____	____	____
246	____	____	____	____	____	____
253	____	____	____	____	____	____
260	____	____	____	____	____	____

JDAY									
176									
183									
190									
197									
204									
211									
218									
225									
232									
239									
246									
253									
260									

JDAY									
176									
183									
190									
197									
204									
211									
218									
225									
232									
239									
246									
253									
260									

Estimates of energy absorbed as heat of vaporization

A description of the calculations of energy absorbed as heat of vaporization was given in this UNIT for a whitetail fawn weighing 4 kg. Fill in the blanks below for a species of your choice to estimate the heat of vaporization from a wet hair surface. All of the symbols and parameters used have been discussed in previous PARTs, CHAPTERs, and UNITs.

Species: ______________________________

LIWK = ______ kg

BLM = ______

MBLM = ______

ELMD = ______ kcal per day

TSAM = ______ sq meters

TSAC = ______ sq centimeters

exposed TSAC = ______ sq cm

mm water per sq cm = ______

total water = ______ milligrams

HEVA = ______ cal per gm water

total HEVA = ______ cal

total HEVA = ______ kcal

total HEVA in kcal/ELMD = ______ x 100 = ______ = percent of ELMD represented by HEVA

Repeat the above for upper and lower estimates of the area of the hair coat exposed and the amount of water absorbed by the hair coat; additional blanks are provided on the next page. Does it not appear that prolonged wet, cold weather places a demonstrated energy drain on the neonate?

Species: ______________________________

LIWK = ______ kg

BLM = ______

MBLM = ______

ELMD = ______ kcal per day

TSAM = ______ sq meters

TSAC = ______ sq centimeters

exposed TSAC = ______ sq cm

mm water per sq cm = ______

total water = ______ milligrams

HEVA = ______ cal per gm water

total HEVA = ______ cal

total HEVA = ______ kcal

total HEVA in kcal/ELMD = ______ x 100 = ______ = percent of ELMD represented by HEVA

Species: ______________________________

LIWK = ______ kg

BLM = ______

MBLM = ______

ELMD = ______ kcal per day

TSAM = ______ sq meters

TSAC = ______ sq centimeters

exposed TSAC = ______ sq cm

mm water per sq cm = ______

total water = ______ milligrams

HEVA = ______ cal per gm water

total HEVA = ______ cal

total HEVA = ______ kcal

total HEVA in kcal/ELMD = ______ x 100 = ______ = percent of ELMD represented by HEVA

UNIT 2.3: ANIMAL RESPONSES IN THE FALL

The fall period, from September 21 (JDAY 264) to December 20 (JDAY 354), is a period of often rapid change. Weather conditions can change rapidly in early fall, and from the beginning to the end of fall there is an overall trend from summer-like to winter-like conditions. Animals, however, are prepared to respond to these changes in weather conditions. Winter coats have been growing since late summer, so insulation is approaching maximum. Animal weights reach the annual maximum in the fall, and the fat composition is at maximum. Thus metabolic reserves are maximum, and the layers of fat provide additional subskin thermal insulation.

Differences in responses of white-tailed deer to snow and cold in late fall compared to late winter were discussed in Moen (1976). Changes in the environment and the animal's response are more gradual than abrupt; "...there is a continuum involved in each change and subsequent response." A deer exposed to a harsh combination of temperature, wind, and snow conditions in December is much better able to cope with the resulting energy costs than one exposed to this same combination in March. The important point to be made is that analyses of deer and other animals' responses to environmental changes should be on a sequential basis through the winter rather than on overall averages for the winter.

Profiles of the animals should be compiled for this time period, as usual, in the WORKSHEET. Changes in animal distributions, portions of the range used, and habitat selection become additional considerations as the animals go through the fall period of change and enter the winter period of potentially high thermal and nutritive stress.

LITERATURE CITED

Moen, A. N. 1976. Energy conservation by white-tailed deer in winter. Ecology 57(1):192-198.

REFERENCES, UNIT 2.3

ANIMAL RESPONSES IN THE FALL

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	13--3	314	315	od--	deer forag observatns, uta	smith,jg	1949

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	90--2	123	136	odvi	distr, movs reln env fctrs	drolet,ca	1976
JANSA	45--2	365	376	odvi	nutritin thrghout the year	holteer,jb; urba/	1977
JOMAA	39--2	309	311	odvi	aspects of blood chemistry	wilber,cg; robins	1958
JOMAA	48--4	655	656	odvi	hypotherm, water-chilled d	moen,an	1967
JWMAA	19--3	358	364	odvi	rnge apprsl, missouri ozar	dunkeson,rl	1955
JWMAA	33--4	881	887	odvi	repro pattrns rel nutr pln	verme,lj	1969
JWMAA	35--1	37	46	odvi	falling temp, heat product	silver,h; holter/	1971
JWMAA	38--2	220	228	odvi	influ lt, weathr,obsrvblty	zagata,md; haugen	1974
JWMAA	41--2	315	317	odvi	seasnl chnge circad activ,	kammermeyer,ke; m	1977
JWMAA	42--4	715	738	odvi	seasnl chngs hrt rate, act	moen,an	1978
MGQPA	31...	142	150	odvi	fall ecology, nc minnesota	waddell,bh	1971
NAWTA	24---	201	215	odvi	evergl hrd, rng cond, life	loveless,cm; liga	1959
NYCOA	14--2	30	31	odvi	big deer vs lit deer, food	severinghaus,cw;/	1959
NYCOA	29--4	18	20	odvi	advances, science deer mgt	severinghaus,cw	1975
PCGFA	18---	57	62	odvi	importnce variety to s dee	lay,dw	1964
SJAFD	1....	10	13	odvi	use of clear cuts, sw virg	blymyer,mj; mosby	1977
WLSBA	6---2	88	90	odvi	the fat cycle in deer	mautz,ww	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	48--2	275	282	odhe	feed intake, heat producti	nordon,hc; cowan/	1970
JRMGA	15---	278	281	odhe	rng mgt, habitat, hrd prod	julander,o	1962
JRMGA	30--2	122	127	odhe	eval habita on nutri basis	wallmo,oc; carpe/	1977

odhe continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	22--3	275	283	odhe	food hab, rang use, montan	lovaas,al	1958
JWMAA	29--2	352	366	odhe	stom cont anal rel to cond	anderson,ae; sny/	1965
JWMAA	31--4	651	656	odhe	char herds, range n e utah	richens,vb	1967
NAWTA	20---	568	588	odhe	factrs infl dee, ariz brsh	hanson,wr; mccull	1955
PMASA	19...	72	79	odhe	annu cycl of cond, montana	taber,rd; white,/	1959
WLMOA	20---	1	79	odhe	ceel, doca, rnge ecol, mon	mackie,rj	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
EKPOA	17-22	381	389	ceel	repartitn of habita niches	dzieciolowski,r	1969
JOMAA	49--4	762	764	ceel	physiologi stud, rocky mts	herin,ra	1968
NCANA	101-3	505	516	ceel	shiras moos, rng reltnshps	stevens,dr	1974
NZJSA	36...	429	463	ceel	eval cond free-rng dee, nz	riney,t	1955
PZESA	14---	34	39	ceel	ruru,sensitv to temp fluct	christie,ahc	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	24--1	52	60	alal	food comp, rng relns, hare	dodds,dg	1960
JWMAA	39--4	653	662	alal	odvi,relnshp on burn, minn	irwin,ll	1975
JWMAA	40--4	645	657	alal	odvi, habita use, symp rng	kearney,sr; gilbe	1976
NCANA	101-1	417	436	alal	influence of snow, behvior	coady,jw	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CBPAB	60A-2	123	126	rata	seas change growth hormone	ringberg,t; jaco/	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	87--4	433	454	ovca	chilcotin river bigh popul	demarchi,da; mitc	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	43--2	437	444	many	hab partitioni, fire, mont	singer,fj	1979
NCANA	103-3	153	167	many	resour div, commun lg herb	hudson,rj	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
RVTSA	7....	466	479	dosh	thermal reguln, two breeds	webster,ajf; blax	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ANYAA	301..	110	127	----	influnc exrcise skin tempe	adams, wc	1977
BISNA	18-11	1041	1043	----	critical thermal environme	moen,an	1968
IJBMA	20--2	139	156	dome	signif meteorol, anim prod	bianca,w	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS-----------	YEAR
JWMAA	24--1	92	94	ungu	asses phys cond, field tch	riney,t	1960

Chapter 17, Worksheet 2.3a

Animal characteristics during the fall season

Animal characteristics for each of the JDAY's from September 24 (JDAY 267) through December 17 (JDAY 351) at 7-day intervals may be completed by referring to the equations below.

CLWK: See CHAPTER 1, WORKSHEET 1.4b
MBLM: See CHAPTER 7, WORKSHEET 1.1a
ELMD: See CHAPTER 7, WORKSHEET 6.1a, 6.1b
DIDI: See CHAPTER 11, WORKSHEET 3.3a
DWFK: See CHAPTER 12, WORKSHEET 3.1a

Complete the calculations using equations given in other PARTs or for animals in your local area and tabulate the results below. Many other parameters could be included, of course; the format on the next page may be used to tabulate your selections.

JDAY	AGDA	CLWK	MBLM	ELMD	DIDI	DWFK
267	____	____	____	____	____	____
274	____	____	____	____	____	____
281	____	____	____	____	____	____
288	____	____	____	____	____	____
295	____	____	____	____	____	____
302	____	____	____	____	____	____
309	____	____	____	____	____	____
316	____	____	____	____	____	____
323	____	____	____	____	____	____
330	____	____	____	____	____	____
337	____	____	____	____	____	____
344	____	____	____	____	____	____
351	____	____	____	____	____	____

JDAY									
267	____	____	____	____	____	____	____	____	____
274	____	____	____	____	____	____	____	____	____
281	____	____	____	____	____	____	____	____	____
288	____	____	____	____	____	____	____	____	____
295	____	____	____	____	____	____	____	____	____
302	____	____	____	____	____	____	____	____	____
309	____	____	____	____	____	____	____	____	____
316	____	____	____	____	____	____	____	____	____
323	____	____	____	____	____	____	____	____	____
330	____	____	____	____	____	____	____	____	____
337	____	____	____	____	____	____	____	____	____
344	____	____	____	____	____	____	____	____	____
351	____	____	____	____	____	____	____	____	____

JDAY									
267	____	____	____	____	____	____	____	____	____
274	____	____	____	____	____	____	____	____	____
281	____	____	____	____	____	____	____	____	____
288	____	____	____	____	____	____	____	____	____
295	____	____	____	____	____	____	____	____	____
302	____	____	____	____	____	____	____	____	____
309	____	____	____	____	____	____	____	____	____
316	____	____	____	____	____	____	____	____	____
323	____	____	____	____	____	____	____	____	____
330	____	____	____	____	____	____	____	____	____
337	____	____	____	____	____	____	____	____	____
344	____	____	____	____	____	____	____	____	____
351	____	____	____	____	____	____	____	____	____

UNIT 2.4: ANIMAL RESPONSES IN THE WINTER

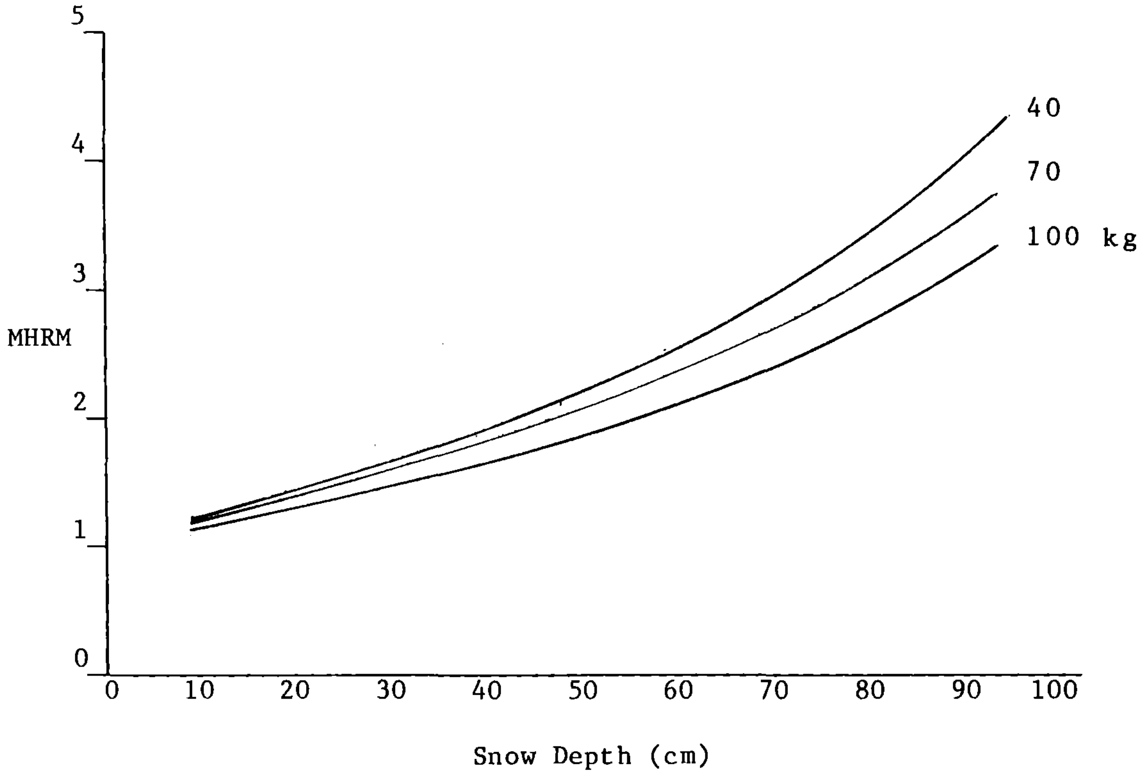
Winter is a time of potentially critical hypothermal environments and negative energy balances. In fact, the smallest animals in a population, late-born young-of-the-year, are almost certain to have critical energy balances unless the winter is unusually mild. Small fawns, for example, do not have the fat reserves to meet metabolic demands when forage is not readily available and quality is low. Furthermore, small fawns have distinct physical disadvantages, including shorter legs and shorter reaches than larger deer, less well-developed hair coats, higher surface area ratios, and others. They also have social disadvantages, being subject to the more dominant adult does and bucks. All of these disadvantages make it most difficult for the smallest, youngest members of the population to survive.

Larger members of the deer family, such as moose, have definite advantages over smaller animals in the snow. Their long legs make it relatively easy to walk through deep snow, and bedding down in deep, soft snow creates a depression that protects from the wind. Since fluffy snow has a low heat capacity and is good insulation, such bedding behavior is good body heat conservation. Lesser snow depths offer the same advantages to white-tailed deer, of course.

There are two possible strategies for coping with the potential critical thermal environments of winter. One is to increase heat production to offset heat loss, and the other is to increase heat conservaion to reduce heat loss. It is very clear that wild ruminants, at least the smaller species and probably all of them choose the latter. It is the only ecologically reasonable strategy because food resources are limited in the winter and are often inaccessible due to snow. Snow is a mechanical barrier to deer movements that may cause energy expenditures to increase to levels that result in negative returns from forage ingested. The effect of snow accumulations on heart rates have been estimated from data in Jacobsen (1973) and Mattfeld (1974) and expressed as a multiple of the heart rate per minute (MHRM). This may then be applied to the heart rate-metabolism conversion equation discussed in CHAPTER 7, UNIT 5.2. The predicted MHRM is:

$$MHRM = e^{0.692402 \quad SNDE/[12.5(CLWK^{0.21}) + 8.0\,(CLWK^{0.25})]}$$

Note that MHRM is a function of both snow depth (SNDE) and calculated live weight in kg (CLWK). These independent variables illustrate how larger deer, with a greater belly height, are not affected as much by increasing snow depths as smaller deer are, as illustrated on the next page. Multiples of heart rate may be predicted for deer of different weights in snow from 0 to 100 cm deep in WORKSHEET 2.4b.



An energy conservation adaptive strategy does not allow animals to struggle through deep snow at high energy costs. Neither does it allow them to increase their metabolic rates to high levels to offset high heat losses. Rather, there is a reduction in the ecological metabolism during the winter to the lowest point in the annual cycle, and heat energy is conserved further by the excellent insulation of the winter hair coat.

The reduction is not simply a voluntary restriction of activity that results in less energy expenditure. Thyroxine, a thyroid hormone that affects metabolic rate, is also at low levels in the winter, resulting in metabolic depression (Seal et al. 1972). Other details substantiating the existence of seasonal metabolic rhythms, including the winter metabolic depression, are given in Moen (1978).

The important field application to be made from the recognition of the winter metabolic depression is that any activity which causes deer to move more and over wider areas in the winter is counter to their long-term adaptive strategy. The potential effects of disturbances by snowmobiles were mentioned in the paper on energy conservation in the winter (Moen 1976), and another paper in press (New York Fish and Game Journal) describes the accelerated heart rates in response to controlled snowmobile experiments. No evidence of habituation was found over an entire winter of tests. Deer are not frightened by the noise per se; chain saws attract deer when they result in trees cut and more food made available, and snowmobiles which pull sleds with artificial feed into wintering areas also attract them. Such management practices are very labor intensive, however, and not realistic solutions to winter stress over large areas, and especially if the populations are to remain as wild as possible.

Thermal energy balances of deer are being evaluated as a result of wind tunnel and outdoor research at the Wildlife Ecology Laboratory from 1973-1980. The overall heat transfer approach is being used (See CHAPTER 16, TOPIC 2). The results are being prepared for journal publication, and it would be premature to present them here. Suffice it to say that radiation, wind profiles, air temperatures, hair depth, weight, surface area, bed area, and posture are variables being evaluated, and preliminary results indicate that reasonable thermal energy balances are maintained by regulating behavior patterns and habitat selection for larger animals, that the smaller animals are in more precarious energy balances, and that certain combinations of thermal parameters do have the potential for creating critical hypothermic environments.

Thorough analyses of these results for deer will be followed by analyses for other species of ruminants. It is expected that larger species, such as elk and moose, will have less precarious thermal balances than smaller species, such as deer. One of the most interesting species to analyze will be caribou because of their relatively small size and rather harsh winter environment. A critical hair depth may be a very important characteristic to quantify.

Energy balances during the winter are interesting to quantify, and considerable insight into the relative importances of different parameters may be gained by simulating a variety of weather and behavioral combinations. One of the most important factors to emerge from these thermal analyses and from the metabolic and nutritive analyses discussed in CHAPTERS 7 and 12 is the length of winter, or the timing of the arrival of spring conditions. If spring conditions arrive early, winter mortality will likely be very low. If it arrives later, winter mortality will likely occur among the younger, smaller animals. If it arrives very late, winter mortality may occur among older deer. Thus the annual cycle is complete, with the importance of spring conditions discussed in UNIT 2.1. As data analyses become more complete, more details will be added to our mental and mathematical analyses and our understanding will be made more complete.

LITERATURE CITED

Jacobsen, N. K. 1973. Physiology, behavior, and thermal transactions of white-tailed deer. PhD. Thesis, Cornell University, Ithaca, N.Y. 346 p.

Mattfeld, G. F. 1974 The energetics of winter foraging by white-tailed deer--a perspective on winter concentration. PhD. Thesis, State University College of Environmental Science and Forestry, Syracuse, N.Y. 306 p.

Moen, A. N. 1976. Energy conservation by white-tailed deer in the winter. Ecology. 57(1):192-198.

Moen, A. N. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. J. Wildl. Manage. 42(4):715-738.

Moen, A. N. and C. W. Severinghaus. 1981. The annual weight cycle and survival of deer in New York. New York Fish Fish and Game Journal 28(2):162-177.

Seal, U. S., L. J. Verme, J. J. Ozaga, and A. W. Erickson. 1972. Nutritional effects on thyroid activity and blood of white-tailed deer. J. Wildl. Manage. 36(4):1041-1052.

REFERENCES, UNIT 2.4

ANIMAL RESPONSES IN THE WINTER

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
FUOFA	66...	174	186	cerv	wint prob, northern cervid	markgren,g	1971
JWMAA	42--2	352	361	cerv	dist, brows,sno cvr,albrta	telfer,es	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	44--1	51	72	od--	surv, rang forag trnds, ca	dasmann,wp; hjers	1958

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	85--2	141	145	odvi	odhe, winter ecol, alberta	kramer,a	1971
CAFNA	90--2	123	136	odvi	distr, movs reln env fctrs	drolet,ca	1976
CJZOA	54--8	1307	1313	odvi	eff wint condtns, manitoba	kucera,e	1976
ECOLA	16--4	535	553	odvi	wint relns to forsts, mass	hosley,nw; ziebar	1935
ECOLA	57--1	192	198	odvi	enrgy conservation in wint	moen,an	1976

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ISJRA	47--3	199	217	odvi	pil knb st pk, win dee hav	zagata,md; haugen	1973
JANSA	45--2	365	376	odvi	nutritin thrghout the year	holteer,jb; urba/	1977
JMNAA	37--1	16	18	odvi	winter obsrvtns, se minnes	dorn,rd	1971
JOMAA	39--2	309	311	odvi	aspects of blood chemistry	wilber,cg; robins	1958
JOMAA	48--4	655	656	odvi	hypotherm, water-chilled d	moen,an	1967
JRMGA	3---2	130	132	odvi	feedng dee on brws sp, win	smith,ad	1950
JWMAA	6---4	287	291	odvi	winter habits, central ny	cook,db; hamilton	1942
JWMAA	11--2	167	177	odvi	odhe,surv ovr-pop rang,us	leopold,a; sowls/	1947
JWMAA	13--1	135	141	odvi	avail wint forg, hrdwd for	hough,af	1949
JWMAA	14--2	156	161	odvi	obs, histopath, starv, wis	rausch,r	1950
JWMAA	19--3	358	364	odvi	rnge apprsl, missouri ozar	dunkeson,rl	1955
JWMAA	24--4	364	371	odvi	test of shelt req pen deer	robinson,wl	1960
JWMAA	24--4	387	395	odvi	deer-for hab relnshps, ark	halls,lk; crawfor	1960
JWMAA	32--3	566	574	odvi	index wint weather severit	verme,lj	1968
JWMAA	33--3	511	520	odvi	hab-deer relns in enclosur	segelquist,ca; w/	1969
JWMAA	33--4	881	887	odvi	repro pattrns rel nutr pln	verme,lj	1969
JWMAA	34--2	431	439	odvi	wintr feed pattrns, penned	ozoga,jj; verme,l	1970
JWMAA	35--1	37	46	odvi	effct temp on heat prodctn	silver,h; holter/	1971
JWMAA	35--4	732	743	odvi	limitns of wint aspn brows	ullrey,de; youat/	1971
JWMAA	36--3	892	896	odvi	response to winter weather	ozoga,jj; gysel,l	1972
JWMAA	38--2	220	228	odvi	influ lt, weath,obsrvblity	zagata,md; haugen	1974
JWMAA	39--3	563	569	odvi	effcts snowmobiles on wt-d	dorrance,mj; sav/	1975
JWMAA	41--2	315	317	odvi	seasnl change circad activ	kammermeyer,ke; m	1977
JWMAA	41--4	700	708	odvi	assess mortality, upp mich	verme,lj	1977
JWMAA	42--4	715	738	odvi	seasonl chngs hrtrate, act	moen,an	1978
JWMAA	42--4	746	754	odvi	metab indictrs of hab difs	seal,us; nelson,/	1978
MFNOA	223..	....	....	odvi	wint covr type use, minnes	fedkenheuer,aw; h	1971
NAWTA	18---	581	596	odvi	yard carry capac, browsing	davenport,la; sw/	1953
NAWTA	24---	201	215	odvi	evergl hrd, rng cond, life	loveless,cm; liga	1959
NAWTA	34---	137	146	odvi	eff of nutr, clim, so deer	short,hl; newsom/	1969
NYCOA	7---5	2	4	odvi	selectn, use winterg yards	severinghaus,cw	1953
NYCOA	14--2	30	31	odvi	big deer vs lit deer, food	severinghaus,cw;/	1959
NYCOA	27--2	28	31	odvi	weather and the deer popul	severinghaus,cw	1972
NYCOA	27--5	41	41	odvi	winter deer feeding	kelsey,pm	1973
NYCOA	29--1	39	40	odvi	return of the deer	severinghaus,cw	1974
NYCOA	29--4	18	20	odvi	advances, science deer mgt	severinghaus,cw	1975
PCGFA	18---	57	62	odvi	importnce variety to s dee	lay,dw	1964
RWLBA	6---2	327	385	odvi	wint, spr obsrv, adirndcks	spiker,cj	1933

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
SJAFD	1....	10	13	odvi	use of clear cuts, sw virg	blymyer,mj; mosby	1977
TISAA	63--2	198	201	odvi	deer trap corr weath fctrs	hawkins,re; klims	1970
WLSBA	6---2	88	90	odvi	the fat cycle in deer	mautz,ww	1978
XFNCA	52---	51	59	odvi	eff sno conds vuln to pred	mech,ld; frenzel/	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CGFPA	21...	1	20	odhe	doca, wint rng use, 2 4 d,	anderson,ae	1969
CJZOA	48--2	275	282	odhe	feed intake, heat producti	nordon,hc; cowan/	1970
ECMOA	2----	1	46	odhe	seasonal migratn of mule d	russell,cp	1932
JRMGA	15---	278	281	odhe	rng mgt, habitat, hrd prod	julander,o	1962
JRMGA	25--1	66	68	odhe	fec grp cts rel to win rng	anderson,ae; med/	1972
JRMGA	30--2	122	127	odhe	eval habita on nutri basis	wallmo,oc; carpe/	1977
JRMGA	32--1	40	45	odhe	dosh, forg selec, wint rng	smith,ma; malech/	1979
JWMAA	6---3	210	220	odhe	survey winter range, oregn	edwards,ot	1942
JWMAA	9---2	145	151	odhe	winter study,nevada mule d	aldous,cm	1945
JWMAA	16--3	289	299	odhe	wint mort, rng conds, utah	robinette,wl; ju/	1952
JWMAA	22--3	275	283	odhe	food hab, rang use, montan	lovaas,al	1958
JWMAA	29--2	352	366	odhe	stom cont anal rela condtn	anderson,ae; sny/	1965
JWMAA	31--4	651	656	odhe	char herds, range n e utah	richens,vb	1967
JWMAA	34--1	15	23	odhe	effect of snow depth on de	gilbert,pf; wall/	1970
JWMAA	36--2	571	578	odhe	numbs, shrb yld util, wint	anderson,ae; med/	1972
JWMAA	39--3	605	616	odhe	doca, rng relns, prair hab	dusek,gl	1975
JWMAA	42--1	108	112	odhe	b-t d wint rnge, se alaska	bloom,am	1978
NAWTA	20---	568	588	odhe	factrs infl dee, ariz brsh	hanson,wr; mccull	1955
NAWTA	29---	415	431	odhe	wnt rng, deer, phys envirn	loveless,cm	1964
NAWTA	35...	35	47	odhe	eval win deer use orchards	harder,jd	1970
PMASA	19...	72	79	odhe	annu cycl of cond, montana	taber,rd; white,/	1959
WLMOA	20---	1	79	odhe	ceel, doca, rnge ecol, mon	mackie,rj	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
EKPOA	17-22	381	389	ceel	repartitn of habita niches	dzieciolowski,r	1969
FUNAA	19...	31	37	ceel	red deer during winter	mehl,r	1966
JOMAA	49--4	762	764	ceel	physiologi stud, rocky mts	herin,ra	1968
JWMAA	43--2	564	567	ceel	met resp to cold, eff post	gates,cc; hudson,	1979
JZOOA	186--	544	550	ceel	sex difs in qual win areas	watson,a; staines	1978
NCANA	101-3	505	516	ceel	shiras moos, rng reltnshps	stevens,dr	1974
NZJSA	36...	429	463	ceel	eval cond free-rng dee, nz	riney,t	1955
PZESA	14---	34	39	ceel	ruru,sensitv to temp fluct	christie,ahc	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	92--2	189	192	alal	late wint bedding practice	mcnicol,jg; gilbe	1978
CWRSB	15---	1	27	alal	odvi, behav, snow, new bru	kelsall,jp; presc	1972
JOMAA	50--2	302	310	alal	odvi, struct adaptat, snow	kelsall,jp	1969
JRMGA	16--5	227	231	alal	apprais moose range,montan	peek,jm	1963
JWMAA	24--1	52	60	alal	food comp, rng relns, hare	dodds,dg	1960
JWMAA	34--1	37	46	alal	wint ecol, gallat mts, mon	stevens,dr	1970
JWMAA	34--3	553	559	alal	odvi, winte habitat select	telfer,es	1970
JWMAA	39--4	653	662	alal	odvi,relnshp on burn, minn	irwin,ll	1975
JWMAA	40--4	645	657	alal	odvi, habita use, symp rng	kearney,sr; gilbe	1976
NCANA	101-1	67	80	alal	distrib, winter habit, que	brassard,jm; aud/	1974
NCANA	101-1	417	436	alal	influence of snow, behavio	coady,jw	1974
NCANA	101-3	481	492	alal	snow cond, moose, wolf rel	peterson,ro; alle	1974
QSFRA	3----	51	73	alal	influence of snow, behavio	desmeules,p	1964

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATICA	12...	158	179	rata	snow, factr in winter ecol	pruitt,wo,jr	1959
ATICA	30...	101	108	rata	feeding sites, snow, alask	laperriere,aj; le	1977
CAFNA	95---	363	365	rata	varrio snow index, ovrwntr	pruitt,wo,jr	1981

rata continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CBPAB	40A-3	789	795	rata	thyrox sec, sex, age, seas	yousef,mk; luick,	1971
CBPAB	60A-2	123	126	rata	seas change growth hormone	ringberg,t; jaco/	1978
IJBMA	12--1	21	27	rata	wint activ, reltn sno, ice	henshaw,j	1968
RIJUA	30---	289	293	rata	intractins w/ habita, alas	klein,dr	1970
UABPA	1----	324	334	rata	carib and sno cond, se man	stardom,rrp	1975
UABPA	1----	414	419	rata	weath effct on behav, migr	gavin,a	1975
UABPA	18...	1	41	rata	behav, energtcs, cratering	thing,h	1977
XFWWA	43---	1	48	rata	st matthew isl reind range	klein,dr	1959

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	31--1	159	164	anam	mort, severre wint, n mont	martinka,cj	1967
JWMAA	41--3	560	571	anam	wint behav reln to habitat	bruns,eh	1977
JWMAA	42--4	755	763	anam	met indics hab con, stress	seal,us; hoskinso	1978
NAWTA	15---	627	644	anam	rng ecol, wichita mts refu	buechner,hk	1950
XARRA	148--	1	4	anam	starv, full stomachs, feed	pearson,ha	1969

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NPSMD	1----	1	161	bibi	bison of yellowstn nat prk	meagher,mm	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	52--2	68	84	ovca	winter obsvtns, sierra nev	mccullogh,dr; sch	1966
CAFNA	87--4	433	454	ovca	chilcotin river bigh popul	demarchi,da; mitc	1973
CWRSB	39---	1	50	ovca	rng ecol in canad natl pks	stelfox,jg	1976
JWMAA	35--2	257	269	ovca	winter ecology in yellowst	oldemyer,jl; bar/	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	51--9	987	993	oram	ovca,eff sno cov,soc behav	petocz,rg	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMZOA	16--4	699	710	many	fat, energy, mamml survivl	young,ra	1976
JWMAA	20--2	159	168	many	sno depth, ungu abund, can	edwards,ry	1956
JWMAA	43--2	437	444	many	hab partitioni, fire, mont	singer,fj	1979
NATUA	234--	482	484	many	water, energ turnover, des	macfarlane,wv; h/	1971
NCANA	103-3	153	167	many	resour div, commun lg herb	hudson,rj	1976
QSFRA	8----	79	96	many	eff hiemal env fctrs behav	pichette,c	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ZEJAA	3---2	69	79	caca	[mortlty 1955-56, roe dee]	braunschweig,a	1957
ZORVA	28...	97	197	caca	winter ecolg, north sweden	markgren,g	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CNJNA	43--1	39	46	dosh	low env temp, physi respon	hess,ea	1963
JRMGA	6---1	51	54	dosh	eff graz intens, nutr valu	cook,cw; stoddar/	1953
RVTSA	7....	466	479	dosh	thermal regul, two breeds	webster,ajf; blax	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	24--1	92	94	ungu	asses phys cond, field tch	riney,t	1960
ZEJAA	9---4	121	124	ungu	[loss, wint 1962-63,grmny]	stubbe,c	1963

CODEN	VO-NU	BETA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ANYAA	301..	110	127	----	influnc exrcise skin tempe	adams, wc	1977
BINPA	1----	1	176	----	snow covr,mamml, bird ecol	formozov,an	1946
BISNA	18-11	1041	1043	----	critical thermal environme	moen,an	1968
IJBMA	20--2	139	156	dome	signif meteorol, anim prod	bianca,w	1975

CHAPTER 17, WORKSHEET 2.4a

Animal characteristics during the winter season

Animal characteristics for each of the JDAY's from December 24 (JDAY 358) through March 19 (JDAY 78) at 7-day intervals may be completed by referring to the equations below.

CLWK: See CHAPTER 1, WORKSHEET 1.4b
MBLM: See CHAPTER 7, WORKSHEET 1.1a
ELMD: See CHAPTER 7, WORKSHEET 6.1a, 6.1b
DIDI: See CHAPTER 11, WORKSHEET 3.3a
DWFK: See CHAPTER 12, WORKSHEET 3.1a

Complete the calculations using equations given in other PARTs or for animals in your local area and tabulate the results below. Many other parameters could be included, of course; the format on the next page may be used to tabulate your selections.

JDAY	AGDA	CLWK	MBLM	ELMD	DIDI	DWFK
358	____	____	____	____	____	____
1	____	____	____	____	____	____
8	____	____	____	____	____	____
15	____	____	____	____	____	____
22	____	____	____	____	____	____
29	____	____	____	____	____	____
36	____	____	____	____	____	____
43	____	____	____	____	____	____
50	____	____	____	____	____	____
57	____	____	____	____	____	____
64	____	____	____	____	____	____
71	____	____	____	____	____	____
78	____	____	____	____	____	____

JDAY									
358									
1									
8									
15									
22									
29									
36									
43									
50									
57									
64									
71									
78									

JDAY									
358									
1									
8									
15									
22									
29									
36									
43									
50									
57									
64									
71									
78									

Chapter 17, Worksheet 2.4b

Heart rate increases in relation to snow depths

Heart rate increases in relation to snow depths may be estimated with the equation below for deer of any weight. Complete the calculations for your choices of weights and fill in the table below. Then apply the multiples to the heart rate-to-metabolism conversions discussed in CHAPTER 7, UNIT 5.2.

	SNDE										
LIWK	0	10	20	30	40	50	60	70	80	90	100

CLOSING COMMENTS

This CHAPTER 17 concludes discussions of an interesting area of study--thermal exchange--for me, the subject of my Ph.D. Thesis at the University of Minnesota in 1966. That subject was chosen because of my enjoyment of winter, and because my observations of white-tailed deer in winter in west-central Minnesota differed from those reported for deer in forested areas to the east. Some important syntheses remain to be done; completion of the "overall heat transfer coefficient" analyses in relation to thermal boundary region characteristics will result in understanding of heat transfer between animal and environment. Then, thermal energy balances will be recalculated for deer, and the concepts and patterns applied to other species.

Aaron N. Moen
January 24, 1982

GLOSSARY OF SYMBOLS - CHAPTER SEVENTEEN

ADTC = Average daily temperature in Celsius
AGDA = Age in days
AMNT = Average minimum temperature in Celsius
AMXT = Average maximum temperature in Celsius

BLM = Base-line metabolism

CLWK = Calculated live weight in kg

DIDI = Diet digestibility
DWFK = Dry weight forage in kg

ELMD = Ecological metabolism per day

FEWK = Fetal weight in kg

HEVA = Heat of vaporization

JDAY = Julian day

MBLM = Multiple of base-line metabolism
MHRM = Multiple of the heart rate per minute

PREC = Precipitation

QREE = Quantity of radiant energy emitted

RAIN = Rain

SNDE = Snow depth
SNOW = Snow
SORA = Solar radiation

TSAC = Total surface area in square centimeters
TSAM = Total surface area in square meters

WIVE = Wind velocity

Z_o = Roughness coefficient

GLOSSARY OF CODENS - CHAPTER SEVENTEEN

SERIALS are identified by five-character, generally mnemonic codes called CODEN, listed in 1980 BIOSIS, LIST OF SERIALS (BioSciences Information Service, 2100 Arch Street, Philadelphia, PA 19103).

The headings for the lists of SERIALS are:

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

The volume and issue numbers (VO-NU) are given after the CODEN entry, followed by beginning page (BEPA), ending page (ENPA), species discussed (ANIM), KEY WORDS from the title, AUTHORS [truncated if necessary, slash (/) indicates additional authors], and year.

AJAEA Australian Journal of Agricultural Research (Australia)
AJPHA American Journal of Physiology (US)
AMNAA American Midland Naturalist (US)
AMZOA American Zoologist (US)
ANYAA Annals of the New York Academy of Sciences
ATICA Arctic (Canada)
AZOFA Annales Zoologici Fennici (Finland)

BINPA Boreal Institute for Northern Studies, University of Alberta Occasional Publication
BISNA Bioscience
BPURD Biological Papers of the University of Alaska Special Report

CAFGA California Fish and Game
CAFNA Canadian Field Naturalist (Canada)
CBCPA Comparative Biochemistry and Physiology
CBPAB Comparative Biochemistry and Physiology A Comparative Physiology
CGFPA Colorado Division of Game, Fish, and Parks Special Report
CJZOA Canadian Journal of Zoology (Canada)
CNJNA Canadian Journal of Animal Science (Canada)
CWRSB Canadian Wildlife Service Report and Management Bulletin Series

DWINA Defenders of Wildlife News

ECMOA Ecological Monographs (US)
ECOLA Ecology
EKPOA Ekologia Polska Seria A

FUNAA Fauna (Oslo)
FUOFA Fauna och Flora (Stockholm)

IJBMA International Journal of Biometeorology
ISJRA Iowa State Journal of Research

JANSA Journal of Animal Science (US)
JAPEA Journal of Applied Ecology (England)
JFUSA Journal of Forestry (US)
JMNAA Journal of the Minnesota Academy of Science
JOMAA Journal of Mammalogy (US)
JRMGA Journal of Range Management (US)
JSAVA Journal of the South African Veterinary Medical Association
JSWCA Journal of Soil and Water Conservation
JWMAA Journal of Wildlife Management (US)
JZOOA Journal of Zoology (London)

MFNOA Minnesota Forestry Notes
MGQPA Minnesota Department of Natural Resources Game Research Project Quarterly Progress Report
MOCOA Missouri Conservationist

NATUA Nature (England)
NAWTA North American Wildlife and Natural Resources Conference, Transactions of the
NCANA Naturaliste Canadien, Le
NEXAA New Mexico Agricultural Experiment Station Bulletin (US)
NFGJA New York Fish and Game Journal (US)
NJZOA Norwegian Journal of Zoology (Norway)
NPSMD United States National Park Service Scientific Monograph Series
NYCOA New York State Conservationist
NZJSA New Zealand Journal of Science

OIKSA Oikos (Denmark)

PASCC Proceedings of the Alaskan Scientific Conference (US)
PCGFA Proceedings of the Southeastern Association of Game and Fish Commissioners (US)
PMACA Papers of the Michigan Academy of Sciences, Arts and Letters
PMASA Proceedings of the Montana Academy of Sciences
PSAFA Proceedings of the Society of American Foresters (US)
PZESA Proceedings of the New Zealand Ecological Society

QSFRA Quebec Service de la Faune Rapport (Quebec Wildlife Service Report)

RIJUA Riistatieteellisia Julkaisuja
RVTSA Research in Veterinary Science
RWLBA Roosevelt Wild Life Bulletin

SCNAB Schweizer Naturschutz Protection de la Nature
SJAFD Southern Journal of Applied Forestry
SJECA Soviet Journal of Ecology (English translation of Ekologiya)
SZSLA Symposia of the Zoological Society of London (England)

TISAA Transactions of the Illinois State Academy of Science (US)
TJSCA Texas Journal of Science
TPCWD Colorado Division of Wildlife Technical Publication
TWASA Transactions Wisconsin Academy of Sciences, Arts, and Letters

UABPA Biological Papers of the University of Alaska
UTSCB Utah Science (US)

VILTA Viltrevy (Sweden)

WCDBA Wisconsin Conservation Department Technical Bulletin
WLMOA Wildlife Monographs (US)
WLSBA Wildlife Society Bulletin
WSCBA Wisconsin Conservation Bulletin

XAGCA U S D A Circular
XARRA U S Forest Service Research Note RM (US)
XFIPA U S Forest Service Research Paper INT (US)
XFNCA U S Forest Service Research Paper NC (US)
XFPNA U S Forest Service Research Paper PNW (US)
XFWRA U S Fish and Wildlife Service Research Report
XFWWA U S Fish and Wildlife Service Special Scientific Report - Wildlife

ZEJAA Zeitschrift fuer Jagdwissenschaft
ZORVA Zoologisk Revy (Sweden)

LIST OF PUBLISHERS - CHAPTER SEVENTEEN

The headings for the lists of BOOKS are:

TYPE PUBL CITY PAGE ANIM KEY WORDS----------------- AUTHORS/EDITORS-- YEAR

All essential information for finding each book in the library is given on just one line. The TYPE of book could have either AUTHORS (aubo) or EDITORS (edbo). Publishers (PUBL) and CITY of publication are given with four-letter mnemonic symbols defined below. The PAGE column gives the number of pages in the book; ANIM refers to the species discussed in the book (given as a four-letter abbreviation of genus and species), and KEY WORDS listed are from the title. The AUTHORS/EDITORS and YEAR of publication are given in the last two columns.

acpr	Academic Press	New York, NY	nyny
blsp	Blackwell Scientific Publications	Oxford, England	oxen
lefe	Lea and Febiger	Philadelphia, PA	phpa
oxup	Oxford University Press	London, England	loen
spve	Springer-Verlaug Inc.	New York, NY	nyny
uppr	University Park Press	Baltimore, MD	bama
usup	Utah State University Press	Logon, UT	lout
whfr	W. H. Freeman Company	San Francisco, CA	sfca

GLOSSARY OF ANIMAL CODE NAMES

Wild ruminants are referred to in this CHAPTER by a 4-character abbreviation from the family, genus and genus-species. These are listed below under Abbreviation.

Scientific names of North American wild ruminants are those used in BIG GAME OF NORTH AMERICA, edited by J.C. Schmidt and D. L. Gilbert (1979: Stackpole Books, Harrisburg, PA 17105, 494 p.), and may be different from the scientific names given in the original literature.

The abbreviations used for North American wild ruminants are listed below.

CLASS: MAMMALIA

ORDER: ARTIODACTYLA	Abbreviation
FAMILY: CERVIDAE	cerv
GENUS: *Odocoileus* (deer)	od--
SPECIES: *O. virginianus* (white-tailed deer)	odvi
O. hemionus (mule deer)	odhe
GENUS: *Cervus* (Wapiti, elk)	ce--
SPECIES: *C. elaphus*	ceel
GENUS: *Alces* (moose)	
SPECIES: *A. alces*	alal
GENUS: *Rangifer* (caribou)	
SPECIES: *R. tarandus*	rata
FAMILY: ANTILOCAPRIDAE	
GENUS: *Antilocapra*	
SPECIES: *A. americana* (pronghorn)	anam
FAMILY: BOVIDAE	bovi
GENUS: *Bison* (bison)	bi--
SPECIES: *B. bison*	bibi
GENUS: *Ovis* (sheep)	ov--
SPECIES: *O. canadensis* (bighorn sheep)	ovca
O. dalli (Dall's sheep)	ovda
GENUS: *Ovibos*	
SPECIES: *O. moschatus* (muskox)	obmo
GENUS: *Oreamnos*	
SPECIES: *O. americanus* (mountain goat)	oram

The abbreviations used for European wild ruminants are listed below.

CLASS: MAMMALIA

ORDER: ARTIODACTYLA	Abbreviation
FAMILY: CERVIDAE	cerv
GENUS: Capreolus (roe deer)	ca--
SPECIES: C. capreolus	caca
GENUS: Dama (fallow deer)	da--
SPECIES: D. dama	dada
GENUS: Cervus (Wapiti, elk)	ce--
SPECIES: C. elaphus (red deer)	ceel
GENUS: Alces (moose)	
SPECIES: A. alces	alal
GENUS: Rangifer (caribou)	
SPECIES: R. tarandus	rata
FAMILY: BOVIDAE	
GENUS: Bison (bison)	
SPECIES: B. bonasus	bibo
GENUS: Capra (ibex, wild goat)	cp--
SPECIES: C. aegagrus (Persian ibex)	cpae
C. siberica (Siberian ibex)	cpsi

OTHERS

Abbreviations for a few other species and groups of species may appear in the reference lists. These are listed below.

Axis axis (axis deer)	axax
Elaphurus davidianus (Pere David's deer)	elda
Cervus nippon (Sika deer)	ceni
Hydropotes inermis (Chinese water deer)	hyin
Muntiacus muntjac (Indian muntjac)	mumu
Moschus moschiferus (musk deer)	momo
Ovis nivicola (snow sheep)	ovni
Ovis musimon (moufflon)	ovmu
Ovis linnaeus (Iranian sheep)	ovli
Rupicapra rupicapra (chamois)	ruru
big game	biga
domestic sheep	dosh
domestic cattle	doca
domestic goat	dogo
domestic ruminant	doru
herbivore	hrbv
mammals	mamm
three or more species of wild ruminants	many
ruminants	rumi
ungulates	ungu
vertebrates	vert
wildlife	wldl
wild ruminant	wiru

JULIAN DAY: MONTH AND DAY EQUIVALENTS*

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029	[060]	088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

* For leap year, February 29 = JDAY 60. Add 1 to all subsequent JDAYs.

LIST OF WORKSHEETS - CHAPTER SEVENTEEN