TOPIC 2. ACTIVITY LOCATIONS AND TIMES

Locations and times of activities of free-ranging animals are rather predictable on both a daily and seasonal basis. Locations are dependent on food, cover, and weather. Activity times are related to current weather conditions and to the light regime. Seasonal patterns of activity times are related to the physiological condition of the animals, which is dependent on hormone balances and range conditions. References to hormones may be found in PART I, CHAPTER 2, UNIT 1.7, and to range conditions, including such things as the distribution and abundance of food resources, weather conditions that affect the ease of movement and forage availability, and energy exchange in different cover types in PARTS IV and V.

Activity occurs only as a result of physiological processes; metabolism must occur before an animal can do anything. This being true, it must be recognized that all activities have associated metabolic costs, and the total cost of living, or ecological metabolism, is related to the amounts and kinds of activities considered in this CHAPTER 4, and to the maintenance and production costs considered in CHAPTER 7.

Activity patterns, both daily and seasonal, may be detected when animals are studied through their daily and seasonal cycles. The use of radio telemetry in the past 20 years has made regular and sometimes continuous locations possible, contributing to our knowledge of the behavior of elusive, secretive, and often nocturnal animals.

Activity levels are often but not always related to vital signs which may also be telemetered from free-ranging animals. When an animal is in a rest period during the daily cycle, heart and respiration rates are reduced. They are also reduced in the winter, a long-term "rest-period." Data on vital signs may be used to interpret activity levels, but heart rate measurements at the Wildlife Ecology Laboratory have also shown marked variations due to transient stimuli. Heart rates alone are not always good indicators of the level of physical activity.

Daily and seasonal activity patterns are discussed and quantified in the next two UNITS. It is difficult to determine activity-time patterns with a high level of precision because different activities are not always easy to quantify. Walking, for example, is an activity, and so is foraging. Animals walk intermittently while foraging, however, and judgement is necessary when determining the amount of time actually spent walking and the amount spent foraging. Guidelines for recording activity times are necessary, such as stating that walking between "bites" is a part of foraging, but directed walking from one spot to another, with no attempt to forage along the way, is defined as walking. Deviations from the expected patterns occur in response to transient stimuli. Anyone who has tried to quantify time budgets of free-ranging animals is aware of these difficulties.

Changes in daily activity patterns result in changes in seasonal activity patterns. It is helpful to set up a series of possible daily and seasonal time allotments for different activities when evaluating potential

energy benefits due to different behavioral regimes. An example of this kind of analysis may be found in Moen (1976) where the importance of reductions in activity levels as part of the energy conservation adaptation was illustrated. Since there are some absolute mathematical limits and some reasonable biological limits in analyses of activity-time budgets, first approximations using reasonable combinations of time allotments may be quite realistic. For example, the sum of the time spent each day in all activities must equal 24 hours. Bedding usually does not continue all day. Foraging periods usually occur several times a day. Running cannot continue for hours because animals do not have the stamina to do so. In fact, wild ruminants are quite capable of short bursts of speed, but generally do not run for periods of time longer than a few minutes at the very most.

Literature data and common sense enable one to put together reasonable first approximations of activity-time budgets, and variability analyses allow one to test the effects of different time allotments to different activities.

Details of daily activity patterns are discussed in UNIT 2.1 and seasonal activity patterns in UNIT 2.2

LITERATURE CITED

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

UNIT 2.1: DAILY PATTERNS

Free-ranging animals exhibit different daily locations and patterns of activity at different times of the year. These patterns are based on external factors, such as cover, light and weather conditions, and internal conditions, such as hormone balance and nutrient needs.

Locations of daily activities are fairly predictable in terms of the kind of habitat chosen, but not necessarily the location in that kind of habitat when there are several options. Foraging, for example, occurs where there is forage available. One hardly expects to find deer in a plowed field or under a dense canopy during the period of time after sunrise when they are expected to be foraging.

The location of beds in relation to the surrounding topography seems to be important. White-tailed deer in west-central Minnesota tended to bed more frequently near the tops of hills than near the bottoms, with the majority of beds located on the upper one-third of the hill (Moen 1963). Small mounds and slight rises were also used; visibility seemed to be an important factor in choosing bed sites. Such sites are also likely to be drier than sites further downslope.

Geist (1959) observed that nearly all moose beds were in open, elevated locations in British Columbia. Good visibility in all directions seemed to be most important.

There are discussions in the early literature about whether animals use the same bed more than once. Moose do not use the same bed over and over, but bighorn sheep and mountain goats do (Geist 1971). Deer may, but this does not seem to be the usual occurrence, at least during spring, summer, and fall. Individuals have been observed to use the same bed site repeatedly (Severinghaus and Cheatum 1956) but this is not necessarily the custom of most deer. A deer wintering area may have hundreds of beds in the snow if new snow does not cover them, and many of them may be used more than once. Sibling (presumably) fawns appear to bed close together often. Two smaller beds very close to each other and a larger bed a short distance away suggests that a doe and her fawns bedded there.

It is necessary, for practical reasons, to limit field observations to definable, consistent categories of behavioral activities. Several activities may be recognized in the daily regime of an animal. Five activities--bedding, standing, walking, foraging, and running--are considered essential for evaluating daily activity-time patterns of wild ruminants. These can be further divided, of course--standing activity may or may not include grooming activity, and bedding activity may or may not include rumination, for example, but field observations are often lacking in such fine details. Also, night-time activities are very difficult to observe, even for major activities.

The time of sunrise and sunset seems to regulate the timing of the activities of many different animals, and this is not surprising. Ruminants generally show peaks in activity at sunrise and sunset, with additional activity periods during the day and night. There are shifts in the timing of activity periods from one season to the next. The general trend in the winter is toward more activity during daylight hours, and later in the day too when air temperatures are warmer.

Animals of different ages and sexes have different activity patterns. Ruminant neonates are, as a group, remarkably well-developed at birth. Some, such as white-tailed deer, are quite inactive for a day or two after birth, increasing their activities as they grow larger and stronger. Others, such as caribou and sheep, are quite active just hours after birth. Lighter-than-average young are less well-developed physiologically than heavier-than-average ones. The much lighter-than-average ones can be considered "premies," exhibiting a lag in their stage of development in relation to age.

Activity characteristics, and other characteristics too, appear to be more closely related to weight than age. By the end of the suckling period, the young are very similar to the adults in their activity patterns because they associate with them, either their dam or a group of adults, assuming the adult behavior patterns.

The fractions of time spent in various activities by fawns has been measured at the Wildlife Ecology Laboratory, and can be predicted from the age of the fawn. Neonatal behavior includes a large proportion of time bedded, with a rapid decline during the first month of life. The foraging or feeding fraction per day increases rapidly during the first month, the pattern being almost a mirror image of the bedded activity pattern. The remaining three activities--standing, walking, and running--combined occupy from 7 to 11% of the fawn's time from birth to 105 days of age. The fractions of the day spent standing, walking, and running are less predictable than the fractions of the day spent bedding and feeding (foraging), but since 7 to 11% of the day is a small amount of time, the errors contribute little to the 24-hour total that is dominated by the more predictable bedding and feeding fractions. The equations listed below for determining fractions of time in each activity merge at 105 days of age into the adult equations for fractions of time spent in different activities, given in Moen (1978).

Bedded:	FTBD	=	0.98 - 0.07306 ln AGDA
Standing:	FTSD	=	0.05 + 0.00285 ln AGDA
Walking:	FTWD	=	0.02 + 0.00280 ln AGDA
Foraging:	FTFD	=	0.08173 ln AGDA - 0.14
Running:	FTRD	=	0.00255 ln AGDA

After AGDA 105, the equations for adults give in Moen (1978) should be used as the fractions of time spent in an activity varies seasonally, independent of the age of the deer. These are given in UNIT 2.2.

The sum of the costs of each activity during a 24-hour period is one component of the total cost of living for that period, and the equations for predicting time spent daily in different activities in this UNIT will be used in estimating ecological metabolism in CHAPTER 7, UNIT 6.1.

The daily sum of hours spent in all of the activities must equal 24, of course, and the sum of the fractions of time spent in each per 24-hour period must equal 1.0. Reasonable estimates may be made if complete field data are not available, and evaluations of changes in metabolism due to changes in daily activity patterns made. Such variability analyses provide much insight into ecological relationships and compensations. An illustration based on field observations may be found in Moen (1976).

A mathematical format expressing a general pattern for a day should also allow for changes in the amounts of time spent in different activities due to transient changes in the environment. A very cold winter day, for example, may cause an animal to remain bedded longer than usual. Animals may remain bedded during a snowstorm, and the accumulation of large amounts of snow alters their activity patterns after the storm. Electronic computing systems may be programmed so general patterns are calculated first, followed by overrides of calculated values with observed values or variations for error analyses.

Complete the WORKSHEETS using observed data of your own or in the literature, and then vary the categories to test the effects of variations.

LITERATURE CITED

Geist, V. 1959. Diurnal activity of moose. Memoranda Societas pro Fauna et Flora Fennica 35:95-101.

Geist, V. 1971. Mountain Sheep. The University of Chicago Press, Chicago. 383 p.

Moen, A. N. 1963. A study of the winter bedding cover of the white-tailed deer in deciduous forest areas. M.S. Thesis, St. Cloud State College, Minnesota. 114 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. Journal of Wildl. Manage. 42(4): 715-738.

Severinghaus, C. W. and E. L. Cheatum. 1956. Life and times of the white-tailed deer. Pages 57-186 In W. P. Taylor, Ed., The Deer of North America. The Stackpole Company, Harrisburg, PA. 668 p.

REFERENCES, UNIT 2.1

DAILY PATTERNS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
ZOBEA	12--2	219	250	cerv	etholog observatns, n amer	geist,v	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
ECOLA	53--2	262	270	odvi	activ patt, young deer,tex	jackson,rm; whit/	1972
ECOLA	57--1	192	198	odvi	energy conservatn in wintr	moen,an	1976
JWMAA	27--3	422	427	odvi	nocturnl mvts, activ rhyth	montgomery,gc	1963
JWMAA	29--3	632	634	odvi	mechan recordr, meas activ	ozoga,jj; gysel,l	1965
JWMAA	33--1	196	203	odvi	mvmnts translocated, telem	hawkins,re; montg	1969
JWMAA	39--4	679	683	odvi	activ pattrn, durng estrus	ozoga,jj; verme,l	1975
JWMAA	41--2	315	317	odvi	seas chang,circadian activ	kammermeyer,ke; m	1977
JWMAA	42--4	715	738	odvi	seas chang, heart rate, ac	moen,an	1978
JWMAA	44--4	927	929	odvi	diurnal behavior, neonate	lagory,ke	1980
PCGFA	21---	51	57	odvi	drinking habits, sou texas	michael,ed	1967
TJSCA	21--4	417	428	odvi	activity patterns, s texas	michael,bd	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
AZWBA	3----	1	109	odhe	mule de, arizona chaparral	swank,wg	1958
BZOBA	20---	282	289	odhe	play behav, general activi	muller-schwarze,/	1969
JWMAA	33--3	704	708	odhe	photo-elec syst,noct activ	harder,jd	1969
JWMAA	39--3	605	616	odhe	doca,rnge rel, prairie hab	dusek,gl	1975
WLMOA	20---	1	79	odhe	ceel,doca, rnge ecol, mont	mackie,rj	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
BEHAA	20--3	377	416	alal	behavr no amer moose in bc	geist,v	1963
CAFNA	83--4	339	343	alal	observ, feeding on aquatic	ritcey,rw; verbee	1969
JOMAA	39--1	128	139	alal	summr obsrvtns, behv,ontar	de vos,a	1958
MSFFA	35---	95	100	alal	diurnal activity of moose	geist,v	1959
MUZPA	25---	1	44	alal	moose of isle royale	murie,a	1934

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	40--1	151	162	rata	obmo, summer range relatns	wilkinson,pf; sh/	1976
NPOAA	1974-	129	138	rata	mnth patt, feed intk, rein	nyholm,es	1976
OECOB	48---	64	70	rata	seas dev, circad act, capt	erriksson,l-o; k/	1981

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CGFPA	3----	1	28	anam	literature review,behavior	prenzlow,ej	1965
CGFPA	17---	1	16	anam	some behavior patterns of	prenzlow,ej; gil/	1968
JAPEA	12--2	411	420	anam	doca, comprtv grazng behav	ellis,je; travis,	1975

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

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
IGWBA	1----	1	154	ovca	status,life hist,man,idaho	smith,dr	1954
CAFNA	77--2	77	94	ovca	bahavior of a bighorn herd	blood,dal	1963

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

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
FRKZA	12--4	125	130	obmo	biol, polar musk ox,norway	pleticha,p	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CGFPA	8----	1	23	oram	literature review, ecology	hibbs,ld	1966
IGWBA	2----	1	142	oram	life history, manag, idaho	brandborg,sm	1955

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
BEHAA	71--3	246	290	caca	time-budgeting, agric area	turner,dc	1979
IZYBA	4----	297	300	caca	artif rearing, behav obser	pinter,h	1962
VILTA	11--8	315	353	caca	daily, seasnl activ pattrn	cederlund,g	1981

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JASIA	44--1	5	66	doca	inf win nut depres grow,re	voubert,dm	1954

OTHER PUBLICATIONS

Skinner, M. P. 1924. The American Antelope in Yellowstone National Park. Roosevelt Wildl. Forest Expt. Sta., Syracuse, N.Y. 32 p.

CHAPTER 4, WORKSHEET 2.1a

Five major daily activities of wild ruminants

Daily activity patterns may be divided into two main components: resting and active. Resting includes the time spent lying down, and may be further divided into postures, considering head position and leg positions. Active time may be divided into 4 major categories: standing, walking, foraging, and running. These may be subdivided into two or more categories each.

This WORKSHEET presents a format for recording the five major activity groups given above for use in calculating energy costs in PART III, CHAPTER 7, TOPIC 4. Complete the time budgets below based on your field observations or data in the literature. Data for different behavioral regimes of white-tailed deer may be used as examples if you do not have your own data.

Activity	JDAY and time fractions of different activities						
JDAY =	____	____	____	____	____	____	____
Bedding	____	____	____	____	____	____	____
Standing	____	____	____	____	____	____	____
Walking	____	____	____	____	____	____	____
Foraging	____	____	____	____	____	____	____
Running	____	____	____	____	____	____	____
SUMS	1.00	1.00	1.00	1.00	1.00	1.00	1.00

LITERATURE CITED

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

Activity	JDAY and time fractions of different activities						
JDAY =							
Bedding							
Standing							
Walking							
Foraging							
Running							
SUMS	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Activity	JDAY and time fractions of different activities						
JDAY =							
Bedding							
Standing							
Walking							
Foraging							
Running							
SUMS	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Activity	JDAY and time fractions of different activities						
JDAY =							
Bedding							
Standing							
Walking							
Foraging							
Running							
SUMS	1.00	1.00	1.00	1.00	1.00	1.00	1.00

CHAPTER 4, WORKSHEET 2.1b

Time spent in different postures and activity intensities

This WORKSHEET is an expansion of the previous one, incorporating posture and intensity into the five major activities of WORKSHEET 2.1a. Complete the blanks as before for later use in calculating activity costs as described in PART III, CHAPTER 7, TOPIC 4.

		Time fraction	Time fraction	Time fraction	Time fraction
Bedding:	Head up	_____	_____	_____	_____
	Head down	_____	_____	_____	_____
Standing:	Loitering	_____	_____	_____	_____
	Alert	_____	_____	_____	_____
Walking:	*Speed	_____	_____	_____	_____
	*Vertical ascent	_____	_____	_____	_____
Foraging:	Speed	_____	_____	_____	_____
	Vertical ascent	_____	_____	_____	_____
Running:	Speed	_____	_____	_____	_____
	Vertical ascent	_____	_____	_____	_____

*Speed and vertical ascent are used when calculating the costs of walking, foraging and running. Recording these along with time spent in these activities makes it convenient to complete energy cost calculations in CHAPTER 7, TOPIC 4.

		Time fraction	Time fraction	Time fraction	Time fraction
Bedding:	Head up	_____	_____	_____	_____
	Head down	_____	_____	_____	_____
Standing:	Loitering	_____	_____	_____	_____
	Alert	_____	_____	_____	_____
Walking:	*Speed	_____	_____	_____	_____
	*Vertical ascent	_____	_____	_____	_____
Foraging:	Speed	_____	_____	_____	_____
	Vertical ascent	_____	_____	_____	_____
Running:	Speed	_____	_____	_____	_____
	Vertical ascent	_____	_____	_____	_____

		Time fraction	Time fraction	Time fraction	Time fraction
Bedding:	Head up	_____	_____	_____	_____
	Head down	_____	_____	_____	_____
Standing:	Loitering	_____	_____	_____	_____
	Alert	_____	_____	_____	_____
Walking:	*Speed	_____	_____	_____	_____
	*Vertical ascent	_____	_____	_____	_____
Foraging:	Speed	_____	_____	_____	_____
	Vertical ascent	_____	_____	_____	_____
Running:	Speed	_____	_____	_____	_____
	Vertical ascent	_____	_____	_____	_____

CHAPTER 4, WORKSHEET 2.1c

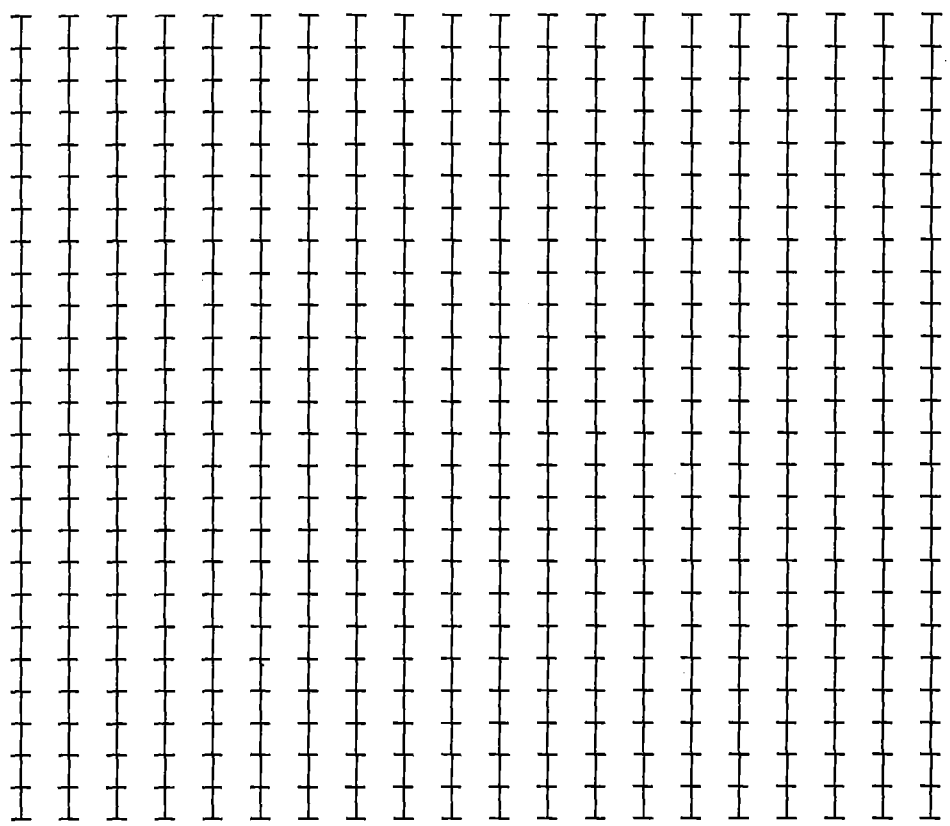
Estimates of activity-time fractions from birth to weaning

The equations given in UNIT 2.1 for calculating fractions of time in different activities included logarithmic changes in the fractions over time. They also merged with adult equations in Moen (1978) at AGDA = 105.

If fractions of time at birth and fractions of time at weaning are known or estimated, first approximations may be made by using a logarithmic fit between these points. Four of the five may be determined in this way, and the fifth by subtraction.

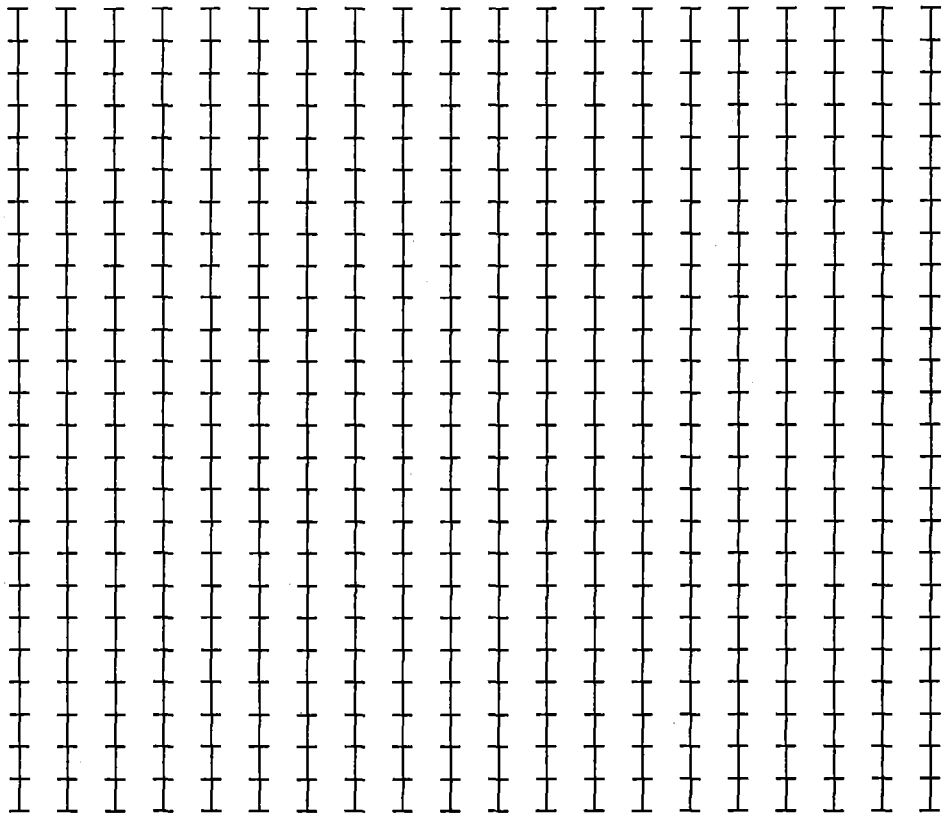
This procedure illustrates how estimates may be made because they must be made when evaluating the total ecology of animals from birth to death. If you have a better way to make such estimates, do so. You must not say "I don't know" and leave it out, for that is a certain mistake.

Make your estimates and plot the results below.



LITERATURE CITED

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.



UNIT 2.2: SEASONAL PATTERNS

Locations of wild ruminants and their activity times vary from one season to the next because they are closely related to seasonal changes in range resources and conditions, and to the productivity cycle of the animals. Thus when the cost of living is high because of lactogenesis, the amount of foraging activity is also high. In the winter when the cost of living is low because of the metabolic depression, the amount of activity is also low, a reasonable adaptive response to a range with limited forage resources. Seasonal changes in the use of space were discussed in CHAPTER 3, UNIT 3.2. The discussion here in this UNIT 2.2 will be directed toward activity times and how they change through the year.

Verbal descriptions of activity cannot be communicated directly to programmed electronic computing systems. Codes and time intervals must be entered, determining the fractions of time spent in different activities such as bedding, standing, walking, foraging, and running. The time spent per day in each of these activities may change gradually through the year, and may be expressed as continuous mathematical functions based on the time of year (JDAY).

Sine wave equations that were determined for the time spent in different activities by captive white-tailed deer (Moen 1978) illustrate an approach that is very useful when evaluating seasonal changes in activity patterns and in energy costs. Observed times spent by wild ruminants in different activities in different areas may be fit to equations in a similar way, providing a mathematical format for expressing time functions in different activities through the year.

The format is similar to that for expressing weights as described in PART I, CHAPTER 1, UNIT 1.4. The equations are given below.

$$FTBD = \{0.0885 \sin[(JDAY)(0.9863) - 103] + 0.0005\} + 0.597$$

$$FTSD = \{0.0934 \sin[(JDAY)(0.9863) + 77] - 0.0004\} + 0.100$$

$$FTWD = \{0.0208 \sin[(JDAY)(0.9863) + 77] - 0.0000\} + 0.066$$

$$FTFD = \{0.0232 \sin[(JDAY)(0.9863) - 103] + 0.0002\} + 0.231$$

$$FTRD = \{-0.0006 \sin[(JDAY)(0.9863) - 103] - 0.0004\} + 0.006$$

where FTBD = fraction of time bedded,
FTSD = fraction of time standing,
FTWD = fraction of time walking,
FTFD = fraction of time foraging, and
FTRD = fraction of time running.

It is difficult to get enough data to derive equations for activity patterns of free-ranging animals over the annual cycle. Thus data on year-long activity patterns are virtually lacking for wild ruminants. Measurements of activity patterns over several annual cycles on penned animals may be compared with accounts of scattered field observations reported in the literature. Franzmann and Hebert (1971), for example, briefly mention "the docility of bighorns in late winter may be a behavioral mechanism to conserve energy and enhance survival . . ." This indicates a metabolic depression and reduced activity, which is useful information when making first approximations of seasonal activity patterns.

A useful first step in determining whether sine waves are appropriate expressions of the fractions of time in each activity over the annual cycle is the plotting of the data. If the patterns show seasonal differences with sine-wave patterns, annual averages for the five activities may be determined and deviations from the annual averages fit as described for the weight analyses in the CHAPTER 1, UNIT 1.4. Primary and secondary phase corrections may also be made as described in CHAPTER 1. One important point to remember is that the sum of the fractions of time in each activity must equal 1.0. If five activities are considered, four may be fit to curves and the fifth expressed as the difference between the sum of the other four and 1.0.

Transient changes occur between seasons in the annual cycle, depending primarily on range conditions. An open winter with little snow and ample range resources allows greater mobility, more movement, and higher activity levels than a cold, deep-snow winter. Such changes in the amounts of different activities are changes in the amplitudes of sine waves, and may be easily accomodated mathematically. The important point to remember is that increases in some activities must result in decreases in others since the total amount of time spent in any day throughout the year cannot exceed 24 hours.

The two WORKSHEETS at the end of this UNIT provide opportunities for evaluating seasonal changes in time spent daily in different activities.

LITERATURE CITED

Franzmann, A. W. and D. M. Hebert. 1971. Variation of rectal temperature in bighorn sheep. J. Wildl. Manage. 35(3):488-494.

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 2.2

SEASONAL PATTERNS

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS----------	AUTHORS/EDITORS--	YEAR
aubo	stac	hapa	238	anam	prnghrn antlp & its mngmnt	einarsen,as	1948

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
AMNAA	77--3	390	417	cerv	socai behav, repro period	devos,a; broky,p/	1967
JOMAA	37--2	165	170	cerv	territorialism in deer	graf,w	1956

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
BUCDA	27--2	83	83	odvi	wint sprng movt, indiv, fl	bridges,rj; march	1969
CJZOA	44--1	59	62	odvi	breeding seasons	ransom,ab	1966
ECOLA	41--2	327	333	odvi	wint act, wh ced swamp, wi	habeck,jr	1960
ECOLA	57--1	192	196	odvi	energy conservat in winter	moen,an	1976
JFUSA	63--7	523	529	odvi	swamp conifer deer yards	verme,lj	1965
JWMAA	10--3	249	263	odvi	breeding season, new york	cheatum,el; morto	1946
JWMAA	24--4	364	371	odvi	test shelt req, penned dee	robinson,wl	1960
JWMAA	32--3	615	618	odvi	summer flight behav, adiro	behrend,df; lubec	1968
JWMAA	34--2	420	431	odvi	season activ patt, sou dak	sparrowe,rd; spri	1970
JWMAA	34--2	431	439	odvi	winte feeding patt, penned	ozoga,jj; verme,l	1970
JWMAA	34--3	553	559	odvi	winter habitat selection	telfer,es	1970
JWMAA	39--4	679	683	odvi	actv pattrns during estrus	ozoga,jj; verme,l	1975
JWMAA	41--2	315	317	odvi	seasonl chang circad activ	kammermayer,ka; m	1977
JWMAA	42--4	715	738	odvi	seasonal heart rates, meta	moen,an	1978
PIAIA	79--2	74	78	odvi	wint movt, home rang, iowa	zagata,md; haugen	1972
WSCBA	17--4	20	21	odvi	deer scattered throu winte	wisc conserv dept	1952
WCDBA	7----	1	32	odvi	wint habits, censu methods	kabat,c; collias/	1953

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFGA	36--4	343	365	odhe	calif mule d,chaparral for	cronemiller,fp; b	1950
CGFPA	7----	1	26	odhe	literature review,behavior	dorrance,mj	1966
ECMOA	2---1	1	46	odhe	seasonal migration, mule d	russell,cp	1932
ECOLA	45--2	249	256	odhe	relat weather, migra movem	mccullough,dr	1964
JOMAA	31--4	426	429	odhe	rel moon phas,occr salt lk	buss,il; harbert,	1950
JOMAA	37--2	143	164	odhe	behavr, ref to pop ecolgy	dasmann,rf; taber,	1956
JOMAA	51--2	248	260	odhe	distr patt in rela to envi	miller,fl	1970
JWMAA	39--3	605	616	odhe	range relatn, doca, prarie	dusek,gl	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	9---4	295	319	ceel	roosvlt elk, olympic penin	schwartz,je,II; m	1945
JWMAA	32--3	553	557	ceel	diff distr, sex, age, mont	peek,jm; lovaas,a	1968
WLMOA	33---	1	50	ceel	home range, activ pattern	craighead,jj; cr/	1973
VEZOA	4---5	15	19	ceel	ecolo, c. elaphus brauneri	kormylytsyn,aa	1970
ZETIA	24--1	80	114	ceel	behavior, during the rut	struhsaker,tt	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
ANBEA	6---2	155	159	alal	social integration of calf	altmann,m	1958
BEHAA	20--3	377	416	alal	behavr no amer moose in bc	geist,v	1963
BYMOA	82--1	29	40	alal	winter distr, ussr, migrat	sobanski,gg	1977
CAFNA	89--1	47	52	alal	season movement, laurenti	roussel,ye; audy/	1975
JOMAA	39--1	128	139	alal	summr obsrvtns behv, ontar	de vos,a	1958
JOMAA	53--1	129	138	alal	north limits, west canada	kelsall,jp	1972
JWMAA	24--2	162	170	alal	mvmnts, food hab, pop,mont	knowlton,ff	1960
JWMAA	34--2	439	445	alal	mvmnts, hunted area, ontar	goddard,j	1970
JWMAA	34--3	553	559	alal	winter habitat selection	telfer,es	1970
JWMAA	35--1	63	71	alal	radiotelemet, ne minnesota	val vallenberghe,	1971
JWMAA	37--3	266	278	alal	moveme patterns, range use	phillips,rl; ber/	1973

alal continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
LYNXA	12...	5	24	alal	migrations, central europe	briedmann,l	1971
NAWTA	21---	510	525	alal	summer studies in ontario	de vos,a	1956
NCANA	101--	51	65	alal	distributn,habitat, status	dodds,dg	1974
NCANA	101--	143	178	alal	distribu, habitats, alaska	leresche,re; bis/	1974
NCANA	101--	379	392	alal	seasonal movements, europe	pulliainen,e	1974
NCANA	101--	393	415	alal	migrations in north americ	lefesche,re	1974
QSFRA	3----	51	73	alal	influence snow on behavior	des meules,p	1964

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
ANBEA	13--2	259	264	rata	rutting behavio, bar gr ca	lent,pc	1965
ANBEA	18--2	256	258	rata	consequ of travel, rutting	henshaw,j	1970
ATICA	23--3	199	200	rata	abnormal migratory behavio	espmark,y	1970
JWMAA	24--3	250	258	rata	behav, bar gr car, calving	devos,a	1960
JWMAA	38--1	54	66	rata	synchronous matng, bar gro	dauphine,tc; mccl	1974
NPOAA	1974-	129	138	rata	mnth patt, feed intk, rein	nyholm,ex	1976
OECOB	48---	64	70	rata	seas dev, circad,act, capt	erriksson,l-o; k/	1981
TNWSD	1961-	1	31	rata	reprod season, newfoun car	bergerud,at	1961
ZETIA	23--6	701	756	rata	calving, relat soc behavio	lent,pc	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
AMNAA	43--2	257	354	anam	lif his, eco, ran use, tex	bueshner,hk	1950
CAFGA	30--4	221	241	anam	prng-hrnd antlp,california	mclean,dd	1944
CGFPA	3----	1	28	anam	literature review,behavior	prenzlow,ej	1965
CGFPA	17---	1	16	anam	some behavior patterns of	prenzlow,ej; gil/	1968
JOMAA	10--2	135	141	anam	pronghorn antelope	grinnell,gb	1929
JOMAA	50--1	129	138	anam	territorial, bucks, montan	bromley,pt	1969

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

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JOMAA	18--2	205	212	ovca	prelim study, yllwstn n pk	mills,hb	1937
JOMAA	19--1	88	94	ovca	summer activity, yllstn pk	davis,wb	1938
JWMAA	35--3	488	494	ovca	variatn of rectal temperat	franzmann,aw; heb	1971

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
BMSIA	11---	139	144	oram	radio tracking, w montana	rideout,cb	1974
CGFPA	8----	1	23	oram	literature review, ecology	hibbs,ld	1966

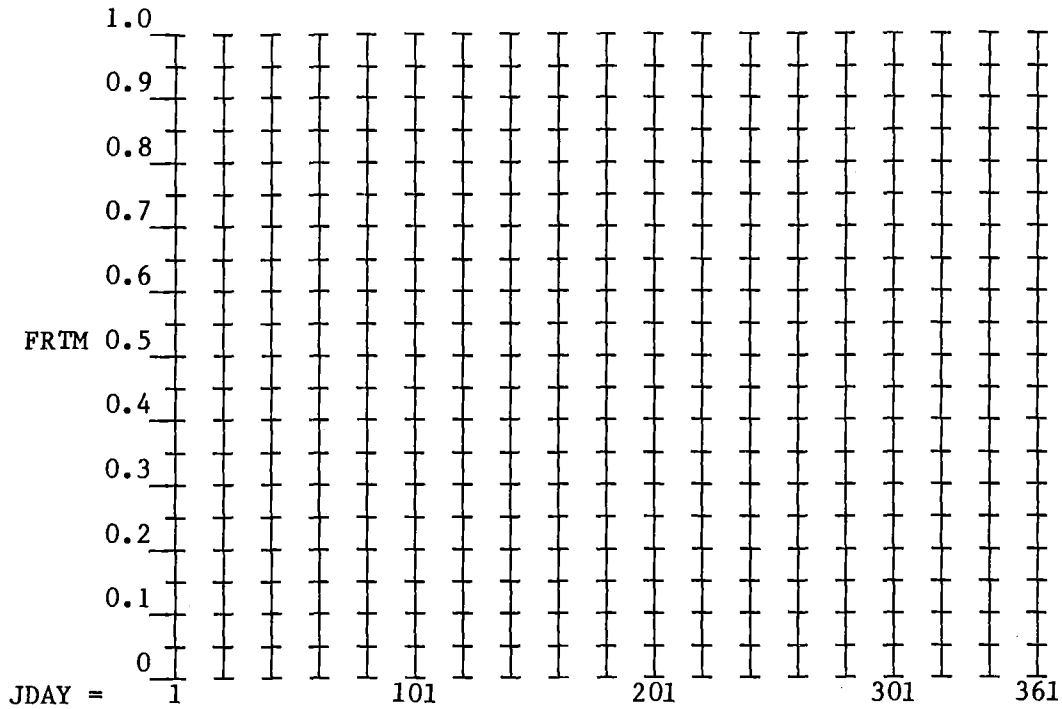
OTHER PUBLICATIONS

Skinner, M. P. 1924. The Americn Antelope in Yellowstone National Park. Roosevelt Wildl. Forest Expt. Sta., Syracuse, N.Y. 32p.

CHAPTER 4, WORKSHEET 2.2a

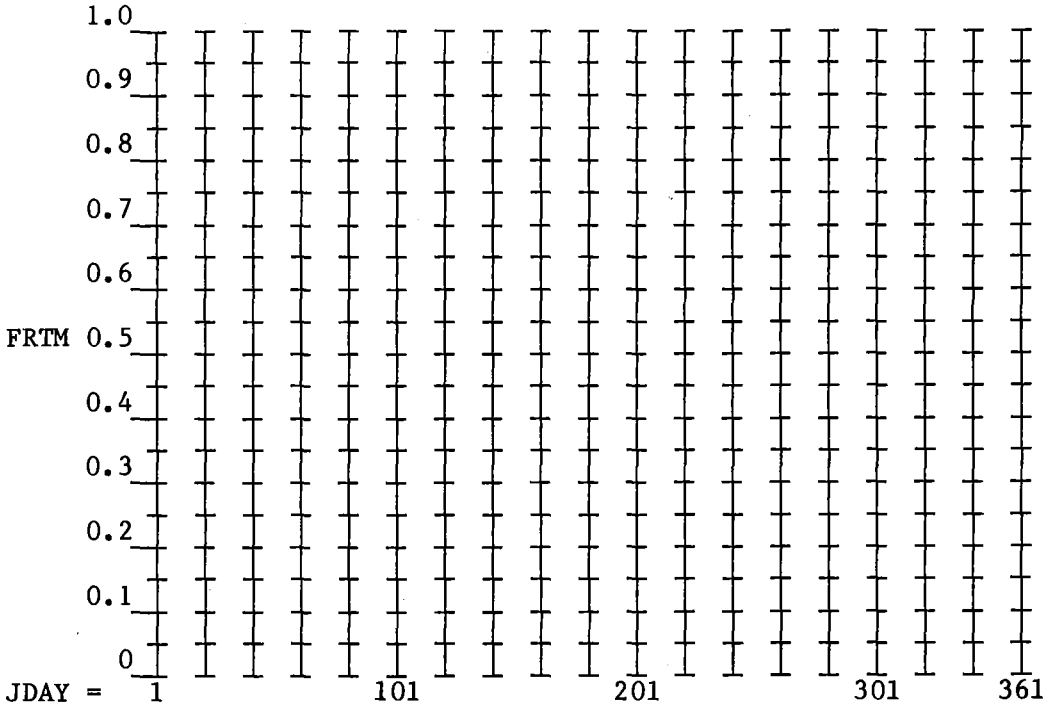
Seasonal activity patterns

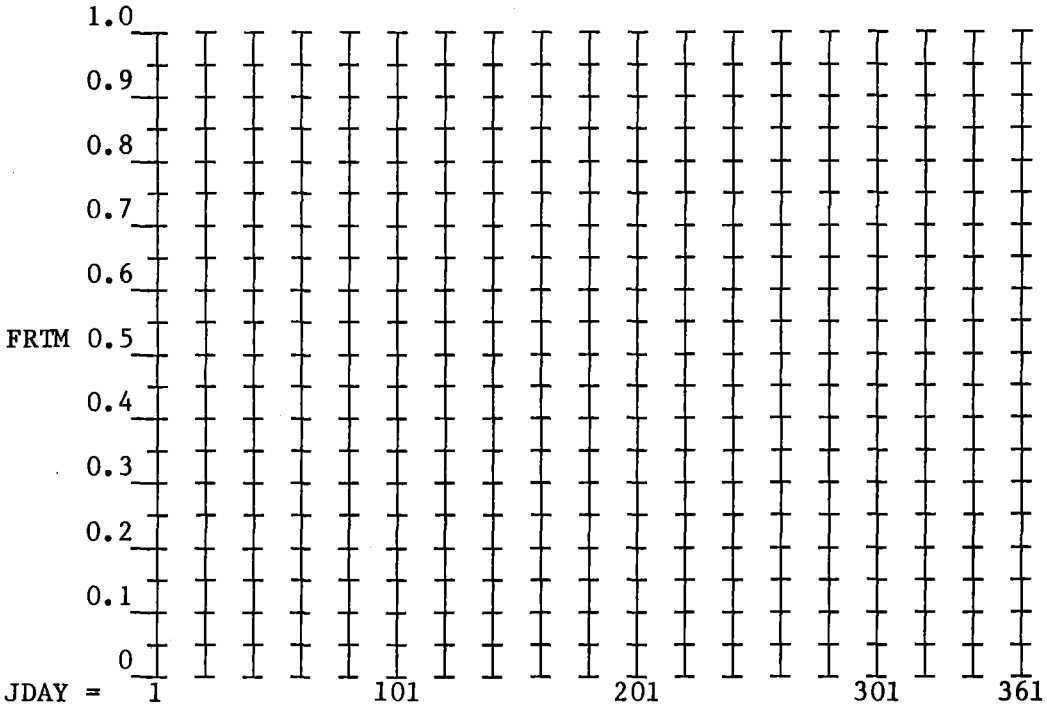
Seasonal activity patterns are made from a collection of daily activity patterns through the annual cycle. Refer back to WORKSHEET 2.1a for a listing of fractions of time in five major activities on different JDAYs. Plot the fractions of time (FRTM) you derived in the grid below. If you do not have data for enough JDAYs to complete patterns through the year, complete more days of activity patterns in WORKSHEET 2.1a and then complete this WORKSHEET.



Use the space below to write or derive equations for the data plotted.

Additional plots may be made on the two grids on the next page.


1.0
0.9
0.8
0.7
0.6
FRTM 0.5
0.4
0.3
0.2
0.1
0
JDAY = 1
101
201
301
361


1.0
0.9
0.8
0.7
0.6
FRTM 0.5
0.4
0.3
0.2
0.1
0
JDAY = 1
101
201
301
361

CHAPTER 4, WORKSHEET 2.2b

Variability in seasonal activity patterns

Patterns over the annual cycle are emphasized in all seven PARTS of The Biology and Management of Wild Ruminants. This WORKSHEET provides an opportunity for adjusting fractions of time through the year. The variations presented here will be useful when calculating the energy costs of activities in PART III, CHAPTER 7, TOPIC 4.

Use Figure 5 in my paper on seasonal rhythms (Moen 1978) as a starting point. Note that peaks in the sine waves occur on about JDAYs 16 and 196. Considering running to be 1.0% (FTRD = 0.01) throughout the year in this illustration, the following estimates may be made.

	JDAY 16	JDAY 196
FTBD =	0.50	0.68
FTSD =	0.19	0.01
FTWD =	0.09	0.06
FTFD =	0.21	0.24
FTRD =	0.01	0.01
SUMS =	1.00	1.00

Each of these may be expressed as symmetric sine waves as described in PART I, CHAPTER 1, UNIT 1.4. In the above example, FTBD = 0.59 $\pm$ 0.09, and the phase correction is -103. Thus:

$$FTBD = 0.09 \sin [(JDAY)(0.9863) - 103] + 0.59$$

Equations for each of the others may be written in the same way. Be sure to determine proper phase corrections; some are 180° out of phase.

FTSD =

FTWD =

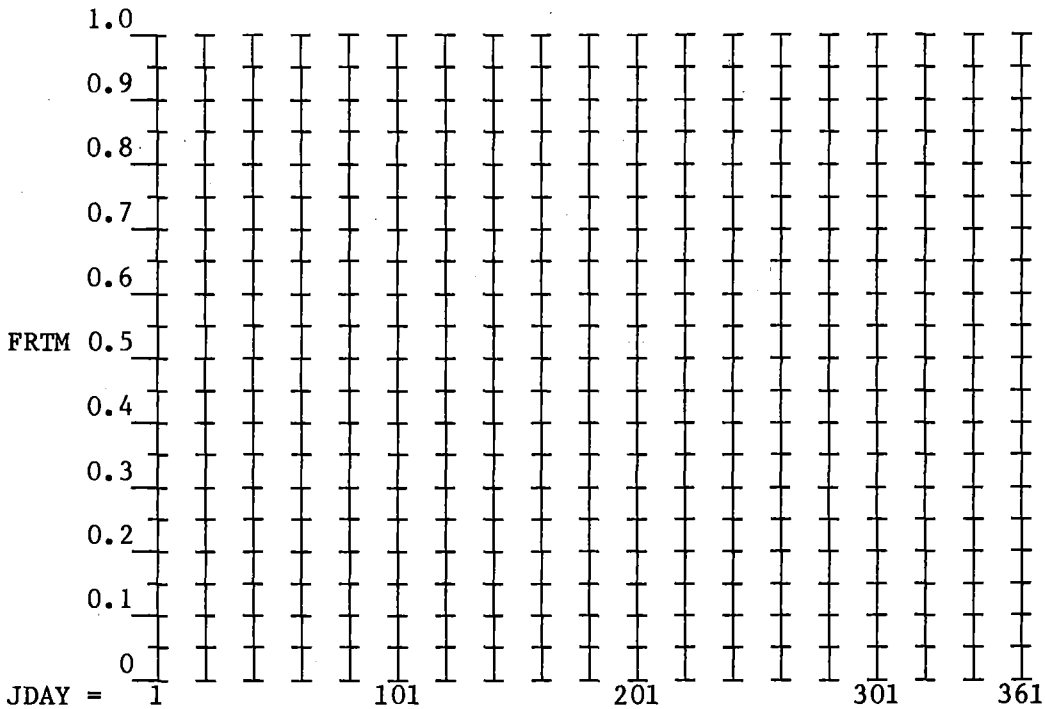
FTFD =

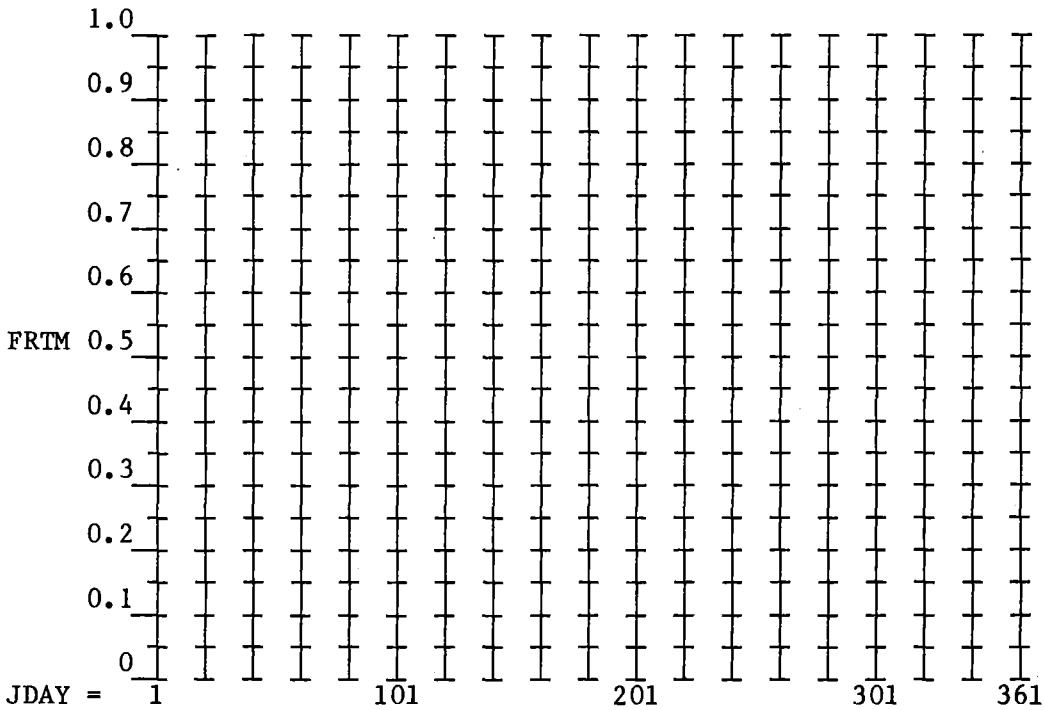
FTRD = 0.01

After writing the equations suggested above, alter the maximum and minimum fractions of time in each activity, and the timing, or phase of each of the patterns. Write the equations and plot the results in the grid on the next page. Be sure that the total FRTM for any JDAY calculated = 1.00.

LITERATURE CITED

Moen, A. N. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. J. Wildl. Manage. 41(4):715-738.


1.0
0.9
0.8
0.7
0.6
FRTM 0.5
0.4
0.3
0.2
0.1
0
JDAY = 1
101
201
301
361


1.0
0.9
0.8
0.7
0.6
FRTM 0.5
0.4
0.3
0.2
0.1
0
JDAY = 1
101
201
301
361

CLOSING COMMENTS

This CHAPTER 4 included descriptions of different activities and of two very important temporal--daily and seasonal--behavior patterns. There are limited data on these two patterns, but the mathematical frameworks described provide ways to estimate the effects of different behavior patterns and activity levels on energy expenditures over time periods of 24 hours and 365 days in PART III. The results will be used to determine ecological metabolism in PART III, and in all of the remaining PARTS as calculations are made for individuals and populations, and of carrying capacity.

Aaron N. Moen
November 12, 1981

GLOSSARY OF SYMBOLS - CHAPTER FOUR

BDNG = Bedding

FGNG = Foraging
FRTM = Fraction of time
FTBD = Fraction of time bedded
FTFD = Fraction of time foraging
FTRD = Fraction of time running
FTSD = Fraction of time standing
FTWD = Fraction of time walking

GESP = Genus and species

JDAY = Julian day

RNNG = Running

STNG = Standing
SUMS = Sums

WKNG = Walking

GLOSSARY OF SERIAL CODENS - CHAPTER FOUR

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)1, KEY WORDS from the title, AUTHORS [truncated if necessary, slash (/) indicates additional authors], and YEAR.

AMNAA American Midland Naturalist (US)
AMNTA American Naturalist (US)
ANBEA Animal Behaviour (England)
ATICA Arctic (Canada)
AZWBA Arizona Game and Fish Department Wildlife Bulletin (US)

BEHAA Behaviour (Netherlands)
BMSIA Biomedical Sciences Instrumentation
BPURD Biological Papers of the University of Alaska Special Report
BUCDA Bulletin of the Georgia Academy of Sciences
BVJOA British Veterinary Journal
BYMOA Byulletin Moskovskago Obshchestva Ispyrtatalei Prirody Otdel Biologicheskii (USSR)
BZOBA Bonner Zoologische Beitraege

CAFGA California Fish and Game (US)
CAFNA Canadian Field Naturalist (Canada)
CFGGA California Department of Fish and Game, Game Bulletin
CGFPA Colorado Division of Game, Fish, and Parks Special Report (US)
CJZOA Canadian Journal of Zoology (Canada)
CWRSB Canadian Wildlife Service Report and Management Bulletin Series

ECMOA Ecological Monographs (US)
ECOLA Ecology

FEPRA Federation Proceedings (US)
FRKZA Freunde de Koelner Zoo
FUNAA Fauna (Oslo)

IGWBA Idaho Department of Fish and Game Wildlife Bulletin
IUNRA International Union for Conservation of Nature and Natural Resources Annual Report (Switzerland)
IZYBA International Zoo Year Book

JAPEA Journal of Applied Ecology (England)
JASIA Journal of Agricultural Science (England)
JFUSA Journal of Forestry (US)
JOMAA Journal of Mammalogy (US)
JRMGA Journal of Range Management (US)
JTBIA Journal of Theoretical Biology
JWMAA Journal of Wildlife Management (US)

LYNXA Lynx (Czechoslovakia)

MDCBA Minnesota Department of Conservation Technical Bulletin
MDCRA Michigan Department of Conservatioon Game Division Report
MRLTA Murrelet, The
MSFFA Memoranda Societatis pro Fauna et Flora Fennica
MUZPA Miscellaneous Publications, Museum of Zoology, University of Michigan

NAWTA North American Wildlife and Natural Resources Conference, Transactions of the (US)
NCANA Naturaliste Canadien, Le
NPOAA Norsk Polarinstitutt Arbok (Norway)
NPSMD United States National Park Service Scientific Monograph Series

OECOB Oecologia (Berlin)

PASCC Proceedings of the Alaskan Scientific Conference (US)
PCGFA Proceedings of the Southeastern Association of Game and Fish Commissioners
PIAIA Proceedings of the Iowa Academy of Science
PZSLA Proceedings of the Zoological Society of London

QRBIA Quarterly Review of Biology
QSFRA Quebec Service de la Faune Rapport (Quebec Wildlife Service Report)

RWLBA Roosevelt Wild Life Bulletin

SCBUB Sierra Club Bulletin
SCIEA Science
SCZFA Schweizerische Zeitschrift fuer Forstwesen

TISAA Transactions of the Illinois State Academy of Science (US)
TJSCA Texas Journal of Science
TLPBA Theoretical Population Biology
TNWSD Transactions of the Northeast Section, The Wildlife Society (US)

UABPA Biological Papers of the University of Alaska
UCPZA University of California Publications in Zoology

VEZOA Vestnik Zoologii
VILTA Viltrevy (Sweden)
VLUBB Vestnik Leningradskogo Universiteta Biologiya

WCDBA Wisconsin Conservation Department Technical Bulletin
WGFBA Wyoming Game and Fish Commission Bulletin
WLMOA Wildlife Monographs (US)
WMBAA Wildlife Management Bulletin (Ottawa) Series 1 (Canada)
WSCBA Wisconsin Conservation Bulletin

XNFSA U S National Park Service Fauna of the National Parks of the United States, Fauna Series

ZEJAA Zeitschrift fuer Jagdwissenschaftl
ZETIA Zeitschrift fuer Tierpsychologie
ZOBEA Zoologisch Beitraege
ZOGAA Zoologische Garten
ZOOLA Zoologica (New York)
ZSAEA Zeitschrift fuer Saeugetierkunde

LIST OF PUBLISHERS - CHAPTER FOUR

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.

aakn	Alfred A. Knopf	New York, NY	nyny
acpr	Academic Press	New York, NY	nyny
apcc	Appleton-Century-Crofts	New York, NY	nyny
botc	Bouilliere, Tindall & Cassell	London, England	loen
cite	Cambridge Institute of Terrestrial Ecology	Cambridge, England	caen
dodo	Doubleday Doran	New York, NY	nyny
dohr	Dowden, Hutchinson, & Ross	Stroudsburg, PA	stpa
fost	Forest and Stream Publishing Co.	New York, NY	nyny
hill	Hill	London, England	loen
iucn	International Union for the Conserrvation of Nature and Natural Resources	Morges, Switzerland	mosw
jwis	John Wiley and Sons, Inc.	New York, NY	nyny
macm	MacMillan Co.	New York, NY	nyny
meth	Methuen & Co.	London, England	loen
mhbc	McGray-Hill Book Company, Inc.	New York, NY	nyny

olbo	Oliver & Boyd	Edingurgh, Scotland	edsc
oxup	Oxford University Press	London, England	loen
plpc	Plenum Publishing Corporation	New York, NY	nyny
prha	Prentice-Hall, Inc.	Englewood Cliffs, NJ	ecnj
qupr	Queen's Printer	Ottawa, Ontario	oton
saco	Saunders Publishing Co.	Philadephia, PA	phpa
sfes	USDA Forest Servide, Southern Forest Experiment Station	Nacagdoches, TX	nate
stac	Stackpole Company, The	Harrisburg, PA	hapa
ucap	University of California Press	Berkely, CA	beca
uchp	University of Chicago Press	Chicago, IL	chil
unbp	University of Nebraska Press	Lincoln, NE	line
utop	University of Toronto Press	Toronto, Ontario	toon
uwyp	University of Wyoming Press	Laramie, WY	lawy
whfr	W. H. Freeman Co.	San Francisco, CA	sfca
wimi	Wildlife Management Institute	Washington, DC	wadc
wiso	Wildlife Society, The	Washington, DC	wadc
wiwi	Williams and Wilkins	Baltimore, MD	bama

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.

	Abbreviation
CLASS: MAMMALIA	
ORDER: ARTIODACTYLA	
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.

	Abbreviation
CLASS: MAMMALIA	
ORDER: ARTIODACTYLA	
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. aegargrus*(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 reevesi (Chinese muntjac)	mure
Moschus moschifer (Chinese 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 FOUR