INTRODUCTION

TO PART I

PHYSICAL, CHEMICAL AND GENETIC CHARACTERISTICS OF WILD RUMINANTS

Individual animals have characteristics that identify them as members of different groups. Animals with hair, for example, are mammals, and animals with feathers are birds. Most mammals have four legs that are used for locomotion, and most birds have wings that are used for flying. In some species, however, these structures are no longer functional, or are adapted for other uses.

Some characteristics are used to group animals according to physiological similarities rather than anatomical ones. Those that use internal regulatory mechanisms to maintain fairly uniform body temperatures are called endotherms, and those that are much more dependent on external conditions are called exotherms. The degree of development at birth may also be used as a basis for grouping animals; the young of wild ruminants are very well-developed and the young of marsupials very poorly developed at birth. Similar categories exist for birds; the young of some species are very precocial, and of other species, altricial. Many other categories may also be used to compile similarities in animal characteristics.

Sometimes categories are often more sharply delineated than biological functions warrant. Hibernators, for example, are often considered separately from semi-hibernators and non-hibernators. Functionally, however, these three categories are all part of a gradient of energy conservation adaptations, and it may be better to consider the gradient rather than the categories when evaluating ecological relationships. This will be discussed in more detail later, especially in Part III.

A review of the physical, chemical, and genetic characteristics of a species is a good way to start a series of analyses of animal-range relationships. Much natural history of species has been accumulated over the years by biologists, naturalists, ecologists, and wildlife managers, and these natural history data are important biological inputs into high-speed computer analyses.

Many of the equations in this book are mathematical versions of previously-expressed natural history facts. For example, lengths of gestation periods of wild ruminants can be related to the dates of parturition and conception to determine the cost of living for the pregnant female during that period of time. The growth rate and chemical composition of the fetus and associated reproductive tissues and the cost of maintenance of maternal body tissue must also be known since these costs must all be met if the animal is to reproduce sucessfully. Such costs are worthy of anlayses because population growth is very much more dependent on the productivity of the living than on mortality rates or the characteristics of the dead.

Many biological functions are on a rather predictable time schedule. Each species has a sequence of events through its life from conception to death that comprises a biological chronology for the species. The timing of these events is generally under hormonal control, mediated by the light regime, with short-term changes due to transient local conditions. Time-dependent equations, based on the sequence of biological events in the life of an animal from conception to death, express certain ecological commitments. Conception, for example, commits the female to a gestation period of rather fixed length, parturition at a particular time, and a lactation period of somewhat fixed length. After gestation and lactation have been completed, the time period before the next conception is also of rather fixed length, and the cycle begins again. Annual cycles tend to be repetitive after reproductive maturity is reached as gestation, parturition, and lactation dominate the production throughout the year by the females of each species.

The Julian calendar is used for expressing time through each annual cycle. Presentation of the sequence of biological events over successive annual cycles is done by dividing the annual cycle into 365 days (Julian day = JDAY) rather than months and days. Many annually-occurring biological functions can be represented by sine waves, where one annual cycle is one sine wave. Days of the year are converted to degrees in a circle with the conversion factor 360/365 = 0.9863. JULIAN DAY:MONTH AND DAY EQUIVALENTS are shown on the next page.

The two CHAPTERS in PART I are rather descriptive, setting the stage for many interactive and mutually dependent relationships analyzed in the remaining six PARTS of this book. Characteristics presented first (weight, for example) are used in later analyses [metabolism = f(weight), for example] as relationships are evaluated sequentially [forage requirements = f(weight) = f(metabolism), for example]. One important guideline followed throughout all seven parts of this book is that equations representing biological characteristics or functions are merged with other equations representing related biological characteristics or functions whenever possible and appropriate. Not all of the many possible characteristics, functions, and equations are presented, of course, and students, research scientist, and wildlife managers are encouraged to derive additional equations for species of interest and for populations in local areas.

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		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

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The lists of references that follow provide essential bibliographic information for books and articles containing general information on several biological characteristics. These general references will be helpful in many of the UNITS that follow, but they are not listed again after each UNIT as the UNIT lists are limited to more specific articles of direct application to the material discussed in each UNIT.

REFERENCES, PART I

PHYSICAL, CHEMICAL, AND GENETIC CHARACTERISTICS OF WILD RUMINANTS

BOOKS

type	publ	city	page	anim	kewo	auth/edit	year
aubo	rokp	loen	597	cerv	deer of g. britain, irelan	whitehead,gk	1964
aubo	huho	nyny	426	od--	deer, antelope of america	caton,jd	1877
edbo	stac	hapa	668	od--	deer of north america	taylor,wp	1956
aubo	stac	hapa	128	od--	if deer are to survive	dasmann,w	1971
aubo	vipr	nyny	194	od--	deer of the world	whitehead,gk	1972
aubo	omcc	eail	107	odvi	the white-tailed deer	madson,j	1961
edbo	nhfg	conh	256	odvi	the white-tai deer, new ha	siegler,hr	1968
aubo	ucap	beca	567	odhe	a herd of mule deer	linsdale,jm; tomic	1953
aubo	oxup	loen	215	ceel	herd of red deer, behavior	darling,ff	1937
aubo	stac	hapa	386	ceel	elk of north america	murie,oj	1959
aubo	wiwe	eail	125	ceel	the elk	madson,j	1966
aubo	ucap	beca	209	ceel	tule elk	mccullough,dr	1971
aubo	utop	toon	280	alal	north american moose	peterson,rl	1955
aubo	macm	nyny	300	rata	bar-gr car of north canada	pike,w	1892
aubo	ukap	laka		rata	bar-ground carib, keewatin	harper,f	1955
aubo	qupr	oton	339	rata	migratory, barren-ground c	kelsall,jp	1968
aubo	stac	hapa	238	anam	the pronghorn antelope	einarsen,as	1948
aubo	utop	toon	957	bibi	the north american buffalo	roe,fg	1951
aubo	thcr	nyny	242	bibi	the buffalo	haines,f	1970
aubo	aakn	nyny	339	bibi	time of the buffalo	mchugh,t	1972
aubo	swap	atoh	374	bibi	the buffalo book, saga ani	dary,d	1974
aubo	uchp	chil	383	ov--	mt sheep, behavior, evolut	geist,v	1971
aubo	coup	itny	248	ov--	mt sheep, man, norther wil	geist,v	1975
aubo	usgp	wadc	242	ovca	the bighorn of death valley	welles,re; welles	1961
aubo	qupr	oton	166	obmo	muskoxen in canada	tener,js	1965

aubo	dalt	laen	271	dada	fal de: histor, distr, bio	chapman,d; chapman	1975
aubo	doup	nyny	318	many	americ anim; popular guide	stone,w; cram,we	1902
aubo	cscs	nyny	347	many	our big game	huntington,d	1904
aubo	cscs	nyny	1267	many	life hist northern animals	seton,et	1909
aubo	ropr	nyny	129	many	wildlife in alaska, ecolog	leopold,as; darlin	1953
edbo	holt	nyny	264	many	records of n a big game an	boone & crockett c	1958
aubo	ropr	nyny	547	many	mammals of north america	hall,er; kelson,kr	1959
aubo	ucap	beca	586	many	wildlife of mexico	leopold,as	1959
aubo	vipr	nyny	304	many	wildlife in america	matthiessen,p	1959
aubo	repu	nyny	335	many	principals of mammalogy	davis,de; golley,f	1963
aubo	blsp	loen	308	many	guide, study of productivi	golley,fb; buechne	1968
aubo	jhpr	bamd	769	many	mammals of the world	walker,ep; paradis	1968
aubo	whfr	sfca	458	many	wildlife ecology	moen,an	1973
aubo	utop	toon	438	many	the mammals of canada	banfield, awf	1974
aubo	repu	nyny	1023	dome	bioenergetics and growth	brody,s	1945
edbo	coup	itny	1463	dome	duke's physiol domest anim	swenson,mj	1970
aubo	dipr	nyny	276		problems of relative growt	huxley,js	1932
aubo	wbsc	phpa	601		the vertebrate body	romer,as	1970
aubo	wbsc	phpa	574		fundamentals of ecology	odum,ep	1971
aubo	dohr	stpa	361		biblio of quantita ecology	schultz,vll; eber/	1976

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
MDCBA	5----	1	64	odvi	w-tailed deer of minnesota	erickson,ab; gunv	1961
MDCRA	14---	1	80	odvi	michigan white-tailed deer	jenkins,dh; bartl	1959
WCDBA	14---	1	282	odvi	white-tailed deer, wiscons	dahlberg,bl; guet	1956

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AZWBA	3----	1	109	odhe	in arizona chaparral	swank,wg	1958
CFGGA	8----	1	163	odhe	life hist, managemt, calif	taber,rd; dasmann	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
UCPZA	88---	1	209	ceel	tule elk: hist, behav, eco	mccullough,dr	1969
WLMOA	16---	1	49	ceel	status, ecol, roosevel elk	harper,ja; harn/	1967
WLMOA	24---	1	66	ceel	the sun river elk herd	knight,rr	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
NCANA	101--	1	436	alal	ecol, proc inter sym, pt 1	bedard,j	1974
NCANA	101--	437	735	alal	ecol, proc inter sym, pt 2	bedard,j	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BPURD	2----	1	215	rata	ecol, caribou, prudhoe bay	white,rg; thomso/	1975
CWRSB	38---	1	71	rata	biology, kaminuriak popula	dauphine,tc,jr	1976
UABPA	8----	1	82	rata	ecology, managment, sweden	skunke,f	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
WMBAA	10A--	1	79	rata	prelim investigation, pt 1	banfield,awf	1954
WMBAA	10B--	1	112	rata	prelim investigation, pt 2	banfield,awf	1954
WMBAA	12---	1	148	rata	caribou, continued studies	kelsall,jp	1957
WMBAA	15---	1	145	rata	barrn gr carib, coop study	kelsall,jp	1960

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AMNAA	43--2	257	354	anam	life hist, ecology, texas	buechner,hk	1950
JOMAA	3----	82	105	anam	the prong-horn	skinner,mp	1922

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AMNAA	24--3	505	580	ov--	distribut, variat, no amer	cowan,imct	1940
AZWBA	1----	1	153	ov--	desert bighorn	russo,jp	1956
WLMOA	4----	1	174	ov--	united sta, past to future	buechner,hk	1960

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AMNAA	56--2	297	324	ovca	ecology of mountain sheep	mccann,lj	1956
WGFBA	1----	1	127	ovca	wyoming bighorn study	honess,rf; frost,	1942
XNFSA	6----	1	242	ovca	th bighorn of death valley	welles,re; welles	1961

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	81--1	1	22	oram	observat, brit col, canada	holroyd,jc	1967
CGFPA	8----	1	23	oram	liter review on ecology of	hibbs,ld	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
NATUA	221--	59	60	dada	geographi var, fallow deer	chapman,di; chapm	1969

OTHER PUBLICATIONS

Proceedings of the White-tailed Deer in the Southern Forest Habitat Symposium

Transactions of the Annual Meeting of the Northeast Deer Study Group

Proceedings of the North American Moose Conference

Proceedings of the International Reindeer/Caribou Symposium

Proceedings of the Biennial Antelope States Workshop

Transactions of the Interstate Antelope Conference

Transactions of the North American Wild Sheep Conference

Transactions of the Desert Bighorn Council

Proceedings of the International Mountain Goat Symposium

Proceedings of the Annual Conference of Western Association of State Game & Fish Commissioners

LIST OF PUBLISHERS - PART I

aakn	Alfred A. Knopf	New York	nyny
blsp	Blackwell Scientific Publications	London	loen
coup	Cornell University Press	Ithaca, NY	itny
cscs	Charles Scribner's Sons	New York	nyny
dalt	Dalton	Lavenheim, England	laen
dipr	Dial Press, The	New York	nyny
dohr	Dowden, Hutchinson & Ross	Stroudsburg, PA	stpa
doup	Doubleday, Pace, & Co.	New York	nyny
hocl	Hollis & Carter Ltd.	London	loen
huho	Hurd Houghton	New York	nyny
holt	Holt	New York	nyny
jhpr	John Hopkins Press	Baltimore, MD	bamd
macm	MacMillan Co.	New York	nyny
nhfg	New Hampshire Fish & Game Deptartment	Concord, NH	conh
omcc	Olin Mathieson Chem. Corp.	E. Alton, IL	eail
oxup	Oxford University Press	London	loen
qupr	Queen's Printer	Ottowa, Canada	oton
ropr	Ronald Press	New York	nyny
repu	Reinhold Publishing	New York	nyny
rokp	Routledge & K. Paul	London	loen
stac	The Stackpole Company	Harrisburg, PA	hapa
swap	Swallow Press	Athens, OH	atoh
thcr	Thomas Crowell Co.	New York	nyny
ucap	University of California Press	Berkely, CA	beca
uchp	University of Chicago Press	Chicago, IL	chil
ukap	University of Kansas Press	Lawrence, KA	laka
utop	University of Toronto Press	Toronto, Ontario	toon
usgp	U. S. Government Printing Office	Washington D. C.	wadc
vipr	Viking Press	New York	nyny
wbsc	W. B. Saunders Co.	Philadelphia	phpa
whfr	W. H. Freeman Co.	San Francisco, CA	sfca
wiwe	Winchester-Western Press	East Alton, Il	eail

GLOSSARY OF CODE NAMES, PART I

Code names (CODEN) of Serials are defined in a GLOSSARY OF CODENS at the end of each CHAPTER. The GLOSSARY below includes the CODENS listed as Serials in this PART I. It is a miniature version of the lists given at the ends of CHAPTERS.

AMNAA	American Midland Naturalist
AZWBA	Arizona Game and Fish Department Wildlife Bulletin (US)
BPURD	Biol. Pap. Univ. Alaska Spec. Rep.
CAFNA	Canadian Field Naturalist (Canada)
CFGGA	California Department of Fish and Game, Game Bulletin
CGFPA	Colorado Division of Game, Fish, and Parks Special Report
CWRSB	Canadian Wildlife Service Report and Management Bull. Series
JOMAA	Journal of Mammalogy
MDCBA	Minnesota Deptartment of Conservation Technical Bulletin
MDCRA	Michigan Department of Conservation Game Division Report
NATUA	Nature (England)
NCANA	Naturaliste Canadien, Le
UABPA	Proceedings of the Utah Academy of Sciences, Arts and Letters
UCPZA	University of California Publications in Zoology
WCDBA	Wisconsin Department of Natural Resources Technical Bulletin
WGFBA	Wyoming Game and Fish Commission Bulletin
WLMOA	Wildlife Monographs
WMBAA	Wildlife Management Bulletin
XNFSA	U S National Park Service Fauna of the National Parks of the United States, Fauna Series

THE BIOLOGY AND MANAGEMENT OF WILD RUMINANTS

CHAPTER ONE

PHYSICAL CHARACTERISTICS

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CONTENTS OF CHAPTER ONE

CHAPTER 1. PHYSICAL CHARACTERISTICS

Wild ruminants have many physical characteristics that are important adaptations for survival and production in their natural environments. Weights vary as fat reserves are accumulated and used in relation to seasonal variations in the availability of food resources. Pelage characteristics change as thermal conditions change from season to season. Individuals alter their exposed surface areas and postures as parts of social and thermoregulatory behavioral regimes. The volume of the gastrointestinal tract and the rate of passage of forage through the tract are related to the amount of nutrients required by the animal. These are just a few examples of physical characteristics that affect the relationships between organism and environment.

Physical characteristics are best expressed with internationally defined units of measurements. MASS, WEIGHT, and GROWTH (TOPIC 1) are expressed in kg from the fetus to the mature adult, and are used later in calculations of metabolism, reproductive rates, and other characteristics. GEOMETRY (TOPIC 2) may be described by using several linear measurements, expressed in cm, to calculate such things as vertical profiles and surface areas in different postures. SYSTEMS CHARACTERISTICS (TOPIC 3) are important when considering such things as upper limits to forage volumes that can be ingested, volume of blood in the cardiovascular system, potential mineral reserves in the bones, and many more. These are important when evaluating nutrient balances of animals.

The TOPICS and WORKSHEETS that follow provide information on physical characteristics and also on curve-fitting and statistical techniques. It is desirable to go through each of them in the sequence presented so the proper skills are available when new problems and WORKSHEETS are presented.

TOPIC 1. MASS, WEIGHT, AND GROWTH

The body of an animal is a mass subject to gravitational forces, and the measured force has traditionally been expressed as weight. The live weight of an animal is composed of the animal's metabolically active tissues (muscle, for example), tissues that have ceased metabolic activity (hair, for example), and ingested material that has not yet been digested and absorbed. The live weight of a pregnant female includes not only the weight of the female herself, but also the weight of fetuses and associated reproductive tissues. Weights increase from birth to physical maturity, with a more rapid increase early in life and a less rapid increase as maturity is approached.

Weights of wild ruminants vary seasonally, with highest weights usually observed in the fall after an abundance of forage during the growing season, and fruits and seeds, or mast, have been available. Lowest weights are observed when the balance beween resources required and resources available is most negative. This often occurs in late winter and early spring when dormant forage resources are depleted and new growth is not yet available.

Pregnant females metabolically support their own body tissue, and the increasing mass of fetal tissue plus associated membranes and other tissues in the uterus. Pregnant females may go into negative balances in order to provide nutrients for fetal growth, mobilizing their own body reserves to supplement ingested nutrients. Lowest weights of reproducing females may occur after parturition When the fetus has been expelled and the high requirements for the costly process of milk production must be met. The lactating female may mobilize her own body tissue in order to produce milk for suckling offspring.

It is desirable to express the weight of an individual as a continuous mathematical function over time. Sine functions can be used to represent weight changes through the annual cycle, providing the biological continuity desired when weights are used in the calculation of other biological functions, such as metabolism. Weight is used in many other calculations in this book also; the mathematical expressions of weight should be fully understood before proceeding to later units.

Most weight data for wild ruminants come from one of two sources: one, hunter-killed animals that are weighed at checking stations, or two, captive animals that are weighed for experimental purposes. Live weights may be estimated from field-dressed weights of hunter-killed animals with conversions equations, although there are several sources of error.

Weights of captive animals may be determined more accurately than those of hunter-killed animals, but there are questions about how well the weights of captive animals coincide with those of wild ones since they are on different diets and are living under different conditions. While there are problems associated with the measurement of weights of free-ranging and captive ruminants, weights are very important when evaluating the ecological relationships of a population. Weight data from both hunter-killed and experimental animals may be used judiciously to recognize patterns, however, and first approximations of weight structures of populations determined.

The first time-period used in deriving weight equations for a species is from conception to birth (UNIT 1.1). The second is from birth to weaning (UNIT 1.2), and then, post-weaning weights are used to derive equations for the expression of seasonal variations in weights over successive annual cycles as the animal grows older (UNIT 1.3). One important consideration when expressing weight as a mathematical function over time is that equations used for different time periods in the animal's life must merge. Fetal weights, for examqle, must end at birth weight, neonate growth must begin at the birth weight and continue to a weaning weight, and seasonal variations in growth after weaning must begin at the weaning weight used. If this consideration is not made, then there will be discontinuities between the growth curves from conception through seasonal variations of the adults, and such discontinuities are not biologically reasonable.

The UNITS that follow include descriptions of curve-fitting procedures for deriving equations from conception through physical maturity, with no discontinuities between different stages of growth.

UNIT 1.1: FETAL WEIGHTS AND GROWTH

The general pattern of growth of the ruminant fetus shows a slow of increase in the first 1/4 to 1/3 of the gestation period, a faster rate of increase in the middle of the gestation period, and a rapid rate of increase in the last 1/3 to 1/4 of the gestation period. The basic problem to be solved here is that of representing fetal weights of different species with mathematical expressions. Three kinds of formulas may be used to represent increasing rates over time. They are:

exponential: $FEWK = a\ e^{b(DIGE)}$
logarithmic: $FEWK = a + b \ln (DIGE)$
power: $FEWK = a\ (DIGE)$

where FEWK = fetal weight in kg and DIGE = days into gestation. FEWK are entered as the dependent variable, and DIGE as the independent variable. The best fit of the three curves is then used to express FEWK as a function of DIGE.

The lengths of the gestation periods of the wild ruminants are different; fetuses of different species have different amounts of time to develop from fertilized eggs to full-term fetuses. The aproximate lengths of the gestation periods (LEGP) from the table in TOPIC 3, UNIT 3.4, are:

	LEGP
white-tailed deer; odvi	200
mule deer; odhe	200
elk; ceel	260
moose; alal	245
caribou; rata	220
pronghorn; anam	240
bison; bibi	290
bighorn sheep; ovca	150
Dall sheep; ovda	150
muskox; obmo	270
mountain goat; oram	180

Lengths of the gestation periods are used in comparing growth between species. Mountain goat fetuses, for example, develop from conception to parturition in 0.75 of the time (150/200 = 0.75) required by white-tailed deer. Since both of these species, and all wild ruminants, give birth to well-developed young, fetal growth must be quite proportional throughout the gestation periods; development is relative throughout the length of the gestation period.

The WORKSHEETS illustrate how data on fetal growth can be expressed with equations, how first approximations of equations for fetal growth can be made when only birth weights are available, and how equations can be derived for estimating the fetal growth of all species of wild ruminants.

REFERENCES, UNIT 1.1

FETAL WEIGHTS AND GROWTH

SERIALS

CODEN	vo-nu	bepa	enpa	anim kewo	auth	year
AMNAA	43--3	650	666	odvi*fetal develop, white-taile	armstrong,ra	1950
JOMAA	40--1	108	113	odvi breeding records, captive	haugen,ao	1959
JOMAA	47--2	266	280	odvi endoc glan, seas, sex, age	hoffman,ra; robin	1966
JWMAA	14--3	290	295	odvi breeding records of white-	haugen,ao; davenp	1950
JWMAA	16--3	400	400	odvi late breeding record for w	erickson,ab	1952
JWMAA	22--3	319	321	odvi/determin age of young fawn	haugen,ao; speake	1958
JWMAA	34--2	383	388	odvi*morphol develop, aging, fe	short,c	1970
JWMAA	39--4	684	691	odvi*uterine compositio, growth	robbins,ct; moen,	1975
NAWTA	28---	431	443	odvi*nutrit, growth, fetal, faw	verme,lj	1963

CODEN	vo-nu	bepa	enpa	anim kewo	auth	year
CJZOA	48--1	123	132	odhe*development, fetal period	ommundsen,p; cowa	1970
CJZOA	48--2	275	282	odhe/feed intake, heat producti	nordan,hc; cowan/	1970
JOMAA	36--1	145	145	odhe unusual twin fawns in mule	illige,dj; erling	1955
JOMAA	52--3	628	630	odhe contrib organ tot bod mass	hakonson,te; whi/	1971
JWMAA	23--3	295	304	odhe*embryo, fetal developmentm	hudson,p; browman	1959
JWMAA	28--4	773	784	odhe evaluat, eye lens tec, agi	longhurst,wm	1964
JWMAA	34--2	383	388	odhe morphol developp, aging,fe	short,c	1970

CODEN	vo-nu	bepa	enpa	anim kewo	auth	year
CJZOA	47--6	1418	1419	ceel sexual dimorphism, fetuses	retfalvi,l	1969
JWMAA	23--1	27	34	ceel*breed seas, known-age embr	morrison,ja; tra/	1959
JZOOA	164-2	250	254	ceel weight, newb calves, scotl	mitchell,b	1971

CODEN	vo-nu	bepa	enpa	anim kewo	auth	year
				alal		

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
LBASA	21--6	817	824	rata	reindeer in biomed researc	dieterich,ra; lui	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				bibi			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	46--3	524	525	ovca	fetal measure, milk charac	forrester,dj; sen	1965
JOMAA	58--1	106	106	ovca	brth wt, gest, capt rcky m	blunt,m: dawson,/	1977

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AMNTA	114-1	101	116	ungu/matern repro effort, fetal		robbins,ct; robbi	1979
JPHYA	114--	306	317	mamm	relat fetal wt, concep age	huggett,astg; wid	1951

CHAPTER 1, WORKSHEET 1.1a

Fetal growth of white-tailed deer (odvi)

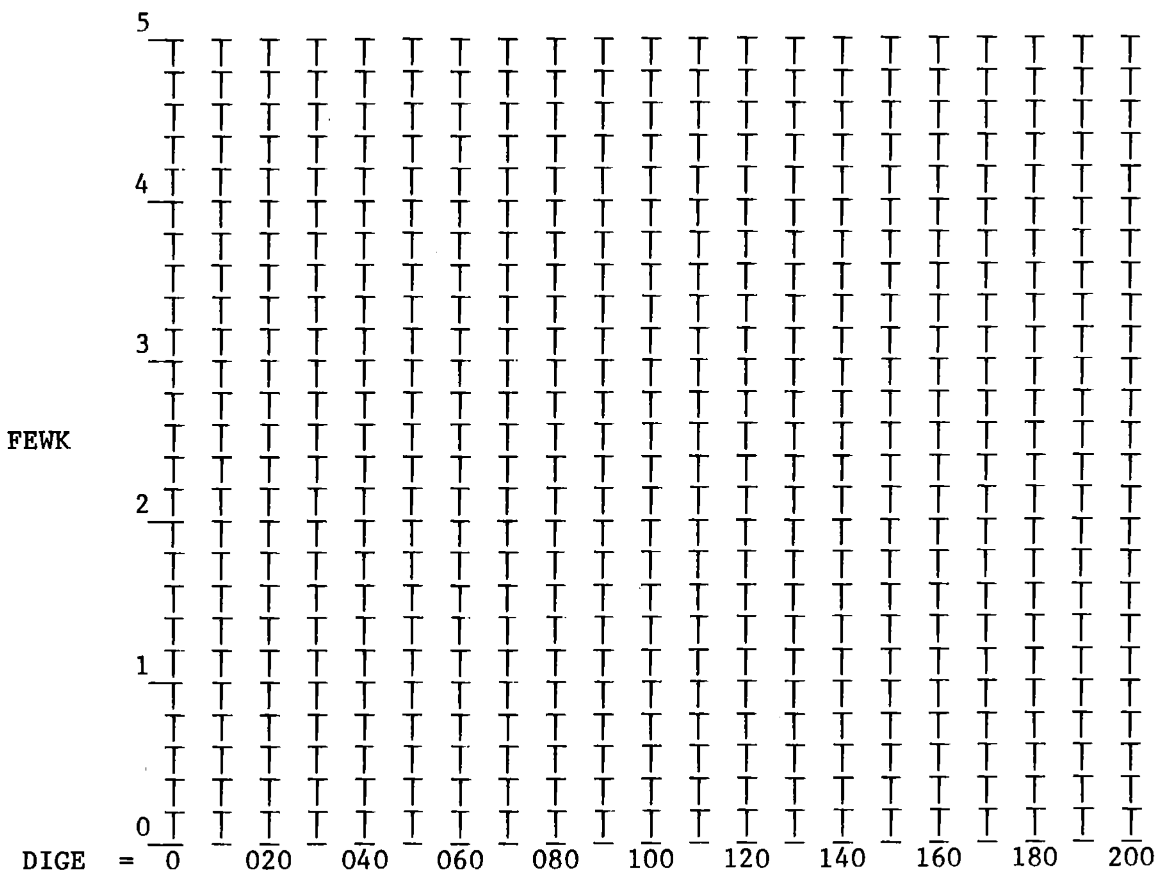
Mean weights of twin fetuses of white-tailed deer in Robbins and Moen (1975) are:

DIGE = 50;	FEWK = 0.019
100	0.289
145	1.240
190	3.580

These data fit an exponential curve with an R^2 of 0.96, a logarithmic curve with an R^2 of 0.69, and a power curve with an R^2 of 1.00, a perfect fit. The equation for a power curve is:

$$FEWK = 4.094 \times 10^{-9} (DIGE)^{3.924}$$

Verify the equation with DIGE = 200 and FEWK = 4.38, and then calculate enough data points to plot the curve from DIGE = 1 to 200.



LITERATURE CITED

Robbins, C. T. and A. N. Moen. 1975. Uterine composition and growth in pregnant white-tailed deer. J. Wildl. Manage. 39(4):684-691.

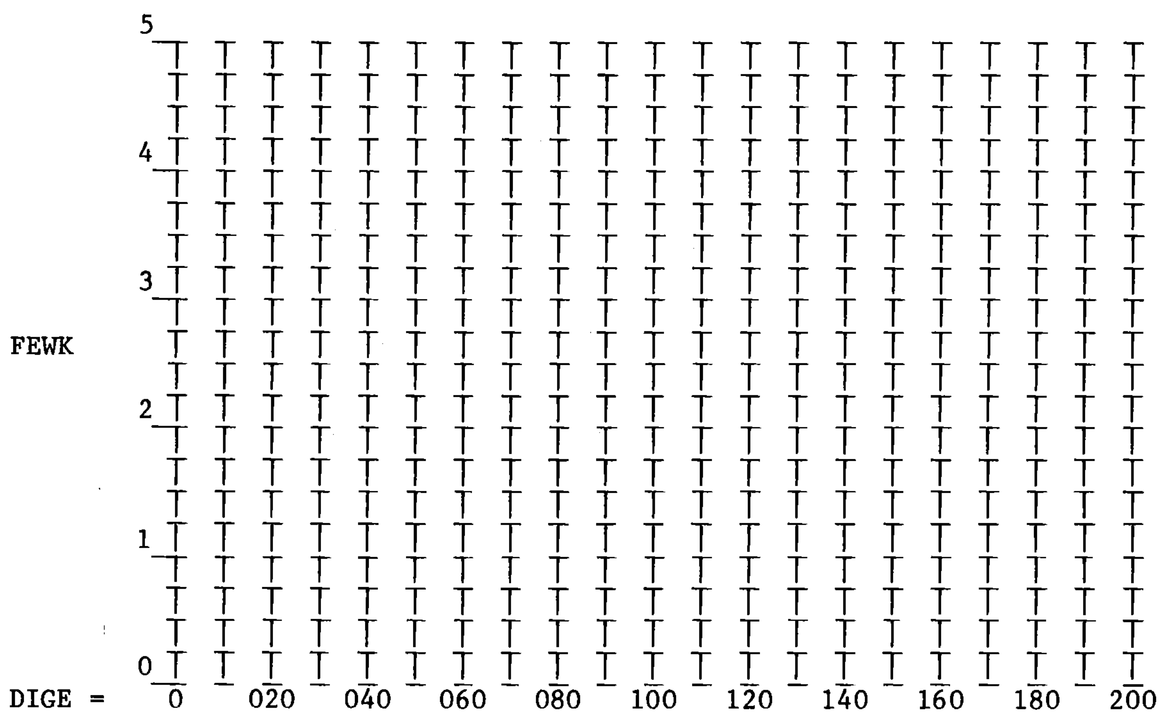
Fetal weights and growth (odvi)

This worksheet illustrates how to calculate fetal weights of white-tailed deer for any weight at birth.

Fetal growth of white-tailed deer may be represented with a power curve. The equation derived from data of Robbins and Moen (1975) resulted in a weight at AGDA = 1 of 4.094×10^{-9}, the value of the coefficient a in the equation for whitetail fawns in the previous WORKSHEET, and at birth (DIGE = 200) of 4.38 kg. Some fawns are lighter and some heavier at birth, however. An array of equations may be easily derived by fitting just two pairs of data--FEWK @ DIGE = 1, and FEWK @ DIGE = 200--to a power curve. Use FEWK = 4.094×10^{-9} (just a fraction of a gram) at DIGE = 1. This is reasonable biologically, and necessary mathematically when using a power curve as the y value in the x, y pair must be different from zero and positive. This data point is then connected to birth weight in kg (BIWK) by curve-fitting procedures. The equations for different fetal weights at birth (FWAB) are:

If BIWK = 2.0, FEWK = 4.094×10^{-9} $DIGE^{3.776}$; @ DIGE = 100: 0.146
If BIWK = 2.5, FEWK = 4.094×10^{-9} $DIGE^{3.818}$; @ DIGE = 100: 0.177
If BIWK = 3.0, FEWK = 4.094×10^{-9} $DIGE^{3.853}$; @ DIGE = 100: 0.208
If BIWK = 3.5, FEWK = 4.094×10^{-9} $DIGE^{3.882}$; @ DIGE = 100: 0.237
If BIWK = 4.0, FEWK = 4.094×10^{-9} $DIGE^{3.907}$; @ DIGE = 100: 0.267
If BIWK = 4.5, FEWK = 4.094×10^{-9} $DIGE^{3.929}$; @ DIGE = 100: 0.295
If BIWK = 5.0, FEWK = 4.094×10^{-9} $DIGE^{3.949}$; @ DIGE = 100: 0.324

Plot FEWK for several DIGE for each FWAB on the graph below:



Fetal weights and growth of all wild ruminant species

The previous WORKSHEET (1.1b) illustrated how fetal weights of white-tailed deer could be calculated for any weight at birth. This WORKSHEET illustrates how fetal weights of any wild ruminant can be calculated for any birth weight. The only assumption is that the fetal weight growth pattern of these different species is similar to that of the white-tailed deer. This is a reasonable assumption; all ruminants exhibit slow fetal growth early in the gestation period and rapid growth late in the gestation period.

The parameters needed to derive an equation for calculating fetal weights of any species at any time during the gestation period are lengths of the gestation period (LEGP), days into gestation (DIGE), and birth weights in kg (BIWK). The values used in curve-fitting b (from WORKSHEET 1.1b) in relation to BIWK ARE:

BIWK	b
2.0	3.776
2.5	3.818
3.0	3.853
3.5	3.882
4.0	3.907
4.5	3.929
5.0	3.949

A logarithm curve fits these data perfectly (R^2 = 1.00); a = 3.6452 and b = 0.1888. The equation is:

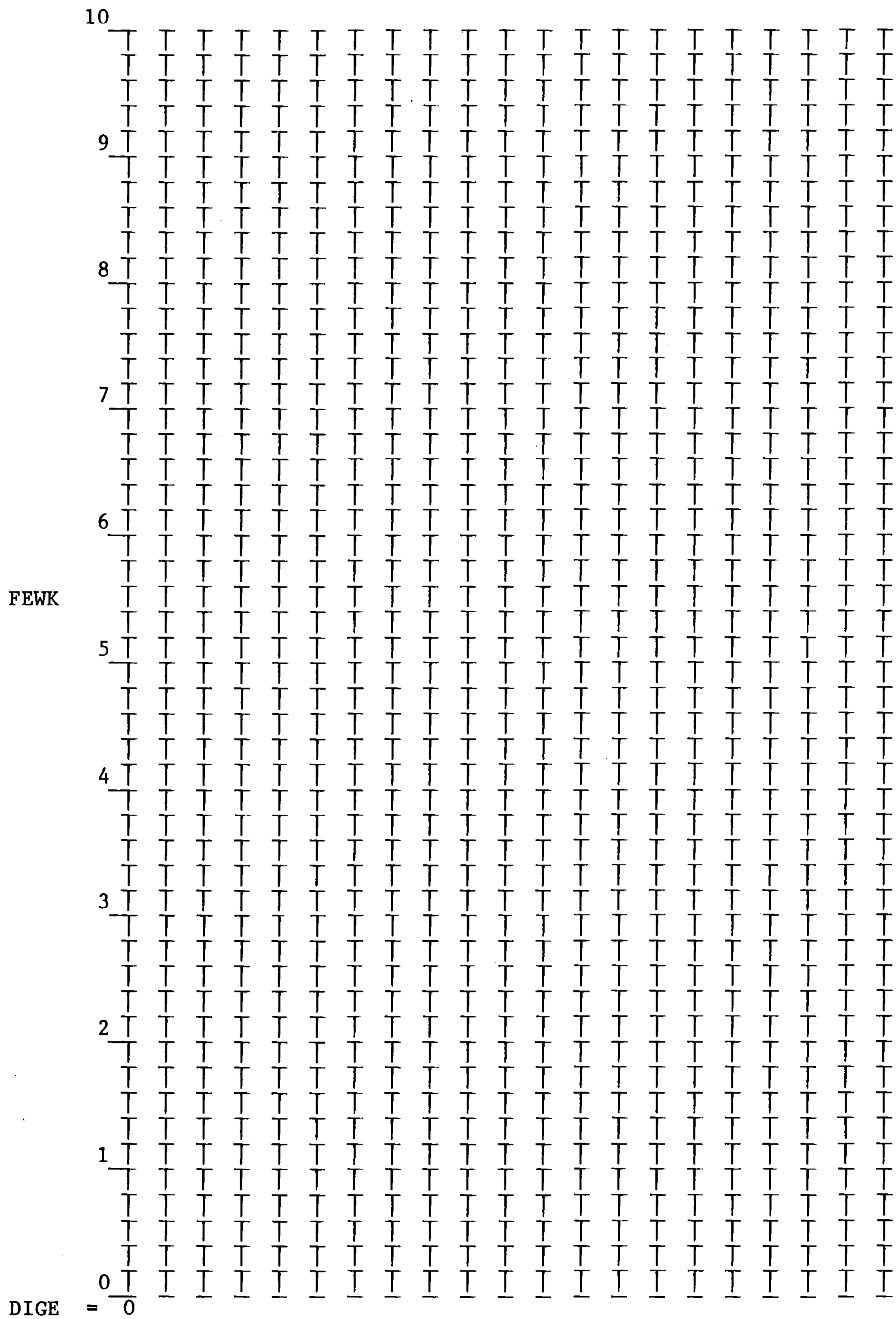
$$b = 3.6452 + \ln 0.1888 \text{ BIWK}$$

Since this is a perfect fit, extrapolation to larger birth weights results in b values that are exactly proportional to those from 2.0 to 5.0 for white-tailed deer. Thus b can be predicted for the birth weight of any wild ruminant as long as its fetal growth is proportional to the fetal growth of white-tailed deer, and the above equation substituted for b in the equation for a power curve given in WORKSHEET 1.1b. The combined overall equation is:

$$\text{FEWK} = 4.094 \times 10^{-9}[(\text{DIGE/LEGP})200]^{(3.6452 + 0.1888 \ln \text{BIWK})}$$

The phrase within the brackets, [(DIGE/LEGP)200], makes the lengths of the gestation periods porportional. For example, if DIGE = 234 and LEGP = 260, the gestation period is 90% complete, which is equivalent to 180 days of gestation (0.90 x 200 = 180) for a deer.

Since BIWK must be stipulated, the calculated FEWK will always be within the appropriate range for any species, and the fetal growth pattern will show the increasing rates characteristic of the last 1/3 to 1/4 of the gestation period which was expressed very well for white-tailed deer with a power curve. Choose a species, label the x-axis (DIGE = 0 - ________ and graph the results on the next page.


10
9
8
7
6
FEWK
5
4
3
2
1
0
DIGE = 0

UNIT 1.2: SUCKLING WEIGHTS AND GROWTH

The weight curve for the suckling animal begins with birth weight (BIWK) and continues through the suckling period to the weaning weight. The growth of suckling ruminants may be expressed with linear, exponential, logarithmic, or power functions. Growth from birth through weaning has been essentially linear for whitetail fawns at the Wildlife Ecology Laboratory; deviations from a constant rate of gain have been small and linear regression equations have been good overall representation of the growth curve. Linear regression is expressed with the formula:

$$CLWK = a + b\ AGDA$$

where CLWK = calculated live weight in kg, a is the intercept, b the slope of the line, and AGDA = age in days.

There are no data describing the growth of the suckling young of some of the wild ruminants. Linear regression equations may be used as first approximations, and can be easily determined by considering birth weight to be the intercept at AGDA = 0, and the slope calculated by subtracting birth weight from weaning weight and dividing that by AGDA at weaning. The quotient is the slope of the line, b. This is explained further and illustrated in the WORKSHEETS.

Whatever mathematical function is used, it is important that suckling weights begin at the birth weights calculated using the equations for fetal growth in the previous UNIT. Further, weaning weights must merge with weights calculated using equations for older animals in the next UNIT. This constraint must be respected or there will be discontinuities in the overall growth curves from birth through physical maturity.

REFERENCES, UNIT 1.2

SUCKLING WEIGHTS AND GROWTH

SERIAL PUBLICATIONS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	40--1	108	113	odvi	breeding records, captive	haugen,ao	1959
JWMAA	14--3	290	295	odvi	breeding records of white-	haugen,ao; davenp	1950
JWMAA	16--3	400	400	odvi	late breeding record for w	erickson, ab	1952
JWMAA	20--3	221	232	odvi	nutri req, growt, antl dev	french,ce; mcewe/	1956
JWMAA	24--4	439	441	odvi	rear, breeding fawns, capt	murphy,da	1960
JWMAA	25--1	66	70	odvi	deer milk, subst for fawns	silver,hs	1961
JWMAA	34--4	887	903	odvi	reprod, grow, residu, diel	murphy,da; korscg	1970
JWMAA	39--2	355	360	odvi*	milk consumpt, weight gain	robbins,ct; moen	1975
JWMAA	41--3	506	510	odvi	growth, var ener, cons pro	holter,jb; hayes	1977
NAWTA	22---	119	132	odvi	nutrient requirements, w-t	mcewen,lc; frenc/	1957
NAWTA	28---	431	443	odvi*	nutrit, growth, fetal fawn	verme,lj	1963

odvi continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
NFGJA	11--1	13	27	odvi	produc, growth, adiron, ny	severinghaus,cw /	1964
VJSCA	27--2	49	49	odvi	age, wt, heart girth relat	russell,md; voge/	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	40--4	593	603	odhe	periodicity of growth, odo	wood,aj; cowan,i/	1962
CJZOA	48--6	1401	1410	odhe*	comparative growth, body w	bandy,pj; cowan,/	1970
GROWA	20--3	179	186	odhe	factor anal, growth, calif	mankins,jv; bake,	1956
JOMAA	52--3	628	630	odhe	contrib organ tot body mas	hakonson,te; whi/	1971
JWMAA	19--3	331	336	odhe*	growth rate of blacktailed	cowan,im; wood,aj	1955
JWMAA	20--2	212	214	odhe	post-natal grow, milk cons	kitts,wd; cowan,/	1956
JWMAA	28--4	773	784	odhe	evaluat, eye lens tec, agi	longhurst,wm	1964
JWMAA	37--3	312	326	odhe/	effect nutr chan on captiv	robinette,wl; ba/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	14-10	141	151	ceel	growth, devel, red deer ca	dzieciolowski,r	1969
JWMAA	9---4	295	319	ceel	roosev elk, olymp penn, wa	schwartz,je; mitc	1945
JWMAA	15--4	396	410	ceel	biology of the elk calf	johnson,de	1951
JWMAA	23--1	27	34	ceel*	breed seas, known-age embr	morrison,ja; tra/	1959
JWMAA	34--2	467	470	ceel	rearing red dee calv, capt	youngson,rw	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	51--2	403	405	alal*	characteric, captive moose	verme,lj	1970
JWMAA	23--2	231	232	alal*	feeding, grow, captiv calf	dodds,dg	1959
JWMAA	26--4	360	365	alal	studies, gravelly mt. mont	peek,jm	1962
VILTA	4---1	1	42	alal	captive hand-reared calves	markgren,g	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	39--7	845	856	rata/	clima, metab, therm, infan	hart,js; heroux/	1961
CJZOA	40--5	863	869	rata*	growth studies, reind fawn	krebs,cj; cowan,i	1962
CJZOA	46--5	1023	1029	rata*	growth, developm, postnata	mcewan,eh	1968
CJZOA	48--2	391	392	rata	energy metab, barren groun	mcewan,eh	1970
CJZOA	49--4	443	447	rata*	measurem milk intake, calv	mcewan,eh; whiteh	1971
CWRSB	38--4	1	71	rata	growth, reprod, ener reser	dauphine,tc,jr	1976
LBASA	21--6	817	824	rata	reindeer in biomed researc	dieterich,ra; lui	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	35--1	76	85	anam	measurem, weights, carcass	mitchell,gj	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CNJNA	38--1	87	90	bibi	doca, hybrid,feedlot study	peters,hf	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	44--1	116	118	ovca	growth, behav, captiv lamb	forrester,dj; hof	1963
JOMAA	46--3	524	525	ovca	fetal measure, milk charac	forrester,dj; sen	1965
JWMAA	29--2	387	391	ovca	growth, develop, des bigho	hansen,cg	1965
JWMAA	34--2	451	455	ovca	weights,growth,west alber	blood,da; flook,/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	90--2	157	162	ovda	weights, growth, yukon ter	bunnell,fl; olsen	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	19--4	417	429	oram	two-year study, crazy moun	lentfer,jw	1955

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AMNTA	114-1	101	116	ungu	neonate growth patt, repro	robbins,ct; robb	1979

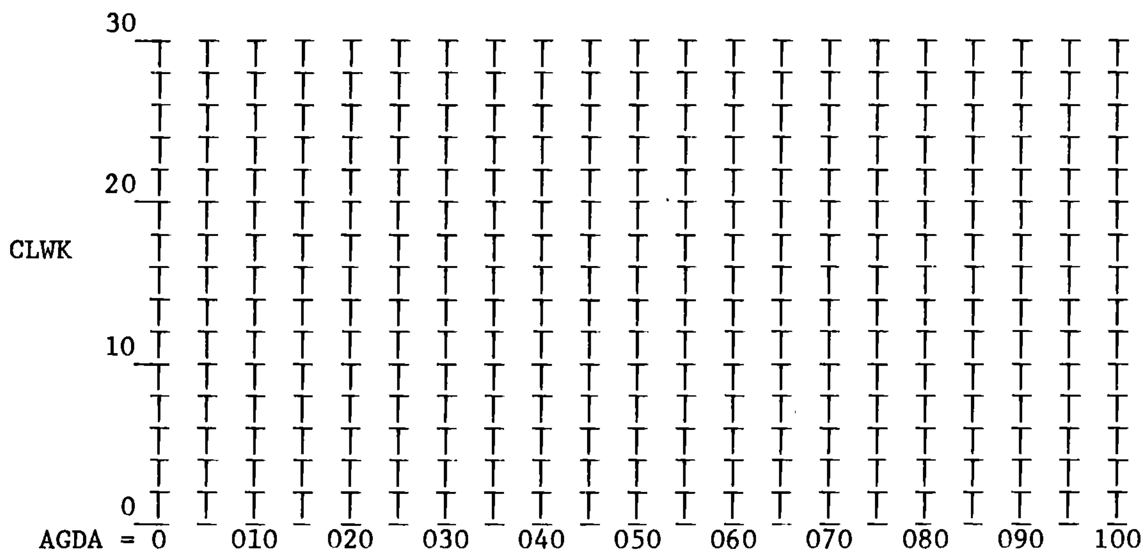
Suckling weights and growth of white-tailed deer (odvi)

Weight gains of three maternal-nursed fawns and two groups of bottle-fed fawns at the Wildlife Ecology Laboratory (Robbins and Moen 1975) were essentially linear over the suckling period. The calculated live weight in kg (CLWK) of the maternal-nursed fawns may be determined with the equation:

$$CLWK = 2.96 + 0.244\ AGDA$$

Birth weight was 2.96 (the intercept a at AGDA = 0), and the daily gain was 0.244 kg (the slope, b, of the regression line) which is 244 grams per day. Seven bottle-fed males gained an average of 250 gms per day, and two females, 247 gms per day, and another group of bottle-fed fawns, 245 gms per day.

Plot the weights using the equation above for a 100-day suckling period. Then substitute 0.250 for the 0.244 given in the equation and plot the weights again. Since the line is straight, you only need to calculate the weight at one AGDA (100 is the best one to choose in this case) and simply draw a straight line between the intercept, 2.96, and CLWK @ AGDA = 100.



LITERATURE CITED

Robbins, C. T. and A. N. Moen. 1975. Milk consumption and weight gain of white-tailed deer. J. Wildl. Manage. 39(2):355-360.

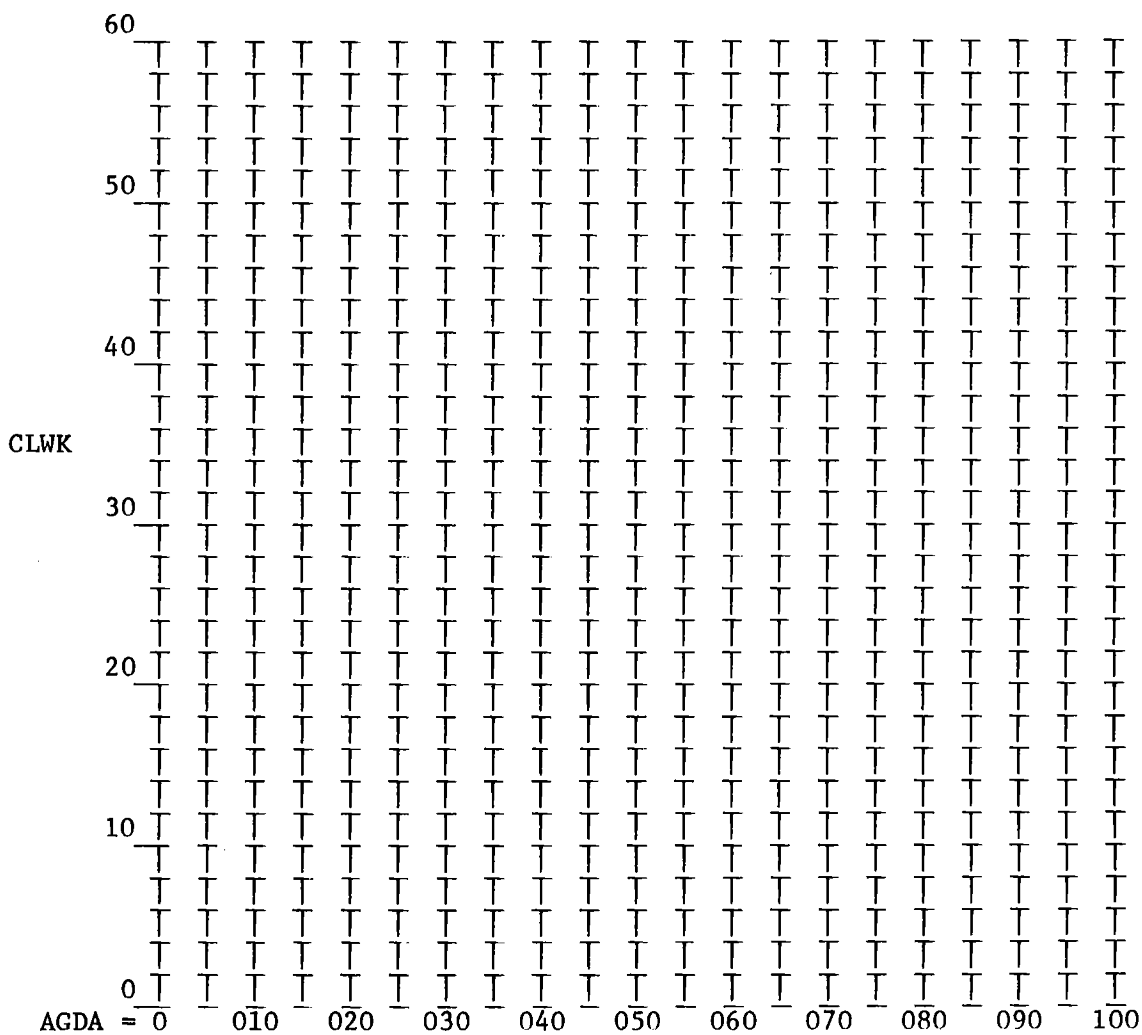
CHAPTER 1, WORKSHEET 1.2b

Linear approximations of suckling weights and growth

A range of fetal weights at birth (FWAB) from 2.5 to 5.0 were given in WORKSHEET 1.1 in the previous UNIT. Rates of gain were described as linear in WORKSHEET 1.2a in this UNIT with daily gains ranging from 244 to 250 gms per day. Suppose a fawn weighed 3 kg at birth and reached 28 kg in 100 days (AGDA = 100). The linear regression expression for that weight curve includes the intercept, a, of 3.0, and the slope, b, which is determined by (28.0 - 3.0)/100 = 0.250. The equation is:

$$CLWK = 3.0 + 0.250\ AGDA$$

Plot this weight curve, and derive additional weight curves for birth weights ranging from 2.5 to 5.0 kg and suckling weights up to 60 kg. The main idea of this exercise is to illustrate how a linear approximation of the growth curve can be made from birth weights and weaning weights. Note that birth weights must equal fetal weights at birth discussed in UNIT 1.1 if discontinuities between equations are to be avoided.



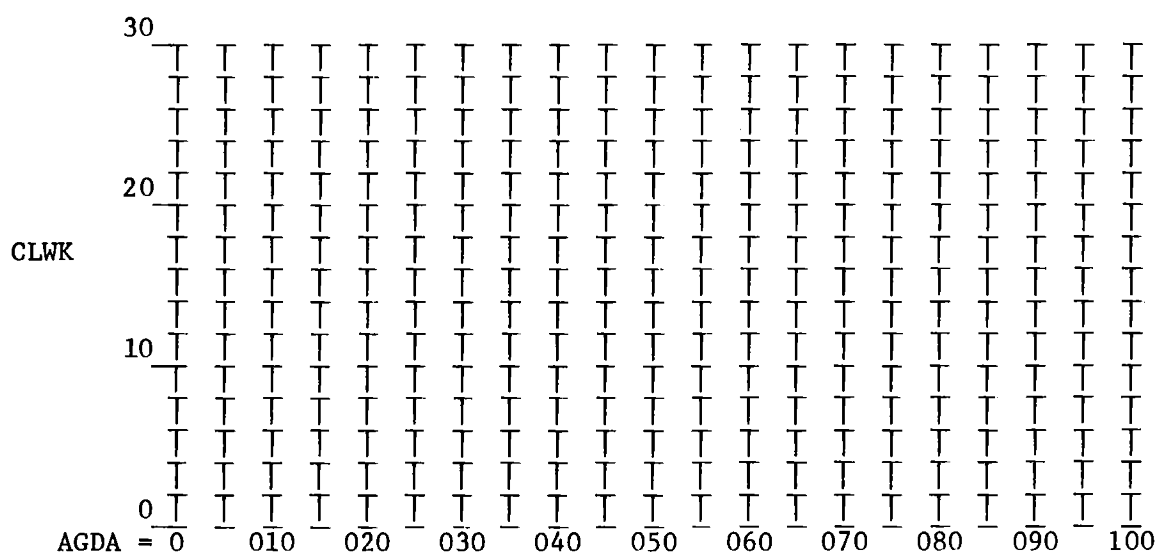
CHAPTER 1, WORKSHEET 1.2c

Suckling weights and growth of different subspecies of mule deer (odhe)

The weight curves of several individuals of different subspecies of *Odocoileus hemionus* were expressed by Wood et al. (1962) with exponential equations. The published equations were for weight in pounds. Converting to kg and substituting AGDA for the symbol "t" given in the original equations, the equations for four individuals, all males, are:

$$CLWK = 3.91\ e^{0.01831\ AGDA};\quad \text{at } AGDA = 100,\ CLWK = 24.40$$
$$CLWK = 3.55\ e^{0.01324\ AGDA};\quad \text{at } AGDA = 100,\ CLWK = 13.34$$
$$CLWK = 4.32\ e^{0.00996\ AGDA};\quad \text{at } AGDA = 100,\ CLWK = 11.70$$
$$CLWK = 3.91\ e^{0.01134\ AGDA};\quad \text{at } AGDA = 100,\ CLWK = 12.15$$

Verify the use of these equations with the CLWK given for AGDA = 100 in the table above, and plot the data points at several values of AGDA from 1 to 100 in the graph below.



LITERATURE CITED

Wood, A. J., I. McT. Cowan, and H. C. Nordan. 1962. Periodicity of growth in ungulates as shown by deer of the genus *Odocoileus*. Can J. Zool. 40(4):593-603.

CHAPTER 1, WORKSHEET 1.2d

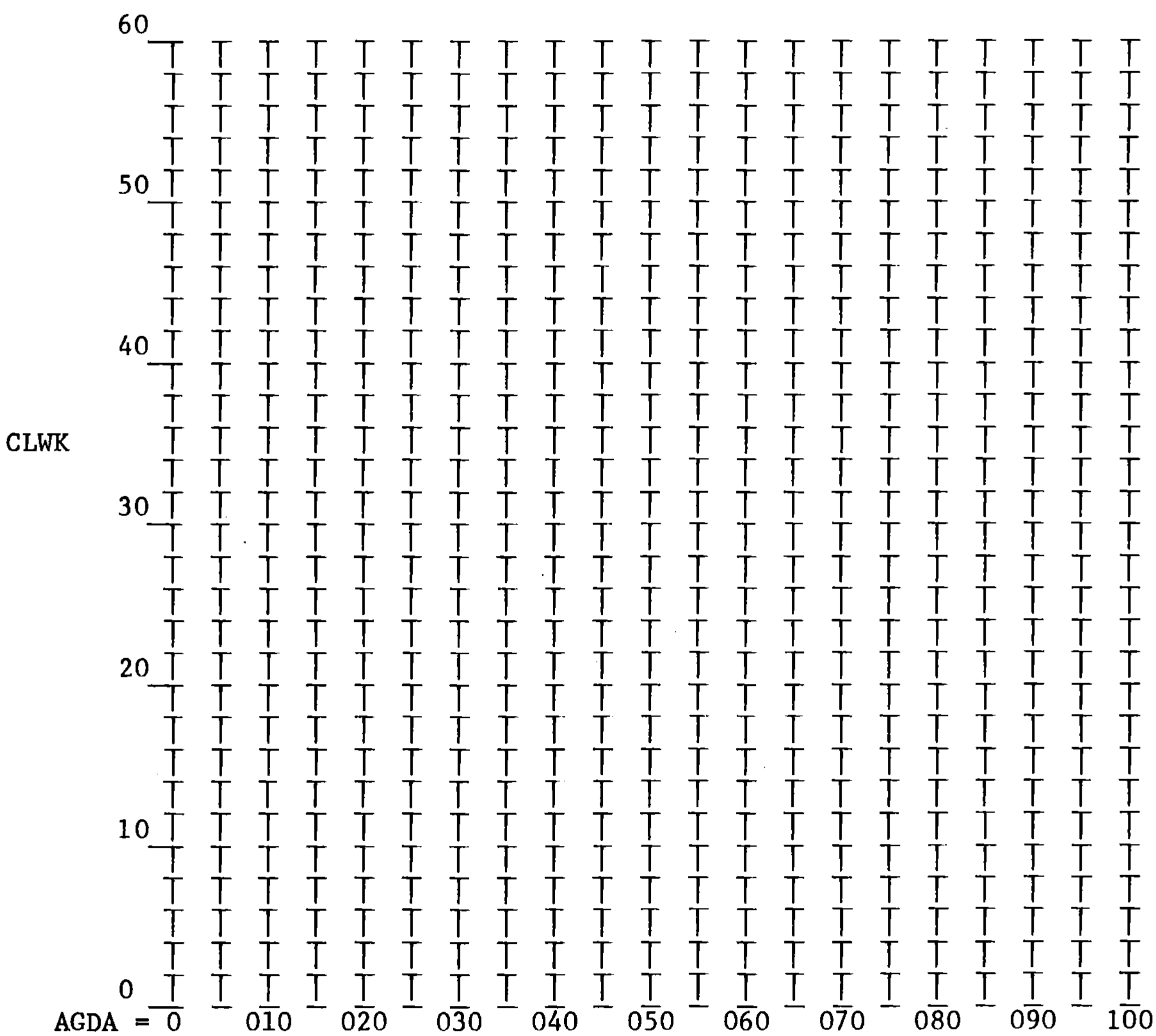
Exponential approximations of suckling weights and growth

Exponential approximations of weight curves for species of any birth weight and weaning weight can be easily derived with a curve-fitting program by entering two pairs of data inputs: birth weight at AGDA = 0 and weaning weight at whatever AGDA weaning occurs.

Suppose birth weights were 4.0 kg, and weaning weights ranged from 15 to 30 kg. The equations determined with this procedure are:

CLWK = 15 at AGDA = 100: $CLWK = 4.0\ e^{0.01322\ AGDA}$
CLWK = 20 at AGDA = 100: $CLWK = 4.0\ e^{0.01609\ AGDA}$
CLWK = 25 at AGDA = 100: $CLWK = 4.0\ e^{0.01833\ AGDA}$
CLWK = 30 at AGDA = 100: $CLWK = 4.0\ e^{0.02015\ AGDA}$

Verify the use of the equations by calculating CLWK when AGDA = 100, and then calculate several data points at selected increments from AGDA 1 to 100 and plot the weight curves. Derive additional equations for species up to 60 kg @ AGDA = 100 also.



UNIT 1.3: ADULT WEIGHTS AND GROWTH

Wild ruminants continue to grow after weaning, reaching physical maturity when they are several years old. The annual rate of growth slows as physical maturity is approached, of course. Seasonal variations are imposed on the annual rate of growth, and are considerably larger than the annual growth increases, in animals two years and older. Two expressions of adult weights and growth--maximum and minimum weights--are described in this UNIT, followed by discussions of seasonal variations in weights and growth in UNIT 1.4.

Maximum weights during each annual cycle, reached in the fall of the year, may be expressed with an equation where maximum weight in kg (MAWK) is the dependent variable Y and the age in days (AGDA) when these maximum weights occur (the independent variable X) each year. The JDAY when MAWK is observed should also be noted for use in determining phase corrections in UNIT 1.4. A tabular format for organizing these inputs for curve-fitting is shown below.

N	AGDA	MAWK	JDAY		LINE	EXPO	LOGN	POWE
1	____	____	____					
2	____	____	____					
.	.	.	.	R^2=	____	____	____	____
.	.	.	.	a =	____	____	____	____
N	____	____	____	b =	____	____	____	____

Field-dressed weights of hunter-killed animals are often the only source of data for estimating maximum live weights. Conversions of field-dressed weights to live weights are described in UNIT 1.5. If live weights need to be estimated from field-dressed weight data, go to UNIT 1.5 for the conversion equations and then come back to this UNIT to derive the live weight equations.

Live weights estimated from field dressed weights of hunter-killed animals may not be maximum, however, since the animals could already be in the weight-decline period when they are removed from the range. Conversions may be made after evaluating the concepts and techniques discussed in UNIT 1.4. For now, use the best estimate of maximum fall weights that you have and begin the curve-fitting procedures.

After tabulating the AGDA when maximum weight (MAWK) is reached and estimating JDAY of maximum weight, determine the R^2, a, and b values for the linear, exponential, logarithmic, and power curves. The equation with the best fit is then selected for the overall equation used in determining seasonal fluctuations in weights discussed in the next UNIT.

An equation expressing the relationship between minimum weights in kg (MIWK; the dependent variable Y), and AGDA (the independent variable X) is determined in the same way as for MAWK. The JDAY when minimum weights occur should also recorded for use in UNIT 1.4. As minimum weights occur after the maximum weights, the animals are older, of course, and this must be considered when tabulating AGDA. The tabular format is illustrated below.

N	AGDA	MAWK	JDAY		LINE	EXPO	LOGN	POWE
1	____	____	____					
2	____	____	____					
.	.	.	.	R^2=	____	____	____	____
.	.	.	.	a =	____	____	____	____
N	____	____	____	b =	____	____	____	____

After tabulating the AGDA when minimum weight (MIWK) is reached and estimating JDAY of minimum weight, determine the R^2, a, and b values for the linear, exponential, logarithmic, and power curves. The equation with the best fit is then selected for the overall equation used in determining seasonal fluctuations in weights discussed in the next UNIT.

The biggest problem in determining the minimum weight equation is the lack of data. Weights of animals that have died in the winter are seldom measured. Animals live-trapped in the winter are seldom weighed, and such weights are not necessarily the minimums possible for recovery from winter stress anyway. Nevertheless, minimum weights can be represented with good approximations by using good judgement and common sense in interpreting available data and deriving the equation.

REFERENCES, UNIT 1.3

ADULT WEIGHTS AND GROWTH

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CPSCA	7---4	217	218	odvi*	organ, body weight relatio	robinson,pf	1966
JOMAA	17--1	67	68	odvi	size, weight adironda deer	schoonmaker,wj	1936
JOMAA	31--1	5	17	odvi*	weight relation, george re	hamerstrom,fn; ca	1950
JWMAA	5---2	182	190	odvi	study, edward plateau, tex	saunders,e	1941
JWMAA	17--2	166	176	odvi	irruption, necedah refuge	martin,fr; krefti	1953
JWMAA	18--4	482	495	odvi	management study, mud lake	hunt,rw; mangus,l	1954
JWMAA	19--3	346	352	odvi	controlled deer hunts,	kruefting,iw; eri	1955
JWMAA	20--3	221	232	odvi	nutri req, growth antl dev	french,ce; mcewan	1956
JWMAA	20--3	286	292	odvi	regional differ, size,pro	gill,j	1956
JWMAA	33--3	482	490	odvi	energy req, winter mainten	ullrey,de; youat/	1969
JWMAA	33--4	1027	1028	odvi	longevi rec, females, mich	ozoga,jj	1969
JWMAA	34--4	887	903	odvi	repro, grow, resid, dieldr	murphy,da; korsch	1970
JWMAA	39--1	48	58	odvi/	morph char, crab orch herd	roseberry,jl; kli	1975
NAWTA	2----	446	457	odvi	weigh, antl meas, pop dens	johnson,fw	1937
NAWTA	3----	261	279	odvi	wt, meas, alleghen nat for	park,bc	1938
NAWTA	22---	119	122	odvi*	nutri requirements of deer	mcewen,rc; french	1957
NAWTA	34---	137	146	odvi	nutri, climate, south deer	short,hl; newsom,	1969
NFGJA	2---2	154	160	odvi	weig as index to range con	severinghaus, cw	1955
NFGJA	2---2	247	247	odvi	fawn weights, regul, antle	severinghaus, cw	1955
NFGJA	11--1	13	27	odvi	growth, adirondacks, new y	severinghus,cw; t	1964
NYCOA	14---	30	31	odvi	big, little deer, food key	severinghaus, cw/	1959
PAABA	600--	1	50	odvi*	nutri req, growt, antl dev	french,ce; mcewa/	1955
PAABA	628--	1	21	odvi*	nutri req, growt, antl dev	magruder,nd; fre/	1957
PCGFA	13---	62	69	odvi	mast abund, weigh, reprod	harlow,rf; tyson,	1959
PIAIA	61---	615	630	odvi	results, iowa's first seas	sanderson,gc; spe	1954
VIWIA	14--3	18	19	odvi	report, 1952 big le refuge	moshby,hs	1952
VIWIA	14-10	18	19+	odvi	highligh, vir 1952 dee stu	richards,ev	1953
VIWIA	16--9	5	7+	odvi	report on glades the deer	davey,sp	1955
WSCBA	4--10	49	51	odvi	wisconsins large dee, 1938	hopkins,r	1939

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	40--4	593	603	odhe*	periodicity of growth, odo	wood,aj; cowan,i/	1962
CJZOA	48--6	1401	1410	odhe	comparat growth in 4 races	bandy,pj; cowan,i	1970
JANSA	36--6	1201	1201	odhe	wt, plasma minrl indx, fem	lesperance,al; h/	1973
JOMAA	45--1	48	53	odhe	comp 3 morph attrib, n mex	anderson,ae; fra/	1964
JOMAA	52--3	628	630	odhe	contrib organ tot body mas	hakonson,te; wh/	1971
JWMAA	15--2	129	157	odhe	in nebraska national fores	mohler,ll; wampo/	1951
JWMAA	17--3	256	267	odhe	operation, check stat, col	rogers,ge	1953
JWMAA	37--3	312	326	odhe/	effect nutr chan on captiv	robinette,wl; b/	1973
NAWTA	22---	179	188	odhe	ovca, feed req, grow, main	cowan,i mct; wood	1957
PMASA	19---	72	79	odhe	ann cycl of condit, montan	taber,rd; white,k	1959

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	11--5	129	194	ceel	morph varia, skul, bod wei	mystkowska,et	1966
ATRLA	14-10	141	151	ceel	growth, dev, calves, capti	dzieciolowski,r	1969
ATRLA	15---	253	268	ceel	relat age and size, poland	dzieciolowski,r	1970
BUFOA	9--97	75	82	ceel	size, recent, prehistoric	walvius,mr	1961
BVJOA	133--	215	218	ceel	dada observ, weighing, dee	dansie,o	1977
JWMAA	15--1	57	62	ceel	weights, measurem, rock mt	quimby,dc; johnso	1951
JWMAA	24--1	15	21	ceel	on afognak island, alaska	troyer,wa	1960
JWMAA	30--1	135	140	ceel*	measurements, weight relat	blood,da; lovaas	1966
NAWTA	29---	237	248	ceel	winter weights, yellowston	greer,kr; howe,re	1964
POASA	47---	406	413	ceel	size, weight, wichita moun	halloran,af	1968
UAABB		80	82	ceel	wt dynam, free ranging elk	gates,cc; hudson,	1979
ZEJAA	1---1	92	98	ceel	[weights, red deer,germny]	ueckermann,e	1955
ZEJAA	2---1	13	20	ceel	[pop densit, wt, antl dev]	caesar,h	1956
ZEJAA	3---4	145	153	ceel	[reprod rates, body weigh]	kroning,f; vorrey	1957
ZOGAA	33---	85	105	ceel	[bod gro, siz eur red dee]	stubbe,c	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	81---	263	269	alal	weight, measurements, albe	blood,da; mcgill/	1967
JOMAA	27--1	90	91	alal	weigh of a minnesota moose	breckinridge,wj	1946
JOMAA	50--2	302	310	alal*odvi,	structur adapt, snow	kelsall,jp	1969
JOMAA	51--2	403	405	alal*charact	of captive, michig	verme,lg	1970
JOMAA	51--4	808	808	alal	weights and measurements o	doutt,jk	1970
JZAMD	6---4	10	12	alal	winch/tripod device, weigh	arneson,pd; franz	1975
VILTA	2---7	409	417	alal	puber, dentit, weigh, swed	markgren,g	1964

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJVRA	3---8	308	311	rata	fattening, sex, increase	hadwen,s	1942
BJNUA	29--2	245	259	rata	seas variation, gluc metab	luick,jr; perso/	1973
CJZOA	44--3	401	411	rata	growth, developmen, bar gr	mcewan,eh; wood,a	1966
CJZOA	46--5	1023	1029	rata*growth,	developm, post-nat	mcewan,eh	1968
CJZOA	48--5	905	913	rata	seas chan, energ, nitr int	mcewan,eh; white/	1970
CWRSB	38---	1	71	rata	kaminuriak barr gr, growth	dauphine,tc	1976
JWMAA	32--2	350	367	rata	introduct, increase, crash	klein,dr	1968
JWMAA	36--2	612	619	rata	growth, domest, wild, norw	reimers,e	1972
NJZOA	24--4	407	417	rata*morph,	fat stor, org weigh	krog,j; wika,m; /	1976
TNWSD	28---	91	108	rata	phys variab, condit, bgcar	dauphine,tc,jr	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	16--3	387	389	anam	measurements, hart mt ante	mason,e	1952
JWMAA	34--2	470	472	anam	derivation, whole weights	o'gara,bw	1970
JWMAA	35--1	76	85	anam	measurem, weights, carcass	mitchell,gj	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	45--4	630	632	bibi	data on bison bison athaba	bayrock,la; hille	1964
POASA	41---	212	218	bibi	weight, meas, wichita moun	halloran,af	1961

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	24--1	1	11	ovca	life hist, rocky mt, color	spencer,cc	1943
JOMAA	44--1	116	118	ovca	growth, behav, captiv lamb	forester,dj; hoff	1963
JOMAA	52--1	242	243	ovca	influence lambing on weigh	woolf,a	1971
JWMAA	22--4	444	445	ovca	some weights and measureme	aldous,mc; craig/	1958
JWMAA	34--2	451	455	ovca	weigh growth, west alberta	blood,da; flook,/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	90--2	157	162	ovda/wt,	grow, kluane pk, yukon	bunnell,fl; olsen	1976
JOMAA	22--4	448	449	ovda	the weights of dall's shee	ulmer,fa	1941

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	12--3	292	297	obmo	experim in re-estab, alask	bell,wb	1931
JOMAA	35--3	456	456	obmo	muskox longevity	buckley,jl; spen/	1954

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	36--1	64	79	caca	fact aff growth, body size	klein,dr; strandg	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BICOB	2---1	55	62	dada	observa, biology, england	chapman,di; chapm	1969
JZOOA	157-1	125	132	dada	teeth, wt, antlr, male age	chaplin,re; white	1969

CHAPTER 1, WORKSHEET 1.3a

Weights and growth of adult white-tailed deer (odvi)

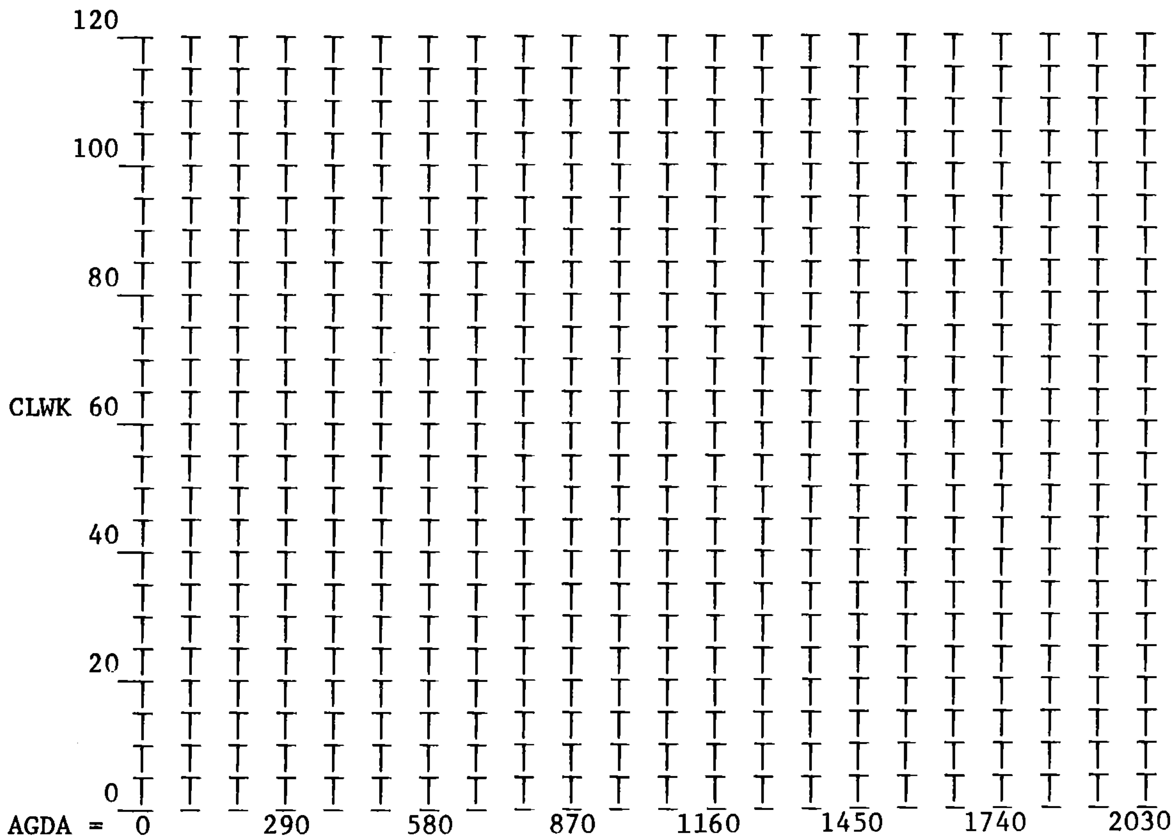
Maximum and minimum weight curves have been determined for white-tailed deer from three areas of New York State. For males, the power curve provided the best fit, and the equations for maximum weight in kg (MAWK) and minimum weight in kg (MIWK) are:

Central Adirondacks: $MAWK = 3.13\ AGDA^{0.45958}$
$MIWK = 0.99\ AGDA^{0.55035}$

Central and Southern Tier: $MAWK = 6.24\ AGDA^{0.38906}$
$MIWK = 2.23\ AGDA^{0.47800}$

Central Catskills: $MAWK = 3.36\ AGDA^{0.45233}$
$MIWK = 0.79\ AGDA^{0.58830}$

Plot the curves for males, comparing the weights between these three areas, below.



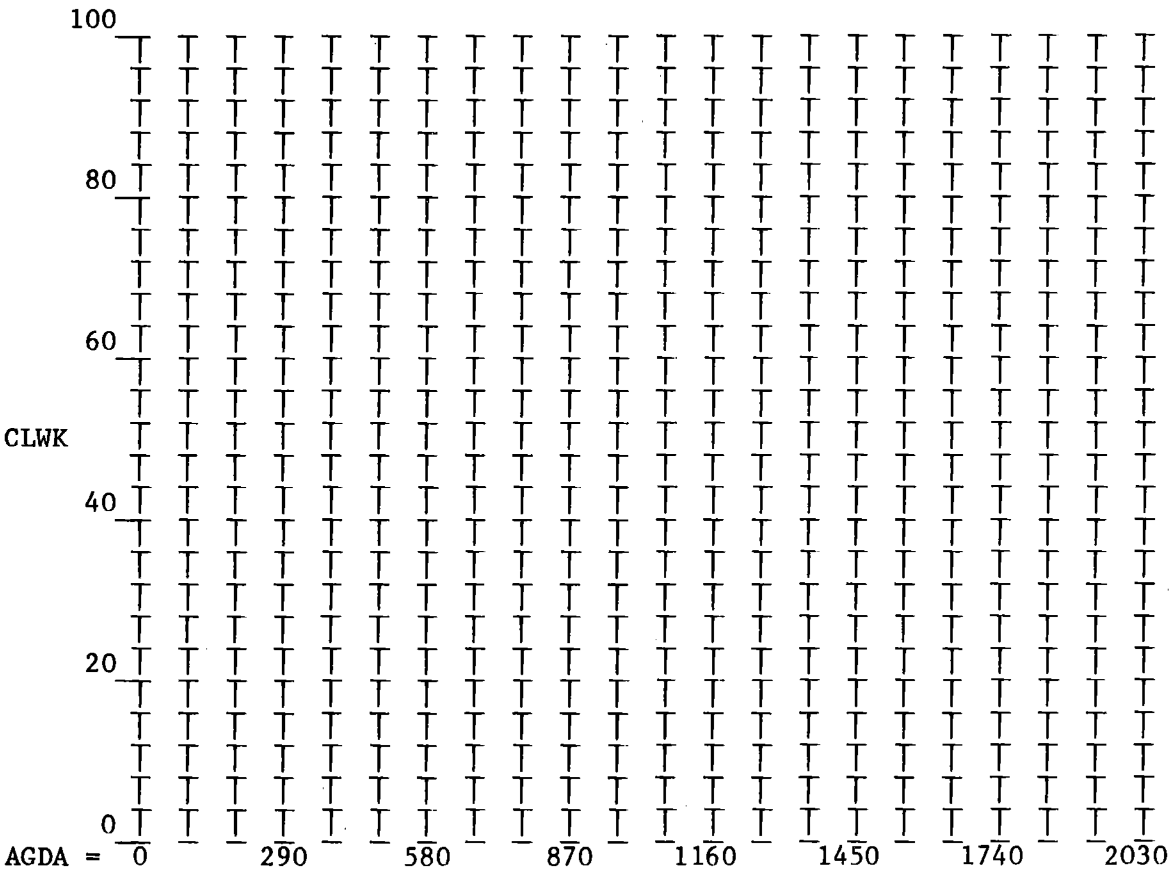
LITERATURE CITED

Moen, A. N. and C. W. Severinghaus. 1981 [In press.] Annual cycle weight equations and survival of white-tailed deer. N.Y. Fish and Game Journal.

For females, logarithmic curves provided the best fit, and the equations for MAWK and MIWK are:

Central Adirondacks:	$MAWK = 10.97253 \ln AGDA - 23.40$
	$MIWK = 9.23499 \ln AGDA - 28.85$
Central and Southern Tier:	$MAWK = 12.80383 \ln AGDA - 24.23$
	$MIWK = 11.75924 \ln AGDA - 33.88$
Central Catskills:	$MAWK = 13.35857 \ln AGDA - 38.05$
	$MIWK = 12.25631 \ln AGDA - 47.66$

Plot the curves for females, comparing the weights between these three areas below.

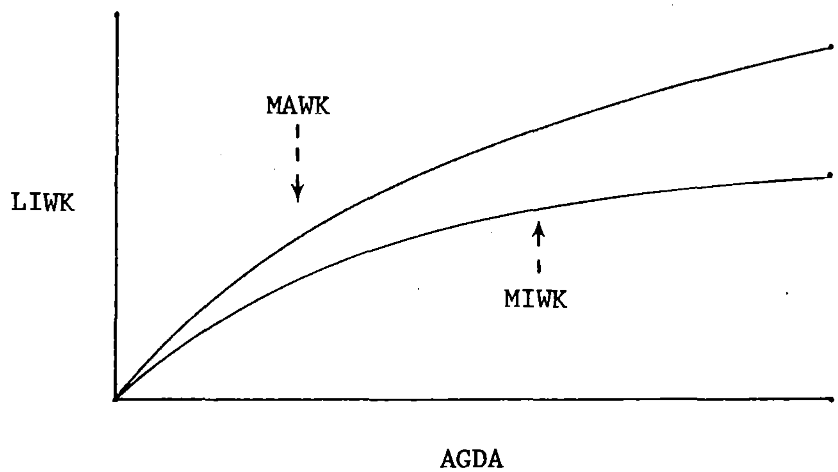


LITERATURE CITED

Moen, A. N. and C. W. Severinghaus. 1981 [In press.] Annual cycle weight equations and survival of white-tailed deer. N.Y. Fish and Game Journal.

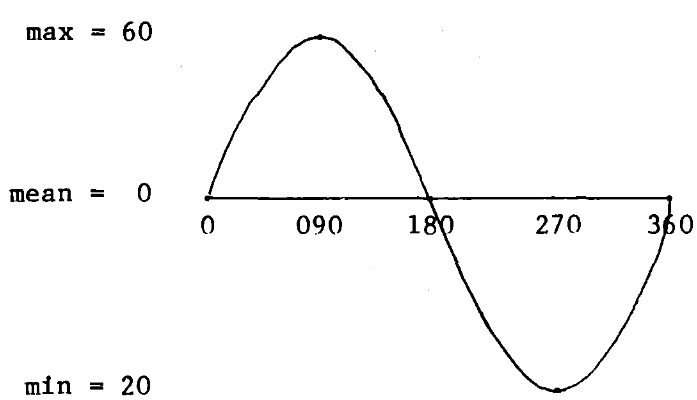
UNIT 1.4: SEASONAL VARIATIONS IN WEIGHTS

Seasonal variations in weights arm characteristic of wild ruminants on ranges with seasonal variations in the quality and quantity of forage. Maximum weights are usually reached near the end of the growing season, and minimum weights in late winter, early spring, or summer, depending on weather, snow conditions, and reproductive demands. An equation for determining calculated live weight in kg (CLWK) permits one to express weight fluctuations between these maxima and minima as indicated below.



Seasonal variations are calculated by combining the maximum weight curve, minimum weight curve, and sine functions into a single continuous equation. The sine functions smooth the change from increasing to decreasing and decreasing to increasing weights as maximums and minimums are reached.

An understanding of the basic form of a sine wave is necessary before calculating sinusoidal variations in animal weights from season to season. The sine wave shown below is labeled in degrees on the horizontal axis, beginning with 0 and ending with 360, which is one complete sine wave.



Using your hand calculator with trig functions, determine the sine of 0, 90, 180, 270, and 360. They are:

$$\sin 0 = \_\_\_$$
$$\sin 90 = \_\_\_$$
$$\sin 180 = \_\_\_$$
$$\sin 270 = \_\_\_$$
$$\sin 360 = \_\_\_$$

Note that the amplitude of the sine wave varies 20 units above and below the mean value of 40, which can be expressed as:

$$40 \pm 20, \text{ range} = 20 \text{ to } 60$$

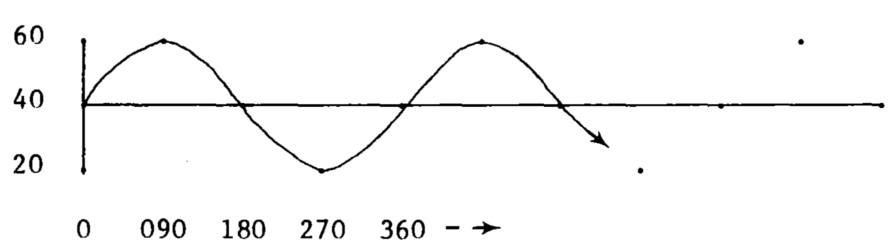
The value of Y at any point along this sine wave can be determined with a simple formula:

$$Y = 40 + \sin X\ [(\text{maximum} - \text{minimum})/2].$$

Substituting numerical values for X, the equations are:

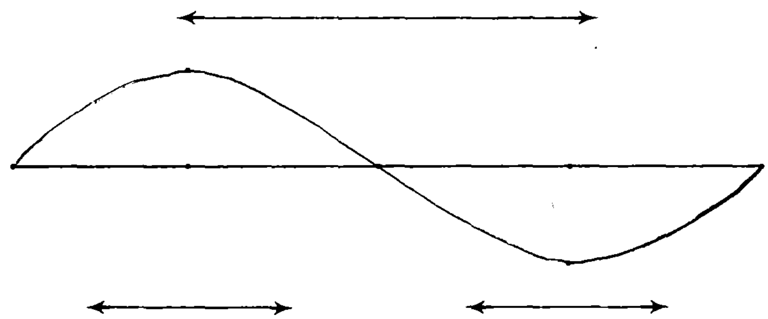
$$\text{If } X = 0{:}\ Y = 40 + \sin 0\ [(60 - 20)/2] = 40 + 0(20) = 40$$
$$\text{If } X = 90{:}\ Y = 40 + \sin 90\ [(60 - 20)/2] = 40 + +1(20) = 60$$
$$\text{If } X = 180{:}\ Y = 40 + \sin 180\ [(60 - 20)/2] = 40 + 0(20) = 40$$
$$\text{If } X = 270{:}\ Y = 40 + \sin 270\ [(60 - 20)/2] = 40 + -1(20) = 20$$
$$\text{If } X = 360{:}\ Y = 40 + \sin 360\ [(60 - 20)/2] = 40 + 0(20) = 40$$

This basic relationship is used to calculate weights of animals exhibiting one maximum and one minimum weight through one annual cycle. The X axis is the days in the year, where each day is 360/365 = 0.9863, and the Y axis is weight. The range in weights is determined by subtracting the calculated minimum weight for a given date from the calculated maximum weight on that date, using equations derived for maximum and minimum weights. This is comparable to the (60 - 20) component of the equation above. The deviation from the mean is determined by dividing this range by 2. The deviation from the mean is multiplied by the sine function (sign considered), and added to the mean value (40 in the equations above). The relationships are illustrated for three annual cycles below.



The time of occurrence of the maximum and minimum weights throughout the year is an important consideration when deriving the overall equation. Maximum weights may not fall on 90 (when sine = +1.0) and minimum weights may not fall on 270 (when sine = -1.0), and they may not be exactly six months apart. Phase corrections are used to represent the time of occurrence of maximum and minimum weights. These involve shifting of the entire sine wave (primary phase correction) and of the maximum and minimum deviations (secondary phase corrections) as illustrated below.

Primary Phase Correction



Secondary
Phase
Corrections

The steps used to make the necessary phase corrections for adjusting the sine components of the weight equation so weights reach maximums and minimums at the appropriate times of the year are shown below.

Step 1. Determine the number of days from maximum to minimum weight: ______

Step 2. Subtract 182.5 from the answer in Step 1: ______

Step 3. Divide the difference in Step 2 by 2 to get the secondary phase correction, SEPC: SEPC = ______

Step 4. Add (sign considered) the quotient in Step 3 to JDAY for maximum weight to get adjusted JDAY for maximum weight:

adj. JDAY = ______

Step 5. Determine the primary phase correction by:

sin[(adj. JDAY for MAWK)(0.9863) + PRPC] = 1.0

Since sin 90 = 1.0,

[(adj. JDAY)(0.9863) + PRPC = 90

90 - (__________)(0.9863) = PRPC PRPC = ______

Primary and secondary phase corrections determined in this way result in sine values that are within 2% when the JDAYs of maximum and minimum weights are greater than 126.5 and less than 238.5 days apart (See Step 1).

The overall formula for calculating live weights through successive annual cycles consists of three parts. They are: one, the average weight, which is the sum of the maximum and minimum divided by 2; two, the sine expressions with both primary and secondary phase corrections; and three, the deviation from the average weight, determined by dividing the difference between maximum and minimum weights by 2. The formula is shown, with parts labeled (the middle line is the sine expression), below.

$$\mathrm{CLWK} = \overbrace{[\mathrm{MAWK} + \mathrm{MIWK}]/2}^{\text{Average weight}} + \sin\left\{(\mathrm{JDAY})(0.9863) + \left[\left(\sin\{[(\mathrm{JDAY})(0.9863) + \mathrm{PRPC}] + (\mathrm{SEPC})\}\,\mathrm{SEPC}\right) + \mathrm{PRPC}\right]\right\} \underbrace{[\mathrm{MAWK} - \mathrm{MIWK}]/2}_{\text{Deviation from average weight}}$$

Note that there are no biological constants in the formula. Maximum weight equations, minimum weight equations, and phase corrections are all determined from observed data; the formula may be used for any population for whom data are available.

There is one further consideration to be made when calculating the weights of reproducing females. The weight of the pregnant female may be divided into two compartments: maternal tissue, and fetal plus associated reproductive tissues. An immediate weight loss occurs at parturition as fetuses, fluids, and other tissues are expelled; their weight is subtracted from the total live weight at that time. After parturition, maternal weights may remain low during the first part of the lactation period due to the high cost of milk production. As milk production decreases in the last two-thirds of the lactation period, weight gains begin to occur, and the animals reach maximum weights in the fall again. This consideration will be discussed again in later analyses.

The three main components of the overall weight equation are illustrated in the WORKSHEETS that follow, with several examples to provide practice in deriving equations for seasonal variations in weights over successive annual cycles.

REFERENCES, UNIT 1.4

SEASONAL VARIATIONS IN WEIGHTS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CPSCA	7---4	217	218	odvi	organ/body wt rel, marylnd	robinson,pf	1966
JOMAA	41--1	23	29	odvi	response bucks, artif ligh	french,ce; mcewe/	1960
JOMAA	47--2	267	280	odvi*	seas chang, sex, age, glan	hoffman,ra; robin	1966
JWMAA	18--4	482	495	odvi	deer management study: mud	hunt,rw; mangus,l	1954
JWMAA	20--3	221	232	odvi	nutri req, growth antl dev	french,ce; mcewan	1956
JWMAA	33--3	482	490	odvi	energy req, winter mainten	ullrey,de; youat/	1969
NAWTA	22---	119	122	odvi*	nutri requirements of deer	mcewen,rc; french	1957
NAWTA	34---	137	146	odvi	nutri, climate, south deer	short,hl; newsom,	1969
PAABA	PR209	1	11	odvi	feed, season, antler devel	long,ta; cowan,r/	1959
PAABA	600-1		50	odvi	nutr req, growth, antl dev	french,ce; mcewa/	1955
PAABA	628-1		21	odvi	nutr req, growth, antl dev	magruder,nd; fre/	1957
PIAIA	61---	615	630	odvi	resul, 1st recent iowa sea	sanderson,gc; spe	1954
PCGFA	21---	24	32	odvi	seas wt gain, food consump	fowler,jf; newso/	1967

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	31--1	3	11	odhe	conditio, sequoia nat park	dixon,js; herman,	1945
CJZOA	40--4	593	603	odhe*	periodicity of growth, odo	wood,aj; cowan,i/	1962
PMASA	19---	72	79	odhe	ann cycl of condit, montan	taber,rd; white,k	1959
SZSLA	21---	89	96	odhe	nutrit req, growth, captiv	nordan, hc, cowa/	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
NAWTA	29---	237	248	ceel	winter weights, yellowston	greer,kr; howe,r	1964
POASA	47---	406	413	ceel	size, wt, wichita mt, okla	halloran,af	1968
ZEJAA	1---1	92	98	ceel	[weights, red de,germany]	ueckermann,e	1955

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	56--2	298	306	alal*	weights, measureme, alaska	franzmann,aw; le/	1978

alal continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	51--2	403	405	alal*	charact of captive, michig	verme,lg	1970
JZAMD	6---4	10	12	alal	winch/tripod, weighi moose	arneson,pd; franz	1975
VILTA	2----	409	416	alal	pubert, dentit, wt, sweden	markgren,g	1964

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJVRA	3---8	308	311	rata	fattening, sex, increase	hadwen,s	1942
BJNUA	29--2	245	259	rata	seas variatio, gluc metabo	luick,jrs; perso/	1973
CJZOA	46--5	1023	1029	rata*	growth, developm, post-nat	mcewan,eh	1968
CJZOA	50--1	107	116	rata*	seas chang, body h20, flui	cameron,rd; luick	1972
CWRSB	38---	1	71	rata*	growth, reprod, ener reser	dauphine,tc jr	1976
JWMAA	36--2	612	619	rata	growth, domest, wild, norw	reimers,e	1972
PASCC	22---	12	12	rata	wint grow patt,female calv	luick,jr;white;re	1971
TNWSD	28---	91	108	rata	phys variab, condit, bar g	dauphine,tc,jr	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	34--2	470	472	anam	derivation, whole weights	o'gara,bw	1970
JWMAA	35--1	76	85	anam	measurem, weights, carcass	mitchell,gj	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	34--2	451	455	ovca	weigh growth, bigh, albert	blood,da; flook,/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CHAPTER 1, WORKSHEET 1.4a

Primary and secondary phase corrections

Primary and secondary phase corrections are determined with the five steps listed below.

Step 1. Determine the number of days from maximum to minimum weight: ______

Step 2. Subtract 182.5 from the answer in Step 1: ______

Step 3. Divide the difference in Step 2 by 2 to get the secondary phase correction, SEPC: SEPC = ______

Step 4. Add (sign considered) the quotient in Step 3 to JDAY for maximum weight to get adjusted JDAY for maximum weight: adj. JDAY = ______

Step 5. Determine the primary phase correction by:

sin[(adj. JDAY for MAWK)(0.9863) + PRPC] = 1.0

Since sin 90 = 1.0,

[(adj. JDAY)(0.9863) + PRPC = 90

90 - (__________)(0.9863) = PRPC PRPC = ______

Using the JDAYs of MAWK and MIWK given below, determine the primary and secondary phase correctins, verifying the use of the five steps.

Sex	Region	JDAY MAWK	JDAY MIWK*	PRPC	SEPC
M	Central Adirondacks	301	106	-200.71	-6.25
F		301	121	-208.71	+1.25
M	Central and Southern Tier	301	106	-200.71	-6.25
F		331	106	-215.51	-21.25
M	Central Catskills	301	106	-200.71	-6.25
F		316	106	-208.11	-13.75

*Early spring minimum; further reductions occur at parturition.

These phase corrections, from Moen and Severinghaus (1981), are combined with the MAWK and MIWK equations from WORKSHEET 1.3a to derive the overall weight equation discussed in the next WORKSHEET, 1.4b.

LITERATURE CITED

Moen, A. N. and C. W. Severinghaus. 1981. Annual cycle weight equations and survival of white-tailed deer. N. Y. Fish and Game Journal. [In press].

Annual cycle weight equations for white-tailed deer (odvi)

The equations for MAWK and MIWK from WORKSHEET 1.3a and the PRPC and SEPC from WORKSHEET 1.4a may now be combined in the overall formula for calculating weights during the annual cycle below.

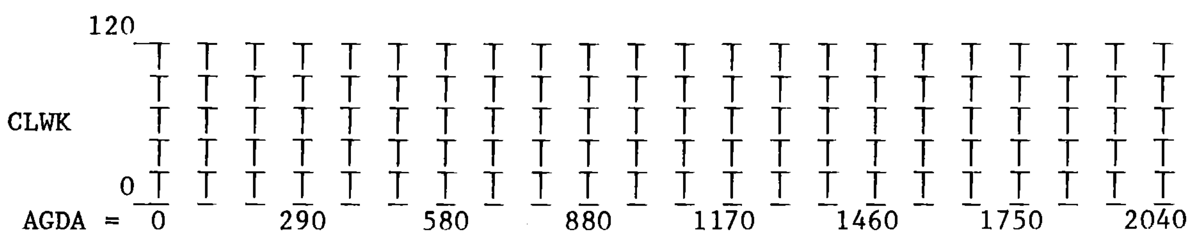
$$CLWK = \overbrace{[MAWK + MIWK]/2}^{\text{Average weight}} + \sin\Big\{(JDAY)(0.9863) + \Big[\Big(\sin\{[(JDAY)(0.9863) + PRPC] + (SEPC)\}SEPC\Big) + PRPC\Big]\Big\} \underbrace{[MAWK - MIWK]/2}_{\text{Deviation from average weight}}$$

Calculate the weights and plot the curves for successive annual cycles. Begin with birth on JDAY 151, so an animal reaches AGDA = 105 on JDAY 256, and increment with 15-day intervals as in the JDAY: AGDA pattern below.

JDAY	AGDA	JDAY	AGDA	JDAY	AGDA	JDAY	AGDA
256	105	301	150	346	195	31	245
271	120	316	165	361	210	.	.
286	135	331	180	16	230*	.	.
						Continue to maturity	

*Note that five extra days are added to AGDA at the end of the year, resulting in the next JDAY being 16. Fifteen-day intervals could be used throughout, resulting in different JDAYs through each annual cycle. The above format is simpler, requiring one adjustment at the end of the year.

The use of 15-day increments results in very smooth weight curves over several annual cycles. Write out the overall equations for male and female deer by substituting the equations for MAWK, MIWK, PRPC, AND SEPC and begin the calculations. Results will be obtained quickly if programmed computing is used. Plot the data on a full-size sheet of graph paper for five successive annual cycles. The labels are shown below.



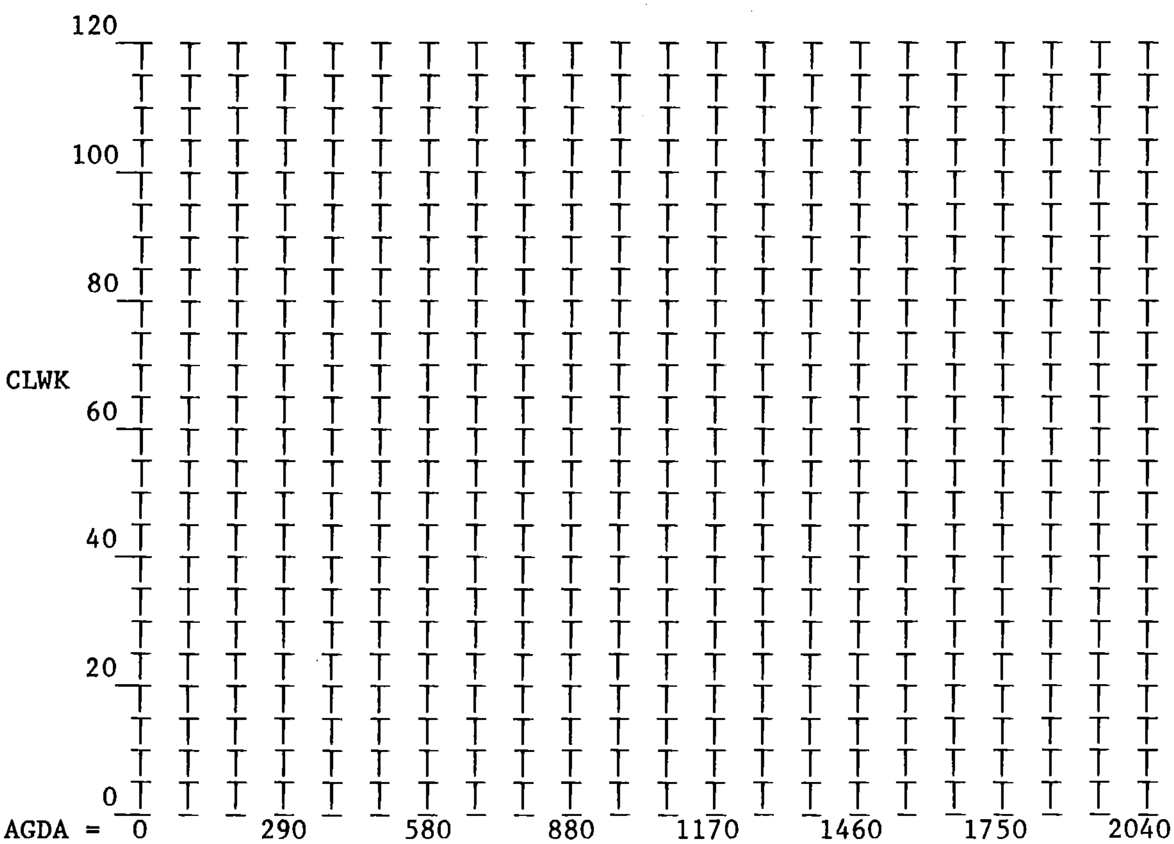
LITERATURE CITED

Moen, A. N. and C. W. Severinghaus. 1981. Annual cycle weight equations and survival of white-tailed deer. N. Y. Fish and Game Journal. [In press].

Seasonal variations in weights of black-tailed deer (odhe)

The weights of several black-tailed deer from birth through four years of age are plotted in Wood et al. (1962), and the equations given for maximum and minimum weights. The patterns of seasonal variations can be easily calculated with the annual cycle weight formula given in WORKSHEET 1.4b. Since equations for both MAWK and MIWK are given by Wood et al., phase corrections are all that remain to be determined. Estimate the JDAYs of MAWK and MIWK from their plotted figures and determine the phase corrections with the steps in WORKSHEET 1.4a. Then, write the equations below, make the calculations, and plot on a full sheet of graph paper using labels given.

$$CLWK = \overbrace{[MAWK + MIWK]/2}^{\text{Average weight}} + \underbrace{[MAWK - MIWK]/2}_{\text{Deviation from average weight}}\ \sin\left\{(JDAY)(0.9863) + \left[\left(\sin\{[(JDAY)(0.9863) + PRPC] + (SEPC)\}SEPC\right) + PRPC\right]\right\}$$



LITERATURE CITED

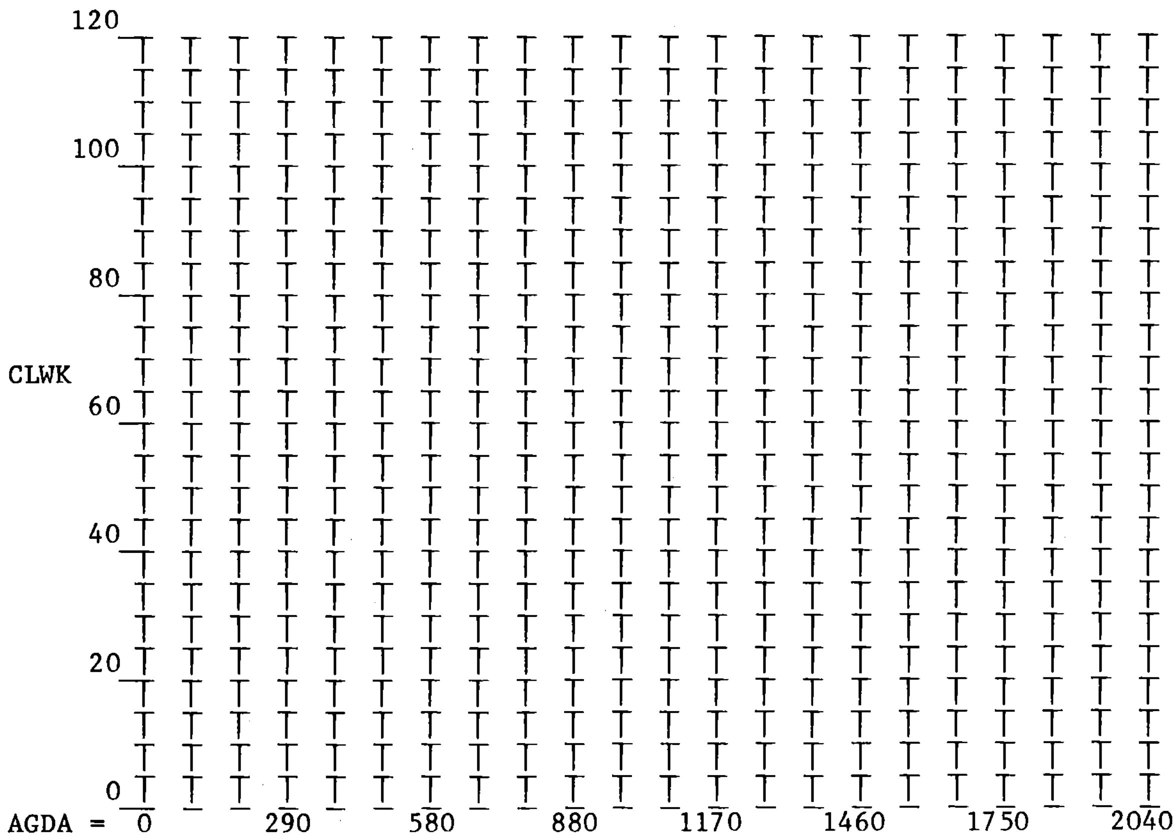
Wood, A. J., I. McT. Cowan, and H. C. Nordan. 1962. Periodicity of growth in ungulates as shown by deer of the genus Odocoileus. Can. J. Zool. 40(4): 593-603.

CHAPTER 1, WORKSHEET 1.4d

Seasonal variations in weights of deer (odvi) and of caribou (rata) from plotted data

Plots of deer weights in Hoffman and Robinson (1966) and caribou weights in Dauphine (1976) clearly illustrates seasonal variations in weights. Data points may be estimated by laying transparent gridded overlays on the figures and estimating the x and y values. Estimates of MAWK and MIWK may then be tabulated in relation to AGDAs and JDAYs and curve-fitting of MAWK and MIWK completed. The equations are:

Derive the equations and plot estimates of CLWK below.



LITERATURE CITED

Dauphine, T. C., Jr. 1976. Biology of Kaminuriak population of barren-ground caribou. Part 4: Growth, reproduction and energy reserves. Can. Wildl. Serv. Rep., Ser. No. 38.

Hoffman, R. A. and P. F. Robinson. 1966. Changes in some endocrine glands of white-tailed deer as affected by season, sex and age. J. Mammal. 47(2):267-280.

UNIT 1.5: LIVE WEIGHT, INGESTA-FREE, AND DRESSED WEIGHT RELATIONSHIPS

It is difficult to measure live weights of free-ranging ruminants, and most of the weights available in the literature are for some fractions of live weights. Field dressed weights are often measured at check-stations where hunters bring field-dressed animals. Some data are available in the literature on weights of ingesta and organs of the gastrointestinal tract, and of the heart, lungs, and liver. These data may be used to estimate the weights of ingesta and organs removed in field-dressing and help establish the validity of equations for converting field-dressed weights to live-weights when the weights of ingesta and all organs are removed in field-dressing are summed, the total should be equal to the differences between field-dressed and live weight as determined by equations expressing live weight--field dressed weight relationships.

Some of the references listed contain equations that have been determined for different species in different areas. No single weight conversion equation is applicable everywhere, however, as the weights of body components, especially fat, vary between range, during the year, and from year to year. The best equation for the species in your area or a first approximation based on expected similarities with animals in other areas may be used to convert dressed weights to estimated live weights.

Live weight--field-dressed weight relationships. Field-dressed weights are applied to the carcass with the entrails removed but with the heart, liver, and lungs left in. Estimated live weights in kg (ELWK) from field-dressed weights in kg (FDWK) are useful when weight data on wild ruminants are needed for analyses of ecological relationships.

Gastrointestinal tract weight characteristics. Stomach and intestinal weights in relation to live weights are used when partitioning weight differences between field-dressed weights and live weights. While the organs of the gastrointestinal tract contribute to the total gastrointestinal weight, the weight of the ingesta is a major component of this difference.

Ingesta-free weight. The weight of the ingesta within the gastrointestinal tract should be known when calculating energy metabolism since the ingesta are not part of the animal's metabolic tissue. Direct measurements of heat production are usually completed when the animals are in a post-absorptive condition; the gastrointestinal tracts are essentially empty. This is necessary because the exothermic metabolic processes of many millions of rumen microflora, both bacteria and protozoa, contribute thermal energy to the host that is measured by direct calorimetry. If the host is not in a negative thermal energy balance, this heat must be dissipated to prevent a rise in total body heat content and body temperature. If the host is in a negative thermal energy balance, heat energy released by rumen microflora breaking down the mass of ingesta is a desirable contribution to the total thermal energy balance of the host.

Live weight--hog-dressed weight relationships. Hog-dressed weights are applied to the carcass with the entrails, heart, liver, and lungs removed. Weights of the heart, liver and lungs may be subtracted from field-dressed weights to determine hog-dressed weights.

Live weight--field-dressed--edible meat relationships. Edible meat includes the muscle tissue available for consumption. The amount of edible meat on the carcasses of wild ruminants is an obviously important parameter for calculating their economic values. Data are very limited, however; studies are needed on just about every species.

The total live weight of an animal equal to the sum of the weights of all the individual organs and ingesta. The accountability of the separate equations may be evaluated by comparing the sum to the total weight. These live weight:dressed weight equations and the equations for the organs of different body systems given in TOPIC 3 in this CHAPTER may be compiled for such comparisons.

Comparisons of independently-calculated values of parameters of ecological importance is an excercise in "ecological accounting." Such comparisons are important because so many parameters of ecological importance must be measured indirectly or estimated for different animals and species in different areas, and the results compiled. Errors in measurements and differences between animals from different areas may result in unreasonable conclusions. The sum of all calculated organ and ingesta weights might exceed measured live weight, for example, which is biologically unreasonable.

Statistical tests for differences between population characteristics are essential when evaluating the magnitude of differences. Uses of statistical tests are described later in this text. For now, remember the concept of "ecological accounting," keeping in mind that equations from different areas should not be combined without caution.

REFERENCES, UNIT 1.5

LIVE WEIGHT, INGESTA-FREE, AND DRESSED WEIGHT RELATIONSHIPS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	18--4	435	442	odvi	mammals of anticostiislan	newsom,wm	1937
JOMAA	31--1	5	17	odvi*	weight relation, george re	hamerstrom,fn,jr/	1950
JWMAA	11--4	349	350	odvi*	dressed weights, edible me	hamilton,wj,jr	1947
JWMAA	18--4	482	495	odvi	deer manage, mud lake wild	hunt,rw; mangus,l	1954
JWMAA	20--3	286	302	odvi	regional diff, size, produ	gill,j	1956
JWMAA	37--4	553	555	odvi	weight tape, deer in virgi	smart,cw; giles,/	1973
JWMAA	39--1	48	58	odvi*	morphol charact, crab orch	roseberry,jl; kle	1975
NYCOA	14---	30	31	odvi	big, little d, food is key	severinghaus,cw;/	1959

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	40--4	593	603	odhe	periodicity of growth, odo	wood,aj; cowan,i/	1962
JOMAA	45--1	48	53	odhe	three morpholog attrib, nm	anderson,ae; fra/	1964
WAEBA	589--	1	6	odhe	the mule deer carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	15---	253	268	ceel	relat age and size, poland	dzieciolowski,r	1970
JOMAA	27--4	308	327	ceel	mammals of northern idaho	rust,hj	1946
JWMAA	15--1	57	62	ceel*	weights, measurem, rock mt	quimby,dc; johnso	1951
JWMAA	24--1	15	21	ceel*	roosev elk afognak isl, al	troyer,wa	1960
JWMAA	30--1	135	140	ceel	meas, weight relat, manito	blood,da; lovaas,	1966
NAWTA	29---	237	248	ceel	weights, north yellowst el	greer,kr; howe,re	1964
WAEBA	594--	1	8	ceel	the elk carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	81--4	263	269	alal*	weights, measurem, alberta	blood,da; mcgilli/	1967
JOMAA	27--1	90	91	alal	weights of a minnesota moo	breckinridge,wj	1946
JOMAA	50--2	302	310	alal*	odvi, struct adap for snow	kelsall,jp	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				rata			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	34--2	470	472	anam	derivation of whole weight	o'gara,bw	1970
WAEBA	575--	1	6	anam	pronghorn antelope carcass	field,ra; smith,f/	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	43--1	173	178	bibi	age criter, dres carc weig	novakowski,ns	1965
JOMAA	38--1	139	139	bibi*	live, dressed weights	halloran,af	1957
POASA	41---	212	218	bibi	weights, measure, oklahoma	halloran,af	1961

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	22--4	444	445	ovca*	weights, measurem, dese bh	aldous,mc; craigh/	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	36--1	64	79	caca	fact aff growth, body size	klein,dr; strongg	1972

Live weight:field dressed weight relationships of white-tailed deer (odvi)

Linear regression equations for live weight:field dressed weight relationships have been determined for "normal" and "acorn" years in Michigan. Published equations in pounds have been converted to new equations for estimated live weight in kg (ELWK). They are (Hamerstrom and Camburn 1950):

1. Normal year: ELWK = 3.89 + 1.265 (FDWK)
2. Acorn year: ELWK = 1.19 + 1.251 (FDWK)

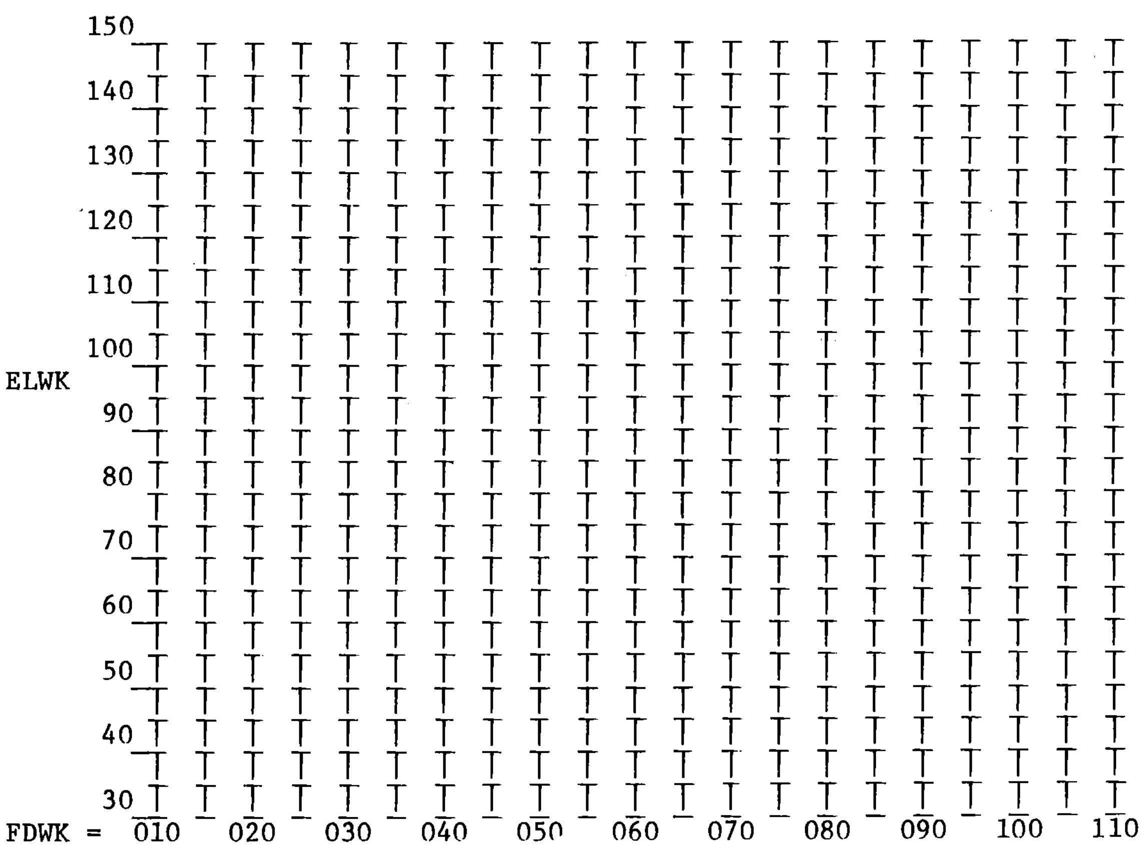
Severinghaus and Cheatum (1956) present an equation for New York deer on "good" range. The equation is:

3. ELWK = 1.89 + 1.249 (FDWK)

An equation by Hesselton and Sauer (unpublished) for the Seneca Army Depot and Dutchess County, New York, is:

4. ELWK = 1.61 + 1.238 (FDWK)

Since all of these equations are linear, it is necessary to calculate only two Y values to determine the line for each equation. Plot and label each of the lines on the graph below.



LITERATURE CITED

Hamerstrom, R and F. L. Camburn. 1950. Weight relationships in the George Reserve Deer Herd. J. Mammal. 31(1):5-17.

Severinghaus, C. W. and E. L. Cheatum. 1956. Pages 57-186 In Taylor, W. P., Ed., The Deer of North America. The Stackpole Company, Harrisburg, PA.

CHAPTER 1, WORKSHEET 1.5b

Stomach tissue weights of white-tailed deer (odvi)

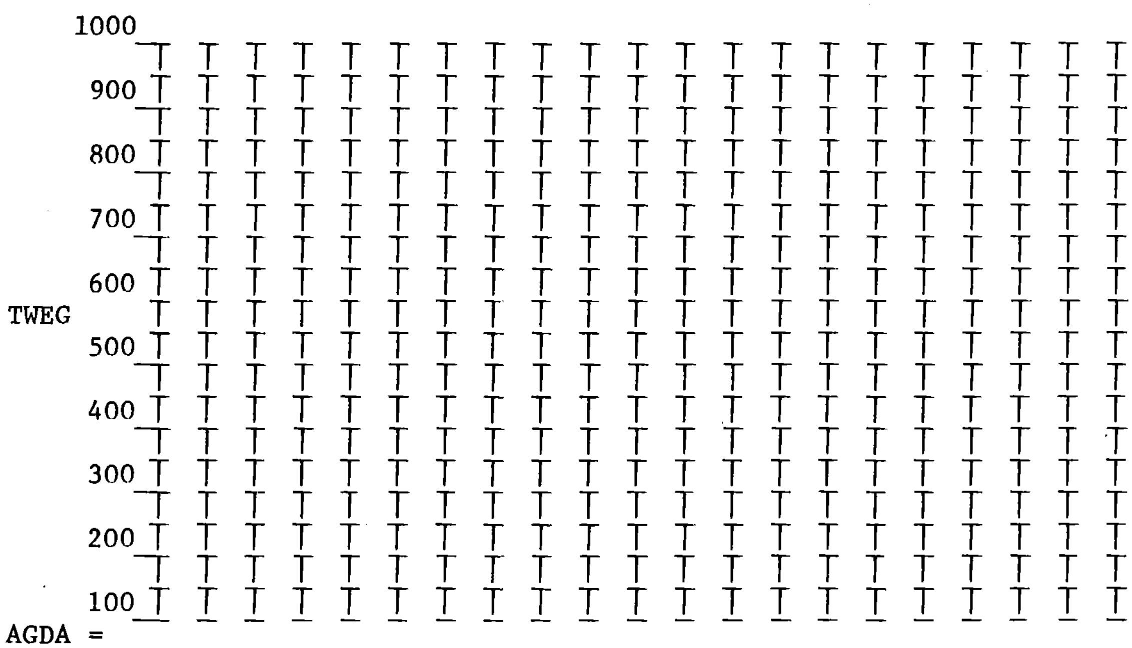
Weights of stomach tissue by parts given by Short (1964) are:

Tissue Weights in grams (TWEG)

AGMO	AGDA	Rumen	Reticulum	Omasum	Abomasum	SUMS
0	1	7	2	2	25	36
0.5	15	26	7	5	47	85
1.0	30	47	7	3	32	89
2.0	60	183	27	17	70	297
3.0	90	189	21	11	45	266
4.0	120	321	29	19	48	417

AGYE	AGDA	Rumen	Reticulum	Omasum	Abomasum	SUMS
1.5	548	845	64	58	101	1068
5.5	2008	935	75	102	145	1257

Label the x axis, plot the points and curve-fit the data to find the best-fitting equations.



LITERATURE CITED

Short, H. L. 1964. Postnatal stomach development of white-tailed deer. J. Wildl. Manage. 28(3):448.

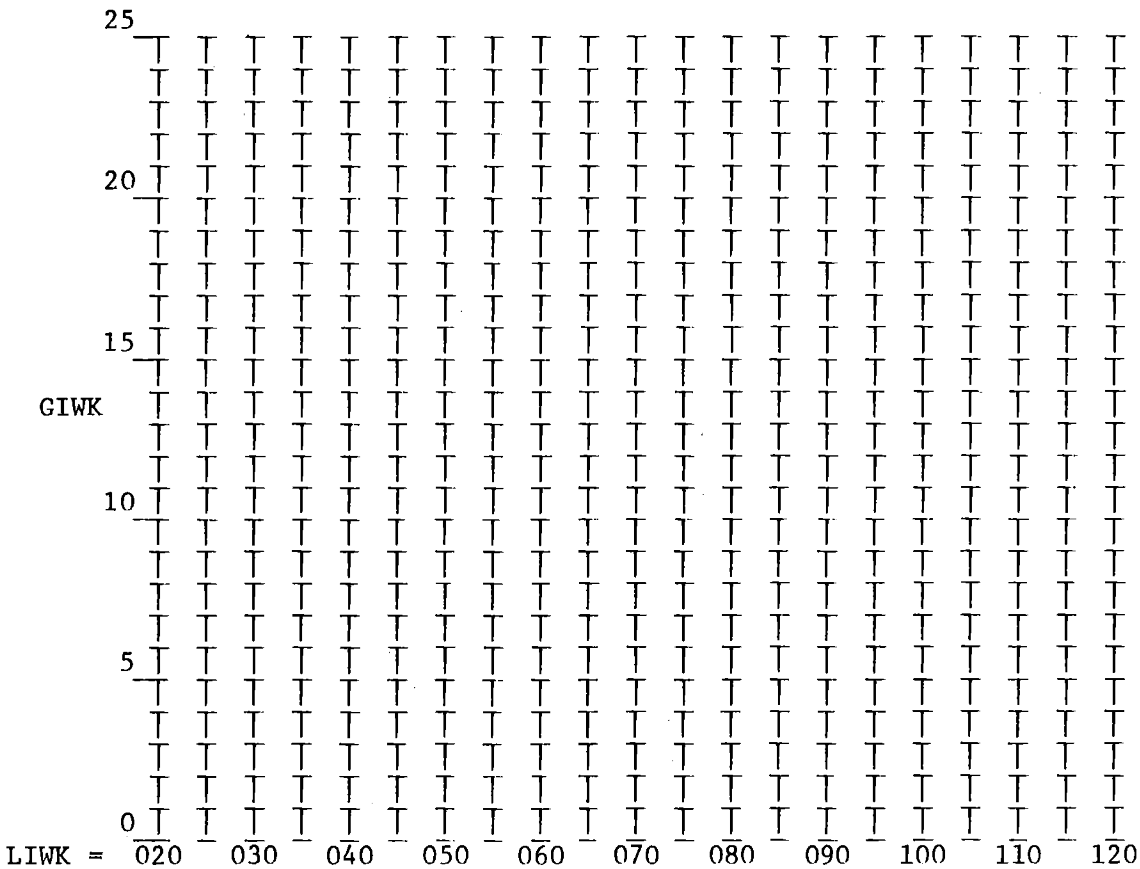
CHAPTER 1, WORKSHEET 1.5c

Gastrointestinal tract weights of white-tailed deer (odvi)

The weights of the gastrointestinal tract, including the 4-part stomach, small and large intestines, and rectum of white-tailed deer were obtained by Hamerstom and Camburn (1950). The equation expressing these gastrointestinal weights in kg (GIWK) in relation to live weight in kg (LIWK) is:

$$GIWK = 0.327 + 0.197\ LIWK$$

Calculate 2 points and draw the line below.



LITERATURE CITED

Hamerstrom, F. N. and F. L. Camburn. 1950. Weight relationships in the George Reserve deer. J. Mammal. 31(1):5-17.

CHAPTER 1, WORKSHEET 1.5d

Ingesta-free weights of white-tailed deer (odvi)

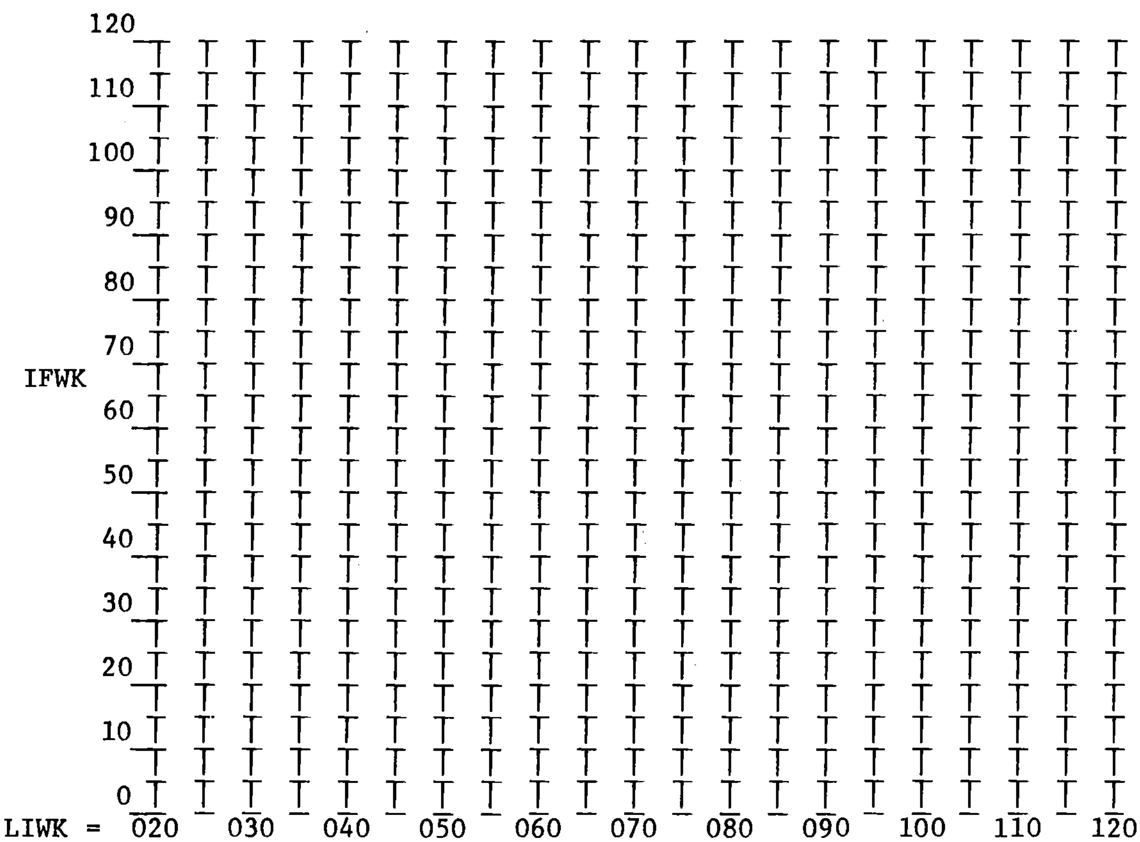
Ingesta-free weights in kg (IFWK) have been determined in relation to live weights in kg (LIWK) by Robbins et al. (1974). The exponential equation, rearranged from the published equation, is:

$$IFWK = e^{(0.9928 \ln LIWK - 0.0771)}$$

There is less than 1% error, however, when using the approximation,

$$IFWK = 0.9 \, LIWK$$

Complete the calculations and plot the values for both equations. How much error is involved when using this equation as an approximation for a larger species, such as moose?



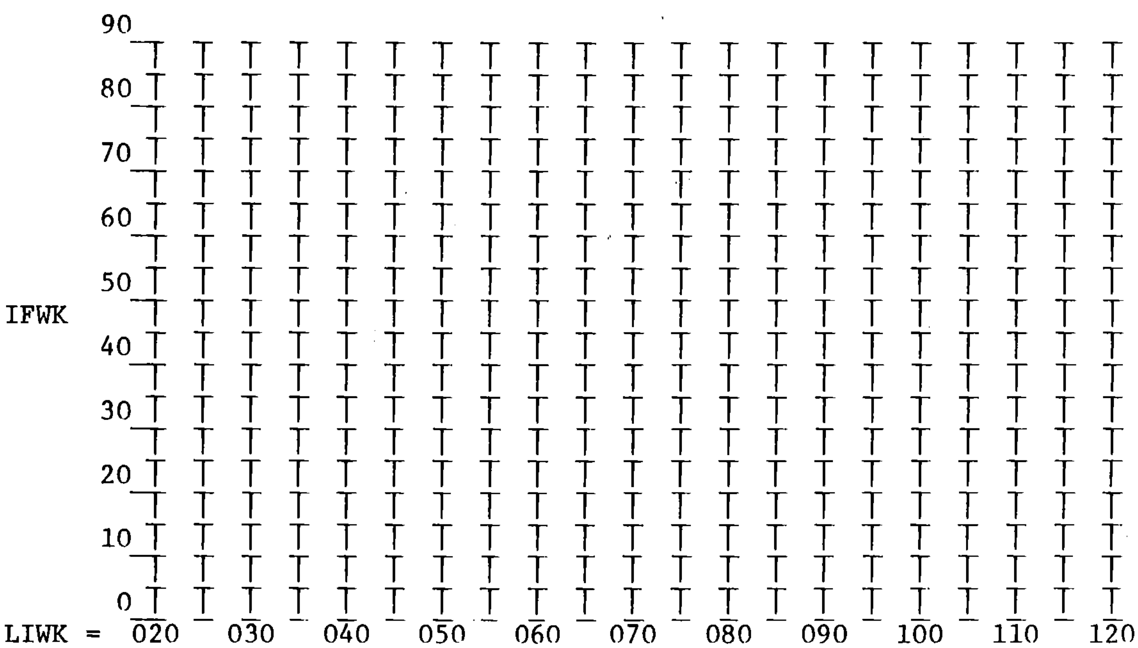
LITERATURE CITED

Robbins, C. T., A. N. Moen, and J. T. Reid. 1975. Body composition of white-tailed deer. J. Anim. Sci. 38(4):371-387.

Live weight: field-dressed and gastrointestinal tract weight relationships of white-tailed deer (odvi)

This worksheet illustrates the determination of the contributions of the weight of ingesta and gastrointestinal tract organs to the weight removed in field-dressing a deer.

The live weight of a deer less the field dressed weight = the weight of the ingesta and the organs removed in field-dressing. Equations have been presented for weights of ingesta and organs of the gastrointestinal tract. Subtract gastrointestinal organ ingesta weights as calculated in WORKSHEETS 1.5b and 1.5c from live weights and compare to the live weight: field dressed weight relationships described in WORKSHEET 1.5a. What are the sources of differences?



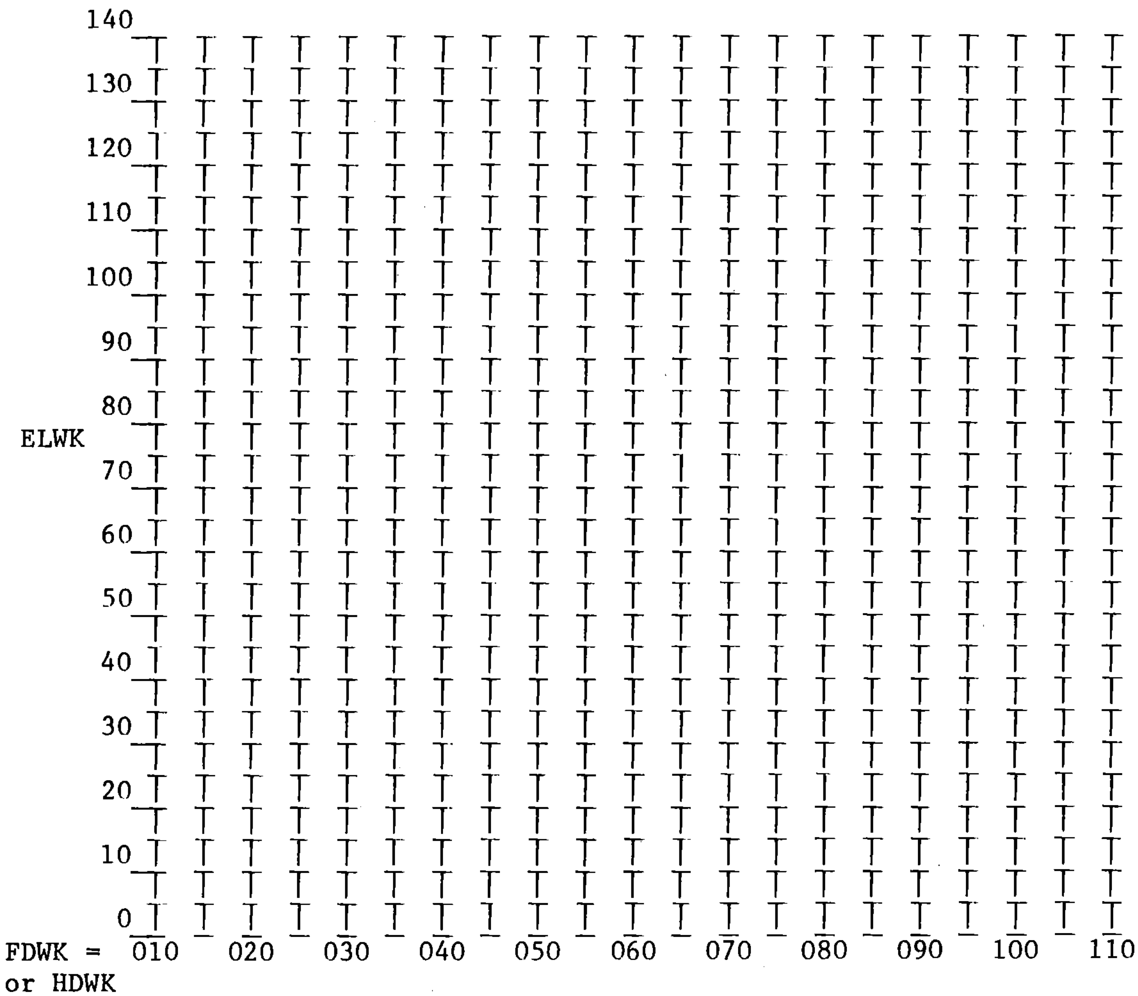
CHAPTER 1, WORKSHEET 1.5f

Live weight: field dressed: hog dressed weight relationships of
white-tailed deer (odvi)

Field dressed weights have been used to estimate live weights with regression equations. Field-dressed weights generally include the weight of the carcass with the entrails removed, but with the heart, liver, and lungs left in. Hog-dressed weight refers to carcass weights with the entrails, heart, liver, and lungs removed.

Field dressed weights (FDWK) and hog dressed weights in kg (HDWK) may be used to derive estimated live weight in kg (ELWK) with the equations below, derived from data in the table in Cowan et al. (1968).

$$ELWK = 4.05 + 1.14\ FDWK$$
$$ELWK = 5.32 + 1.17\ HDWK$$



LITERATURE CITED

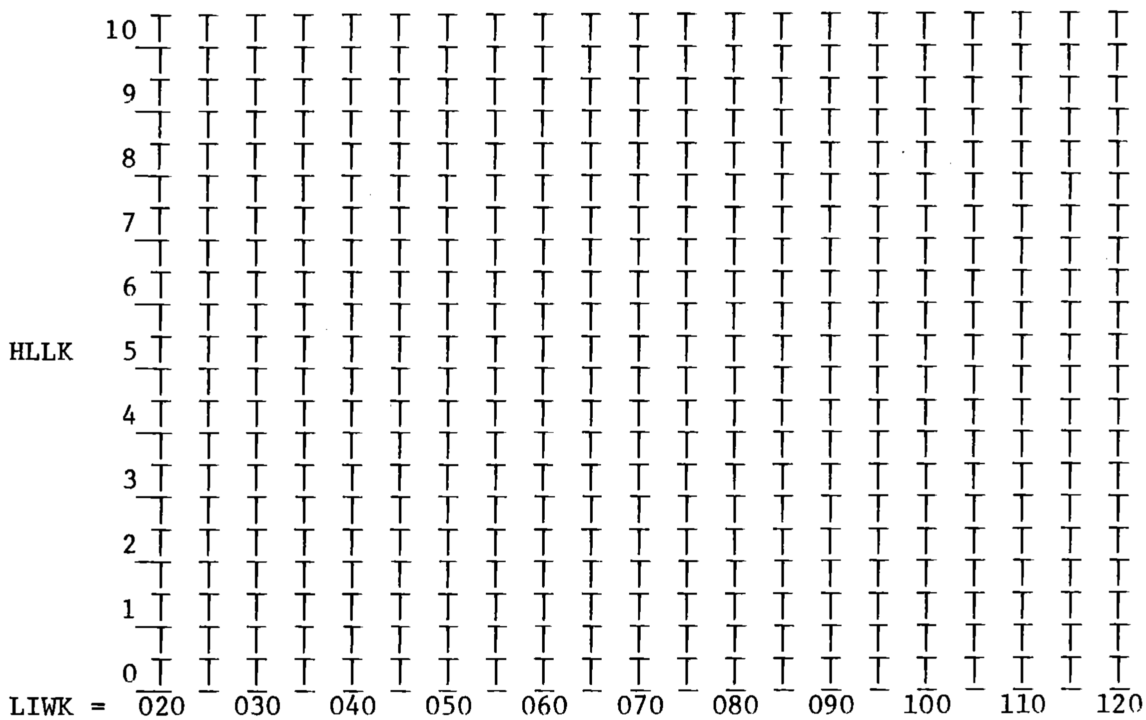
Cowan, R. L., E. W. Hartsook, J. B. Whelan, J. L. Watkins, J. S. Lindzey, R. W. Wetzel, and S. A. Liscinsky. 1968. Weigh your deer with a string. Pennsylvania Game News 39 (11): 17-18.

Heart, lung and liver weights in relation to live weight of white-tailed deer (odvi)

Heart, lungs, and liver weights in relation to live weight of white-tailed deer have been determined by Hamerstrom and Camburn (1950) for deer from the George Reserve, Michigan. The equation in kilograms (HLLK) is:

$$HLLK = 0.114 + 0.0525\ LIWK;\ r^2 = 0.8$$

Plot the relationship below.

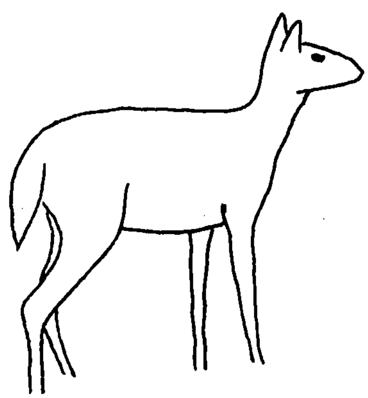


LITERATURE CITED

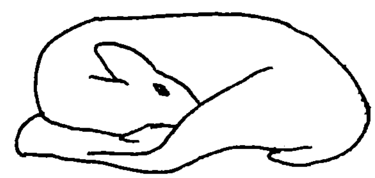
Hamerstrom, R. and F. L. Camburn. 1950. Weight relationships in the George Reserve Deer Herd. J. Mammal. 31(1):5-17.

TOPIC 2. GEOMETRY

The geometry of an animal is an important consideration in ecological analyses because it affects so many fundamental relationships, especially physical ones, between the animal and the characteristics of the range. For example, the amounts of accumulated snow affect animals of different sizes differently; a small fawn has shorter legs than a large buck, and this is an important consideration when evaluating the effects of snow on movements. Size differences affect the heights animals can reach for forage, and that determines the upper limit to the range for each individual. Vertical height profiles are of interest to biologists when evaluating thermal relationships in relation to vertical wind profiles in differrent habitats. Further, the amount of thermal exchange between animal and environment is related to the posture and surface areas of animals as illustrated below.



Maximum surface area, standing



Minimum surface area, bedded, curled

One might guess that the surface area of the standing animal on the left is considerably larger than the surface area of the bedded animal on the right. Further considerations of intermediate postures can be made; a bedded animal may have its head up, increasing its surface area exposed to the atmosphere, and it may extend its legs somewhat, increasing its surface area exposed to the substrate. These subtle changes in posture may have very important thermoregulatory functions; they can be evaluated when surface areas of body parts are considered in calculations of thermal exchange.

The effects of geometric differences are of distinct ecological significance when evaluating physical animal: range relationships. The geometric considerations discussed above are objective. Some geometric characteristics are subjective--postures of animals indicate whether an animal is a potential aggressor or a sub-dominant--but these are considered in Part II, Behavior of Wild Ruminants. Surface area and geometric considerations are discussed in the next four UNITS.

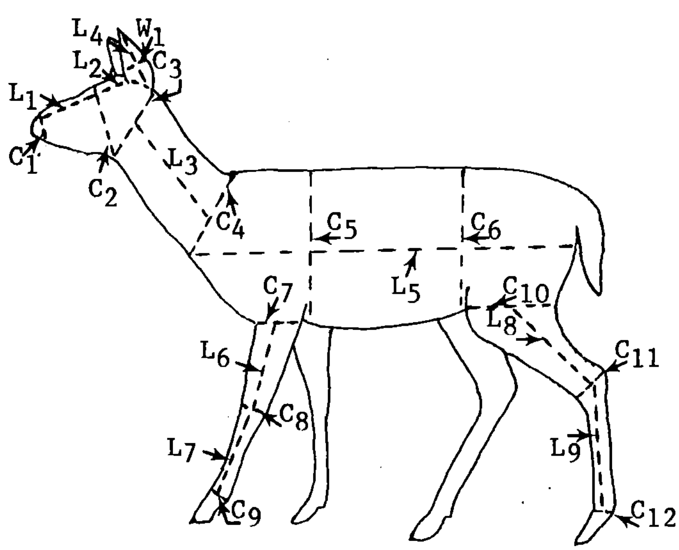
UNIT 2.1: LINEAR MEASUREMENTS

Linear measurements, relatively easy to make with inexpensive equipment, may be used for several purposes. Mammalogists often record a rather standard series of measurements, including the body length, tail length, hind foot length, and skeletal lengths. Such measurements have been useful in evaluating taxonomic relationships between populations in different areas. Subspecies are sometimes identified on the basis of linear measurements. Some of these measurements are made on internal skeletal characteristics; these are discussed in TOPIC 3, SYSTEMS CHARACTERISTICS. Linear measurements of fetuses have been made and related to age and sex. These are useful when estimating the time of breeding, and of fetal or maternal mortality.

The heart girth, or circumference of the chest just behind the front legs, may be used to estimate field-dressed and live weights. Then, heart girth in cm (HEGC) is the independent variable and field-dressed weight in kg (FDWK) or estimated live weight in kg (ELWK) the dependent variable. Linear measurements of lengths and diameters of body parts may be used to calculate vertical profiles when animals are in different postures. External linear measurements, easily made with a flexible tape, may be used in calculating surface areas of different parts of the body.

Regression equations for relationships between linear measurements and weights are useful for predicting geometric dimensions over a range of weights. Interspecies comparisons can also be made, and the lack of data may make it necessary to estimate geometric considerations of one species from data on another.

The linear measurements indicated on the silhouette below are used in calculating vertical profiles discussed in UNIT 2.2 and surface areas discussed in UNITS 2.3 and 2.4.



REFERENCES, UNIT 2.1

LINEAR MEASUREMENTS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	1---3	130	133	od--	skull measurem, northern d	phillips,jc	1920
JOMAA	39--3	347	367	od--	mammals of mex state, guer	davis,wb; lukens,	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AMNAA	43--3	650	666	odvi*	fetal developme, white-tai	armstrong,ra	1950
JOMAA	9---1	57	59	odvi	new white-tailed de, louis	miller,fw	1928
JOMAA	17--1	67	68	odvi	size, weight, adirond deer	schoonmaker,wj	1936
JOMAA	25--4	370	403	odvi	notes on mexican mammals	davis,wb	1944
JOMAA	32--4	411	421	odvi	analys reproduc patte, tex	illige,d	1951
JOMAA	40--1	108	113	odvi	breeding records, captive	haugen,ao	1959
JOMAA	47--2	266	280	odvi	endocrin glands, seas, sex	hoffman,ra; robin	1966
JWMAA	5---2	182	190	odvi	study, edwards plat, texas	sanders,e	1941
JWMAA	5---3	333	336	odvi	trends, kill of wisco buck	schunke,wh; buss,	1941
JWMAA	20--3	286	292	odvi	reg diff, size prod, w vir	gill,j	1956
JWMAA	22--3	319	321	odvi	determ age, young fawn whi	haugen,ao; speake	1958
JWMAA	24--4	364	371	odvi	shelter require, penned wt	robinson,wl	1960
JWMAA	29--4	699	705	odvi	antlers in female white-ta	donaldson,jc; dou	1965
JWMAA	34--2	383	388	odvi*	morphol develop, aging, fe	short,c	1970
JWMAA	34--4	887	903	odvi	repro, grow, resid, dieldr	murphy,da; korsch	1970
JWMAA	37--4	553	555	odvi	weight tape for w-td, virg	smart,cw; giles,/	1973
JWMAA	39--1	48	58	odvi	morphol charact, crab orch	roseberry,jl; kli	1975
NAWTA	28---	431	443	odvi*	nutrition, fetal, fawn gro	verme,lj	1963
PCGFA	19---	118	128	odvi/	meas, estima antler volume	rogers,ke; baker,	1965
TNWSD	28---	91	108	odvi	phys variables, condit, bg	dauphine,tc,jr	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	48--1	123	132	odhe*	development, fetal period	ommundsen,p; cowa	1970
JOMAA	8---4	289	291	odhe	horned does	dixon,j	1927
JOMAA	30--1	76	77	odhe	external measurements of m	halloran,af; kenn	1949
JOMAA	45--1	48	53	odhe	comp 3 morph attrib, n mex	anderson,ae; fra/	1964
JWMAA	15--2	129	157	odhe*	mule deer, nebras nat fore	mohler,ll; wampo/	1951
JWMAA	23--3	295	304	odhe	embryonic, fetal developme	hudson,pj; browma	1959
JWMAA	34--2	383	388	odhe*	morphol develop, aging, fe	short,c	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	14---	141	151	ceel	growth, developmen, calves	dzieciolowski,r	1969
ATRLA	15-17	253	268	ceel/relation age, size, poland		dzieciolowski,r	1970
CJZOA	47--6	1418	1419	ceel	sexual dimorphism, fetuses	retfalvi,l	1968
JOMAA	36--1	145	145	ceel	fetus in yearling cow elk	saunders,jk, jr	1955
JOMAA	47--2	332	334	ceel	fetus resorption in elk	haugen,ao	1966
JWMAA	9---4	295	319	ceel	roosev elk, olymp pen, was	schwartz,je,ii; m	1945
JWMAA	15--1	57	62	ceel	weights, measurem, rock mt	quimby,dc; johnso	1951
JWMAA	15--4	396	410	ceel	biology of the elk calf	johnson,de	1951
JWMAA	23--1	27	34	ceel	breed seas, known-age embr	morrison,ja; tra/	1959
JWMAA	30--1	135	140	ceel	meas, weight relat, manito	blood,da; lovass,	1966
MAMLA	35--3	369	383	ceel	body size, fat, demography	caughley,g	1971
POASA	47---	406	413	ceel	size, wt, wichita mt, okla	halloran,af	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	81--4	263	269	alal	weights, measurem, alberta	blood,d; mcgilli/	1967
CJZOA	56--2	298	306	alal*measurements, weight relat		franzmann,aw; len	1978
JOMAA	27--1	90	91	alal	weights, measurem, minneso	breckinridge,wj	1946
JOMAA	50--2	302	310	alal*odvi struct adapt for snow		kelsall,jp	1969
JOMAA	51--2	403	405	alal*charact of captive, michig		verme,lg	1970
JOMAA	51--4	808	808	alal	weights, measurme of moose	doutt,jk	1970
JWMAA	23--2	231	232	alal	feeding, growth capti calf	dodds,dg	1959
JWMAA	26--4	360	365	alal	in gravelly, snowcrest mou	peek,jm	1962
VILTA	4---1	1	42	alal	captive, hand-reared calve	markgren,g	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	90--4	449	463	rata	annual antl cycle, newf ca	bergerud,at	1976
CJZOA	44--3	401	411	rata	growth, development bar-gr	mcewan,eh; wood,a	1966
JWMAA	28--1	54	56	rata	relat mandible leng to sex	bergerud,at	1964
JWMAA	32--2	350	367	rata	introduct, increase, crash	klein,dr	1968
NJZOA	24--4	407	417	rata*morphol,	fat stor, org wei	krog,j; wika,m;	1976
ZOLZA	44--9	1396	1404	rata	[morphol peculiar, taimyr]	michurin,ln	1965

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	16--3	387	389	anam	measurem, hart mt antelope	mason,e	1952
JWMAA	35--1	76	85	anam/meas,	wts, carc yield, alb	mitchell,gj	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	45--4	630	632	bibi	new data, bis bis athabasc	bayrock,la; hille	1964
POASA	41---	212	218	bibi	wts, meas, wichi mts, okla	halloran,af	1960

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	44--1	116	118	ov	growth, behav, captive lam	forrester,dj; hof	1963

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	46--3	524	525	ovca	fetal measurem, milk chara	forrester,dj; sen	1965
JWMAA	22--4	444	445	ovca	weight, measurem, deser bh	aldous,mc; craig/	1958
JWMAA	29--2	387	391	ovca	growth, develop, desert bh	hansen,cg	1965
JWMAA	34--2	451	455	ovca	heights, growth, w alberta	blood,da; flook,/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	19--4	417	429	oram	two-year study, crazy moun	lentfer,jw	1955
JWMAA	39--4	705	708	oram	girth, measurem, estim wei	rideout,cb; worth	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	57-11	2153	2159	many	morph param, locomot, snow	telfer,es; kelsa	1979
JOMAA	27--4	308	327	many	mammals of northern idaho	rust,hj	1946

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	36--1	64	79	caca	fact aff growth, body size	klein,dr; strandg	1972

CHAPTER 1, WORKSHEET 2.1a

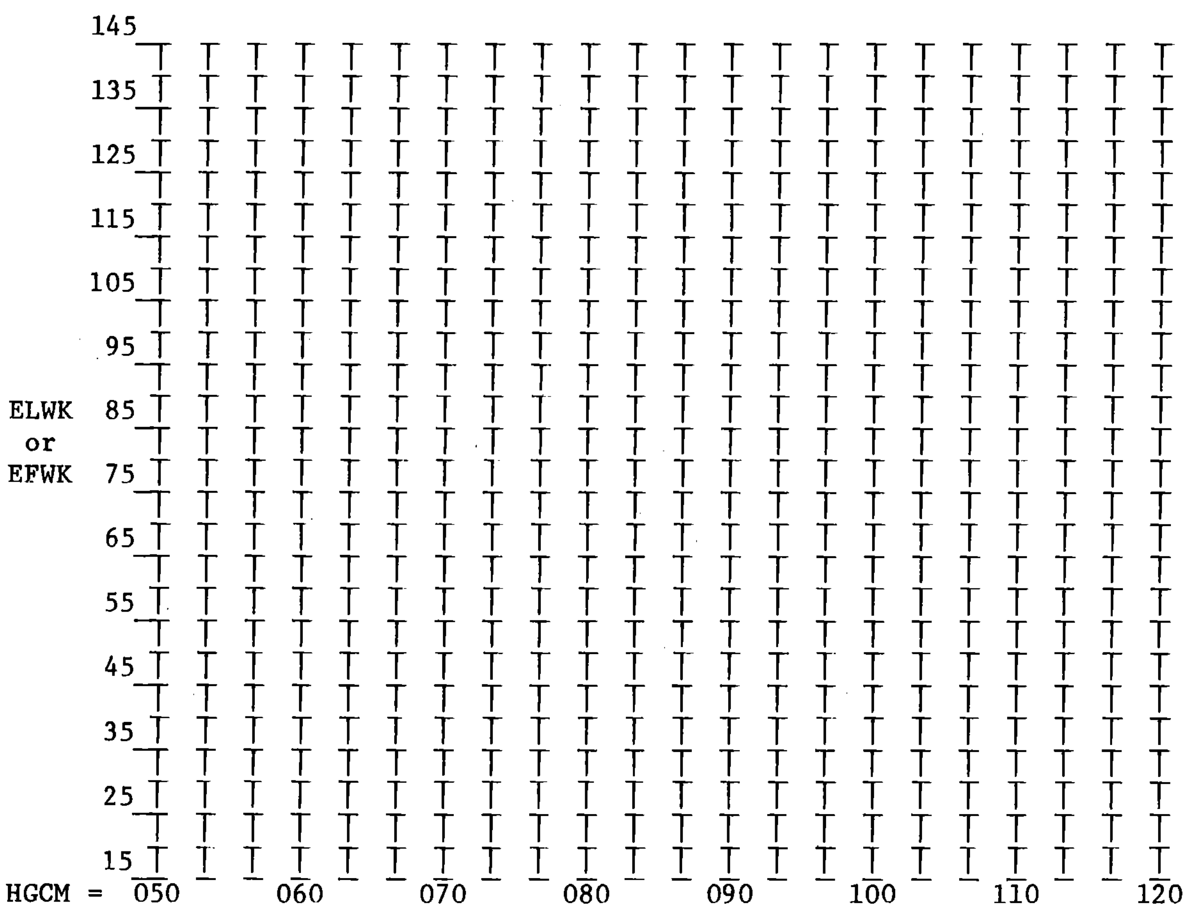
Heart girth: Live weight and field-dressed weight relationships of white-tailed deer (odvi)

Heart girth, the circumference of the chest just behind the forelegs, may be used to estimate live weight and field dressed weights of white-tailed deer based on data in Cowan et al. (1968). Thirteen animals, presumably all males, were measured and the results reported in inches and pounds. These have been converted to centimeters and kilograms and exponential equations for estimated live weight in kg (ELWK) and estimated field-dressed weight in kg (EFWK) derived. The equations are:

$$ELWK = 5.77231\ e^{(HGCM)(0.02664)}$$

$$EFWK = 3.81850\ e^{(HGCM)(0.02898)}$$

Verify the first equation with HGCM = 50.0, ELWK = 21.87 and the second equation with EFWK = 16.26. Then, complete calculations at 10 cm intervals and complete the graph below. How do ELWK and EFWK estimated here compare to earlier estimates of ELWK from EFWK?



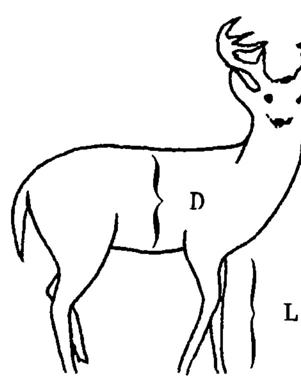
LITERATURE CITED

Cowan, R. L., E. W. Hartsook, J. B. Whelan, J. L. Watkins, J. S. Lindzey, R. W. Wetzel, and S. A. Liscinsky. 1968. Weigh your deer with a string. Pennsylvania Game News 39(11):17-19.

UNIT 2.2: VERTICAL PROFILES

The vertical dimensions of animals may be used to describe the distribution of body parts in relation to different mechanical characteristics of the range. For example, the vertical distribution of the legs, trunks, neck, and head may be related to the vertical distributions of wind velocities in different cover types. An animal in the open is exposed to a wide range of velocities from the ground up to the height of its head. The legs of an animal standing in vegetation that reaches up to its trunk are in a different range of wind velocities than the trunk, neck and head of the animal. How important are these considerations? Their importance can be evaluated in PART 5 where calculations of heat loss in different habitats are described.

Height profiles may be estimated from the measurements described in UNIT 2.1. Leg lengths, trunk diameters, and neck and head dimensions may be summed to determine the vertical height profiles of different species.



D + L = Height

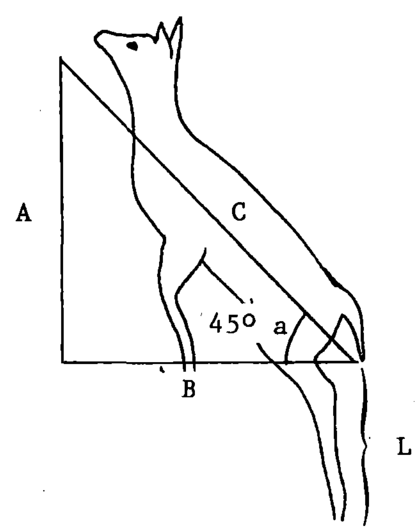
Belly heights are important considerations when snow becomes a barrier to movement, and are estimated from the linear measurements of the legs illustrated in UNIT 2.1. The sum of the upper and lower leg measurements, considered to be belly height, may be expressed in relation to weight be curve-fitting, with belly height as the depedent variable and weight as the independent variable.

Members of the family <u>Cervidae</u> are similar in body proportions, and equations for white-tailed deer may be used as first approximations for mule deer, elk, and moose if measurements on these species are unavailable. They probably also apply fairly well to caribou. Sheep, goats, muskox, and bison have different proportions--their legs seem to be somewhat shorter in relation to body weight--and the deer equation may result in overestimations of belly heights.

Belly heights may be quite easily determined photographically with captive animals. Simply place a clearly-marked measuring stick alongside the trunk of an animal of kown weight and photograph from a distance great enough to eliminate any need for corrections due to parallax. Belly heights may then be read and related to weight. This photographic technique illustrates how simply and inexpensively one can often get data on characteristics that are used in analyzing ecological relationships. Large numbers of animals are not required either; one animal raised from birth to maturity and weighed and photographed regularly provides the data needed for a first approximation. Two animals measured in the same way provide data for a test of differences in the intercepts and slopes for their weight ranges. It is unfortunate that such measurements have not been made on the many species of wild ruminants that have been raised in captivity.

Larger animals can reach higher for forage than smaller ones, so their range has a greater vertical dimension than that of the smaller animal. This is true within species--large deer can reach higher than small deer--and between species--moose can reach higher than deer for forage. This is an important consideration when quantifying the forage supply; the same forage quantities are not available to all animals in a population.

Estimates of the heights reached may be made from the linear measurements of the hind legs, neck, trunk, and head described in UNIT 2.1, with consideration of the angles of these body parts when an animal is in this height-extending posture. The length of the hypotenuse and angle a may



be used to estimate the length of side A with the formula A = (sin a)(C). The equation, if C = 2.0 m and angle a = 45°, is:

$$A = (\sin 45)(2.0) = (0.71)(2.0) = 1.42\text{m} = 142 \text{ cm}$$

Total height reached is determined by adding side A to the length l. The overall formula for determining the height of forage reached (HEFR) is then:

$$\text{HEFR} = (\sin a)(C) + [L]$$

HEFR is the determinant of the upper limit to the availability of forage, which is necessary for determining the total amount of forage on the range. It is much better to use this correct conceptual approach that recognizes differences between the heights reached by animals of different sizes than to use a single arbitrary value for the upper limit of the range. HEFR will be related to the vertical distribution of forage in PART IV.

REFERENCES, UNIT 2.2

VERTICAL PROFILES

BOOKS

type	publ	city	page	anim	kewo	auth	year
aubo	whfr	sfca	453	odvi	wildlife ecology	moen,an	1973

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				odvi			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	30--1	76	77	odhe	external measurement, mule	halloran,af; kenn	1949

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	14---	141	151	ceel	growth, devel, red deer ca	dzieciolowski,r	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	56--2	298	306	alal*	weights, measureme, alaska	franzmann,aw; le/	1978
JOMAA	50--2	302	310	alal*	odvi,structura adapt, snow	kelsall,jp	1969
VILTA	4---1	1	42	alal	captiv, hand-reared calves	markgren,g	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
NJZOA	24--4	407	417	rata*	morphol, fat stor, or wei,	krog,j; wika,m; /	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
POASA	41---	212	218	bibi	weights, measure, wich mo	halloran,af	1961

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

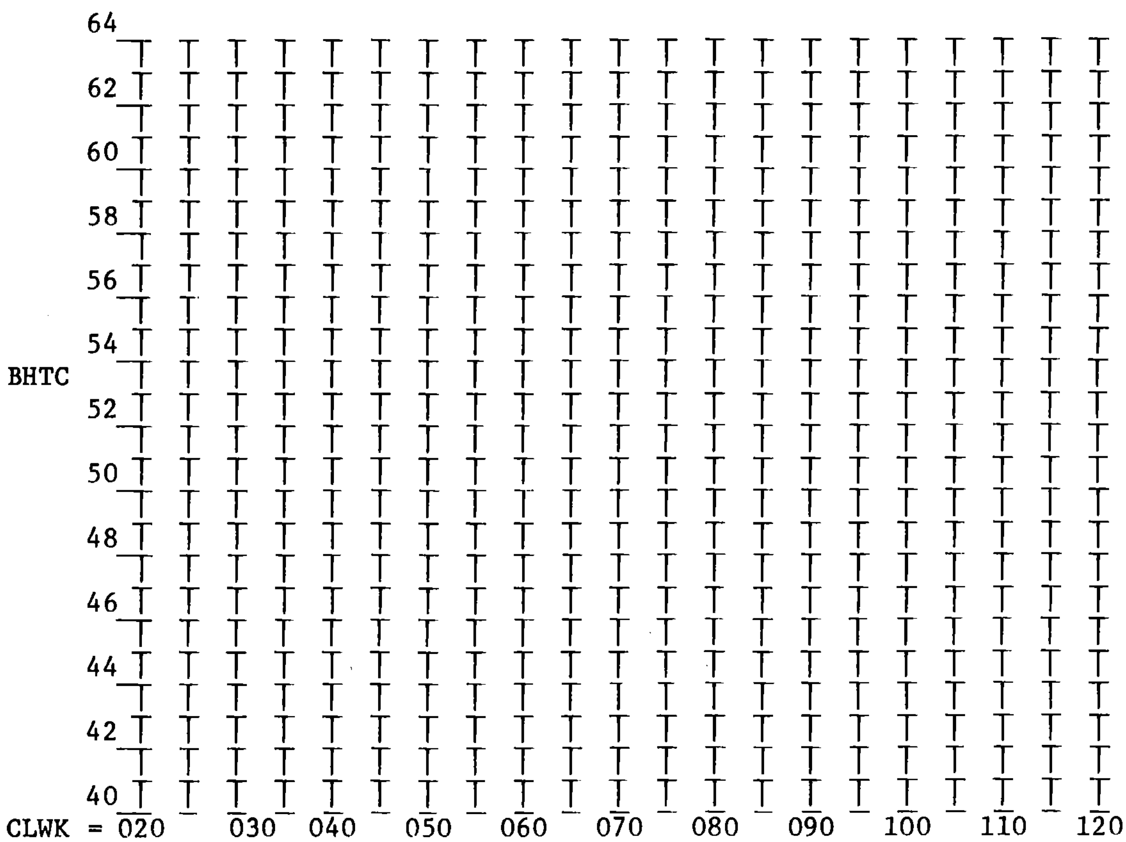
Vertical profiles; belly heights of white-tailed deer (odvi)

Belly heights of white-tailed deer of different weights can be calculated with an equation in Moen (1973; p. 399):

$$BHTC = 12.5\ CLWK^{0.21} + 8.0\ CLWK^{0.25}$$

where BHTC = belly height in cm and CLWK = calculated live weight in kg.

A 60 kg deer has a predicted belly height of 51.8 cm (just over 20 inches). Results for weights from 20 to 120 kg at intervals of 10 kg should be plotted below.



LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman Co., San Francisco. 458 p.

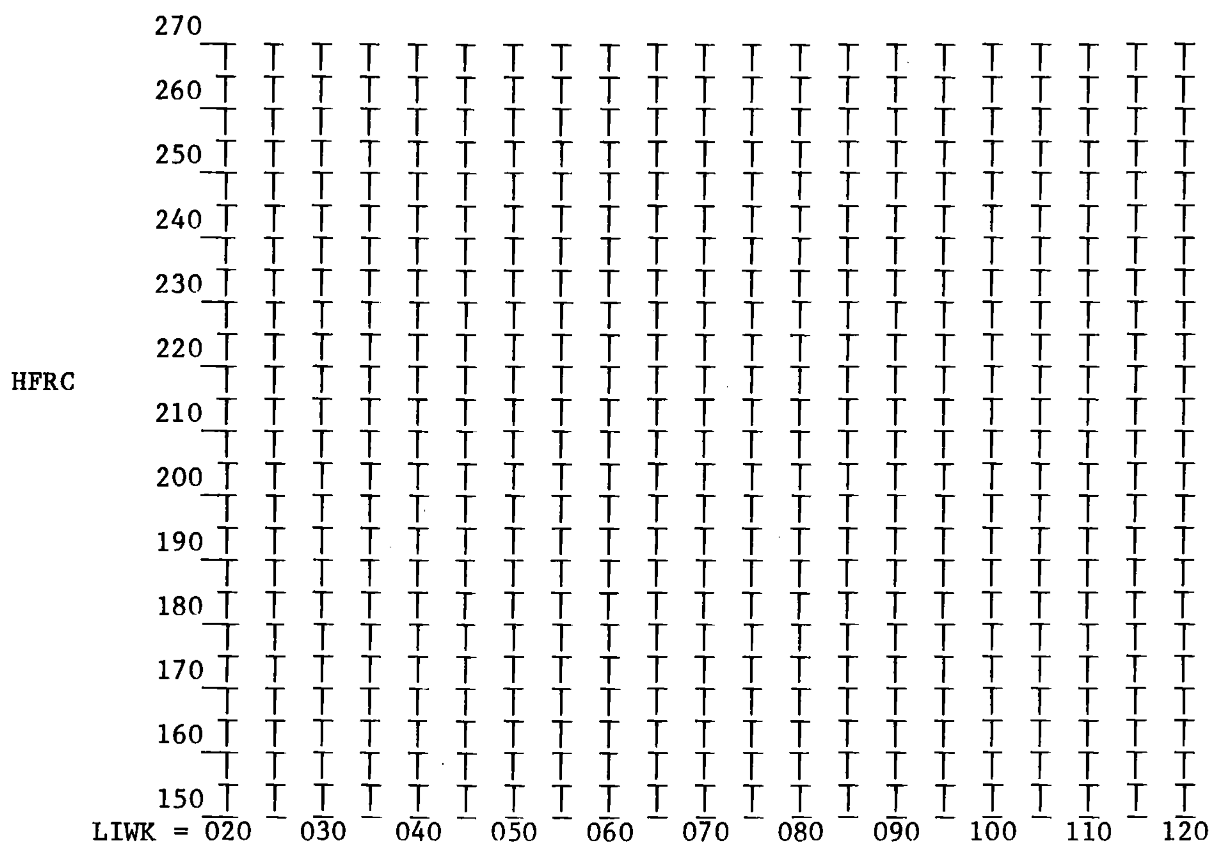
CHAPTER 1, WORKSHEET 2.2b

Vertical profiles; heights of forage reached by white-tailed deer (odvi)

The heights of forage reached by white-tailed deer of different weights have been calculated from the linear measurements discussed earlier in UNIT 2.1. The equation given in Moen (1973; p. 399) is:

$$HFRC = 145 + 0.792 \; LIWK$$

where HFRC = height of forage reached in cm and LIWK = live weight in kg. A deer weighing 60 kg can reach 193 cm, or just over 6.25 feet. Determine HFRC for LIWK = 20 and 120, plot the points and then draw a straight line between them to represent HFRC for any weight between 20 and 120 kg.



LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman Co., San Francisco. 458 p.

UNIT 2.3: SURFACE AREAS

Surface areas have been considered by biologists for some time, and some have gone so far as to derive "surface area laws," suggesting that heat loss and therefore metabolism are proportional to surface area for a species. Surface area is altered considerably by changes in posture, however. Bedded animals expose less surface area to the atmosphere than standing ones as some body parts are in contact with other body parts when the animal curls up, and a portion of the trunk is in contact with the substrate. The magnitude of such changes for individuals is great; a surface area:metabolism "law" cannot be taken seriously. Knowledge of surface areas is necessary for the prediction of heat loss from individuals, however, so considerations of different methods of measurement are important.

Surface areas have not been determined for most species of wild ruminants so estimations must often be made from data on other species. The relationships between surface areas and weights of domestic cattle, for example, may be used to derive first approximations for bison and moose, and equations for white-tailed deer may be used to derive first approximations for mule deer and possibly other smaller wild ruminants. When the accuracy of such estimations becomes a limiting factor in analyses of relationships, then measurements on the species being evaluated should be made.

Surface areas may be estimated in several ways. Skins may be removed, laid out flat and measured directly, or indirectly by tracing their outlines on sheets of polyethelene of known weight per unit area and then weighing the polyethelene facsimile. This technique poses a problem with stretching of the skin when it is laid out. Surface areas may be measured with instruments that totalize area as they are rolled across the animal's surface. The instruments may be accurate, but wild animals do not stand still do so the areas measured are not easily defined. Three-dimensional photography has a lot of potential, but the technique is difficult and expensive to use.

A fairly quick way to estimate the surface area of wild ruminants is by considering them as a collection of cylinders, cones, and curved plates, and measuring the dimensions of these. A cylinder, for example, is a fair representation of the trunk. The head is shaped somewhat like the frustum of a cone, and the ears are curved plates. The upper parts of the legs are frustums of cones, and the lower parts may be considered cylinders. These measurements can be made quickly on dead animals lying in a lateral position. Inexpensive plastic-coated metric tapes are readily available in department and variety stores.

The lengths, widths, and circumferences marked on the silhoutte in UNIT 2.1 are used to calculate surface areas of body parts with equations for cylinders, frustums of cones, and curved surfaces by using the formulas given at the end of this UNIT. The areas of body parts may then be considered as dependent variables and weight as the independent variable and equations for surface areas of body parts in relation to weight determined by curve-fitting. The total surface area is the sum the of the surface areas of the parts. Total surface areas may be considered as the dependent variable and weights as the independent variable when determining a single equation by curve-fitting.

The formulas from Moen (1973:436) for calculating surface areas in square meters from measurements in cm indicated in UNIT 2.1 are:

Body Parts	Formulas for Surface Areas
Face, muzzle area	$AFMM = [(C_1 + C_2)L_1]/2$
Head	$AHEM = [(C_2 + C_3)L_2]/2$
Neck	$ANEM = [(C_3 + C_4)L_3]/2$
Ear	$AEAM = [3 (W_1 L_4)]/4$
Trunk	$ATRM = [(C_5 + C_6)L_5]/2$
Upper front leg	$AUFM = (C_7 + C_8)L_6$
Lower front leg	$ALFM = (C_8 + C_9)L_7$
Upper hind leg	$AUHM = (C_{10} + C_{11})L_8$
Lower hind leg	$ALHM = (C_{11} + C_{12})L_9$

LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman and Company, San Francisco. 458 pp.

REFERENCES, UNIT 2.3

SURFACE AREAS

BOOKS

type	publ	city	page	anim	kewo	auth	year
aubo	whfr	sfca	453	odvi	wildlife ecology	moen,an	1973

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	24--3	921	921	odvi/surf area, meas, tissue wt		whelan,jb; harts/	1965
NAWTA	33---	224	236	odvi energy balance in winter		moen,an	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				odhe			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ceel			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				alal			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				rata			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

bibi

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

ovca

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

ovda

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

obmo

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

oram

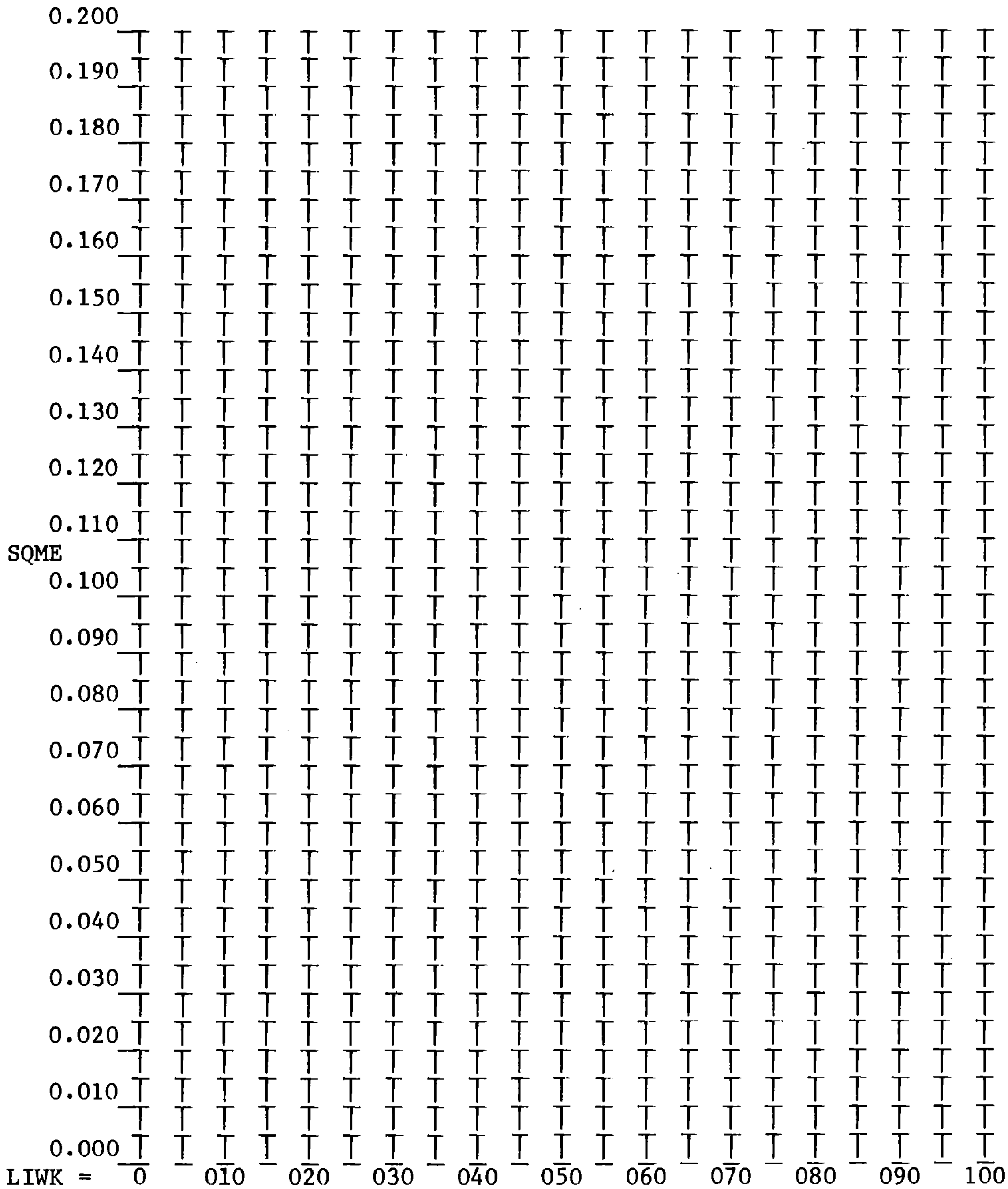
Surface areas of body parts of white-tailed deer (odvi)

Twenty-two linear measurements of several hundred white-tailed deer have been made at the Wildlife Ecology Laboratory and the equations given in UNIT 2.3 used to calculate surface areas of nine body parts. The calculated surface areas of each of these body parts have then been related to live weight in kg (LIWK) by curve-fitting (Moen 1973:437). The equations for estimating surface areas of body parts of white-tailed deer are listed below; areas are calculated in square meters (SQME).

Body Part	Equation
face, muzzle area	$AFMM = 0.0023\ (LIWK^{0.68})$
head, forehead + crown	$AHEM = 0.0083\ (LIWK^{0.57})$
neck	$ANEM = 0.0078\ (LIWK^{0.73})$
ears	$AEAM = 0.0092\ (LIWK^{0.40})$
trunk*	$ATRM = 0.0500\ (LIWK^{0.75})$
upper front legs	$AUFM = 0.0130\ (LIWK^{0.47})$
lower front legs	$ALFM = 0.0160\ (LIWK^{0.41})$
upper hind legs	$AUHM = 0.0220\ (LIWK^{0.51})$
lower hind legs	$ALHM = 0.0240\ (LIWK^{0.44})$

*Plot the area of the trunk in WORKSHEET 2.3b.

Plot and label the areas of each of the body parts on the next page.



LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman Co., San Francisco. 458 pp.

CHAPTER 1, WORKSHEET 2.3b

Total surface area of white-tailed deer (odvi)

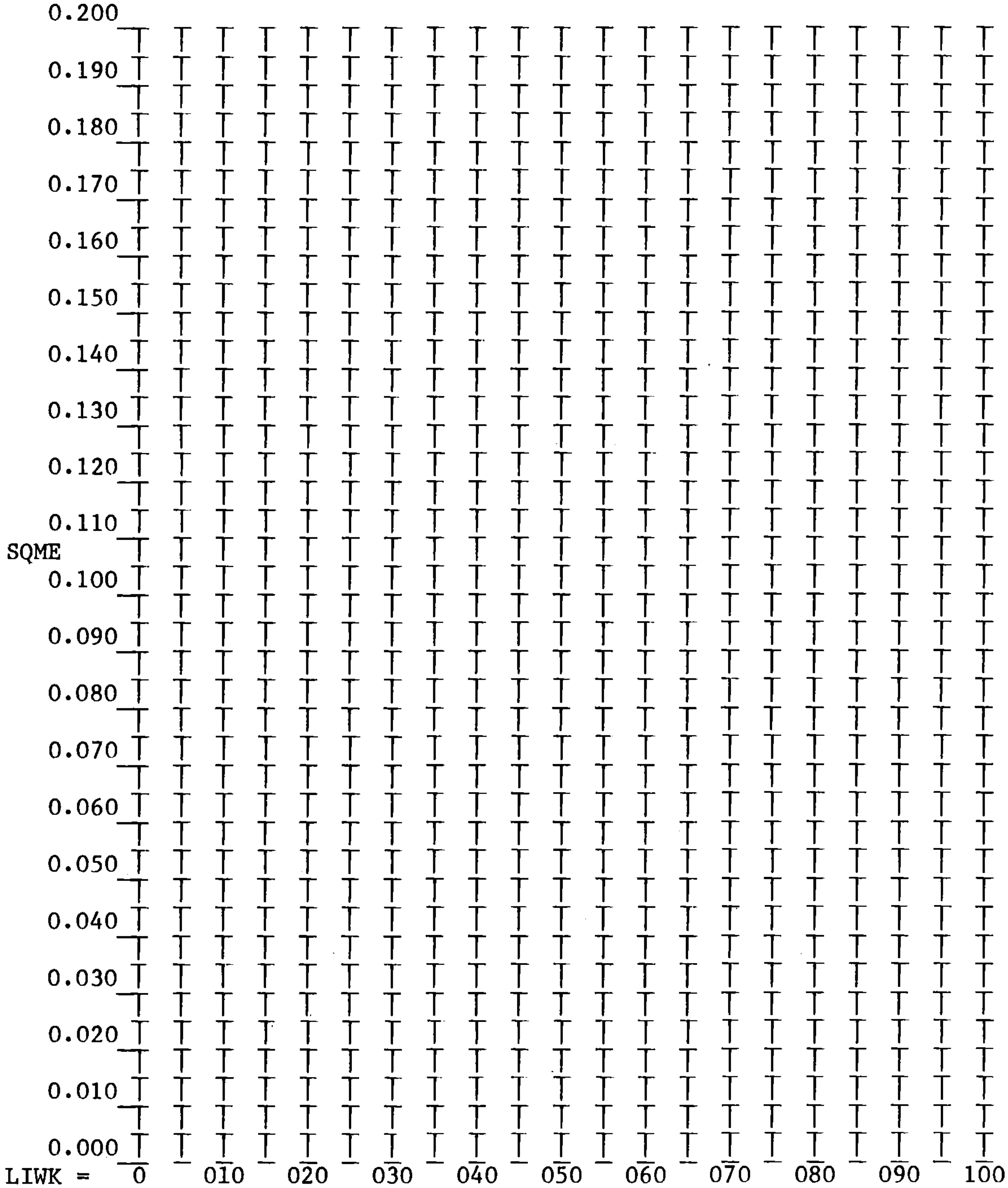
Surface areas of the nine body parts discussed in WORKSHEET 2.3a have been summed and an equation derived for calculating total surface area in meters (TSAM) in relation to live weight in kg (LIWK).

No significant differences were found between total surface area: weight relationships for male and female deer, so one equation (Moen 1973:437) is used for both sexes.

$$TSAM = 0.142\ (LIWK^{0.635})$$

Verify your use of the equation (with LIWK = 50, TSAM = 1.70 SQME, complete the table, and plot TSAM at intervals of 10 for LIWK on the next page. Also plot the area of the trunk using the equation given in WORKSHEET 2.3a

LIWK	TSAM
10	____
20	____
30	____
40	____
50	1.70
60	____
70	____
80	____
90	____
100	____



LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman Co., San Francisco. 458 pp.

CHAPTER 1, WORKSHEET 2.3c

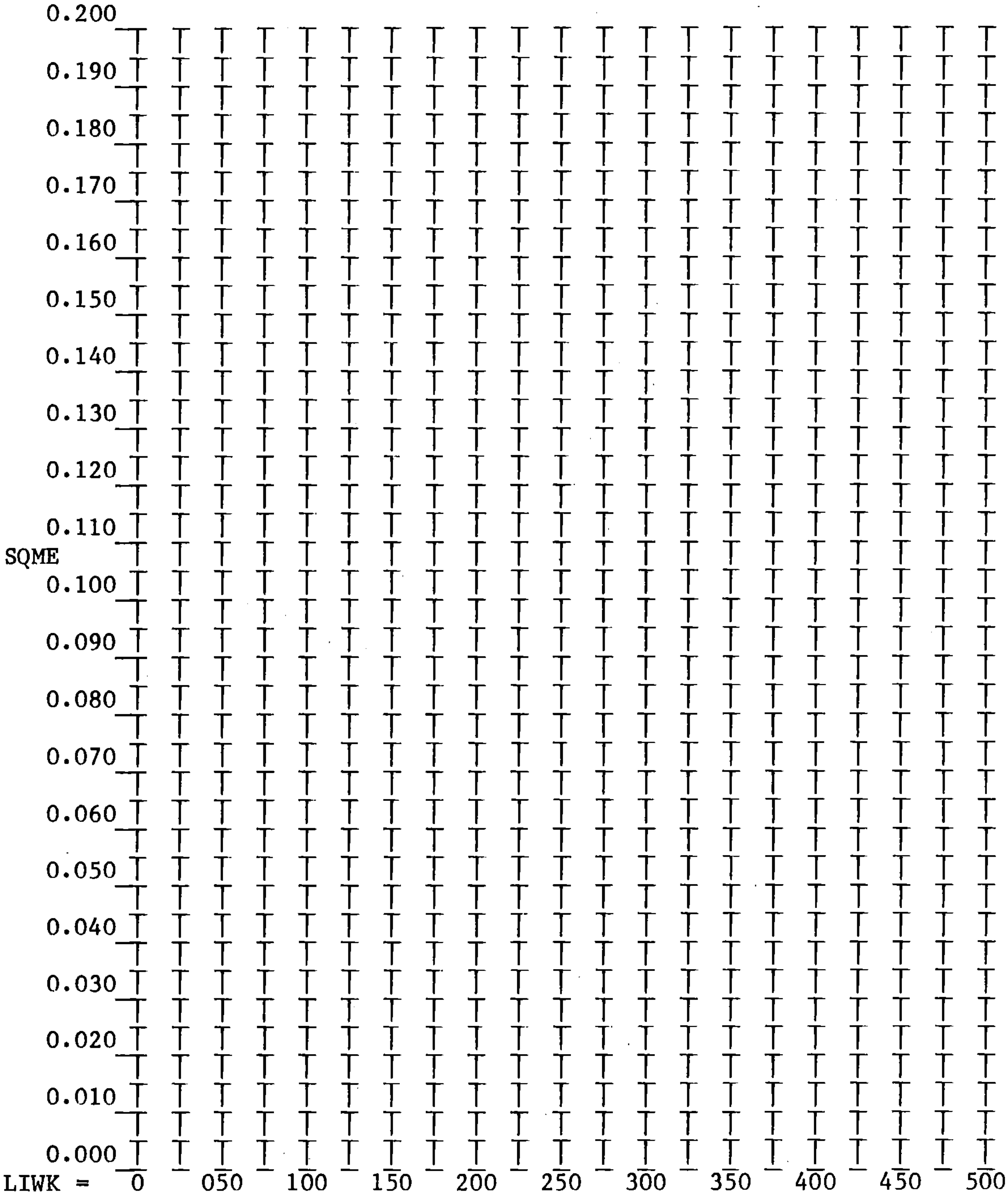
Total surface area of large ruminants

Surface area data are not available for large wild ruminants. The equation for white-tailed deer can be extropolated, or an equation in Brody (1964) derived from holstein and jersey cattle may be used as a first approximation for bison, muskox, moose, and other wild ruminants larger than the white-tailed deer.

The equation, modified from Brody (1964:359) is:

$$TSAM = 0.15\ LIWK^{0.56}$$

Plot the line resulting from the use of this equation, and then calculate TSAM (total surface area in meters) using the deer equation in WORKSHEET 2.3b, extropolating to these weights. The larger surface area calculated with the deer equation may be a reflection of the more angular body of such a small wild ruminant as a white-tailed deer compared to a large one such as a bison. The cattle equation is likely the better representation.



LITERATURE CITED

Brody, S. 1964. Bioenergetics and growth. Hafner Publishing Company, Inc., New York 1023 pp.

UNIT 2.4: BED AREAS

Animals spend parts of each day bedded on different kinds of substrates which may vary from dry leaves to wet snow. Animals assume bedded postures to conserve or dissipate energy;, changes in postures result in changes in surface areas exposed to both the atmosphere and the bed surface. The illustrations below show how different bed areas can be when an animal assumes different postures.

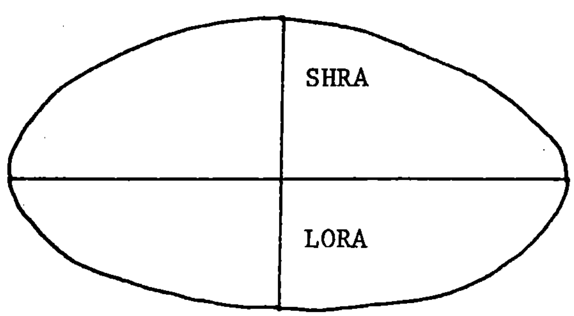
Maximum bed area

Minimum bed area

The bed area, which is part of the total surface area of an animal, is participating in conductive heat transfer to the substrate. The amount of heat dissipated in this way can be quantified when the area of the bed and the thermal characteristics of the animal: substrate interface are known. In the winter, beds are often on snow; analyses of heat loss to the snow are discussed in PART 5.

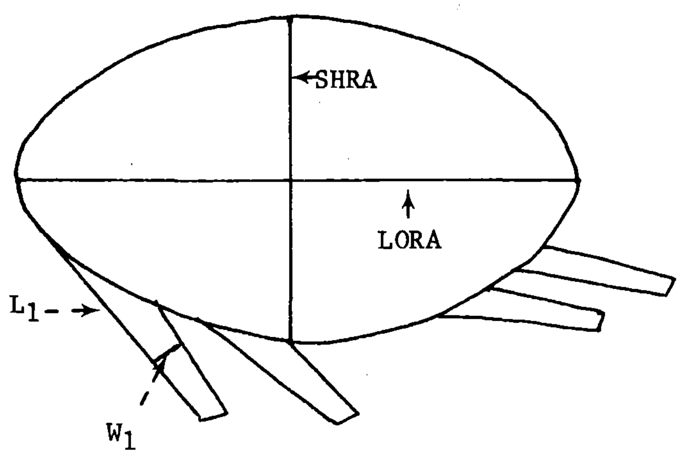
Areas of beds may be determined by direct measurement. The beds are usually somewhat elliptical, and first approximations can be made by measuring the longest radius (LORA) and shortest radius (SHRA), and calculating the bed area (BEAR) with the formula:

$$BEAR = [(LORA + SHRA)/2]^2$$



Beds with irregular shapes, such as those of animals in sprawling postures, are more difficult to measure. Extensions of the legs may be measured for their lengths and widths and the areas added to the bed area occupied by the trunk. Then, the formula for calculating BEAR is:

$$BEAR = [(LORA + SHRA)/2]^2 + L_1W_1 + \ldots L_4W_4$$



overhead view

Snow depths also add complexity to determinations of bed areas. Variations in the curvature and other bed irregularities make it difficult to measure bed dimensions precisely, but the dimensions of curved surfaces illustrated below can be measured with flexible tapes.

cross-section of a bed in the snow

Bed areas can be expressed as fractions of total surface areas, or in relation to weight. The surface area calculated may then be used in evaluating heat transfer by conduction as part of the total thermal exchange between animal species and environment. WORKSHEETS provide the format for estimating bed areas in different ways.

REFERENCES, UNIT 2.4

BED AREAS

SERIALS

CODEN vo-nu bepa enpa anim kewo auth year

odvi

CODEN vo-nu bepa enpa anim kewo auth year

odhe

CODEN vo-nu bepa enpa anim kewo auth year

ceel

CODEN vo-nu bepa enpa anim kewo auth year

alal

CODEN vo-nu bepa enpa anim kewo auth year

rata

CODEN vo-nu bepa enpa anim kewo auth year

anam

CODEN vo-nu bepa enpa anim kewo auth year

bibi

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	20--4	440	455	ovca	the bighorn sheep of texas	davis,wb; taylor,	1939

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

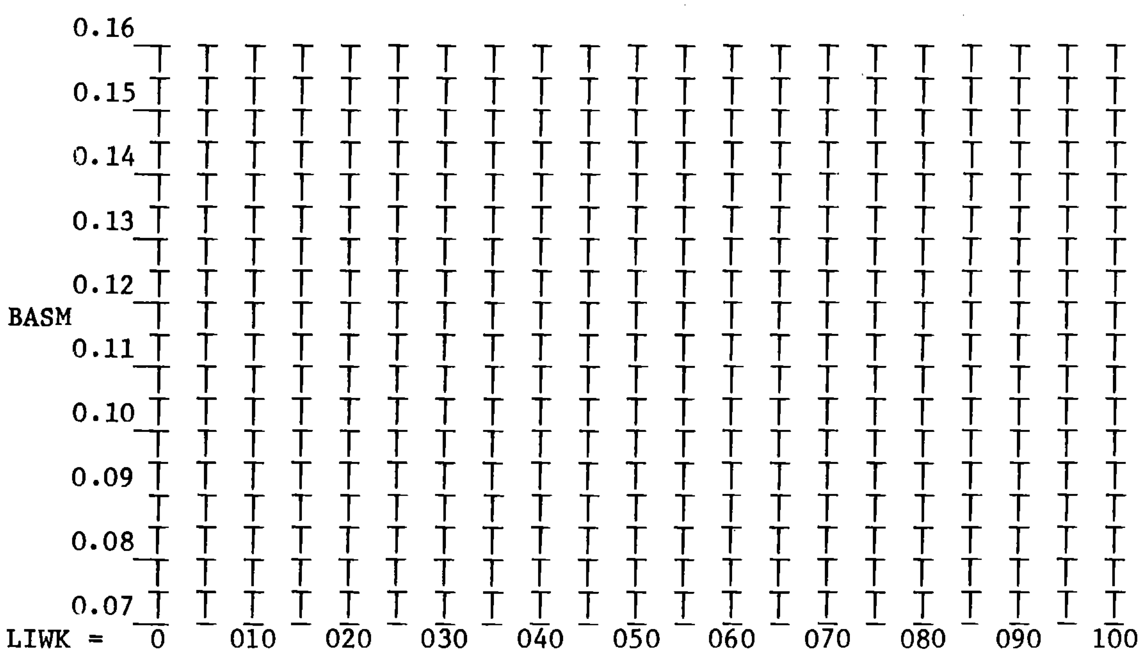
CHAPTER 1, WORKSHEET 2.4a

Bed areas of white-tailed deer (odvi)

Published data on bed areas are not available for any species of wild ruminants, yet all of them exhibit thermoregulatory behavior by altering bedded posture. First approximations must be made for bed areas when evaluating relative proportions of heat losses from animals in different bedded postures.

The white-tailed deer ratios of bed area to total surface area may be suitable for other Cervids, and may be less suitable for other wild ruminants. Bison, for example, have quite a different geometry than white-tailed deer, and the ratio of bed area to total surface area may be different. In the absence of data, however, one is forced to use what is available.

Bed areas of white-tailed deer have been estimated at the Wildlife Ecology Laboratory to be about 6.0% of the total surface area when the animal is in an open bedded posture and 4.5% when in a closed bedded posture. Using the calculations of TSAM in WORKSHEET 2.3b, determine the areas of beds of deer in open and closed bedded postures and plot below. (BASM = bed area in square meters.)



TOPIC 3. SYSTEMS CHARACTERISTICS

Systems of the body have specific biological functions, and their physical characteristics are of particular interest when evaluating these functions in the ecological context.

Anatomical measurements become very useful for interpreting functional capabilities of an animal. These interpretations are essential for an understanding of the animal-environment relationships that exist in natural habitats.

Volumes of the different parts of systems are important considerations in the overall ecology of animals because volumetric constraints may limit the availability of some resources. Ingested forage is processed in the gastrointestinal tract where nutrients are released for transport by the cardiovascular system and synthesis into new body tissue. The volume of the stomach limits the amount of food that can be ingested during a feeding period, which limits the amount of nutrients available for processing before the next feeding period. The volume of the heart, considered in relation to the frequency of the heartbeat, limits the amount of nutrient-carrying blood that can be pumped. There is a limit to the amount of blood present in the vascular system of an animal also. Since blood carries both nutrients and oxygen to different tissues for metabolism, characteristics of both gastrointestinal and cardiovascular systems are of interest when calculating metabolic characeristics in different environmental conditions.

There are many general relationships between the sizes and weights of animals and the sizes, weights, and volumes of different organs in the different systems. These relationships change through time as growth occurs and may limit the amounts or rates of biological activities of importance to animals at different times in their life cycles. The relative sizes of the four compartments of the stomach, for example, change as the nursing animal ingests greater amounts of forage. The rumen and reticulum are undeveloped at birth, but end up to be about 85% of the total volume of the stomach as a fully functional ruminant. The capacity of the rumen and reticulum represents an upper limit to the amount of forage that can be ingested, an important consideration when low-quality forage is being ingested that may not contain enough nutrients to supply a growing animal's needs.

Similar evaluations of biological limits can be made for the organs of the cardiovascular system. The capacity of the heart to pump blood and of the lungs to exchange oxygen and carbon dioxide provide upper limits to the intensity and duration of physical activity. Knowledge of the rates of movement of blood through the cardiovascular system and ingesta through the digestive system, as well as transfer rates through absorption membranes, helps one understand the metabolic limits of animals.

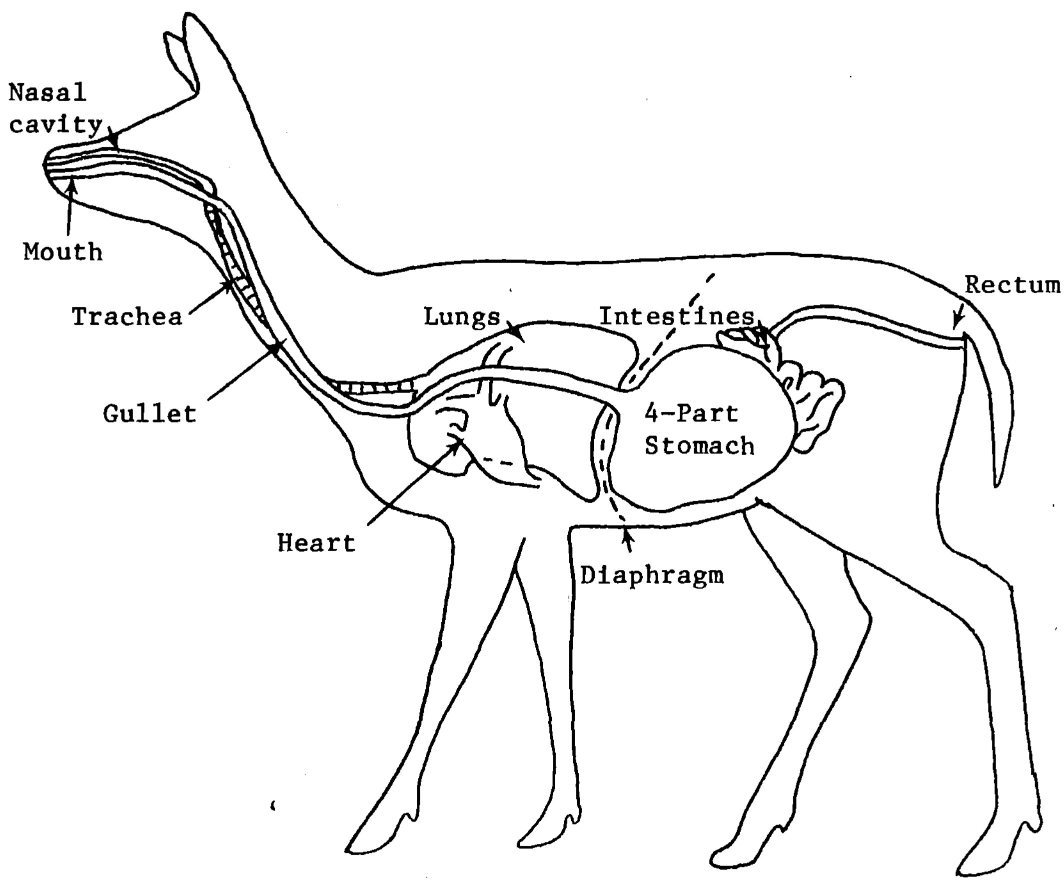
The systems characteristics of wild ruminants are of considerable interest because these animals live under very different conditions, ranging from the arid areas of the southwest part of the United States to the cold interior of Alaska and Canada. Some of them--deer for example--are quite similar in weight to humans. Some--bison--are similar in weight to domestic cattle. Are these wild ruminants more hardy than other mammals of similar weights? Do they have cardiovascular adaptations that make them uniquely capable of thriving under varied conditions of climate and altitude? White-tailed deer have a well-developed carciovscular system, with a heart that is generally larger per unit body weight than that of humans which fall in the same weight range. How ecologically significant is this?

Skeletal characteristics are used by mammalogists for comparative purposes in taxonomic studies, and by ecologists and wildlife managers for sex and age determinations in population studies.

Physical characteristics of the systems discussed above plus discussion of the respiratory, endocrine, reproductive, excretory, muscular, and nervous systems follow in the next eight UNITS. Data describing systems characteristics are generally scattered between species and geographical areas. The relationships evaluated in the WORKSHEETS may be used in later analyses when ecological or management-related questions are being considered.

UNIT 3.1: GASTROINTESTINAL SYSTEM CHARACTERISTICS

The alimentary canal of herbivorous animals has a relatively larger capacity than that of carnivorous animals. This increased capacity permits the extensive fermentation necessary for the break-down by microorganisms of bulky, fibrous plant materials ingested by the host. Carnivores, on the other hand, have shorter digestive tracts in which to digest their food. The differences in the sizes of the alimentary canals of herbivores and carnivores are possible because the former ingest mainly plant food with its thick and certainly complex (from a molecular point of view) cell walls. Carnivore diets, on the other hand, include mainly animal tissue with thin cell membranes, resulting in a fairly rapid breakdown of, for example, protein into amino acids.



The main organs of the gastrointestinal tract of wild ruminants (based on Cheatum, undated Information Leaflet, N.Y. State Conservation Department) are the four-part stomach, small intestine, large intestine (colon), and rectum. These are part of the alimentary canal, which also includes the mouth and esophagus. The four-part stomach is unique to ruminants, and includes, in order of food passage, the rumen, reticulum, omasum, and abomasum. The first three develop as diverticula from the embryonic abomasum, or true stomach.

The relative sizes and positions of these compartments are not constant throughout the life of a ruminant animal (Short 1964; 454). In the newborn, the abomasum or true stomach is larger than the other three parts, and it is not until the age of 1 to 2 months that the volume relationships between the omasum plus abomasum and the rumen-reticulum is reversed. After that time, the rumen increases in size and eventually comprises over 80% of the total stomach capacity (Moen 1973).

When the newborn ruminant is drinking, the milk or water does not go into the rumen, but is diverted directly to the orifice between the reticulum and the omasum through the esophageal groove (Swenson 1970:430). Thus the milk goes directly into the omasum and then to the abomasum where it is digested and absorbed. This diversion results from a reflex action in the young ruminant that gradually disappears as the animal matures.

Rumen development coincides with the increased ingestion of plant materials. Plant materials, which the newborn ruminant begins to eat a few days after birth, go to the rumen where populations of micro-organisms build up as the rumen develops.

The physical development of the alimentary canal of wild ruminants is important because it represents finite limits to the amount of food that the animal can ingest, and this limit extends to the actual amount of potential or gross energy available for metabolic purposes. Variations in the potential or gross energy of foods will be discussed later. There is also variation in the time it takes for breakdown of the food materials, or i.e., turnover times. Thus the physical characteristics of the ruminant alimentary canal are the structural components of a dynamic system of energy intake and output, accomplished in the ruminant with the assistance of microorganisms who form a metabolic system of their own.

Volume and weight characteristics of the organs of the gastrointestinal tract are considered in this UNIT. Volumes are used to evaluate the amounts of forage that can be needed for digestion each day. Weights are used to evaluate live weight: dressed weight relationships, along with weights of other organs.

Stomach volume:body weight relationships of wild ruminants are important when evaluating energy relationships for growth, maintenance, and survival during winter stress, reproductive capabilities, and other productive functions. Animals with greater rumen capacities may be more likely to survive periods of stress than animals with less capacity. Greater capacity provides a larger reserve of food material in the rumen at the onset of a stress period, such as deep snow in the winter, and animals with larger capacities may be able to regain lost energy more quickly.

Differences in the stomach capacity of age classes within a species are of ecological significance, too. Short (1964) points out that the relatively small stomach capacity of deer fawns may be an important factor in winter mortality. The browse diet characteristic of deer in the winter in forested areas may not be digested rapidly enough to satisfy the metabolic rate necessary to maintain body temperature during periods of cold weather. This relationship and other characteristics of the social and thermal energy relationships of fawns with their environment are discussed in detail in later chapters; there are many factors operating against the smaller deer during times of stress.

The accuracy of predictions of forage intake may be checked by comparing intake with the capacities of parts of the gastrointestial tracts. If it takes two days for ingesta to be processed and pass through the rumen, for example, the capacity of the rumen must be at least two times the volume of daily forage intake. This relationships is so important, especially for animals on poor range, that serious efforts should be made to get good estimates of forage intake, live weight: rumen-reticulum volume relationships, and rates of passage of ingesta through the stomach compartments for all species of wild ruminants.

Rumen and reticulum volumes. Relationships between the live weight of an animal and the volume of its rumen and reticulum is especially important since this volume is the space available for ingesta. Finer particles, masticated and partially digested, are continually moving out of this space to be replaced by more recently-ingested forage. Particularly fibrous ingesta, mechanically resistant to breakdown into smaller particles, accumulates in the rumen, and may depressing appetite and inhibiting further ingestion. Such low quality material may take up more space than it is worth nutritionally, and this definitely affects the well-being of an animal. Such conditions develop most often in late winter when only poorly digested forage is available.

Omasum and abomasum volumes. The bulk of the ingesta has been much reduced by the time it gets to the omasum and abomasum as a result of the physical and chemical action in the rumen and reticulum. Water absorption in the omasum reduces the mass of ingested material to a rather solid mixture of fine particles. Thus, the volumes of these last two compartments may be less than the volumes of the first two. It is not known whether omasum and abomasum volumes limit intake by a "damming up" effect, but that likely does not occur.

Relative volumes of the four compartments of the ruminant stomach change with age as milk makes up a decreasing part and forage makes up an increasing part of the diet. The changing proportions can be expressed with equations and volumes calculated for any AGDA during the suckling period. The best data are available for white-tailed deer; equations may be derived for other species that are based on the assumption that development from birth to weaning is parallel in other speceis over the entire length of the suckling period.

The WORKSHEETS that follow the list of REFERENCES provide opportunities for expressing these important physical relationships numerically, and the equations will be used later when evaluating live weight: field-dressed weight relationships, predictions of forage consumed based on animal requirements, and other relationships of importance ecologically.

LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman Co., San Francisco, pp. 160-161.

Short, H. L. 1964. Postnatal stomach development of white-tailed deer. J. Wildl. Manage. 28(3): 445-458.

Swenson, M. J., Ed. 1970. Duke's Physilogy of domestic animals. Cornell University Press, Ithaca, N.Y. 1463 pp.

REFERENCES, UNIT 3.1

GASTROINTESTINAL TRACT CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
MAMLA	38--2	295	314	arti	stomach evol, artiodactyla	langer,p	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CPSCA	7---4	217	218	odvi*	organ:body weight relation	robinson,pf	1966
JANSA	38--4	871	876	odvi*	body composition of white-	robbins,ct; moen/	1974
JOMAA	31--1	5	17	odvi*	weight relations, georg re	hamerstrom,fm,jr/	1950
JWMAA	28--3	445	458	odvi*	postnatal stomach developm	short,hl	1964

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	36--3	474	476	odhe	alimentary canal ph values	browman,lg sears,	1955
JOMAA	46--2	196	199	odhe*	ruminoreticular characteri	short,hl; medin,/	1965
JOMAA	52--3	628	630	odhe*	tiss, organs, tot body mas	hakonson,te; whic	1971
WAEBA	589--	1	6	odhe	the mule deer carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	15---	253	268	ceel	relatio, age, size, poland	dzieciolowski,r	1970
JOMAA	27--4	308	323	ceel	mammals of northern idaho	rust,hg	1946
JWMAA	35--4	673	680	ceel	rumen characteristi, red d	prins,ra; geelen,	1971
JWMAA	39--3	621	624	ceel	compar digestiv organ size	nagy,jg; regelin,	1975
WAEBA	594--	1	8	ceel	the elk carcass	field,ra; smith,/	1973
ZEJAA	4---4	169	171	ceel	[capaci, parts of dig tra]	gill,j; jaczewski	1958
ZSAEA	41--3	167	193	ceel/	[caca forestom mucos anat]	hofmann,rr; geig/	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				alal			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVSPA	57---	1	18	rata	topograph, internal organs	engebretsen,rh	1975
NJZOA	24--4	407	417	rata*	morph,fat stor,org wei,win	krog,j; wika,m; /	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
WAEBA	575--	1	6	anam	the pronghorn carcass	field,ra; smith,/	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				bibi			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	13---	499	509	bibo	capac, weigh, walls, diges	gill,j	1968
ATRLA	14---	349	402	bibo	morphology digestive tract	pytel,sm	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	34--4	887	903		repro, grow, resid, dieldr	murphy,da; korsch	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	35--4	673	680	caca	rumen characteristi, red d	prins,ra; geelen,	1971
JWMAA	39--3	621	624	caca	compar digestiv organ size	nagy,jg; regelin,	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	35--4	673	680	dada	rumen characteristi, red d	prins,ra; geelen,	1971
JWMAA	39--3	621	624	dada	compar digestiv organ size	nagy,jg; regelin,	1975

CHAPTER 1, WORKSHEET 3.1a

Rumen and reticulum volumes of white-tailed deer (odvi)

Rumen and reticulum volumes in cubic centimeters (RRVC) and omasum and abomasum volumes in cubic centimeters (OAVC) are expressed as linear regression equations in Moen (1973; 142) based on data in Short (1964). The equations are:

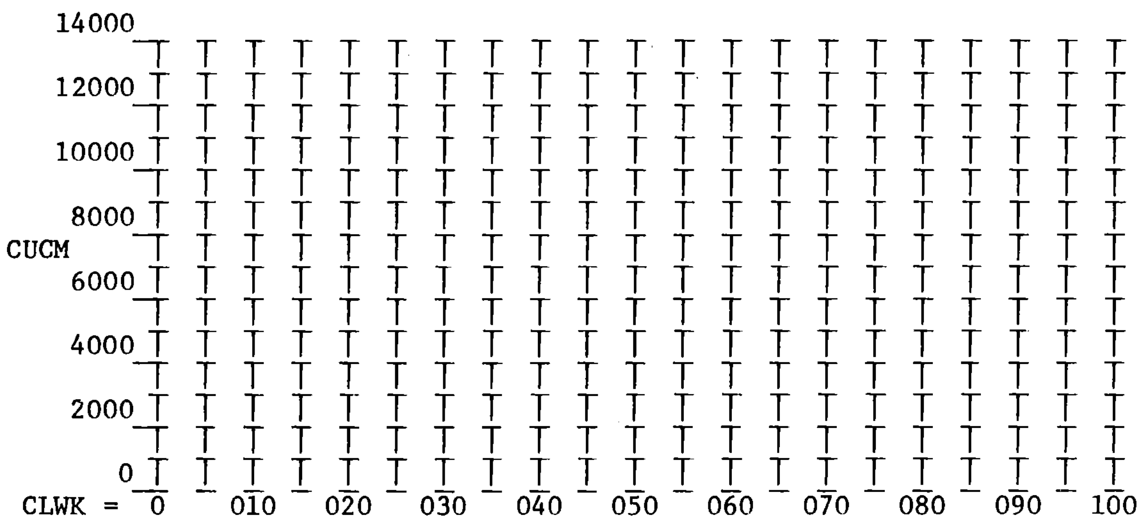
RRVC = 103.35 CLWK + 304.64

OAVC = 11.75 CLWK + 514.64

The total volume of all four stomach compartments in cubic centimeters (TVSC) is the sum of these two equations:

TVSC = 115.10 CLWK + 819.28

Calculate these relationships and plot the three lines. Volumes are expressed in cubic centimeters (CUCM).



LITERATURE CITED

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman Co., San Francisco. 458 pp.

Short, H. L. 1964. Postnatal stomach development of white-tailed deer. J. Wildl. Manage. 28(3):445-458.

CHAPTER 1, WORKSHEET 3.1b

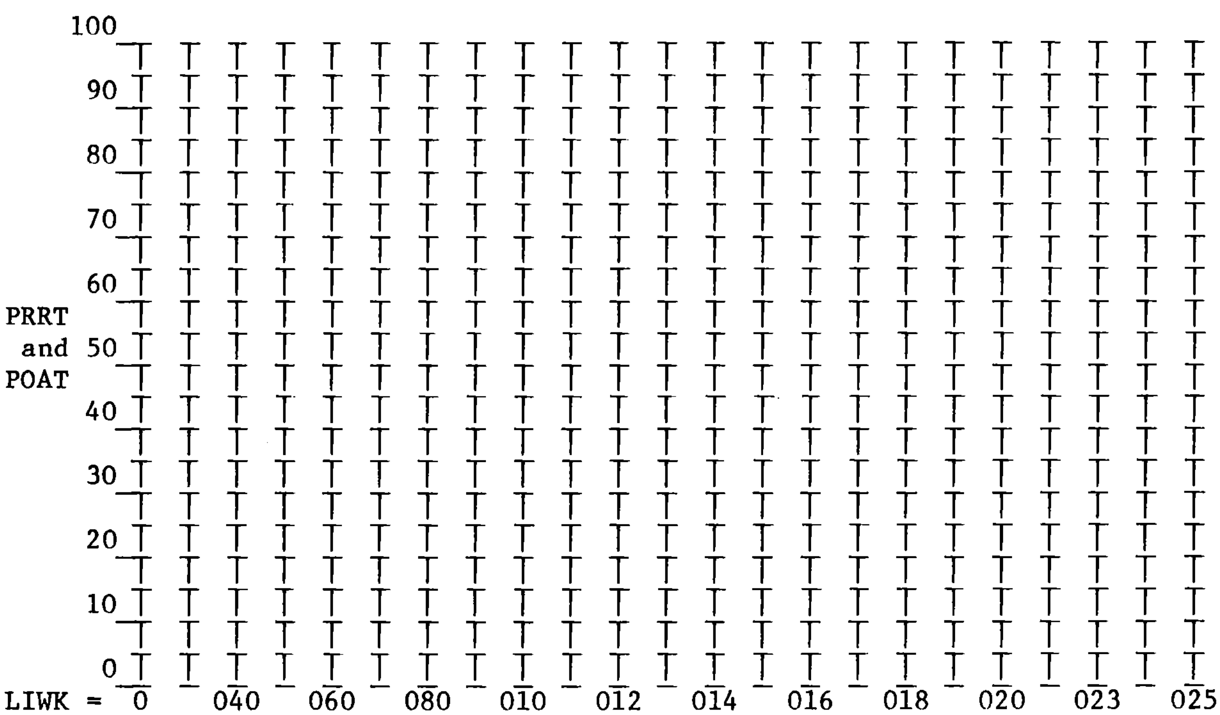
Relative proportions of the stomach compartments of white-tailed deer (odvi) during the suckling periods

Absolute volumes of the different stomach compartments are unique to each species. If development of the different compartments is proportional for different species, then an equation expressing relative proportions in relation to body weight for one species may be transferred for use with other species. The equation in Moen (1973:143) expressing the percent of the total stomach volume attributed to the rumen and reticulum (PRRT) for white-tailed deer is:

$$PRRT = 37.635 \ln LIWK - 35.666$$

The percent of the total volume attributed to the omasum and abomasum (POAT) = 100 - PRRT.

The percent reaches its biological limit for white-tailed deer when CLWK = 25 kg, which is about weaning weight. Plot these relative relationships below.



LITERATURE CITED

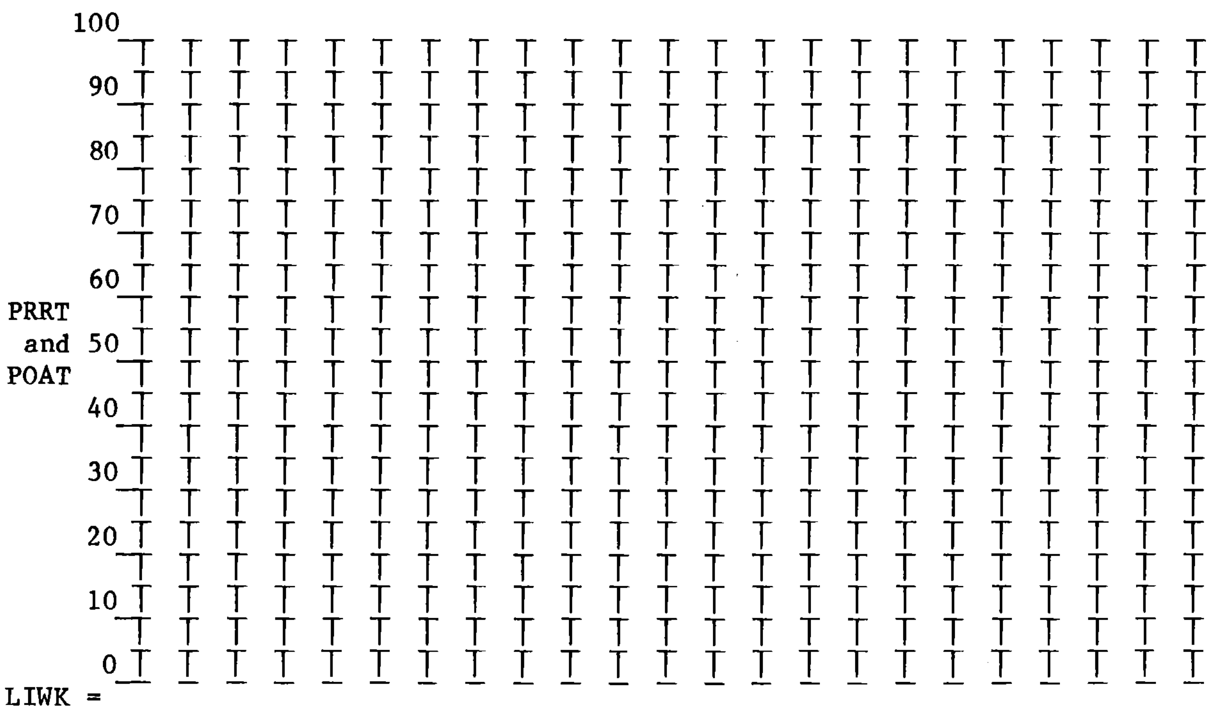
Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman Co., San Francisco. 458 pp.

Relative proportions of the stomach compartments of wild ruminants during the suckling period

If stomach development of other species of wild ruminants is proportional to that of white-tailed deer from birth to weaning, the equation in WS3.1b can be modified for use with any species if weaning weight in kg (WEWK) and the live weight of the nursing young (LIWK) are known. The equation is:

$$PRRT = 37.635 \ln [(25/WEWK)] LIWK - 35.666$$

Label the x-axis for LIWK in the graph below to include the range of weights from birth to weaning of the species selected and plot the approximations of PRRT for these species.



UNIT 3.2: CARDIOVASCULAR SYSTEM CHARACTERISTICS

The cardiovascular system includes the heart, blood vessels, blood, and spleen. The heart pumps the blood through the blood vessels, the blood carries oxygen and nutrients to body cells and waste metabolites away from the cells, and the spleen is a storage organ for red blood cells.

The physical characteristics of the cardiovascular system are of interest because they limit the amounts of the nutrients and respiratory gas involved in metabolism. Cardiac volumes limit the amount of oxygen- and nutrient-carrying blood that can be pumped to the sites of metabolism. Further, the pumping capacity of the heart has a direct bearing on an animal's ability to escape predators and to withstand stressful thermal conditions. These functions may be rate-limited due to limitations to heart and blood volume which, in turn, place limits on nutrient and oxygen transport. Little is known about cardiovascular anatomy and physiology of wild ruminants, however; such research is technically difficult and very expensive.

Heart volume is an important parameter when evaluating heart rates, because it is the stroke volume, a function of the physical size of the heart, and the beat frequency that determines the circulating blood volume.

Blood volumes are an important consideration when evaluating the capabilities of an animal for reacting to stressful situations. Packed cell volumes are sometimes measured in addition to total blood volumes; red cells have important roles in oxygen transport.

It is useful to express heart weights in relation to live weights, ingesta-free weights, and metabolic weights when evaluating cardiac characteristics of a range of weights in a population. In general, larger animals have larger hearts and slower heart rates, which indicates that stroke volumes must also be greater. There are few data on the cardiovascular characteristics of different species, so first approximations have to be made from general relationships between weight and organ characteristics when evaluating the cardiovascular system of the different species of wild ruminants. For some species, the only data available are for groups of organs removed in field-dressing, such as the heart, lungs, and liver. Weights of individual organs may have to be determined by subtracting single organ weights from combined weights. This can be done using data on individual organs from different species, expressing weights of individual organs in relation to body weights and applying the results to other species on the basis of similar proportions between different species.

The format for tabulating heart weights in gms (HEWG) in relation to live (LIWK), ingesta-free (IFWK), and metabolic weights in kg (MEWK = $IFWK^{0.75}$ is shown below. Curve-fitting of linear, exponential, logarithmic, and power curves results in identification of the best fit for numerical representation of this relationship. Similar tabulations may be made for blood weights in gms (BLWG).

	Independent variables			Dependent variables	
	LIWK	IFWK	MEWK	HEWG	BLWG
1.	____	____	____	____	____
2.	____	____	____	____	____
.					
.					
N.	____	____	____	____	____

Reasonable estimates of blood weights can be used to estimate blood volume by multiplying weight by the specific gravity of the blood. Blood volumes may be used to estimate blood weights too, of course.

Similarities and proportional results are certainly to be expected when body weights and heart and blood weights are determined. Brody (1964:596) noted that "athletic" land animals had relatively larger hearts than non-athletic and marine animals. Since wild ruminants have coexisted with swift carnivorous predators, they must be in the "athletic" group, and larger hearts, proportional to body weights might be expected.

LITERATURE CITED

Brody, S. 1974. Bioenergetics and growth. Hafner Publishing Company, N.Y. 1064 pp.

REFERENCES, UNIT 3.2

CARDIOVASCULAR SYSTEM CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ABBIA	127--	711	717	odvi	hemoglobin heterogeneity	huisman,thj; doz/	1968
ABBIA	151-2	540	548	odvi	struct, hemogl alph chains	harris,mj; wilso/	1972
ACBCA	33---	335	343	odvi	struct sickl deer type III	schmidt,wc,jr; g/	1977
AHEMA	3----	250	261	odvi	maj arteries, shoulder,arm	bisaillon,a	1974
AJPHA	199--	190	192	odvi	tactoid forma, hemoglobin	moon,jh	1960
AJVRA	30--1	143	148	odvi	serum prot, normal, arthri	sikes,d; hayes,f/	1969
AJVRA	33-12	2545	2549	odvi	blood seru, arthrit reumat	sikes,d; kistner/	1972
AKASA	30---	50	51	odvi	electroph pattern, 2 subsp	jackman,gs; garne	1976
ANYAA	241--	594	604	odvi	sickling phenomona of deer	taylor,wj; easley	1974
ANYAA	241--	614	622	odvi	compar sickle eryth, human	simpson,cf; taylo	1974
ANYAA	241--	653	671	odvi	dome,embryo, fetal hemoglo	kitchen,h; brett,	1974
BLOOA	29--6	867	877	odvi	hemoglobin polymorphism in	kitchen,h; putna/	1967
BLOOA	43--6	899	906	odvi	ultrastruc sickl erythrocy	simpson,cf; taylo	1974
BLOOA	43--6	907	914	odvi	ultrastr sickl erythr pt 2	taylor,wj; simpso	1974
BUCDA	29--2	105	105	odvi	geogr dist, hemoglo compon	harris,mjw	1971
CBCPA	19--2	471	473	odvi	red cell life span, w-t de	noyes,wd; kitchen	1966
CBPAB	30--4	695	713	odvi/	hemat, bloo chem prot poly	seal,us; erickson	1969
CBPAB	58a--	387	391	odvi	short-term chan, corti, in	bubenik,ga; bube/	1977
CJCMA	34--1	66	71	odvi	ser biochem, hemat par cap	tumbleson,me; cu/	1970
CJZOA	44--4	631	647	odvi	odhe var, blood ser, elect	van tets,p; cowan	1966
CJZOA	53--6	679	685	odvi/	amb temp eff, physio trait	holter,jb; urban/	1975
CPSCA	7---4	217	218	odvi*	organ:body weight relation	robinson,pf	1966
EXMPA	2---2	173	182	odvi	mechan, sickl erythrocytes	pritchard,wr; ma/	1963
JBCHA	247--	7320	7324	odvi	heterog, hemogl alpha chai	taylor,wj; easle/	1972

odvi continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	31--1	5	17	odvi*	weight relations, georg re	hamerstrom,fm,jr/	1950
JOMAA	39--2	269	274	odvi	blood composition of w-t d	teeri,ae; vircho/	1958
JOMAA	39--2	309	311	odvi	aspects of blood chemistry	wilbur,cg; robin/	1958
JOMAA	49--4	749	754	odvi	hematologica volumes, mich	johnson,he; youa/	1968
JOMAA	54--1	270	274	odvi	geograph dist, hemoglo var	harris,mj; huism/	1973
JOPAA	59--6	1091	1098	odvi	hematol chan, fawns, ticks	barker,rw; hoch,/	1973
JWIDA	9---4	342	348	odvi	combin etorphine, xylazine	presidente,pja;/	1973
JWIDA	10---	18	24	odvi	blood char, free-rang, tex	white,m; cook,rs	1974
JWMAA	29--1	79	84	odvi/	comp blood, nurs doe, fawn	youatt,wg; verm/	1965
JWMAA	36--4	1034	1040	odvi	eff immobil, blood analyse	seal,us; ozoga,/	1972
JWMAA	36--4	1041	1052	odvi	nutri eff, thyroi act, blo	seal,us; ozoga,/	1972
JWMAA	38--4	845	847	odvi	restrain appar, blood samp	mautz,ww; davis/	1974
JWMAA	39--2	342	345	odvi	ser cholest lev chan, mich	coblentz,be	1975
JWMAA	39--2	346	354	odvi*	chan blood prot, ges, suck	hartsook,ew; wh/	1975
JWMAA	39--4	692	698	odvi	energ, prot, blood urea ni	kirkpatrick,rl;/	1975
JWMAA	40--3	442	446	odvi	plas progest, pubert, fawn	abler,wa; buckl/	1976
MGQPA	32	113	138	odvi	physiol baselines, hematol	karns,pd	1972
NAWTA	3----	890	892	odvi	enlarg spleen, glac nat pa	aiton,jf	1938
PSEBA	117--	276	280	odvi	sickling, heteroge, hemogl	weisbergen,as	1964
SCIEA	144--	1237	1239	odvi	hemoglob polymor, sickling	kitchen,h; putn/	1964
TJSCA	27	155	161	odvi	var,corr, os cordis, heart	long,ca; smart,d	1976
VJSCA	26--2	61	61	odvi	immobi drug, pack cell vol	wesson,ja III; s	1975
WDABB	3---1	32	34	odvi	serolog surv, 2 herds n y	friend,j; halter	1967

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	34--5	477	484	odhe	age, nutrition, blood chem	kitts,wd; bandy/	1956
CJZOA	35--2	283	289	odhe	age, nutrition, blood chem	bandy, pj; kitt/	1957
CJZOA	47--5	1021	1024	odhe	observa haematology, races	cowan,imct; band	1969
JANSA	33--1	244	244	odhe/	plasma mineral indexes,nev	rohwer,gl; lesp/	1971
JANSA	34--5	896	896	odhe/	lipid, plas comp lev, neva	lesperance,al; /	1972
JANSA	38--6	1331	1332	odhe	blood compon, seas, wt, fe	o'brien,jm; les/	1974
JOMAA	36--3	474	476	odhe	erythrocyte val, mule deer	browman,lg; sear	1955
JOMAA	52--3	628	630	odhe*	tiss, organs, tota body ma	hakonson,te; whi	1971
JOMAA	53--2	384	387	odhe*	total serum protein in pop	anderson,ae; me/	1972
JWIDA	8---2	183	190	odhe/	blood serum electrol, colo	anderson,ae; med	1972
JWMAA	34--2	389	406	odhe	erythrocyte, leukocy, colo	anderson,ae; me/	1970

odhe continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
NAWTA	17---	482	496	odhe	rel hematol, condit, calif	rosen,mnj; bisch	1952
PCZOA	2--10	46	46	odhe	chang, plas lipid thr year	stewart,sf; nor/	1963
WLMOA	39---	1	122	odhe*	carcas, bone, organ, gland	anderson,ae; me/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	15---	253	268	ceel/	relat age and size, poland	dziecioloski,r	1970
CBPAB	43a-3	649	653	ceel	blood chemis roosevelt elk	weber,yb; bliss,	1972
JOMAA	27--4	308	323	ceel	mammals of northern idaho	rust,hg	1946
JOMAA	49--4	762	764	ceel	physiol stud, rocky mounta	herin,ra	1968
JOMAA	53--4	917	919	ceel	sickling phenom, erythrocy	weber,yb; giacom	1972
ZEJAA	4---4	171	177	ceel	[regulation of blood pres]	jaczewski,z; ja/	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ANYAA	97--1	296	305	alal	studi, blood, serum groups	braend,m	1962
CJZOA	53--/	1424	1426	alal	serum cortic, handl stress	franzmann,aw; f/	1975
HEREA	85--2	157	162	alal	var, red cell enzy, scandi	ryman,n; beckma/	1977
JEBPA	12--4	347	349	alal/	rata, card comp emot stres	roshchevskii,mp/	1976
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946
JOMAA	50--4	826		alal	blood chemis, shiras moose	houston,db	1969
VEZOA	69--3	13	18	alal	[venous syst, pector limb]	komarov,av	1969
VEZOA	71--4	31	38	alal	[venous syst, thorac limb]	komarov,av	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
APSSA	396--	96	96	rata	blood circulation, finnish	hirvonen,l; jar/	1973
AVSPA	57---	1	18	rata	topograph, internal organs	engebretsen,rh	1975
CJZOA	44--2	235	240	rata	electroly, red cells, plas	manery,jf; barl/	1966
CJZOA	46--5	1031	1036	rata	hematologi studies, bar-gr	mcewan,eh	1968
CJZOA	47--4	557	562	rata*	changes in blood with age	mcewan,eh; white	1969
CJZOA	50--1	107	116	rata*	seas changes, blood volume	cameron,rd; luic	1972
CNJMA	24--5	150	152	rata	haematol val, bar grou car	gibbs,hc	1960
NJZOA	24--4	407	417	rata/	morpho, fat stor, organ wt	krog,j; wika,m	1976
ZOLZA	57--6	944	948	rata	[dev phys char, 1st month]	segal,an	1978

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BIGEB	9---1	1	11	bibi	two hemoglobin phenotypes	harris,mj; wils/	1973
EVOLA	12--1	102	110	bibi	studies on blood groups	owen,rd; stormon	1958
GENTA	61	823	831	bibi	electroph forms, carb anhy	sartore,g; stor/	1969
JWIDA	11--1	97	100	bibi	hematol, blood chemi, kans	marler,rj	1975
JWIDA	12--1	7	13	bibi	hematolo val, 5 areas, u s	mehrer,cf	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBPAB	40b--	567	570	ovca	ovda,ovmu transfer, hemogl	nadler,cf; woolf	1971
JAVMA	157-5	647	650	ovca	physiol val, cap, handling	franzmann,aw; th	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	39--4	554	559	obmo	serologica evid, relations	moody,pa	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBPAB	23--1	149	157	many	serum proteins, transferri	nadler,cf; hugh/	1967
JWMAA	40--3	517	522	many	iden hemoglob, law enforce	bunch,td; meado/	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	12---	463	465	bibo	electrocard, experim death	nagorski,f; grod	1967
ATRLA	12---	361	365	bibo	curr stat stud blood prope	gasparski,j	1967

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBPAB	40b--	521	530	ovli	transferr, hemoglobi, iran	lay,dm; nadler,c	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JAVMA	157-5	604	606	many	hematol val, arctic mammal	dieterich,ra	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	37--4	584	585		serol tech, ident blo prot	tempelis,ch; rod	1973
NATUA	187--	333	334	elda	sickling phenomenon in dee	undritz,e; betk/	1960

Heart weight:live weight relationships of white-tailed deer (odvi)

Heart weights of 11 male and 8 female white-tailed deer and the a and b values for a linear regression equation for all 19 animals combined are given by Robinson (1966).

Linear, exponential, logarithmic, and power regression equations for each sex have been determined from the data of Robinson to see if a non-linear curve provides a better fit. The R^2 values are:

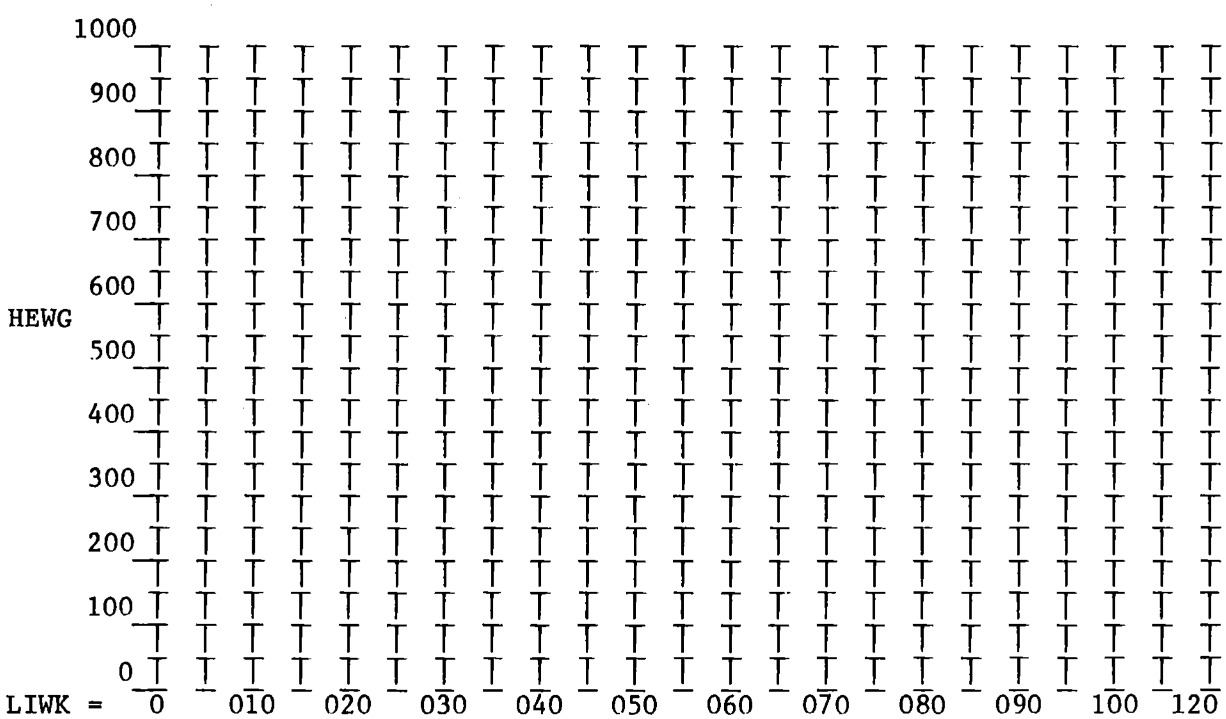
	Linear	Exponential	Logarithmic	Power
male	0.95	0.96	0.88	0.92
female	0.96	0.92	0.96	0.94

The linear fit is best when both sexes are considered. The equations for males and females are:

male: HEWG = 8.71(LIWK) - 105.58
female: HEWG = 9.48(LIWK) - 100.70

A t-test shows that the slopes are not different (P = 0.99) for males and females. Thus, a single equation represents the heart weight:live weight relationships for both sexes. The equation is:

HEWG = 8.54 LIWK - 81.27



LITERATURE CITED

Robinson, P. F. 1966. Organ:body weight relationships in the white-tailed deer, Odocoileus virginianus. Cheasapeake Science 7(4):217-218.

CHAPTER 1, WORKSHEET 3.2b

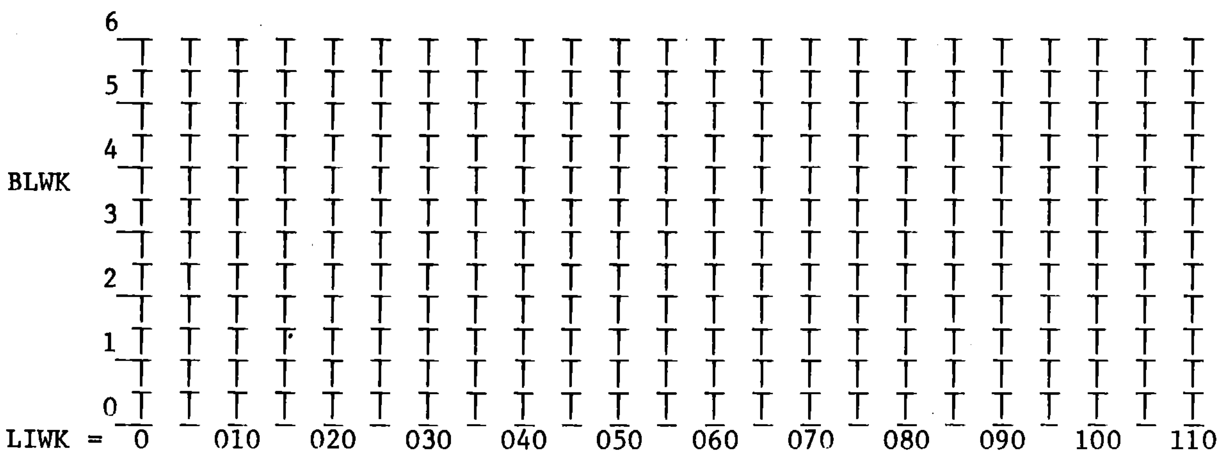
Blood weight:live weight relationship of white-tailed deer (odvi)

The weight of the blood of white-tailed deer, presumably determined by direct collection and measurement of 13 sacrificed male deer was given in relation to live weight by Cowan et al. (1968).

Direct collection of the blood results in an underestimation of the total blood present because some of the residual blood in the capillaries. The equation, based on the data given, is:

$$BLWK = 0.498 + 0.045\ (LIWK)$$

Plot the blood weights in relation to live weight in kg (LIWK) below.



LITERATURE CITED

Cowan, R. L, E. W. Hartsook, J. B. Whelan, J. L. Watkins, J. S. Lindzey, R. W. Wetzel, and S. A. Liscinsky. 1968. Weigh your deer with a string. Penn. Game News 39(11):17-18.

Heart weight:live weight relationship for mature mammals

Brody (1964:596) presents a figure with plotted points and a regression line for the heart weight (kg): body weight (kg) relationship for mature mammals. The equation is:

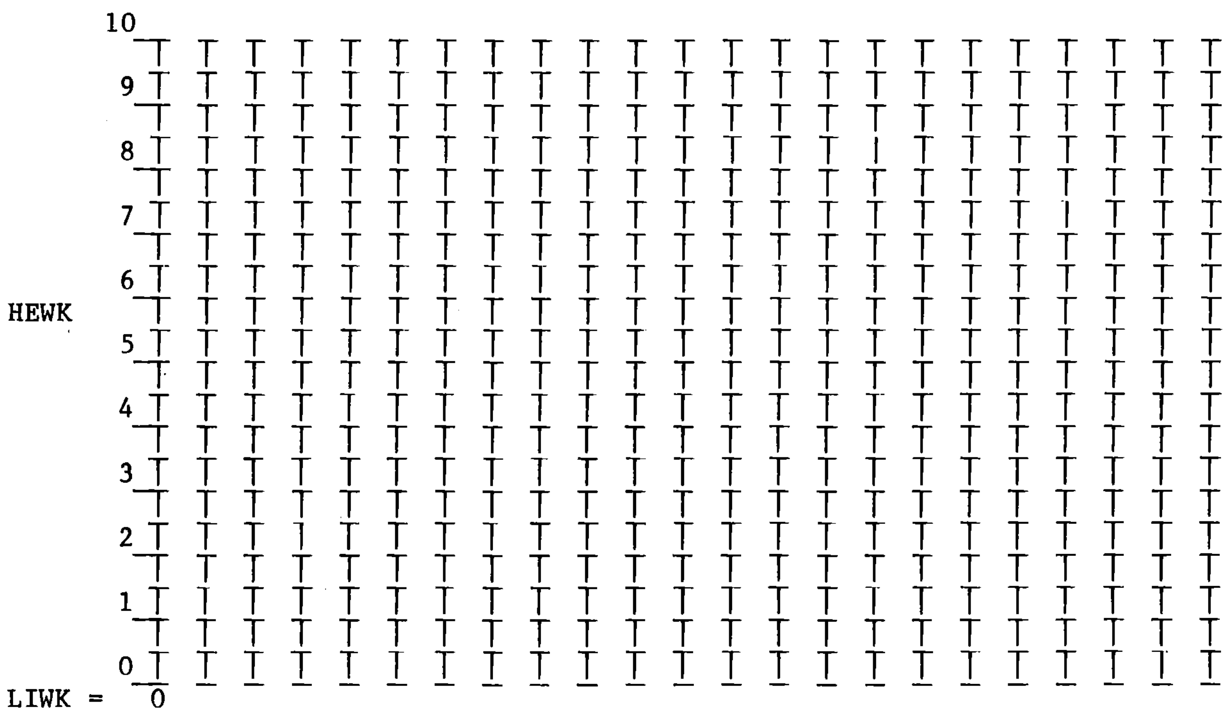
$$HEWG = 0.00588\ LIWK^{0.984}$$

Compare heart weights with this calculation and from WORKSHEET 3.2a for deer weighing 100 kg. Note that the deer equation results in a larger HEWG than the general equation. Complete the table below for species and weights of your choice. Remember that this general equation may result in an underestimation for wild ruminants in general.

Brody (1964:643) gives the a and b values for another equation for dairy cattle. That equation is:

$$HEWK = 0.064\ LIWK^{0.56}$$

Compare the results from this equation to the one for deer.



LITERATURE CITED

Brody, S. 1964. Bioenergetics and growth. Hafner Publishing Company, Inc., New York. 1023 pp.

UNIT 3.3: RESPIRATORY SYSTEM CHARACTERISTICS

The major organs of the respiratory system are the lungs and the air passages leading to them. The lungs, surrounded by pleural sacs, are located in the thorax. The air passages are the mouth cavity, pharynx, larynx, trachea, and bronchi. The diaphragm is the major muscle involved in breathing, assisted by muscles of the thorax. The movement of air through the air passages to ventilate the lungs is called external respiration. The exchange of oxygen and carbon dioxide in the process of metabolism is called internal respiration, and is discussed in Part III.

Lung Surface Area. The lungs of mammals are finely divided into tiny sacs or diverticuli which increase the internal surface areas of each lung tremendously compared to their outer surface areas. This structural characteristic provides large amounts of surface areas for ventilation, resulting in efficient O_2 and CO_2 exchange necessary for continuing internal respiration.

Lung Volumes. Lung volumes of a wide range of weights of mammals (including no wild ruminants, however) were very constant (Gordon 1962;162).

$$LUVO = 0.0567\ IFWK^{1.02}$$

The increase was not quite directly proportional as the equation expressing this relationship includes weight to the power 1.02. This means that lung volumes of larger animals are relatively larger than those of smaller animals, although the increase is slight. The effects of an exponent of 1.02 compared to a direct proportion to weight (1.00) are made in WORKSHEET 3.3a.

Air passages. The structure of the air passages is important for the exchange of heat energy between the animal and the atmosphere. Very cold inhaled air, for example, is warmed as it passes through the respiratory tract, removing heat energy from body tissue. If the air exhaled is warm air, the amount of heat lost could be substantial for a wild ruminant in cold, northern weather conditions.

The air passages of caribou have membranes that are folded over each other, functioning as heat exchanges to warm the inhaled air and cool the air to be exhaled. In this way, heat energy is exchanged within the air passages rather than between the air passages and the atmosphere, resulting in potentially important reductions in respiratory heat loss.

LITERATURE CITED

Gordon, M. S., G. A. Bartholomew, A. O. Grinnell, C. B. Jorgensen, and F. N. White. 1962. Animal Function: Principles and adaptations. The MacMillan Company, New York. 560 pp.

REFERENCES, UNIT 3.3

RESPIRATORY SYSTEM CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	31--1	5	17	odvi*weight relations, georg re		hamerstrom,fm,jr/	1950

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	52--3	628	630	odhe*tiss, organs, tota body ma		hakonson,te; whic	1971
WLMOA	39---	1	122	odhe*carcas, bone, organ, gland		anderson,ae; med/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--4	308	323	ceel	mammals of northern idaho	rust,hg	1946
RSPYA	29--2	225	230	ceel/select oxygen transp param		mckean,t; staube/	1977

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVSPA	57---	1	18	rata	topograph, internal organs	engebretsen,rh	1975
NJZOA	24--4	407	417	rata	/morph, fat stor, organ wt	krog,j; wika,m; /	1976

CODEN vo-nu bepa enpa anim kewo auth year

anam

CODEN vo-nu bepa enpa anim kewo auth year

RSPYA 30--3 305 310 bibi blood respirato properties haines,h; chiche/ 1977

CODEN vo-nu bepa enpa anim kewo auth year

ovca

CODEN vo-nu bepa enpa anim kewo auth year

ovda

CODEN vo-nu bepa enpa anim kewo auth year

obmo

CODEN vo-nu bepa enpa anim kewo auth year

oram

CODEN vo-nu bepa enpa anim kewo auth year

ATRLA 12--- 349 360 bibo physiological properties janusz,g 1967

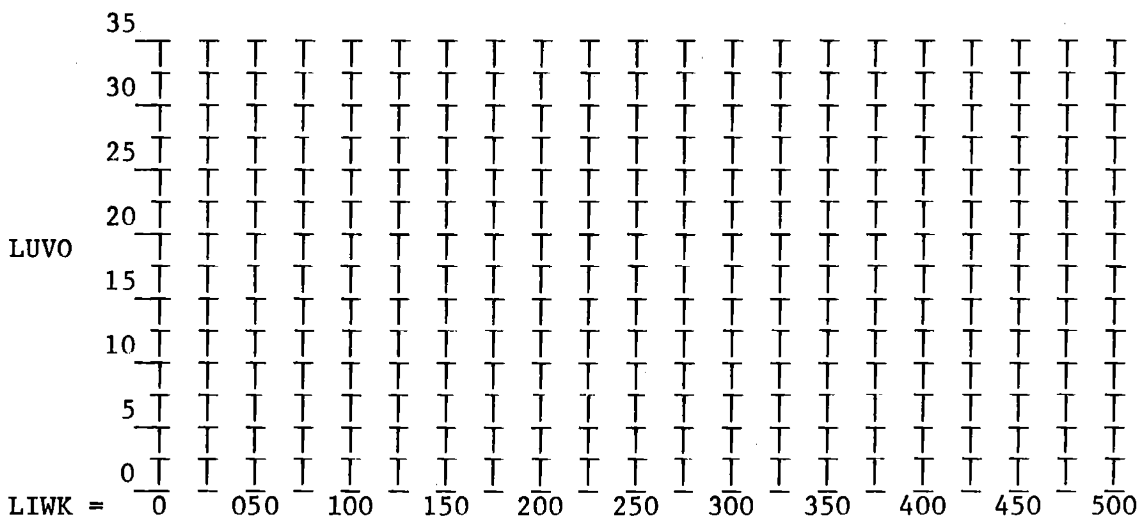
CHAPTER 1, WORKSHEET 3.3a

Lung volumes in relation to body weights

The lung volumes of a wide range of weights of animals may be expressed with the equation modified from Gordon (1962;162):

$$LUVO = 0.0567\ LIWK^{1.02}$$

No ruminants were included in the data used to derive the above equation. Since there are no other data available on lung volumes of wild ruminants, this equation will serve as a first approximation. Lung volumes get larger as animal weights increase since the exponent 1.02 is greater than 1.00. Evaluate lung volumes for animals weighing 50 kg (deer) to 500 kg (bison) using the equation above. Then, use a direct proportion (exponent = 1.00) and calculate LUVO. Plot the results below. What are the differences at different weights?



LITERATURE CITED

Gordon, M. S., G. A. Bartholomew, A. O. Grinnell, C. B. Jorgensen, and F. N. White. 1962. Animal Function: Principles and adaptation. The MacMillan Company, New York. 560 pp.

UNIT 3.4: REPRODUCTIVE SYSTEM CHARACTERISTICS

The reproductive system of wild ruminants includes the scrotum, testes, and penis of the males and the uterus, ovaries and vagina of the females. Characteristics of the male and female reproductive organs are used to evaluate breeding condition and potentials. Testes volumes increase as the rutting season approaches, with the hormone testosterone having a significant role in stimulating these physical changes. The ovaries of the female serve as indicators of the female's reproductive history. Teat lengths measured on hunter-killed animals are very good indicators of lactation the previous summer in yearling deer, helping to establish the frequency of suckling young born to yearlings, which is a good indicator of animal condition in relation to the range.

Several characteristics of the reproductive system are of distinct ecological importance. The age at reproductive maturity is an important characteristic affecting the ratio of breeding: non-breeding animals in a population. Animals that breed at an earlier age contribute new individuals to the population sooner than late-maturing animals do, resulting in potentially greater variations in number from one breeding season to the next.

Lengths of the gestation periods (LEGP) of the North American wild ruminants are:

		LEGP
white-tailed deer;	odvi	200
mule deer;	odhe	200
elk;	ceel	260
moose;	alal	245
caribou;	rata	220
pronghorn;	anam	240
bison;	bibi	290
big-horn sheep;	ovca	150
Dall sheep;	ovda	150
muskox;	obmo	270
mountain goat;	oram	180

Reproductive system characteristics are related to those of the endocrine system, of course. Functional relationships between these two systems are discussed in Part III.

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.

REFERENCES, UNIT 3.4

REPRODUCTIVE SYSTEM CHARACTERISTICS

BOOKS

type	publ	city	page	anim	kewo	auth/edit	year
aubo	coup	itny	670	mamm	patterns mammalian reprodu	asdell,sa	1964

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOANA	94--1	1	33	cerv	aspects of placentation	hamilton,wj; har/	1960

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJANA	126-2	201	241	odvi	morphogen, fetal membranes	sinha,aa; seal,u/	1969
AJANA	127-4	369	395	odvi	ultrastr amnion, amni plaq	sinha,aa; seal,u/	1970
AJANA	132-2	189	205	odvi	ultrastr corpus lute, preg	sinha,aa; seal,u/	1971
AJVRA	39--6	1053	1056	odvi	antl, long bone mass, andr	brown,rd; cowan,/	1978
BIREB	16--3	340	343	odvi	repro ster, fema seas chan	plotka,ed; seal,/	1977
BIREB	17--1	78	83	odvi	repr, proges, estrog, preg	plotka,ed; seal,/	1977
CIRIB	6---2	1053	1056	odvi	collec semen, electro ejac	bierschwal,cj; m/	1968
CJZOA	44--1	59	62	odvi	breeding seasons, manitoba	ransom,ab	1966
CJZOA	56--1	121	127	odvi	seas var LH,FSH, tes, male	mirarchi,re; how/	1978
CNJNA	54--2	259	259	odvi	doca, cotyled attach, uter	scanlon,pf	1974
COVEA	39--3	282	291	odvi	corpora lutea, ovul incide	cheatum,el	1949
CPSCA	7---4	217	218	odvi*	organ:body weight relation	robinson,pf	1966
ENDOA	94--4	1034	1040	odvi	annual testos rhyth, adult	mcmillin,jm; sea/	1974
JANSA	31--1	225	225	odvi/	sperm reserves of w-t deer	lambiase,jt,jr; a	1970
JANSA	39--1	225	225	odvi	dosh, doca, placentomes in	scanlon,pf	1974
JANSA	40--1	185	186	odvi/	andr lev, antl cy, bree se	mirarchi,re; sca/	1975
JANSA	42--1	271	272	odvi/	seas var, gonad char, male	mirarchi,re; sca/	1976
JAVMA	157-5	627	632	odvi	char semen coll, elec ejac	bierschwal,cj; m/	1970

odvi continued on the next page

CODEN	vo-nu	bepa	enpa	anim kewo	auth	year
JOMAA	31--1	5	17	odvi*weight relations, georg re	hamerstrom,fm,jr/	1950
JOMAA	32--4	411	421	odvi analys reproduc pat, s tex	iilege,d	1951
JOMAA	40--1	108	113	odvi/breed record, capt, alabam	haugen,ao	1959
JOMAA	46--1	107	107	odvi placen ingest, partur mort	knowlton,ff; mich	1965
JOMAA	47--2	266	280	odvi*endocrine glands,seas chan	hoffman,ra; robin	1966
JOMAA	53--4	760	773	odvi/ovar comp, repr phys,venez	brokx,pa	1972
JRPFA	47--1	161	163	odvi chan estro, estradi, pregn	harder,jd; woolfl	1976
JWIDA	9---4	356	358	odvi multipl anomali, w-t fetus	wobeser,g; runge,	1973
JWIDA	11--4	497	501	odvi congen anom, neonat, alber	barrett,mw; chalm	1975
JWMAA	10--3	242	248	odvi regi diff, breed poten, ny	moroton,gh; cheat	1946
JWMAA	10--3	249	263	odvi breeding season, new york	cheatum,el; morto	1946
JWMAA	14--3	290	295	odvi/breed rec, upper pen, mich	haugen,ao; davenp	1950
JWMAA	27--1	142	143	odvi technique for preser uteri	haugen,ao	1963
JWMAA	28--1	171	173	odvi birth of white-tai d fawns	michael,ed	1964
JWMAA	29--1	53	59	odvi reproduc cycle, male texas	robinson,rm; tho/	1965
JWMAA	29--1	74	79	odvi/reproducti studies, penned	verme,lj	1965
JWMAA	29--3	487	492	odvi corpora lutea variation of	trauger,dl; hauge	1965
JWMAA	29--3	634	636	odvi fertility in w-t buck fawn	silver,h	1965
JWMAA	30--4	843	845	odvi regional diff, fawning tim	weber,aj	1966
JWMAA	31--1	114	123	odvi reprodtive biolo, manitoba	ransom,ab	1967
JWMAA	33--3	708	711	odvi fertility, male w-t fawns	follmann,eh; klim	1969
JWMAA	33--4	881	887	odvi/repro pattern, nutri plane	verme,lj	1969
JWMAA	35--2	369	374	odvi/accessory corp lute, ovari	mansell,wd	1971
JWMAA	36--3	868	875	odvi/reproductive physiol, male	lambiase,jt,jr; /	1972
JWMAA	37--3	423	424	odvi support dev, field laparot	scanlon,pf; lenke	1973
JWMAA	38--2	183	196	odvi eff diethylstilbes, reprod	harder,jd; peterl	1974
JWMAA	39--4	684	691	odvi/uterin comp, growth, pregn	robbins,ct; moen,	1975
JWMAA	40--2	373	374	odvi initia, preg, lactating de	scanlon,pf; murp/	1976
JWMAA	40--4	792	795	odvi noneff, mechan birth contr	matschke,gh	1976
JWMAA	41--1	87	91	odvi diethylstilbestr, contrace	matschke,gh	1977
JWMAA	41--1	92	99	odvi/ann chang, sperm prod, org	mirarchi,re; sca/	1977
JWMAA	41--2	178	183	odvi androg levels, antl develo	mirarchi,re; sca/	1977
JWMAA	41--2	194	196	odvi antifertil act, syn proges	matschke,gh	1977
JWMAA	41--4	715	719	odvi fact aff peak fawning, vir	mcginnes,bs; down	1977
JWMAA	41--4	731	735	odvi ferti control, steroi impl	matschke,gh	1977
NAWTA	29---	225	236	odvi hypogonadism in wtd, texas	thomas,jw; robin/	1964
NFGJA	16--2	261	261	odvi twin fawns born 2 days apa	hesselton,wt; van	1969
NFGJA	18--1	42,	51	odvi reprod anomali, female, ny	hesselton,wt; jac	1971
NFGJA	20--1	40	47	odvi/breedi, parturit dates, ny	jackson,lw; hesse	1973
OJSCA	78-AP	14	14	odvi possibl superfeta, spontan	lamvermeyer,bl; m	1978
PCGFA	9----	128	131	odvi birth dates of alabama dee	lueth,fx	1955
PCGFA	29---	646	651	odvi oral accep, eff, diethylst	matschke,gh	1975
PIAIA	71---	241	247	odvi/struc, cervic regi, uterus	morris,je	1964

odvi continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
POASA	56---	24	25	odvi	breeding season, e oklahom	dunbar,mr	1976
TJSCA	26	417	420	odvi	breeding season in s texas	harwell,wf; barro	1975
TNWSD	27---	19	38	odvi	photoperiodism, breeding	mcdowell,rd	1970
VJSCA	23--3	116	116	odvi	a laparotomy technique w-t	scanlon,pf; lenke	1972
VJSCA	23--3	116	116	odvi	aspects of early pregnancy	scanlon,pf; murp/	1972
VJSCA	24--3	112	112	odvi	ovula, pregnan, lactat dee	scanlon,pf; murp/	1973
VJSCA	24--3	112	112	odvi	spermatozoan reserves in d	lenker,dk; scanlo	1973
VJSCA	26--2	59	59	odvi	plas androg lev,repro char	mirarchi,re; sca/	1975
VJSCA	26--2	60	60	odvi	seas, age dif, male org wt	russell,md; wess/	1975
VJSCA	27--2	46	46	odvi	plas progest lev, estr cyc	kirkpatrick,rl; /	1976
WLSBA	3---4	152	156	odvi	hormon implan, contr repro	bell,rl; peterle,	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ACATA	84--1	118	128	odhe	anam, morpho, cervix uteri	kanagawa,h; hafez	1973
AMNAA	83--1	303	304	odhe	accidents, parturient deer	miller,fl	1970
ANREA	122--	335	340	odhe	quadruplets in mule deer	sears,hs; browman	1955
APAVD	1976-	208	215	odhe	environ eff on reproductio	sadleir,rmfs	1976
CAFGA	43--1	91	96	odhe	breedin seas, herds, calif	bischcoff,ai	1957
CAFGA	44--3	253	259	odhe	productiv, herds californi	bischoff,ai	1958
CJZOA	48--1	123	132	odhe	odvi, develo, fetal period	ommundsen,p; cowa	1970
CJZOA	54-10	1617	1636	odhe	horm reg, repro, antl cycl	west,no; nordan,h	1976
CJZOA	54-10	1637	1656	odhe	eff methallibure,hormon tr	west,no; nordan,h	1976
JOMAA	38--1	116	120	odhe	gesta per, breed, fawn beh	golley,fb	1957
JOMAA	52--3	628	630	odhe*	tiss, organs, tota body ma	hakonson,te; whic	1971
JOMAA	53--2	403	404	odhe	biolog, an antlered female	mierau,gw	1972
JOMAA	54--1	302	303	odhe	reproductio, b-t deer fawn	thomas,dc; smith,	1973
JRPFA	44--2	261	272	odhe/	reprod pattern, female b-t	thomas,dc; cowan,	1975
JWIDA	7---1	67	69	odhe	bilateral testicular degen	murphy,bd; clugst	1971
JWIDA	11--1	101	106	odhe	testicular atrophy, calif	demartini,jc; con	1975
JWMAA	14--4	457	469	odhe	bree seas, prod, faw, utah	robinette,wl; gas	1950
JWMAA	17--2	225	225	odhe	proof fawns breeding, utah	crane,hs; jones,d	1953
JWMAA	21--1	62	65	odhe	ovarian anal, reprod perfo	golley,fb	1957
JWMAA	40--4	795	796	odhe	preg fawn, quintupl mule d	nellis,ch; prent/	1976

odhe continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
MRLTA	50--1	12	12	odhe	record, multiple ovulation	fowle,ke	1969
SWNAA	15--1	29	36	odhe	indices repro, surv, n mex	anderson,ae; sny/	1970
THGNB	3---3	101	106	odhe	early pubert, female b-t d	mueller,cc; sadle	1975
WLMOA	39---	1	122	odhe*	carcas, bone, organ, gland	anderson,ae; med/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BEHAA	16	84	92	ceel	charact of estrus, captive	morrison,ja	1960
CIRIB	8---4	994	997	ceel	freezi red d semen, polan	jaczewski,z; mor/	1976
JOMAA	36--1	145	145	ceel	fetus in yearling cow elk	saunders,jk jr	1955
JOMAA	47--2	332	334	ceel	fetus resorption in elk	haugen,ao	1966
JOMAA	51--4	812	813	ceel	precoci antl dev, sex matu	moran,rj	1970
JRPFA	25--1	41	54	ceel/	puberty, seas breedin male	lincoln,ga	1971
JRPFA	27--3	427	438	ceel/	female reprodu cycl, scotl	guiness,f; linco/	1971
JWMAA	16--3	313	315	ceel	age at sex maturity, male	conoway,cf	1952
JWMAA	17--2	177	184	ceel	reproduction, yellowstone	kittans,wh	1953
JWMAA	17--2	223	223	ceel	pregnant yearling cow elk	coffin,al; reming	1953
JWMAA	23--1	27	34	ceel	breed seas, known-age embr	morrison,ja; tra/	1959
JWMAA	24--3	297	307	ceel	ovarian char, breed histor	morrison,ja	1960
JWMAA	31--1	145	149	ceel	determ preg, rectal palpat	greer,kr; hawkins	1967
JWMAA	32--2	368	376	ceel	exper studies, contr repro	greer,kr; hawkin/	1968
JZOOA	163-1	105	123	ceel/	seas reprodu changes, stag	lincoln,ga	1971
JZOOA	172-3	363	367	ceel	timing, reproduc, latitude	fletcher,tj	1974
JZOOA	185-1	105	114	ceel	calving times, red d, scot	guiness,fe; gibs/	1978
MAMLA	35--2	204	219	ceel	ruru, season, births, n z	caughley,g	1971
NAWTA	21---	545	554	ceel	postconcept ovulation, elk	halazon,gc; buech	1956
OIKSA	23--1	142	144	ceel	field measu, organ volumes	langvain,r	1972
ZEJAA	1---1	69	75	ceel	caca, dada [time of birth]	rieck,w	1955
ZEJAA	4---3	105	130	ceel	[reproductive phenomena]	valentincic,si	1958
ZEJAA	21--4	238	242	ceel	1 sided testicle shrinkage	wurster,k; hofma/	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVSPA	14--1	81	91	alal	morph, ultrastr, spermatoz	andersen,k	1973
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946
JOMAA	37--2	300	300	alal	late breeding, moose, alce	moisan,g	1956
JWMAA	26--4	360	365	alal	in gravelly, snowcrest mou	peek,jm	1962
JWMAA	39--2	450	451	alal	aerial sexing, wh vulv pat	roussel,ye	1975
VILTA	6---3	1	299	alal/reproductio, moose, sweden		markgren,g	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVSPA	57---	1	18	rata	topograph, internal organs	engebretsen,rh	1975
CAFNA	90--4	449	463	rata	annual antler cycle, newfo	bergerud,at	1976
CAFNA	90--4	498	499	rata	twin fetuses, woodland car	shoesmith,mw	1976
CJZOA	50--1	43	46	rata	reprodu, female reind, car	mcewan,eh; whiteh	1972
CJZOA	53--9	1213	1221	rata/repro seas, carib, newfoun		bergerud,at	1975
CJZOA	56--8	1684	1696	rata/morphol, b-g caribou ovary		dauphine,tc,jr	1978
JOMAA	49--4	778	778	rata	placental remnants, rumens	miller,fl; parker	1968
JOMAA	52--2	479	479	rata	twinning in caribou	mcewan,eh	1971
JOMAA	54--3	781	781	rata	twinning in reindeer, nwt	nowosad,rf	1973
JWMAA	25--2	205	205	rata	sex determi caribou calves	bergerud,at	1961
JWMAA	28--3	477	480	rata	field meth, parturiti rate	bergerud.at	1964
JWMAA	35--1	175	177	rata	antl shedd, parturi, reind	espmark,y	1971
JWMAA	38--1	54	66	rata/synchronous mating, b gr c		dauphine,tc,jr; m	1974
JZOOA	164-4	419	424	rata	collec, exam, reinde semen	dott,hm; utsi,mnp	1971
JZOOA	170-4	505	508	rata	artific insemina, reindeer	dott,hm; utsi,mnp	1973
NCANA	97--1	61	66	rata	calving dates, carib, queb	desmeules,p; sim	1970
NJZOA	24--4	407	417	rata	morpho, fat stor, organ wt	krog,j; wika,m	1976
PASCC	22---	17	17	rata	repro patter, reind, carib	mcewan,eh; whiteh	1971
ZOLZA	46-12	1837	1841	rata	[reproduc, wild, taimyr p]	michurin,ln	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
WMBAA	16---	17	23	bibi	biol, manage, national par	fuller,wa	1962

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	46--5	899	944	ovca	social, physical maturatio	geist,v	1968
JWMAA	9---2	155	156	ovca	non-breeding in bighorn sh	pulling,avs	1945
JWMAA	30--1	207	209	ovca	twinning in bighorn sheep	spalding,dj	1966
SWNAA	22---	153		ovca	minimum breeding age, utah	mccutchen,he	1977

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
FUNAA	24	96	100	obmo	early matur, fecund, norwa	alendal,e	1971
FUNAA	24	101	103	obmo	gestation period of muskox	alendal,e	1971
JWMAA	19--4	417	429	oram	two-year study, crazy moun	lentfer,jw	1955

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JRPFA	21--1	1	8	dada	reproductive cycle, male	chapman,di; chapm	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	12---	333	334	bibo	breeding, zool garden, pol	landowski,j; woli	1967
ATRLA	12---	407	444	bibo	reprod biol, reserve, free	krasinski,z; racz	1967
CBCPA	43A--	673	679	mamm	gestation period, body wt	kihlstrom,je	1972
JZOOA	170-2	150	151	*mure	breed rec, muntjac d, capt	chaplin,re; dange	1973
ZSAEA	33--4	193	214	many/[developm antlers, reprod]		lau,d	1968

*mure = Muntiacus reevesi = muntjac deer

UNIT 3.5: EXCRETORY SYSTEM CHARACTERISTICS

The excretory system includes the kidney, bladder, tubular channels, and the rectum. The first three are connected anatomically, with the kidney being associated with the circulatory system where it acts as a physiological filter for the separation of wastes from the blood. The product of this filtration process, urine, is stored in the bladder between periodic urinations.

The rectum is associated with the digestive system. It is a storage area for undigested food materials, or feces, along with spent metabolic tissue. Feces are eliminated by defecation at periodic intervals.

The defecation rate per day is one of the practical characteristics of the excretory system. Number of defecations per day and the resistance of the feces to breakdown are importyant considerations when using pellet-group census methods. Feces, as undigested food materials, persist on the ground for varying lengths of time, depending on their characteristics and on weather conditions that affect both mechanical breakdown and decomposition by lower organisms.

Fecal materials change seasonally in number and resistance to breakdown, depending on the diet, range phenology, and physical condition of the animals. Diets with lower digestible forage result in fecal groups with higher resistance to breakdown, and these can persist for several years, especially in dry weather conditions. These several considerations of factors surrounding fecal characteristics indicate how interrelated ecological considerations can be when evaluating animal range relationships.

REFERENCES, UNIT 3.5

EXCRETORY SYSTEM CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	26--1	50	55	od	rain, count of pellet grou	wallmo,oc; jacks/	1962
JWMAA	33--3	506	510	od	qual ident forage remnants	zyznar,e; urness,	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CPSCA	7---4	217	218	odvi*	organ:body weight relation	robinson,pf	1966
JOMAA	31--1	5	17	odvi*	weight relations, georg re	hamerstrom,fm,jr/	1950
JWMAA	20--1	70	74	odvi	eval pell gr count, census	eberhardt,l; van	1956
JWMAA	29--4	723	729	odvi	sourc of error, pell group	van etten,rc; ben	1965
NFGJA	7---1	80	82	odvi	persist, wint pelle gr, ny	patric,ef; bernha	1960

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	52--3	628	630	odhe*	tiss, organ, tota body mas	hakonson,te; whic	1971
JWMAA	28--3	435	444	odhe	defacation rates of mule d	smith,ad	1964
JWMAA	31--1	190	191	odhe	anam, id fecal gr, pH anal	howard,vw,jr	1967
JWMAA	34--1	29	36	odhe	ceel, freq dist, pellet gr	mcconell,br; smit	1970
JWMAA	36--2	579	594	odhe/	indices of carc fat, color	anderson,ae; med/	1972
NAWTA	8----	369	380	odhe	census math, management of	rasmussen,di; dom	1943
UASPA	32---	59	64	odhe	weathering, persist pel gr	ferguson,rb	1955
WLMOA	39---	1	122	odhe*	carcas, bone, organ, gland	anderson,ae; med/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	15---	253	268	ceel	relat age and size, poland	dzieliolowski,r	1970
JWMAA	24--4	429	429	ceel	dyes to mark ruminan feces	kindel,f	1960
JWMAA	29--2	406	407	ceel	determ defeca rate for elk	neff,dj; wallmo,/	1965
NZJSA	13--4	663	668	ceel	kidney wt, kidne fat index	batcheler,cl; cl/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	40--2	374	375	alal	daily wint pell gr,bed, al	franzmann,aw; ar/	1976
NCANA	95--5	1153	1157	alal	[numb pellet-gro each day]	desmeules,p	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVSPA	57---	1	18	rata	topograph, internal organs	engebretsen,rh	1975
JWMAA	39--2	379	386	rata*	kidney wt fluct, fat index	dauphine,tc,jr	1975
NJZOA	24--4	407	417	rata/	morpho, fat stor, organ wt	krog,j; wika,m	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				bibi			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ANREA	169-2	343	343	ovca	observ kidney, desert bigh	horst,r; langwort	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--4	308	323	many	mammals of northern idaho	rust,hg	1946

UNIT 3.6: SKELETAL SYSTEM CHARACTERISTICS

The vertebrate skeleton includes an axial portion and an appendicular portion. The axial portion includes the backbone which provides the main line of internal support for the rest of the body. Bones in the axial portion of the skeleton have restricted articulation, and some are fused together tightly. Bones in the appendicular portion articulate freely with other bones. The skeleton serves as a reserve of minerals, nutrients, and blood cells for use by other systems of the body.

Bone is very definitely living tissue, and skeletal growth is essentially positive from birth to death. At birth, the bones are far from mineralized, and as a result they are rather cartilaginous and flexible. They quickly gain more rigidity, and the rapidity of the growth in the dimensions of long bones (legs), flat bones (ribs), and the rest of the skeleton is truly remarkable in wild ruminants.

Maximum skeleton dimensions are generally reached after reproductive maturity. Reproducing females will continue to grow after bearing their first offspring, and males are capable of breeding before they are physically mature.

The skeleton is composed of minerals, primarily calcium and phosphorous, that accumulate during growth, and of water. Horns and antlers, characteristic of the males of all species and the females of some species of ruminants, are extensions of the skeletal system, and represent annual recurrent growth in some species. The minimum amounts of minerals required for horn and antler growth can be estimated by analyzing the quantities deposited. The demand for minerals exceeds the amounts ingested during rapid stages of antler growth, and minerals are mobilized from the long bones and ribs to meet this demand.

Ash contents of white-tailed deer in October were determined by Robbins et al. (1974). Further measurements of chemical composition of deer carcasses throughout the year are being completed at the Wildlife Ecology Laboratory, and the time-dependent equation for ash determined. Data on the ash and specific mineral contents of other species are very limited.

LITERATURE CITED

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

REFERENCES, UNIT 3.6

SKELETAL SYSTEM CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
EVOLA	24--1	220	229	odvi	anal div skull morph, mich	rees,jw	1970
JOMAA	31--2	5	17	odvi*	weight relations, georg re	hamerstrom,fm,jr/	1950
JOMAA	50--2	302	310	odvi/	alal, stuctur adapta, snow	kelsall,jp	1969
JOMAA	52--1	223	226	odvi	mandible variati, sex, age	rees,jw	1971
JOMAA	52--4	724	731	odvi	odhe, anal diver mandi mor	rees,jw	1971
JOMOA	128--	95	112	odvi	morph var, cranium, mandib	rees,jw	1969
JOMOA	128--	113	130	odvi	morph var, mandibl, skelet	rees,jw	1969
JWMAA	29--2	397	398	odvi	kidney, marrow fat, condit	ransom,ab	1965
NYCOA	3---5	19	22	odvi	bone marrow, malnutr index	cheatum,el	1949

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	41--4	629	636	odhe	age determ, ossif, long bo	lewall,ef; cowan,	1963
CAFGA	41--4	327	346	odhe	dosh, dogo, skeletal diffe	hildebrand,m	1955
CAFGA	42--1	15	21	odhe/	odvi, pelv girdl, rel, sex	taber,rd	1956
JOMAA	45--2	226	235	odhe/	rang-rel gro dif, sk ratio	klein,dr	1964
JOMAA	52--3	628	630	odhe*	tiss, organ, tota body mas	hakonson,te; whic	1971
MVPRA	52--4	50	50	odhe	spont repair, comminu frac	dinesen,hl; cliff	1971
WLMOA	39---	1	122	odhe*	carcas, bone, organ, gland	anderson,ae; med/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	11--5	129	194	ceel	morph varib, skull, body w	mystkowska,ec	1966
CJESA	14---	963	986	ceel	postglac ungulates, albert	shackleton,dm; hi	1977
JOMAA	37--1	129	129	ceel	healing, fractured leg bon	gilbert, pf; hill	1956
JWMAA	30--1	135	140	ceel*	measurements, weight relat	blood,da; lovaas,	1966
JWMAA	30--2	369	374	ceel	bone char assoc with aging	knight,rr	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
NZJSA	14--4	993	1008	ceel	hybrid red de, wapiti, n z	caughley,g	1971
PZESA	24---	57	75	ceel	cran stud, adap, hybr, nz	batcheler,cl; mcl	1977
PZSLA	166-3	303	311	ceel	var mandib length, body wt	lowe,vpw	1972
ZEJAA	23--2	92	94	ceel	[anomaly, nasal bones,]	meyer,p	1977

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATICA	19--2	111	113	rata	functn brow tine, caribou	pruitt,wo	1967
AVSPA	57---	1	18	rata	topograph, internal organs	engebretsen,rh	1975
JWMAA	28--1	54	56	rata*relatio mandi length, sex		bergerud,at	1964
NJZOA	24--4	407	417	rata/morpho, fat stor, organ wt		krog,j; wika,m	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	45--4	630	632	bibi	new data, b. bison, athaba	bayrock,la; hill	1964
JOMAA	56--4	871	887	bibi	var cranial char, alberta	shackleton,dm; /	1975
PLNAA	18-60	132	139	bibi	agin, sexi post crani skel	duffield,lf	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
FLDZA	61--1	1	88	ov	co-evo soc beh, cran morph	schaffer,wm; ree	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	51--1	60	73	oram	variation in the mt goat	cowan,imct; mccro	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AMNTA	113--	103	122	mamm	scal, skel mass, body mass	prange,hd; ander/	1979

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--4	308	323	many	mammals of northern idaho	rust,hg	1946

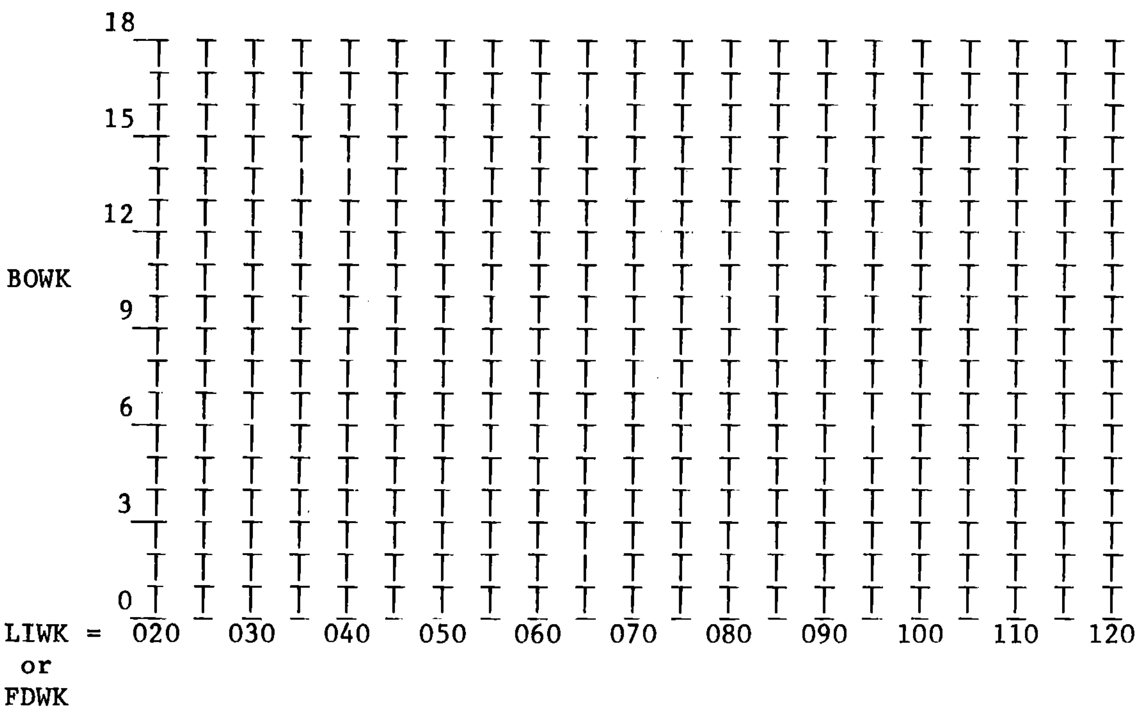
Bone weight:live weight relationships of white-tailed deer (odvi)

Bone weights in relation to live weights and field dressed weights are given by Cowan et al. (1968). The equations derived from these data are:

$$BOWK = 1.215 + 0.108\ LIWK$$

$$BOWK = 1.650 + 0.122\ FDWK$$

Plot the bone weight in relation to live weight and field dressed weights in kg below.



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UNIT 3.7: MUSCULAR SYSTEM CHARACTERISTICS

The muscular system of wild ruminants includes both involuntarily-controlled muscles and voluntarily-controlled ones. Muscles involved in breathing heart muscles, and those of the gastrointestinal tract are the major involuntary muscles. Those involved in movement of the skeletal system are under voluntary control.

The voluntary muscles function primarily in the maintenance of body posture and in locomotion. Wild ruminants are generally more alert than domestic ones, and a larger proportion of maintenance energy may go for maintenance of posture in wild than in domestic ruminants. Wild ruminants also have more highly developed locomotor skills than domestic ones; they run to escape potential danger, and are capable of fast rates of speed.

Muscle characteristics that relate to these functions have not been studied in wild ruminants. Carcass characteristics, including the fraction of whole body weight that is muscle, have been measured, and meat characteristics used for identifying meats for law enforcement purposes have been described for some species.

Carcass characteristics are of interest when evaluating the amount of food provided by a wild ruminant when taken by predators. Muscle makes up a large part of the animal's body, and provides large amounts of nutrients because it is very digestible.

Changing proportions of muscle and other body components in relation to whole body weights are of interest in detailed energy flow studies. Data on muscle weights and chemical composition data, are useful for this purpose. In general, physically mature wild ruminants increase in body weight in the fall, but the function of the body weight that is in muscle remains quite constant. Increases in body weight reflect changing proportions of fat and water rather than muscle tissue. This is discussed further in CHAPTER 2.

REFERENCES, UNIT 3.7

MUSCULAR SYSTEM CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ANANA	137-4	381	394	odvi	musculature of hip, thigh	bisaillon,a	1974
JOMAA	31--1	5	17	odvi*	weight relations, georg re	hamerstrom,fm,jr/	1950

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
HILGA	19---	265	284	odhe	anam accep, food val, meat	cook,bb; witham/	1949
JOMAA	52--3	628	630	odhe*	tiss, organ, tota body mas	hakonson,te; whic	1971
WAEBA	589	1	6	odhe	the mule deer carcass	field,ra; smith,/	1973
WLMOA	39---	1	122	odhe*	carcas, bone, organ, gland	anderson,ae; med/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
WAEBA	594--	1	8	ceel	the elk carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JEBPA	13--2	133	136	alal	ceel, rata, compar myoglob	sukhomlinov,bf; /	1977
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVSPA	57---	1	18	rata	topograph, internal organs	engebretsen,rh	1975

rata continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
HLTPA	18--2	127	134	rata	lead-210,polonium-210, ala	blanchard,rl; moo	1970
HLTPA	20--6	585	591	rata	cesium-137, seas pat, alas	hanson,wc	1971
MNLHA	48-21	1	26	rata	[varia carcass wt, norway]	movinkel,h; prest	1969
NJZOA	24--4	407	417	rata	morpho, fat stor, organ wt	krog,j· wika,m	1976
PASCC	14---	69	69	rata	influence rut, meat palati	winters,rl	1963

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	36--6	1195	1195	anam	collagen charact of muscle	kruggel,wg; field	1973
JFDSA	39--3	639	640	anam	collagen character, muscle	kruggel,wg; field	1974
WAEBA	575--	1	6	anam	the pronghorn carcass	field,ra; smith,/	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				bibi			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	36--6	1195	1195	many	quality, quantity of meat	smith,fc· field,r	1973
JOMAA	27--4	308	323	many	mammals of northern idaho	rust,hg	1946
JWMAA	20--2	169	172	many	identif, game, precip reac	keiss,rw; morriso	1956
JWMAA	34--4	917	921	many	id game meat, electrophore	dilworth,tg; mcke	1970

CHAPTER 1, WORKSHEET 3.7a

Edible meat in relation to live weights and dressed weights of white-tailed deer (odvi)

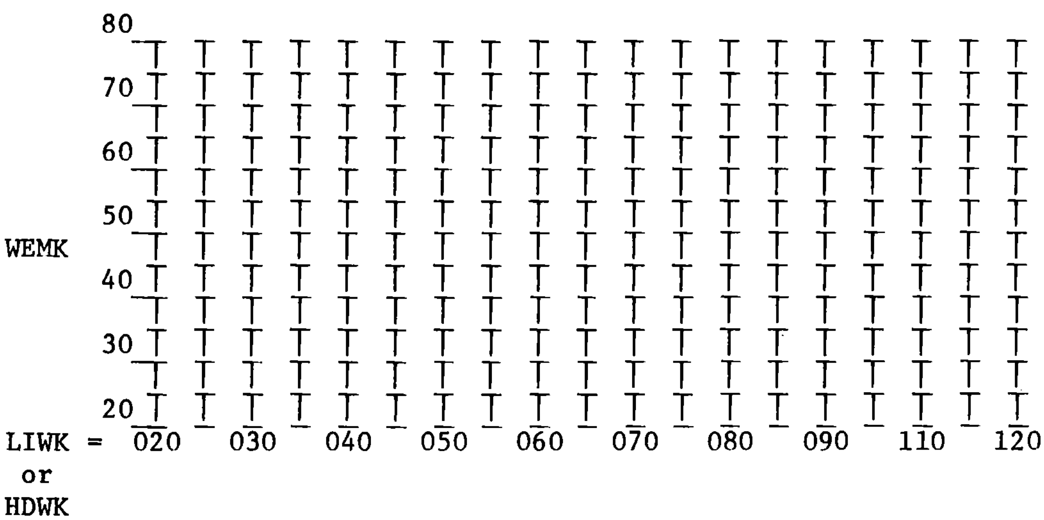
Ratios of calculated live weights and dressed weights to edible meat were published for nine deer by Hamilton (1947). Linear regression equations have been determined from the data in the abbreviated table below. Original data were given in pounds; values in kg are:

Calculated live weight (LIWK)	Hog dressed weight (HDWK)	Weight of edible meat (WEMK)
69.4	54.4	40.4
67.1	52.6	34.0
88.9	69.9	53.5
86.6	68.9	53.5
80.3	63.0	44.0
100.2	78.9	60.8
51.3	40.4	28.6
63.5	49.9	35.8
64.0	50.3	37.6

Using a linear regression curve-fitting program, the equations are:

$$\text{WEMK} = 0.68\ \text{LIWK} - 7.61;\ R^2 = 0.96$$
$$\text{WEMK} = 0.86\ \text{HDWK} - 7.33;\ R^2 = 0.97$$

Verify your linear regression curve-fitting program if you wish, and then plot the data using the equations derived.



LITERATURE CITED

Hamilton, W. J., Jr. 1947. Dressed weights of some game mammals. J. Wildl. Manage. 11(4):349-350.

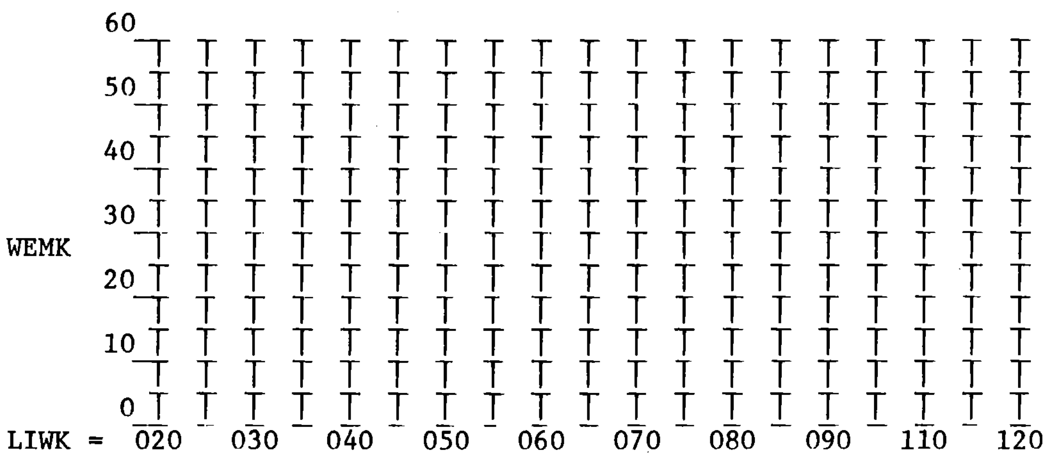
Live weight:edible lean meat relationships in white-tailed deer (odvi)

Live weight:edible lean meat data are given by Cowan et al. (1968). The linear regression equation derived from their table, is:

$$WEMK = 0.69 + 0.44\ LIWK$$

where WEMK = weight of edible meat in kg and LIWK = live weight in kg.

Plot the data below and compare the results with those on the previous WORKSHEET.



LITERATURE CITED

Hamilton, W. J., Jr. 1947. Dressed weights of some game mammals. J. Wildl. Manage. 11(4):349-350.

UNIT 3.8: NERVOUS SYSTEM CHARACTERISTICS

The nervous system of wild ruminants includes the brain, spinal cord, peripheral nerves, and receptors. These major anatomic divisions include billions of cells, all interacting in a coordinated control system that enables various body parts to function well together.

The brain is composed of a medulla oblongata, which connects to the spinal cord, cerebral hemispheres, and cerebellum. Each of these contain different centers for regulating visceral functions such as respiration, blood pressure, and heart rate, and sensory and motor functions. The brain itself contains many parts that perform different functions, though the parts themselves are not necessarily discernible as physical entities. Detailed drawings are available in such books as Swenson (1970) and Weichert (1970).

The spinal cord contains many nerve tracts which connect the brain with spinal nerves (Swenson 1970:866). Tracts for sensory and motor neurons are largely separated; there are tracts for both ascending and descending transmissions between the brain and the peripheral nerves.

Peripheral nerves contain many axons, or connecting fibers between the receptors and the central nervous system. There are also collections of neurons called ganglia outside of the central nervous system. These function as coordinating centers for viscera, glands and muscle tissues, without involving the central nervous system.

Receptors are cells that initiate an impulse to the rest of the nervous system in response to environmental stimuli. Several kinds of receptors are found in wild ruminants, including mechanoreceptors (touch or pressure), chemoreceptors (taste, smell, and blood composition), thermoreceptors (temperatuare changes), light receptors, sound receptors, and gravity and motion receptors. In addition, pain is elicited from different kinds of receptors, and from stimulation of nerve endings in tissues.

There is a dearth of published information on the nervous system characteristics of wild ruminants, so the distribution and capabilities of different receptors is not well known for the different species.

One of the most interesting and challenging characteristics of wild ruminants is their altertness and ability to escape danger, a direct function of the nervous system. We can only assume that the general anatomy is similar to other closely related vertebrates, and generalities are necessary if information is needed on the nervous system characteristics of wild ruminants.

LITERATURE CITED

Swenson, M. J., Ed. 1970. Dukes' physiology of domestic animals. Cornell University Press, Ithaca, N.Y. 1463 pp.

Weichert, C. K. 1970. Anatomy of the chordates. McGraw-Hill Book Company, New York. 814 pp.

REFERENCES, UNIT 3.8

NERVOUS SYSTEM CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJVRA	39--4	699	702	odvi	cone, rod photo receptors	witzel,da; sprin/	1978

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				odhe			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
RVTSA	10---	448	452	ceel	distr nerves, skin, red	jenkinson,dm;malo	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				alal			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVCSA	18---	152	158	rata	alal, caca cornea structur	rehbinder,c; winq	1977
AVSPA	57---	1	18	rata	topograph, internal organs	engebretsen,rh	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ANREA	184-2	187	201	bibi	a macroscopic study, brain	harper,jw; maser,	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BIJOA	119--	47p	47p	many	fatty acids, evol nerv sys	crawford,ma	1970

CLOSING COMMENTS

Physical characteristics of wild ruminants have been introduced in CHAPTER 1. Weights and seasonal variations in weights, geometry, and system characteristics are used in analyses of behavior, metabolism, heat loss, and population structures in later PARTS and CHAPTERS.

The next chapter (CHAPTER 2) contains more detailed information on various body parts. Some of these details are important for understanding biological functions, and some are useful management indicators. These relationships will be evaluated in remaining CHAPTERS.

GLOSSARY OF SYMBOLS USED - CHAPTER ONE

AEAM = Area of the ear in meters
AFMM = Area of the face, muzzle in meters
AGDA = Age in days
AGMO = Age in months
AGYE = Age class in years
AHEM = Area of the head in meters
ALFM = Area of the lower front leg in meters
ALHM = Area of the lower hind leg in meters
ANEM = Area of the neck in meters
ANWG = Antler weight in gms
ANWK = Antler weight in kg
ATRM = Area of the trunk in meters
AUFM = Area upper front leg in meters
AUHM = Area upper hind leg in meters

BASM = Bed area in square meters
BEAR = Bed area
BHTC = Belly height in cm
BIWK = Birth weight in kg
BLWG = Blood weight in gms
BLWK = Blood weight in kg
BOWK = Bone weight in kg

CLWK = Calculated live weight in kg
CUCM = Cubic centimeters (volumes)

DIGE = Days into gestation

EFWK = Estimated field-dressed weight in kg
ELWK = Estimated live weight in kg

FATK = Fat in kg
FDWK = Field-dressed weight in kg
FEWK = Fetal weight in kg
FWAB = Fetal weight at birth

GIWK = Gastrointestinal weight in kg

HAWG = Hair weight in gms
HDWK = Hog dressed weight in kg
HEFR = Height of forage reached
HEGC = Heart girth in cms
HEWG = Heart weight in grams
HEWK = Heart weight in kg
HFRC = Height of forage reached in cm
HFRM = Height of forage reached in m
HLLK = Heart, lung, liver weights in kg

IFWK = Ingesta-free weight in kg

JDAY = Julian day

LEGP = Length of gestation period
LIWK = Live weight in kg
LORA = Longest radius
LUVO = Lung volume

MAWK = Maximum weight in kg
MEWK = Metabolic weight in kg
MIWK = Minimum weight in kg

OAVC = Omasum and abomasum volumes in cubic cms

POAT = Percent of omasum and abomasum of total volume
PRPC = Primary phase correction
PRRT = Percent of rumen and reticulum total volume

RRVC = Rumen and reticulum volumes in cubic cm

SEPC = Secondary phase correction
SHRA = Shortest radius
SQCM = Square cm

TSAM = Total surface are in meters
TVSC = Total volume of stomach in cubic cms

WEMK = Weight of edible meat in kg
WEWK = Weaning weight in kg

GLOSSARY OF CODE NAMES - CHAPTER ONE

CODEN	
ABBIA	Archives of Biochemistry and Biophysics
ACATA	Acta Anatomica
ACBCA	Acta Crystallographica Section B Structural Crystallography and Crystal Chemistry
AHEMA	Anatomia Histologia Embryologia
AJANA	American Journal of Anatomy
AJPHA	American Journal of Physiology
AJVRA	American Journal of Veterinary Research
AKASA	Arkansas Academy of Science Proceedings
AMNAA	American Midland Naturalist
AMNTA	American Naturalist
ANANA	Anatomischer Anzieger
ANREA	Anatomical Record
ANYAA	Annals of the New York Academy of Sciences
APAVD	American Association Zoo Veterinarian Annual Proceedings
APSSA	Acta Physiologica Scandinavica Supplementum
ATICA	Arctic
ATRLA	Acta Theriologica
AVCSA	Acta Veterinaria Scandinavica
AVSPA	Acta Veteinaria Scandinavica Supplementum
AZWBA	Arizona Game and Fish Department Wildlife Bulletin
BEHAA	Behaviour
BICOB	Biological Conservation
BIGEB	Biochemical Genetics
BIJOA	Biochemical Journal
BIREB	Biology of Reproduction
BJNUA	British Journal of Nutrition
BLOOA	Blood
BPURD	Biological Papers of the University of Alaska Special Reports
BUCDA	Bulletin of the Georgia Academy of Sciences
BUFOA	Beaufortia
BVJOA	British Veterinary Journal
CAFGA	California Fish and Game
CAFNA	Canadian Field Naturalist
CBCPA	Comparative Biochemistry and Physiology
CBPAB	Comparative Biochemistry and Physiology - A comparative physiology
CFGGA	California Department of Fish and Game, Game Bulletin
CGFPA	Colorado Division of Game, Fish, and Parks Special Report
CIRIB	Congres International de Reproduction Animale et Insemination Artificielle
CJCMA	Canadian Journal of Comparative Medicine
CJESA	Canadian Journal of Earth Science
CJZOA	Canadian Journal of Zoology
CNJMA	Canadian Journal of Comparative Medicine and Veterinary Science
CNJNA	Canadian Journal of Animal Science

COVEA	Cornell Veterinarian
CPSCA	Chesapeake Science
CWRSB	Canadian Wildlife Service Report Series
ENDOA	Endocrinology
EVOLA	Evolution
EXMPA	Experimental and Molecular Pathology
FLDZA	Fieldiana Zoology
FUNAA	Fauna
GENTA	Genetics
GROWA	Growth
HEREA	Hereditas
HILGA	Hilgardia
HLTPA	Health Physics
JANSA	Journal of Animal Science
JAVMA	Journal of the American Veterinary Medical Association
JBCHA	Journal of Biological Chemistry
JEBPA	Journal of Evolutionary Biochemistry and Physiology
JFDSA	Journal of Food Science
JOANA	Journal of Anatomy
JOMAA	Journal of Mammalogy
JOMOA	Journal of Morphology
JOPAA	Journal of Parasitology
JPHYA	Journal of Physiology
JRPFA	Journal of Reproduction and Fertility
JWIDA	Journal of Wildlife Diseases
JWMAA	Journal of Wildlife Management
JZAMD	Journal of Zoo Animal Medicine
JZOOA	Journal of Zoology
LBASA	Laboratory Animal Science
MAMLA	Mammalia
MDCBA	Minnesota Deptartment of Conservation Technical Bulletin
MDCRA	Michigan Department of Conservation Game Division Report
MGQPA	Minnesota Department of Natural Resources Game Research Project
MNLHA	Meldinger fra Norges Landbrukshogskole
MRLTA	Murrelet, The
MVPRA	Modern Veterinary Practice
NATUA	Nature
NAWTA	North American Wildlife and Natural Resources Conference, Transactions of the,
NCANA	Naturaliste Canadien, Le
NFGJA	New York Fish and Game Journal
NJZOA	Norwegian Journal of Zoology
NYCOA	New York State Conservationist
NZJSA	New Zealand Journal of Science

OIKSA	Oikos
OJSCA	Ohio Journal of Science
PAABA	Pennsylvania Agricultural Experiment Station Bulletin
PASCC	Proceedings of the Alaskan Scientific Conference
PCGFA	Proceedings of the Southeastern Association of Game and Fish Commissioners
PCZOA	Proceedings of the International Congress of Zoology
PIAIA	Proceedings of the Iowa Academy of Science
PLNAA	Plains Anthropologist
PMASA	Proceedings of the Montana Academy of Sciences
POASA	Proceedings of the Oklahoma Academy of Science
PSEBA	Proceedings of the Society for Experimental Biology and Medicine
PZESA	Proceedings of the New Zealand Ecological Society
PZSLA	Proceedings of the Zoological Society of London
RSPYA	Respiration Physiology
RVTSA	Research in Veterinary Science
SCIEA	Science
SWNAA	Southwestern Naturalist
SZSLA	Symposia of the Zoological Society of London
THGNB	Theriogenology
TJSCA	Texas Journal of Science
TNWSD	Transactions of the Northeast Section, The Wildlife Society
UAABB	University of Alberta Agriculture Bulletin
UABPA	Biological Papers of the University of Alaska
UASPA	Proceedings of the Utah Academy of Sciences, Arts and Letters
UCPZA	University of California Publications in Zoology
VEZOA	Vestnik Zoologii
VILTA	Viltrevy
VIWIA	Virginia Wildlife
VJSCA	Virginia Journal of Science
WAEBA	Wyoming Agricultural Experiment Station Bulletin
WCDBA	Wisconsin Department of Natural Resources Technical Bulletin
WDABB	Bulletin of the Wildlife Disease Association
WGFBA	Wyoming Game and Fish Commission Bulletin
WLMOA	Wildlife Monographs
WLSBA	Wildlife Society Bulletin
WMBAA	Wildlife Management Bulletin Series 1
WSCBA	Wisconsin Conservation Bulletin
XNFSA	U S National Park Service Fauna of the National Parks of the U.S., Fauna Series
ZEJAA	Zeitschrift fuer Jagdwissenschaft
ZOGAA	Zoologische Garten
ZOLZA	Zoologicheskii Zhurnal
ZSAEA	Zeitschrift fuer Saeugetierkunde

LIST OF PUBLISHERS - CHAPTER ONE

coup	Cornell University Press	Ithaca, NY	itny
whfr	W. H. Freeman Co.	San Francisco, CA	sfca

LIST OF WORKSHEETS IN CHAPTER ONE

LIST OF WORKSHEETS IN CHAPTER ONE (CONTINUED)

THE BIOLOGY AND MANAGEMENT OF WILD RUMINANTS

CHAPTER TWO

ORGANS, GLANDS, CHEMICAL COMPOSITION AND GENETIC CHARACTERISTICS

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CONTENTS OF CHAPTER TWO

CHAPTER 2. ORGANS, GLANDS, CHEMICAL COMPOSITION, AND GENETIC CHARACTERISTICS

This chapter includes descriptions of many of the organs and glands that perform specific functions in the lives of wild ruminants, and of the chemical and genetic characteristics that are both the building blocks of each individual animal and the potential framework for future generations. The three TOPICS include UNITS that pertain to several different systems and biological functions that are discussed in other CHAPTERS. Antlers, for example, are not only secondary sexual characteristics but also partial determinants of nutrient requirements for mineral metabolism. Further, their growth and maturation affects the behavior of the male through the annual cycle.

The roles of other organs and glands are discussed in later CHAPTERS that contain discussions of the appropriate ecological functions under consideration. The descriptions of organs and glands in this CHAPTER may then be used to interpret adaptations for survival and production. Gastrointestinal tract characteristics are important when evaluating TOPIC 1: Gastrointestinal Support Functions in CHAPTER 6.

The chemicals composing wild ruminants are the end-products of metabolism. Organs, glands, and body tissues are physical entities representing the organization of chemicals ingested, metabolized, and synthesized. Some of these chemicals are deposited in particular tissues that serve as nutrient reservoirs for later use. Fat tissue, for example, is deposited during summer and fall and mobilized later, depending on hormone balances, range conditions, and the availability of forage.

The genetic characteristics of wild ruminants form the potential framework for future generations. The genetics of either individuals or populations cannot be controlled as directly in herds of wild ruminants as in herds of domestic ones because individuals are not selected for mating, but an understanding of basic genetic characteristics may be of value in explaining survival and productivity differences between populations in different areas.

TOPIC 1. CHARACTERISTICS OF ORGANS AND GLANDS

This topic includes descriptions of characteristics and lists of references for specific organs and glands that have particular physiological and ecological functions.

Many measurements of some of the organs of wild ruminants have been made by wildlife biologists. Antler dimensions, for example, have been recorded in many areas because there is an interest in trophies, and the antlers also indicate something about range conditions. Horns are considered in a unit separate from antlers because they are anatomically and physiologically quite different.

Pelage is described because seasonal changes in pelage represent adaptations to changing weather conditions, thermal exchange, and climatic patterns. Detailed measurements of hair lengths and angles over animal surfaces have not been made for most species, however, even though these physical characteristics are very important in determining the effectiveness of the hair as insulation. The pelage is also an example of biological tissue that functions as a reservoir of nutrients. The amount of hair in the winter coat, for example, represents protein costs that were met during the growth of the coat. Once completed, the hair is a static reservoir of protein that cannot be mobilized. Minerals deposited in the skeletal system -- the long bones and ribs, for example -- can be mobilized to meet the high demands of antler and horn growth. Minerals deposited in antlers and horns are not available for later mobilization, however, as antlers are shed annually and horns are not resorbed.

Dentition characteristics are considered because of the use of tooth wear and annuli in aging wild ruminants; there are many references in the literature on this important technique used in evaluating population ecology. Eye lens characteristics have been evaluated as criteria for age too; a short discussion of the references listed is included in one of the units.

Skin glands and endocrine glands are important considerations when evaluating chemical communications and the internal chemical environment. These glands may have far more important roles than we humans realize, simply because we cannot detect the odors or the presence of the chemical regulators called hormones easily, or without special analytical techniques. It is easier to offer explanations for ecological functions on the basis of what we can readily perceive than on the detection of very low concentrations of molecules in the air or the presence of complex chemicals in minute quantities in the blood. Nevertheless, these detailed characteristics are likely to be very important in the overall ecology of free-ranging wild ruminants and we should develop a body of literature for use in ecological interpretations.

UNIT 1.1: ANTLER CHARACTERISTICS

Antlers, organs composed of solid bone that grows for 5-6 months of the year, are characteristic of the family CERVIDAE. They are retained for several months, and then shed annually. Only the males normally have antlers except in the genus Rangifer; both male and female caribou and reindeer have antlers. There are some populations, however, in which very few of the females have antlers.

Antlers are of interest to laymen as trophies, and to biologists as indicators of range conditions. Antlers are larger on animals living on a range with adequate nutrients, and smaller on animals living on range with rather low quantities or poor quality forage. Trophy antlers develop on individuals that are in excellent physical condition and have the appropriate genetic make-up. The number of antler points was once thought to be anindicator of age, but both the number of points and overall antler size are poor indicators of age because of the importance of range conditions.

Genetic characteristics control the general pattern of antler branching. White-tailed and mule deer exhibit species differences in the branching. White-tail antlers have a single main beam with points arising from the main beam. Mule deer antlers are forked, with the points representing equal divisions at the junctions. Moose in North America usually have very definitely palmated antlers. Moose in Scandinavia often have antlers with little or no palmation, resembling elk or red deer (ceel) antlers.

Growing antlers are covered with a highly-vascularized tissue called velvet, which carries blood and metabolites to the antlers. Velvet-covered antlers are subject to damage and subsequent malformation, and males are generally rather docile when the antlers are growing. The large amount of blood flow makes velvet-covered antlers warm to the touch. The amount of heat loss from growing antlers needs to be evaluated in relation to the total thermal exchange before conclusions are reached on the importance of antlers in thermoregulation, however. Certainly they cannot be "necessary" in thermoregulation because then both males and females of all species would have them.

Antler dimensions and weights are of interest when evaluating the cost of antler growth in relation to other production costs. Antlers represent mineral accumulations that cannot be mobilized for other uses since there are no vascular beds in mature antlers.

Antlers are shed each year at a time dependent on several factors, including nutritional relationships between animal and range. In general, they are shed earlier on poor range. Antler shedding by deer may occur as early as December when breeding may still be in progress, and as late as March, when new antler growth begins.

Antler size and geometry, along with body size, are important factors in establishing social relationships within a group. In general, the more dominant animals have larger antlers, and a larger body size. Antlers that have a large spread appear more impressive, but a narrow spread offers more protection to animals while fighting.

ANTLER CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
FOBGA	9---1	47	99	cerv	regenera, transplanta antl	jaczewski,z	1961
MMLRA	5---4	121	172	cerv	antlers, contention	chapman,di	1975
NATUA	182--	1294	1294	cerv	fall-out radioact, antlers	hawthorn,j; duckw	1958
PMASA	18---	27	28	cerv	developm, late winter cond	taber,rd	1958
PMASA	18---	29	31	cerv	det antl wt, linear measmn	white,kl	1958
ZEJAA	2---3	136	141	cerv	[antler formation]	bubenik, aj; pav/	1956
ZSAEA	33--4	193	214	cerv	[developm antl, reproduct]	lau,d	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	22--3	247	367	od	distr,var, pacif coast reg	cowan,imt	1936
JOMAA	45--1	61	68	od	tissu rel dev pedunc, antl	goss,rj; severin/	1964
NAWTA	2----	446	457	od	wt, antl meas, pop density	johnson,fw	1937
SOVEA	20--2	93	98	od	abnorm ant shed, hypogonad	robinson,rm; tho/	1967

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ANREA	117-3	353	376	odvi	histol changes, shedd antl	wislocki,gb; wald	1957
CATRB	14--2	121	130	odvi	testos in growing antl,his	bubenik,ga; brow/	1974
CATRB	14--4	257	274	odvi	ossfctn process,dev antler	banks,wj	1974
CJPPA	53--5	787	792	odvi	gro hormone,cortisol level	bubenik,ga; bube/	1975
CJZOA	56--1	121	129	odvi	seas var LH,FSH, tes, male	mirarchi,re; how/	1978
FEPRA	34--2	337	337	odvi	chelatn, parathyroid, antl	brown,rd; griel,/	1975
FEPRA	35--3	500	500	odvi	antl,lng bone mass,androgn	brown,rd; cowan,r	1976
JANSA	47--2	435	440	odvi	pinealectmy, antl, androgn	brown,rd; cowan,/	1978
JEZOA	194-2	349	358	odvi	sex hormns,antlr bone tiss	bubenik,ga; bube/	1975
JOMAA	31--1	5	17	odvi	*weight relations, georg re	hamerstrom,fm,jr/	1950
JOMAA	35--4	486	495	odvi	odhe, antlr in female deer	wislocki,gb	1954
JOMAA	35--4	599	600	odvi	dichotomous forking, antle	leopold,as	1954

odvi continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	37--2	231	235	odvi	odhe, notes, antl female d	wislocki,gb	1956
JOMAA	38--2	277	278	odvi	odhe, 3 antlered female de	buechner,hk	1957
JOMAA	40--2	230	236	odvi	antl doe, masculiniz tumor	doutt,jk; donalds	1959
JOMAA	41--1	23	29	odvi	responses bucks artif ligh	french,ce; mcewa/	1960
JOMAA	41--4	521	523	odvi	velvet-antlrd pregnant doe	haugen,ao; musta/	1960
JOMAA	44--1	79	98	odvi	occurn certn anomali, mich	ryel,la	1963
JOMAA	49--3	522	523	odvi	antler develop & loss, ill	hawkins,re; schw/	1968
JOMAA	50--1	156	156	odvi	unusual antl-drop schedule	glazener,wc	1969
JOMAA	55--3	656	659	odvi	antler shedding in midwest	zagata,md; moen,a	1974
JWIDA	8---4	311	314	odvi	antl malform by leg injury	marburger,rg; ro/	1972
JWMAA	20--3	221	232	odvi/	nutr req, growth, antl dev	french,ce; mcewa/	1956
JWMAA	20--3	286	292	odvi	reg diff, siz, prod, w vir	gill,j	1956
JWMAA	31--3	588	590	odvi	antler shedding, connectic	behrend,df; mcdo/	1967
JWMAA	29--2	376	380	odvi	char shed antlers, s texas	michael,ed	1965
JWMAA	29--4	699	705	odvi/	antlers in females,4-yr st	donaldson,jc; do/	1965
JWMAA	37--1	106	108	odvi	biopsy tool, sampl antlers	mazur,pe; cowan,r	1973
JWMAA	37--2	187	194	odvi	calcium requi, weaned fawn	ullrey,de; youat/	1973
JWMAA	39--1	48	58	odvi*	morphol charact, crab orch	roseberry,jl; kli	1975
JWMAA	41--2	178	183	odvi	androg levels, antlr devel	mirarchi,re; sca/	1977
NAWTA	2----	446	457	odvi	weigh, antl meas, pop dens	johnson,f	1937
NAWTA	3----	261	279	odvi	weigh, meas, allegh nat fo	park,bc	1938
NAWTA	15---	551	570	odvi*	age, antl bea diam range c	severinghaus,cw	1950
NAWTA	22---	119	132	odvi	nutrient requireme wt deer	mcewan,lc; frenc/	1957
NYCOA	4---3	4	5	odvi	growth of the deer antler	aub,jc; wislocki/	1949
NYCOA	10--4	4	5	odvi	growth of the deer antler	taft,cb; hall,tc/	1956
PAABA	600--	1	50	odvi	nutrit req, grow, antl dev	french,ce; mcewa/	1955
PAABA	628--	1	21	odvi	nutr req, growth, antl dev	magruder,nd; fre/	1957
PAARA	209--	1	11	odvi	feed restriction, antl dev	long,ta; cowan,r/	1959
PSEBA	129	733	737	odvi	calcium stront, age, antlr	cowan,rl; hartso/	1968
PCGFA	19---	118	128	odvi/	measurmnt estim antlr volu	rogers,ke; baker,	1965
SAGCA	17--1	3	3	odvi	antlr growth, bone metabol	cowan,rl; hartso/	1969
SWNAA	22--2	278	280	odvi	obsrvns,antler velvet loss	hirth,dh	1977
VIWIA	16--9	5	7	odvi	report on the glades deer	davey,sp	1955
VJSCA	24--3	112	112	odvi	shedi antlr obsrv, virgini	scanlon,pf; mira/	1973
VJSCA	26--2	58	58	odvi	antler shed times,virginia	mirarchi,re; rus/	1975
WSCBA	4--10	49	51	odvi	wisconsin large deer, 1938	hopkins,r	1939
WSCBA	5---6	42	42	odvi	chem analy of deer antlers	chaddock,tt	1940

CODEN	vo-nu	bepa	enpa	anim kewo	auth	year
CJZOA	41---4	629	636	odhe age det, ossif, long bones	lewall,ef; cowan,	1963
CJZOA	54--10	1617	1636	odhe/horm reg, repro, antl cycl	west,no; nordan,	1976
GCENA	16---2	268	280	odhe leydig cells,antl gro,hist	markwald,rr; da/	1971
JCOQA	7	69	69	odhe cyclc trabeculr bone chngs	mcintosh,je	1972
JDREA	55	b218	b218	odhe current stim,growng antler	lake,f; davis,r/	1976
JOMAA	8----4	289	291	odhe horned does	dixon,j	1927
JOMAA	36---2	202	205	odhe antlerless mule deer bucks	robinette,wl; ga	1955
JOMAA	40---1	96	108	odhe antler anomalies of mule d	robinette,wl; jo	1959
JOMAA	40---2	252	253	odhe another antlered female de	buss,io	1959
JOMAA	52---3	628	630	odhe*tiss, organs, tota body ma	hakonson,te; whi	1971
JOMAA	53---2	403	404	odhe biolog, an antlered female	mierau,gw	1972
JWMAA	15---2	129	157	odhe mule deer, neraska nat for	mohler,ll; wamp/	1951
JWMAA	22---4	449	449	odhe fertile antlered doe	diem,kl	1958
JWMAA	33---3	520	533	odhe/antlr morphometry, colorad	anderson,ae; me/	1969
JWMAA	37---3	312	326	odhe/eff nutrit change, captive	robinette,wl; b/	1973
MRLTA	52---1	10	12	odhe examples of antl variation	rieck,ca; brown,	1971
SWNAA	15---4	485	494	odhe antlr phenol, pop, colorad	anderson,ae; med	1971
TISAA	63---2	189	197	odhe/regnl diffs, wt, antl, ill	richie,wf	1970
WLMOA	39----	1	122	odhe*carcas, bone, organ, gland	anderson,ae; me/	1974
ZZAHA	115--3	314	326	odhe/pituitary, photoper, antlr	nicolls,ke	1971

CODEN	vo-nu	bepa	enpa	anim kewo	auth	year
ATRLA	14-10	141	151	ceel grwth, dev, red d calv, po	dzieciolowski,r	1969
ATRLA	19-32	509	514	ceel antl role, det herd hierar	topinski,p	1974
BAPBA	22--1	67	72	ceel castra, pub, induc antl gr	jaczewski,z; kr/	1974
BJNUA	38--3	301	312	ceel/var wt, sp grav, comp,antl	hyvarinen,h; ka/	1977
FOBGA	24--3	299	308	ceel castra, testos, antlr grow	jaczewski,z; do/	1976
JEEMA	29--2	431	437	ceel antl pedicl,early fetal li	lincoln,ga	1973

ceel continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JEZOA	195-2	247	251	ceel	antlr grwth, congen polled	lincoln,ga; flet/	1976
JOMAA	40--2	252	252	ceel	record of antlered female	buss,io; solf,jd	1959
JOMAA	51--4	812	813	ceel	precoc antl dev, sex matur	moran,rj	1970
JRPFA	42--1	159	161	ceel	efct epididymis, antlr gro	lincoln,ga	1975
JWIDA	8---4	319	319	ceel	injurious antler anomoly	schlegel,mw; lee/	1972
JWMAA	24--1	15	21	ceel	on afognak island, alaska	troyer,aw	1960
JWMAA	30--1	135	140	ceel*measurements, weight relat		blood,da; lovaas,	1966
PZSLA	-----	819	864	ceel/caca, relativ size, antlrs		huxley,j	1931
RIJUA	30---	303	308	ceel	eff adm test prop on antlr	jaczewski,z; galk	1970
VESMA	4	199	201	ceel	antl develop, intern secre	frankenberger,z	1955
ZASMA	34-19	285	300	ceel	[statisti anal shed beams]	ludwig,j; lembck/	1978

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946
OFWRA	10	11	18	alal	antlers, age	timmerman,hr	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	90--4	449	463	rata	annual antler cycle, newfo	bergerud,at	1976
CJZOA	43--3	553	558	rata	antl shed, female b-g cari	lent,pc	1965
FMFUB	6---4	373	381	rata	antl asymmetr, reind, cari	davis,ta	1973
JOMAA	38--2	275	277	rata	disappearance, shed antler	mccabe,ra	1957
NATUA	223--	99	100	rata	vasomotr respon, growi ant	krog,j; reite,ob/	1969
NATUA	224--	1036	1037	rata	antlers, bones of contentn	henshaw,j	1969
NJZOA	24--4	407	417	rata	morph, fat stor, org weigh	krog,j; wika,m	1976
ZEJAA	2---1	21	24	rata	[peculiar antler developm]	bubenik,ab	1956

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--4	308	323	many	mammals of northern idaho	rust,hg	1946
NATUA	220--	813	814	many	horns, antlers, thermoreg	geist,v	1968
NATUA	231--	469	469	many	antlers, unbrittle bones	henshaw,j	1971
SCAMA	220-4	14	122	many	horns and antlers	modell,w	1969
ZSAEA	33--4	193	214	many/	[developm antlers, reprod]	lau,d	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ZEJAA	4---2	57	69	caca	[familial relations, antl]	kleinschmit,r	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JZOOA	157-1	125	132	dada	agng, wt, tooth erup, antl	chaplin,re; white	1969
TRNZA	82--2	569	578	dada	antl grwth, shed, capt, nz	riney,t	1954

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JEZOA	170-3	311	324	ceni	photoper control antl cycl	goss,rj	1969
JEZOA	171-2	223	234	ceni	photopr contrl antl cycl 2	goss,rj	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JBOMA	63--3	629	734	axax	the axis deer in hawaii	graf,w; nichols,l	1967

Body weight: antler characteristics relationships of white-tailed deeer (odvi)

Antler characteristics of white-tailed deer may be predicted in relation to October live weights from data presented by Magruder et al. (1957). The data used are:

Ration	Deer	LIWK	LMBC	NUPO	ANWG
Complete	106	110.9	54.6	11	1244
Complete	120	90.0	43.2	12	690
Complete	130	85.9	43.2	9	526
Low energy	105	63.2	27.9	4	271
Low enerby	115	70.9	36.8	9	384
Low calcium	111	84.6	45.7	8	828
Medium Ca and P	144	45.9	12.7	2	96
Low Ca and P	122	71.8	26.7	6	196
Low Ca and P	143	71.4	27.9	4	231
Low Protein	139	81.8	43.2	9	503
Low Protein	117	75.0	38.1	7	805
Low Protein	109	72.3	38.1	4	368

Equations derived from the data are:

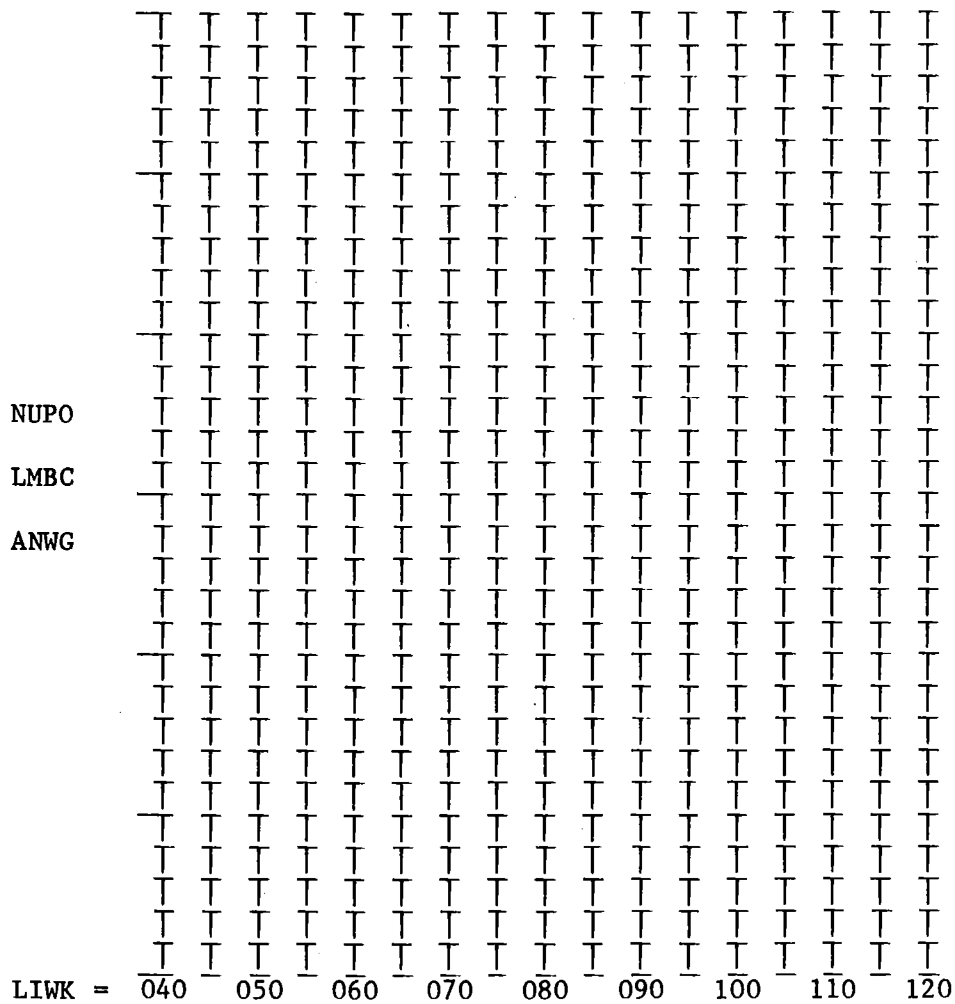
$$NUPO = 0.170\ LIWK - 5.66;\ r^2 = 0.71$$
$$LMBC = 0.655\ LIWK - 13.96;\ r^2 = 0.87$$

$$ANWG = 9.66 \times 10^{-4}\ LIWK^{3.0};\ r^2 = 0.79$$

A yearling buck weighing 65 to 70 kg is predicted to have a total of six points on both antlers. Length of the main beam is predicted to be 27 to 32 cm, and the antlers should weight a total of about 265 to 330 gms.

Label the y-axis on the graph on the next page and plot LMBC, NUPO, and ANWG.

Note that the individual data points fit the general patterns quite well, even though they are derived from deer on different experimental diets. How much evidence is there from other experiments on the role of diet constituents on antler growth? Is the biological relationship between diet and body growth similar to that of diet and antler growth, resulting in good relationships between body growth and antler growth?



LITERATURE CITED

Magruder, N. P., C. E. French, L. C. McEwan, and R. W. Swift. 1957. Nutritional requirements of white-tailed deer for growth and antler development. II. Experimental results of the third year. Bull. 628. The Pennsylvania State University, Coll. of Agric., Agric. Exp. Sta., University Park, PA 21 pp.

CHAPTER 2, WORKSHEET 1.1b.

Age:antler weight relationships of elk (ceel)

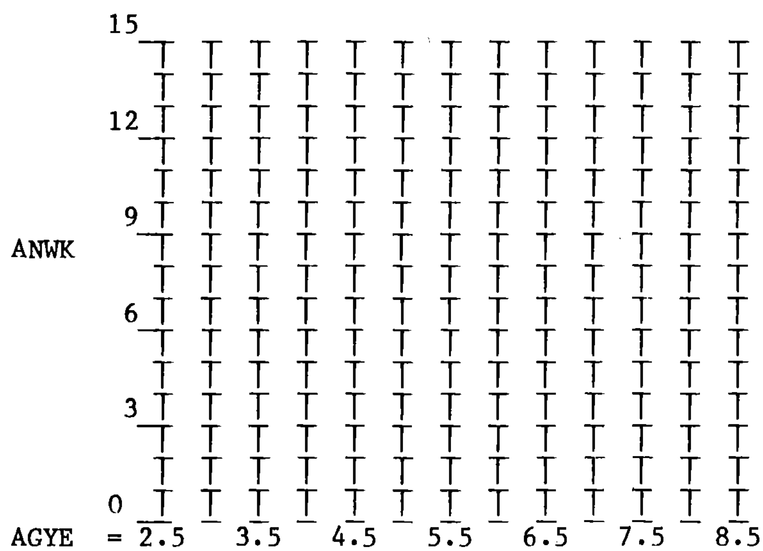
Ages and antler weights of 12 Manitoba elk have been given by Blood and Lovaas (1966). There is a general increase in weight with age, but with variations between years. Individual average weights for each age class in years (AGYE) are given below. Regression equations have been calculated. The a and b values for predicting antler weight in kg (ANWK) from AGYE are given below; the trend toward increasing antler weights with increases in age is best expressed with the exponential equation :

$$\text{ANWK} = a\ e^{b\ \text{AGYE}} = 1.34589\ e^{0.24488\ \text{AGYE}}$$

Complete the calculations and plot the results.

AGYE	ANWK	MEAN ANWK
2.5	1.77	
2.5	2.34	
2.5	2.82	2.31
3.5	2.93	
3.5	3.48	3.21
4.5	6.11	
4.5	7.27	6.69
5.5	6.25	6.25
6.5	6.48	
6.5	9.09	7.79
[7.5]	6.07	6.07
8.5	13.30	13.30

	LINE	EXPO	LOGA	POWE
r^2 =	0.74	0.87	0.70	0.84
a =	-1.30	1.34589	-4.63667	0.79286
b =	1.42	0.24488	6.84604	1.21051



LITERATURE CITED

Blood, D. A. and A. L. Lovaas. 1966. Measurements and weight relationships in Manitoba elk. J. Wildl. Manage. 30(1):135-140.

CHAPTER 2, WORKSHEET 1.1c.

Antler weight: main beam length relationships of elk (ceel)

The 12 pairs of data for antler weight:main beam length relationships given by Blood and Lovaas (1966) are listed below, with the sum of the left and right main beam lengths in cm (LBLC and RBLC) = main beam lengths in cm (MBLC) as the independet variable and antler weight in kg (ANWK) as the dependent variable. Such a relationship, if it is close enough to have predictive value, can be used to estimate antler weight simply by measuring the length of the main beams with a tape. The data are:

MBLC LEFT		MBLC RIGHT		TOTA MBLC	ANWK	LINE	EXPO
47.63	+	71.76	=	119.39	1.77		
74.30	+	73.96	=	148.26	2.34	R^2 = 0.86	0.91
80.01	+	85.09	=	165.10	2.82	a = -7.56	0.39882
76.20	+	72.69	=	148.89	2.93	b = 0.07	0.01294
85.09	+	84.46	=	169.55	3.48		
95.25	+	94.62	=	189.87	6.11	LOGA	POWE
107.95	+	108.59	=	216.54	7.27		
109.52	+	109.86	=	219.38	6.25	R^2 = 0.81	0.92
119.68	+	122.22	=	241.90	6.48	a = -59.49203	0.00001
115.24	+	115.87	=	231.11	9.09	b = 12.44577	2.42660
100.33	+	89.20	=	189.53	6.07		
134.92	+	136.19	=	271.11	13.30		

The best fit is with the power curve; the equation is:

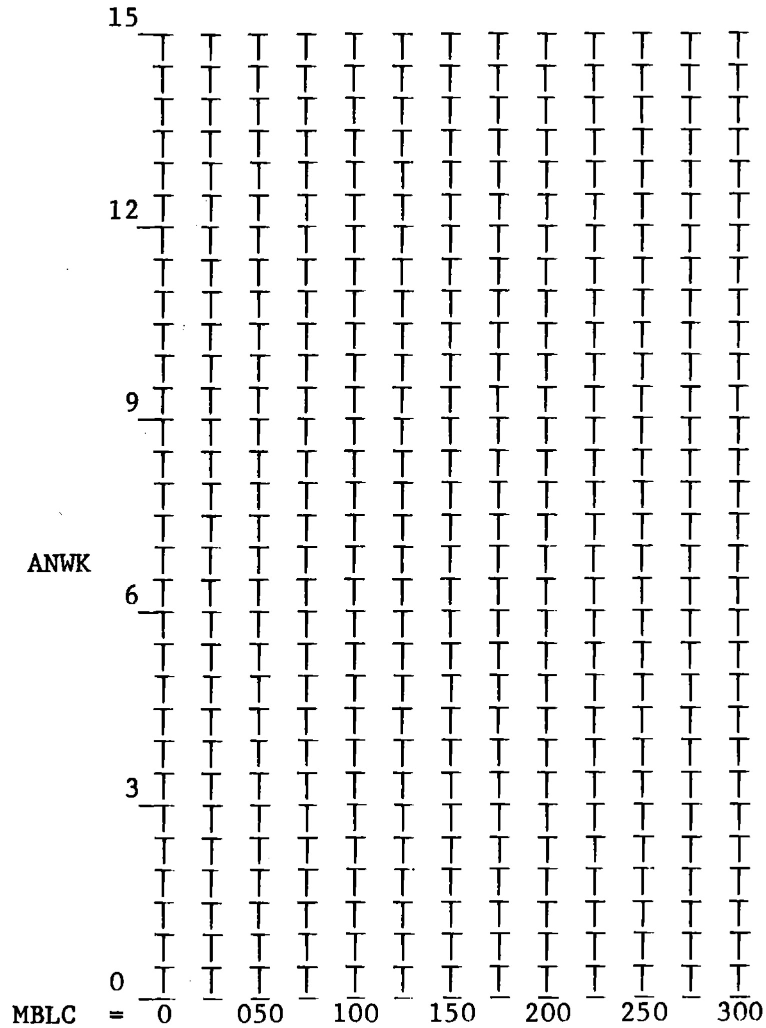
$$ANWK = a\ MBLC^{b} = 0.00001\ MBLC^{2.42660}$$

The r^2 for the exponential curve is very close to the r^2 for the power curve, however. The exponential equation is:

$$ANWK = a\ e^{b\ MBLC} = 0.39882\ e^{0.01294\ MBLC}$$

WS 1.1c is continued on the next page

Plot the data below for both of these equations and note how different the predictions are:



This illustrates how one fit needs to be checked over the entire range of values before determining if a particular equation is useful or not.

LITERATURE CITED

Blood, D. A. and A. L. Lovaas. 1966. Measurements and weight relationships in Manitoba elk. J. Wildl. Manage. 30(1):135-140.

UNIT 1.2: HORN CHARACTERISTICS

Horns are permanent organs that grow from their base each year adding annual increments which may be used in estimating the individual's age. horns are not solid like antlers, but have an outer sheath which is permanent except in the pronghorn, which casts the sheath annually. Both sexes of horned species usually have horns, with the males usually having larger horns than the females.

Differences in horns may be used to identify populations or subspecies. Rocky Mountain bighorn and desert bighorn, both Ovis canadensis, have horn differences, with the horn of the desert bighorn ram more flared than those of the Rocky Mountain bighorn.

The name "pronghorn" is attributed to the forward-located prong on the horns of the "antelope."

REFERENCES, UNIT 1.2

HORN CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	50--2	373	375	anam	horn casting, female prong	ogara,b	1969
JOMAA	56--4	829	846	anam	growth, casting horns, exf	o'gara,bw; matson	1975
JWMAA	16--3	387	389	anam	measurements, hart mt ante	mason,e	1952

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	45--4	630	632	bibi	new data, b. bison, athaba	bayrock,la; hille	1964
JWMAA	23--3	342	344	bibi	horns, teeth, indicati age	fuller,wa	1959
POASA	41---	212	218	bibi	weigh, meas, wichita mount	halloran,af	1961

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
EVOLA	20--4	558	566	ov	evolutionary signif, horns	geist,v	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	30--4	634	635	ovca	validity, horn segm, aging	geist,v	1966
JWMAA	34--2	451	455	ovca	wt, growth, rcky mt, alber	blood,da; flook,/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	33--3	552	558	ovda	horn develop, aging	hemming,je	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--4	308	323	many	mammals of northern idaho	rust,hg	1946
NATUA	220--	813	814	many	horns, antlers, thermoregu	geist,v	1968
SCAMA	220-4	114	122	many	horns and antlers	modell,w	1969

UNIT 1.3: PELAGE CHARACTERISTICS

The pelage of wild ruminants is an important characteristic ecologically as the sesonal molts and growth of winter and summer coats represent adaptations for survival in the changing rigorous climates of the northern regions. There are structural differences in the winter and summer coats, with the winter coat being considerably longer and thicker than the summer one. The winter guard hairs of the cervids are rather stiff, crinkly, and even hollow, while the guard hairs of the other wild ruminants are much finer. Underfur is present in varying amounts, and molting cervids sometimes have a "woolly" appearance as the underfur extends beyond the growing guard hairs.

Molting animals often have a very rugged appearance, especially in the spring when the dense winter coat is being replaced by the short and thin summer coat. Patches of winter hair, especially of the finer haired species like mountain goats, are found caught on twigs as the animals brush against shrubs and trees.

The hides of different species have different thicknesses, and vary in their softness when tanned. Deer hides are thin and very soft, white moose hides are much thicker and yet very soft. Bison hides are thick and rather stiff.

The amount of hair on an individual is of interest because hair represents a production cost that must be met during the growth periods of the summer and winter coats. The amounts of protein, energy, and minerals in the hair represent the lower limits to the energy, protein, and mineral costs of hair growth since the growth had to cost at least as much as the amounts deposited in the hair. These amounts represent the cost of the product itself. There is also an "overhead" associated with the production of hair, just as there is with milk production and other productive functions. The overhead, or cost of production, plus the quantities of energy, protein, and minerals in the hair gives one a realistic estimate of the metabolic costs of hair growth.

The relationship between the weight of a wild ruminant and the weight of its hair coats may be used to estimate the relative cost of hair production in the total metabolism. The heavier winter coat has a higher production cost than the lighter summer coat, of course. It is necessary to determine the total cost in relation to the length of the growth period in order to calculate the cost per day.

Few measurements of hair depth have been made as summer and winter coats grow. In white-tailed deer, the winter coat begins growing in late August or early September, and linear growth may not be complete until December. Shedding of the winter coat begins in April, and the summer coat appears in May and June. The timing is hard to discern in the wild, and there are variations between individuals, locations, and years.

Mathematical representations of hair growth as continuous functions are needed for determining metabolic costs of living, so estimates must be made with few data. The timing of coat changes--both molting periods and growth periods--are important characteristics of the biochronology of an animal in relation to the phenology of the range, and are estimated in the derivation of hair growth equations. WORKSHEETS follow with illustrations equations for predicting hair weights during the annual cycle.

REFERENCES, UNIT 1.3

PELAGE CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
FUNAA	25	277	280	cerv	identifica species by hair	birkeland,k; myh/	1972
VCSZA	33--4	300	312	cerv	[course of molting, deer]	dobroruka,lj	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	22--3	247	367	od	distr,var, pacif coast reg	cowan,imt	1936

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	38--4	871	876	odvi	body composition of w-t de	robbins,ct; moen/	1974
JOMAA	31--1	5	17	odvi*	weight relations, georg re	hamerstrom,fm,jr/	1950
JOMAA	44--1	79	98	odvi	occurn certn anomali, mich	ryel,la	1963
JOMAA	47--1	154	155	odvi	wooly-coated deer, new yor	friend,m; hesselt	1966
PAARA	209--	1	11	odvi	feed, season, antler devel	long,ta; cowan,r/	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	50--5	639	647	odhe	pelage and molt, bl-tld dr	cowan,imt; raddi,	1972
WAEBA	589--	1	6	odhe	the mule deer carcass	field,ra; smith,/	1973
WLMOA	39---	1	122	odhe*	carcas, bone, organ, gland	anderson,ae; med/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	14---	141	151	ceel	growth, devel, reindeer ca	dzieciolowski,r	1969
JZOOA	170-1	69	77	ceel/coat	struct, seasnl change	ryder,ml; kay,rnb	1973
JZOOA	181-2	137	143	ceel/seas	coat changes, grazing	ryder,ml	1977
JZOOA	185-4	505	510	ceel/coat	grwth,day length cycl	kay,rnb; ryder,ml	1978
WAEBA	594--	1	8	ceel	the elk carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	41--3	906	910	alal	hair indicator, mineraliza	flynn,a; franzma/	1975
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
NJZOA	24--4	407	417	rata*	morphol, fat stor, org wei	krog,j; wika,m; /	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
WAEBA	575--	1	6	anam	pronghorn antelope carcass	field,ra; smith,/	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ZETIA	49--1	71	76	bibi	hair display loss, male bi	lott,df	1979

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	86--3	288	289	ovda	color variation, e alaska	guthrie,rd	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BJLSB	6---2	127	141	obmo	wool shedding in muskoxen	wilkinson,pf	1974
JZOOA	177-3	363	375	obmo	length, diamtr coat fibers	wilkinson,pf	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	31--1	192	194	oram	fight injuries, derm shiel	geist,v	1967

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
VCSZA	39	94	103	many	molting	dobroruda,lj	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JBLPA	4	57	64	caca	investigations, skin	pavlovic,m	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
PAANA	5----	138	140	dosh	effct lactatn, wool growth	corbett,jl	1964

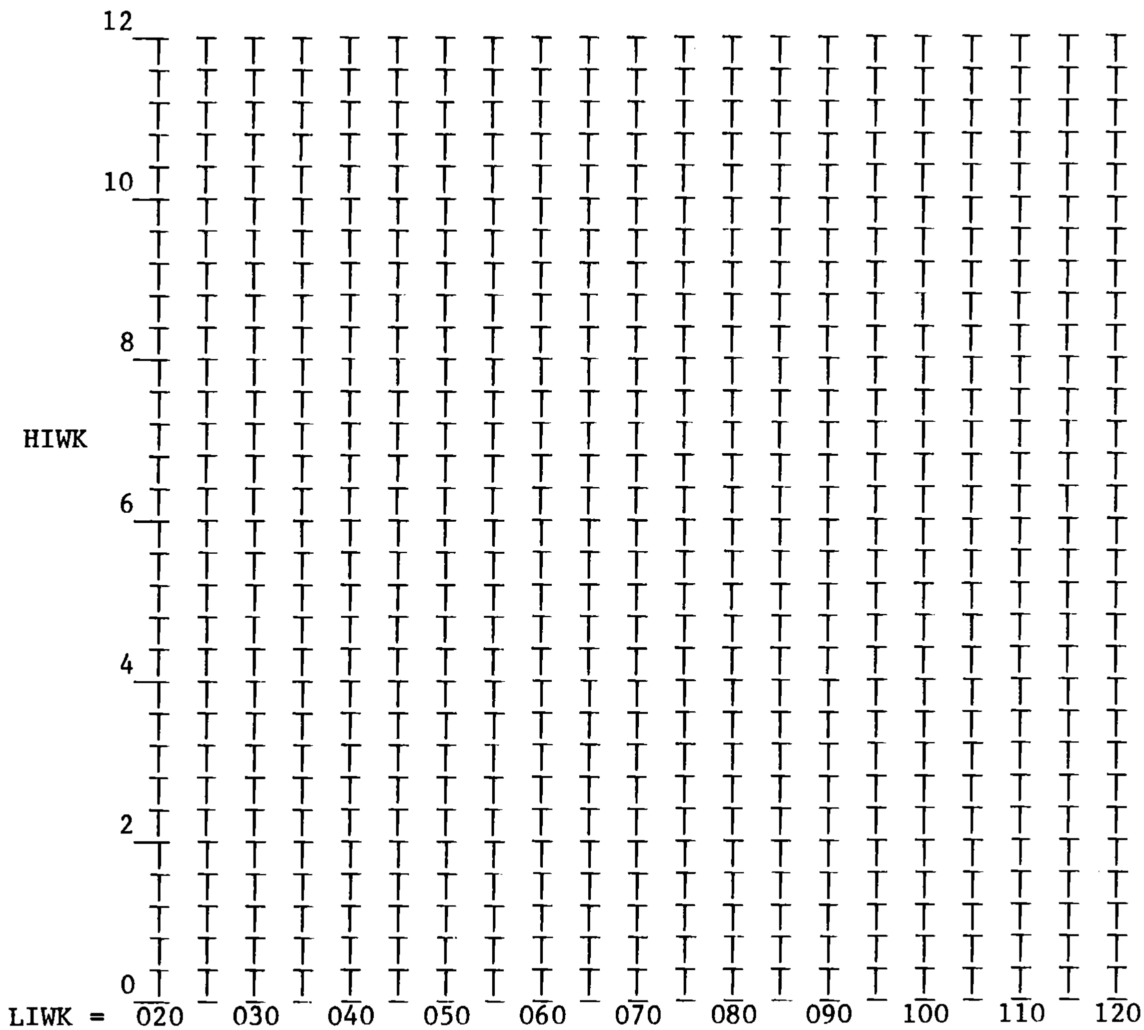
Live weight:hide weight relationships for white-tailed deer (odvi)

Estimates of hide weights, presumably with the hair on, in relation to live and field-dressed weights are given by Cowan et al. (1968). The weights are based on measurements of 13 deer.

The linear regression equation for hide weight in kg (HIWK) based on live weight in kg (LIWK) is:

$$HIWK = 0.11\ LIWK - 1.57$$

The relationship may be plotted below.



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Cowan, R. L., E. W. Hartsook, J. B. Whelan, J. L. Watkins, J. S. Lindzey, R. W. Wetzel, and S. A. Liscinsky. 1968. Weigh your deer with a string. Pennsylvania Game News 39(11):17-19.

CHAPTER 2, WORKSHEET 1.3b

Hair weight:live weight relationships for white-tailed deer (odvi)

The weights of the hair on 16 white-tailed deer, sacrificed from October 24-27 when the winter coat was about 2/3 completed, were measured by Robbins, Moen, and Reid (1974). The equation for the dry weight of the hair in grams (HAWG) in relation to ingesta-free body weight in kg (IFWK) is:

$$HAWG = 542.33 \ln(IFWK) - 1406.51$$

This equation can be combined into a sequence with the equation for ingesta-free weight in relation to live weight, and live weight in relation to age in days (AGDA) and Julian day (JDAY). The sequence is:

$$\text{AGDA and JDAY} \longrightarrow \text{CLWK} \longrightarrow \text{IFWK} \longrightarrow \text{HAWG}$$

Hair weight may be calculated in relation to age and day of the year then by assembling a series of equations. The sequence illustrates how inputs generate outputs, which in turn become inputs for a new equation.

Since the equation given for HAWG was derived from data on deer sacrificed between October 24-27 (JDAY = 297 to 300), a fawn of the year, born on the last day of May (JDAY = 151) would have an AGDA = 300 - 151 = 149. A 1 1/2 year deer would have an AGDA 365 - 149 = 514, a 2 1/2 year deer would have an AGDA = 2(365) - 149 = 879, and so on. Using the two initial inputs (JDAY = 300, AGDA = 149) in the sequence to generate CLWK, determine CLWK, IFWK, and HAWG with the equations given thus far for white-tailed deer. Since the final output, HAWG, is for a winter coat that is 2/3 completed, the answer can be multiplied by 1.5 to give an estimate of the final weight of the winter hair.

Four equations have been determined for white-tailed deer. They are:

1. $344 < JDAY < 365$, $1 < JDAY < 121$ $HAWG = 1.5\,[-1406.51 + 542.33] \ln(IFWK)$

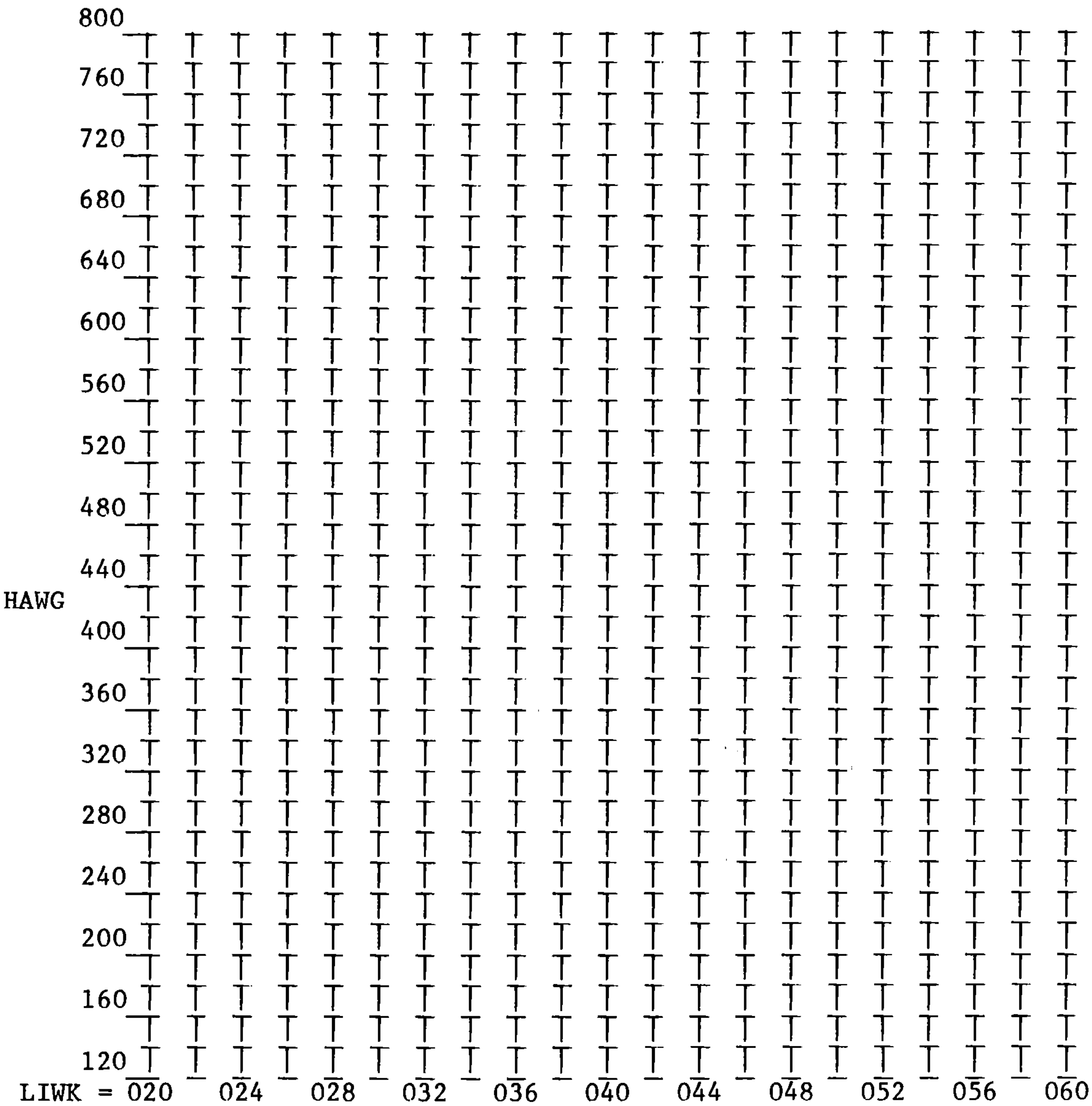
2. $121 < JDAY < 161$ $HAWG = \dfrac{JDAY - 121}{50}(1.5)\,[-1406.51 + 542.33] \cdot \ln(IFWK)$

3. $161 < JDAY < 264$ $HAWG = 0.3\,[-1406.51 + 542.33] \ln(IFWK)$

4. $264 < JDAY < 344$ $HAWG = \dfrac{JDAY - 244}{100}(1.5)\,[-1406.51 + 542.33] \cdot \ln(IFWK)$

Where JDAY = Julian date
HAWG = hair weight in grams
IFWK = ingesta-free weight in kg

The use of four separate equations provides a means to calculate estimates of the cost of hair growth through the year.



LITERATURE CITED

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

UNIT 1.4: DENTITION CHARACTERISTICS

One of the dentition characteristics of interest to mammalogists and taxonomists is the arrangement of the teeth or dental formulas. The formulas are expressed in relation to the order of teeth from front to back, with upper and lower teeth designated. The four kinds of teeth are incisor, canine, premolar and molar, and the formula I:0/4 C:0/0 P:3/3 M:3/3 indicates there are 0 top and 4 bottom incisors, 0 canines, and 3 premolars and 3 molars, both top and bottom. This is the general dental formula for ruminants, with some variations between genera and between sexes of the same species. The dental formulas listed by Gilbert (1979) and Palmer (1949)* for different ruminants are:

	male	female
odvi	0/3 + 0/1 + 3/3 + 3/3	0/3 + 0/1 + 3/3 + 3/3
odhe	0/3 + 0/1 + 3/3 + 3/3	0/3 + 0/1 + 3/3 + 3/3
ceel	0/3 + 1/1 + 3/3 + 3/3	0/3 + (1)/1 + 3/3 + 3/3
alal	0/3 + 0/1 + 3/3 + 3/3	0/3 + 0/1 + 3/3 + 3/3
rata	0/4 + 0/0 + 3/3 + 3/3*	
anam	0/4 + 0/0 + 3/3 + 3/3	0/4 + 0/0 + 3/3 + 3/3
bibi	0/4 + 0/0 + 3/3 + 3/3*	
ovca	0/4 + 0/0 + 3/3 + 3/3*	
ovda		
obmo	0/4 + 0/0 + 3/3 + 3/3*	
oram	0/4 + 0/0 + 3/3 + 3/3*	

Two dentition characteristics of interest to population biologists and managers are tooth wear and annual rings, both of value as indicators of age. Aging by tooth wear has been a useful and relatively easy-to-use technique. Wear rates differ between areas, however, with more wear expected in dryer, dustier climates where more abrasive material is found on the forage and less wear in areas with more moisture and succulent forage. Diet differences can also cause difference in tooth wear, of course.

Examination of cementum annuli for estimating ages is a more recent technique than estimating by tooth wear. Different teeth have been used for aging purposes; these are sometimes indicated in the key words of the titles in the reference lists. The annual-ring aging technique requires that tooth sections be prepared for microscopic interpretation, so there is a delay between the initial field collections and the results.

Aging by counting annual rings is more accurate than by tooth wear, since the annual rings reflect metabolic changes between seasons of the year. In general, aging by tooth wear has resulted in underestimating agescompared to the annual ring technique when known-age wild deer have been studied. Over 50% of white-tailed deer thought to be two years old when aged by tooth-wear were three-years or older when aged by cementum annuli (Moen and Sauer 1977).

Comparisons of these two methods involve several years of field work as large numbers of neonates must be captured and marked for later re-examination as adults of different ages. As a result, few animals have been aged by both methods.

LITERATURE CITED

Gilbert, D. L. 1979. Evolution and taxonomy, Chapter 1. In Big Game of North America, J. S. Schmidt and D. L. Gilbert, Ed. The Stackpole Company, Harrisburg, PA. 494 pp.

Moen, A. N. and P Sauer. 1977. Population predictions and harvest simulations. A paper presented at the Joint Northeast-Southeast Deer Study Group Meeting, Blackstone, VA. In proc. 36pp.

Palmer, E. L. 1949. Fieldbook of natural history. McGraw-Hill Book Company, Inc., New York. 664 p.

REFERENCES, UNIT 1.4

DENTITION CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	53--2	359	366	cerv	superior canines of deer	brokx,pa	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AIPAD	5	182	188	od--	eruption, replcmnt of teet	texera,wa	1974
CAFGA	22--1	43	44	od--	replacem teeth, age determ	mclean,dd	1936
CAFGA	22--3	247	367	od--	distr,var, pacif coast reg	cowan,imt	1936
JOMAA	45--2	319	321	od--	mandibular malformations	short,hl	1964
JWMAA	15--1	99	101	od--	standard terminolog, teeth	riney,t	1951
JWMAA	22--4	442	443	od--	tooth impressn, age determ	flyger,vf	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JAASA	40	128	128	odvi	cement ann vs tooth wear a	boozer,rb	1971
JOMAA	44--1	79	98	odvi	occurn certn anomali, mich	ryel,la	1963
JOMAA	51--4	804	806	odvi	mandib dentl anomali, minn	mech,ld; frenzel/	1970
JOMAA	52--1	223	226	odvi	mandible variati, sex, age	rees,jw	1971
JOMAA	55--3	656	659	odvi	antler shedding in midwest	zagata,md; moen,a	1974
JOMOA	128-1	95	B112	odvi	morphol varia, cran, mandi	rees,jw	1969
JOMOA	128-1	113	130	odvi	morphol varia, mandi, skel	rees,jw	1969
JWIDA	11--1	76	78	odvi	4th pair mandibular molars	abler,wa; scanlon	1975
JWMAA	13--2	195	216	odvi	tooth developme, wear, age	severinghaus,cw	1949
JWMAA	14--4	382	384	odvi	conditn teeth, 16.5 years	severinghous,cw;/	1950
JWMAA	22--4	442	443	odvi	tooth impressi, determ age	flyger,vf	1958
JWMAA	30--1	197	199	odvi	determ age, cement, molars	ransom,ab	1966
JWMAA	30--1	200	202	odvi	aging, annuli, cement, inc	gilbert,ff	1966
JWMAA	34--3	532	535	odvi/	variabi, aging, tooth wear	gilbert,ff: stolt	1970

odvi continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	36--1	46	55	odvi	studi, dental annuli,aging	lockard,gr	1972
JWMAA	36--4	1060	1067	odvi	age determ venezuelan wh-t	brokx,pa	1972
JWMAA	44--1	266	268	odvi	odhe,irreg cemen layr,agng	rice,la	1980
NCANA	103-2	73	76	odvi	comparison 2 meth estm age	lapierre,le	1976
NFGJA	18--1	66	67	odvi	maxillary canine teeth, ny	bergstrom,as; pa/	1971
NFGJA	19--1	32	46	odvi	mandibular, dental anomali	free,sl; bergstr/	1972
NFGJA	22--2	156	158	odvi	romanowsky stains, aging	stone,wb; clauso/	1975
NYCOA	5---2	8	10	odvi	aging a deer--how to do it	severinghaus,cw	1950
PCGFA	17---	31	37	odvi	compar aging techn, alabam	lueth,fx	1963
PCGFA	18---	137	140	odvi	tech, remov trophy mandibl	marshall,cm; smi/	1964
PCGFA	20---	69	74	odvi	mandib cavity tiss, condit	baker,mf; lueth,f	1966
PIAIA	74---	72	77	odvi	eval, dent annu, agng,iowa	sohn,aj	1967
PLNAA	19-65	224	227	odvi	dental annuli age determin	kay,m	1974
PMACA	47	289	316	odvi	validity age determ, mich	ryel,da; fay,ld;	1961
SWNAA	17--2	211	213	odvi	maxil canin, supernu incis	watkins,rk; urnes	1972
SWNAA	18--4	468	469	odvi	anomalous 3rd molars, texa	horejsi,rg; mont/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	51--6	663	664	odhe	cryosat,tool for game biol	child,kn	1973
JOMAA	45--2	315	315	odhe	abnormal dentition, colora	short,hl; short,c	1964
JOMAA	47--4	640	654	odhe*	histol, embry, morph denti	rees,jw; kainer,/	1966
JOMAA	52--3	628	630	odhe	tiss, organs, tota body ma	hakonson,te; whic	1971
JWMAA	21--2	134	153	odhe	tooth development and wear	robinette,wl; jo/	1957
JWMAA	24--2	224	226	odhe	tech, dental impres, restr	barnes,rd; longhu	1960
JWMAA	27--3	466	471	odhe	age determ, annular struct	low,wa; cowan,i m	1963
JWMAA	30--3	629	631	odhe	chron mineral, erupt teeth	rees,jw; kainer,/	1966
JWMAA	33--2	384	388	odhe	effic sectng incisor, agng	erickson,ja; sel/	1969
JWMAA	34--3	523	531	odhe	estimating ages, accuracy	erickson,ja; and/	1970
JWMAA	37--2	232	235	odhe	age determ, dental annulat	thomas,dc; bandy,	1973
JWMAA	39--4	674	678	odhe	accuracy dent wear estimat	thomas,dc; bandy,	1975
WLMOA	39---	1	122	odhe*	carcas, bone, organ, gland	anderson,ae; med/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	15-30	523	525	ceel	addtnl molar, red d, polan	zurowski,w	1970
BGTEA	3	34	52	ceel	age determination of red d	de crombrugge,sa/	1968
JAECA	36--2	279	293	ceel	gr layrs, dent cement, age	mitchell,b	1967
JOMAA	47--3	514	514	ceel	vestig first premolar,mich	moran,rj; fairba	1966
JOMAA	50--2	350	355	ceel	histology, anatomy, canine	seliger,wg; eri/	1969
JWMAA	21--4	435	451	ceel	mandibular dent, age indic	quimby,dc; gaab,	1957
JWMAA	27--3	466	471	odhe	age det, ann struc dent ce	low,wa cowan,imc	1963
JWMAA	30--1	135	140	ceel*	measurements, weight relat	blood,da; lovaas,	1966
JWMAA	31--3	408	417	ceel	sex, age, upper cani teeth	greer,kr; yeager	1967
JWMAA	33--1	175	180	ceel/	erupt-wear pat, cem annuli	keiss,re	1969
JZOOA	152-2	137	153	ceel	teeth, age indicat, scotla	lowe,vpw	1967
MRLTA	32--1	19	22	ceel	techniq, age determination	swanson,cv	1951
NATUA	198--	350	351	ceel	age det, growth layr,scotl	mitchell,b	1963
NZJSA	13--3	352	358	ceel	dental cement layers, agng	douglas,mjw	1970
ZEJAA	16--2	49	55	ceel	[tooth struct, agng,red d]	almasan,ha· rieck	1970
ZEJAA	22--2	65	74	ceel	[agng,1st molar,1st incsr]	ueckermann,e; sch	1976
ZEJAA	24--1	45	47	ceel	[tooth malform,stag red d]	meyer,p	1978
ZOLZA	49--5	778	780	ceel	[age determ, layer cement]	baleisis,r	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	21-23	307	310	alal	age appraisl, moose, polan	dzieciolowski,r	1976
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946
JWMAA	23--3	315	321	alal	age determ, sectioned inci	sergeant,de; piml	1959
JWMAA	33--2	428	431	alal	age determ, cementum layer	wolfe,ml	1969
VILTA	2---7	409	417	alal	puberty, denti, wt, sweden	markgren,g	1964
ZOLZA	52--5	757	765	alal	[tooth,bone tis layrs,age]	klevezal,ga	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	41--1	111	113	rata	seasonal annuli, cementum	mcewan,eh	1963
JOMAA	52--1	164	174	rata	dental anomalies in caribo	miller,fl; tessie	1971
JWMAA	28--1	54	56	rata	relatio mandi length, sex	bergerud,at	1964
JWMAA	30--4	842	843	rata	extraction of incisors of	bergerud,at; rus/	1966
JWMAA	32--4	957	961	rata	relat age tooth cement lay	reimers,e; nordby	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	34--4	962	963	rata	eruption molars, premolar	bergerud,at	1970
JWMAA	36--2	606	612	rata	eruption, mandibular	miller,fl	1972
JWMAA	38--1	47	53	rata	age det, cementu annulatns	miller,fl	1974
NJZOA	24	407	417	rata	storage, organ weight	krog,j; wika,m	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	26--1	1	18	anam	changes mandib dentit, age	dow,sa jr; wright	1962
JWMAA	33--1	172	175	anam	age determ, incisor cement	mccutchen,he	1969
JWMAA	35--4	743	747	anam	validity age wear techniqu	kerwin,ml; mitche	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	43--1	173	178	bibi	cemental depos, age criter	novakowski,ns	1965
JOMAA	35--3	454	456	bibi	first premol, canine tooth	fuller,wa	1954
JWMAA	23--3	342	344	bibi	horns, teeth, indicato age	fuller,wa	1959

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	38--4	523	529	ovca	tooth develop, nelson bigh	deming,ov	1952

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	88--2	227	229	ovda	abnormal dentition, dall s	hoefs,m	1974
JWMAA	33--3	552	558	ovda	cement dep, tooth, horn de	hemming,je	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JZOOA	155-2	141	144	caca	occurence upp canine teeth	chaplin,re; atkin	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	15--7	111	131	dada	developmn teeth, mandibles	chapman,di; chapm	1970
JZOOA	157-1	125	132	dada	tooth eruptn, wear, aging	chaplin,re; white	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JBOMA	63--3	629	734	axax	the axis deer in hawaii	graf,w; nichols,l	1967

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	12-32	459	462	bibo	incisor wear, natu, reserv	wasilewski,w	1967

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--4	308	323	many	mammals of northern idaho	rust,hg	1946
JWMAA	41--2	207	210	many	metachrom stain, age deter	thomas,dc	1977
ZOBIA	34--4	594	604	mama	[ann layr dentl tiss,bone]	klevezal,ga; mina	1973

UNIT 1.5: EYE CHARACTERISTICS

The dimensions and weights of the eye lens have been evaluated in relation to fetal and adult ages, with the expectation that an organ such as the eye lens should be less susceptible to variations in range conditions than many other organs. The relationship is fairly good, but it is inferior to that of annuli evaluations in teeth as an aging technique.

Weights of both eye lens and eyeballs of fetuses of white-tailed deer have been presented by Short (1970) as a possible basis for aging fetuses. The R^2 values are high (0.99, 0.97); WORKSHEET 1.5a includes the equations for calculations.

LITERATURE CITED

Short, C. 1970. Morphological development and aging of mule and white-tailed deer fetuses. J. Wildl. Manage. 34(2):383-388.

REFERENCES, UNIT 1.5

EYE CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	31--1	5	17	odvi*	weight relations, georg re	namerstrom,fm,jr/	1950
JOMAA	47--2	266	280	odvi*	endocrine glands, seas,sex	hoffman,ra; robin	1966
JWMAA	34--2	383	388	odvi*	morphol develop, aging,fe	short,c	1970
JWMAA	36--4	1060	1067	odvi	age determ venezuelan wh-t	brokx,pa	1972
JWMAA	41--2	327	329	odvi	insolu lens prot, estm age	ludwig,jr; dapson	1977
NFGJA	14--2	166	175	odvi/	eff nutrit, eye-lens weigh	friend,m; severin	1967
PCGFA	18---	17	20	odvi	eyelens wts, mangmnt tools	downing,rl; whitt	1964
TKASA	37--3	98	102	odvi/	eye lens weight age indica	keller,cj; landry	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFNA	88--1	78	80	odhe	growth eye lens, age index	child,kn; hagmei/	1974
JWMAA	28--4	773	784	odhe	evalu eye lens tech, aging	longhurst,wm	1964
JWMAA	30--2	417	419	odhe	lens weights of fetuses	nellis,ch	1966
JWMAA	33--3	701	704	odhe/	age-lens weight regression	connolly,ge; dud/	1969
JWMAA	34--3	523	531	odhe/	estim age, techni accuracy	erickson,ja; and/	1970
WLMOA	39---	1	122	odhe*	carcas, bone, organ, gland	anderson,ae; med/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ZEJAA	24--4	178	182	ceel	[caca,age det,lens dry wt]	maringgele,fj	1978

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVCSA	18--2	159	167	alal	lens lesions, elk, sweden	kronevi,t; holmb/	1977

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				rata			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	26-1	112	113	anam	growth of lens of pronghor	kolenosky,gb; mil	1962

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	43-1	173	178	bibi	incisor, eye-lens, dres we	novakowski,ns	1965

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CHAPTER 2, WORKSHEET 1.5a

Fetal eye weights as a predictor of fetal age in white-tailed deer (odvi)

Weights of eyeballs and eyelenses of 21 white-tailed deer fetuses 58-180 days of age were evaluated in relation to fetal age. The fetuses used were from does in "good-to-excellent" condition (Short 1970:384).

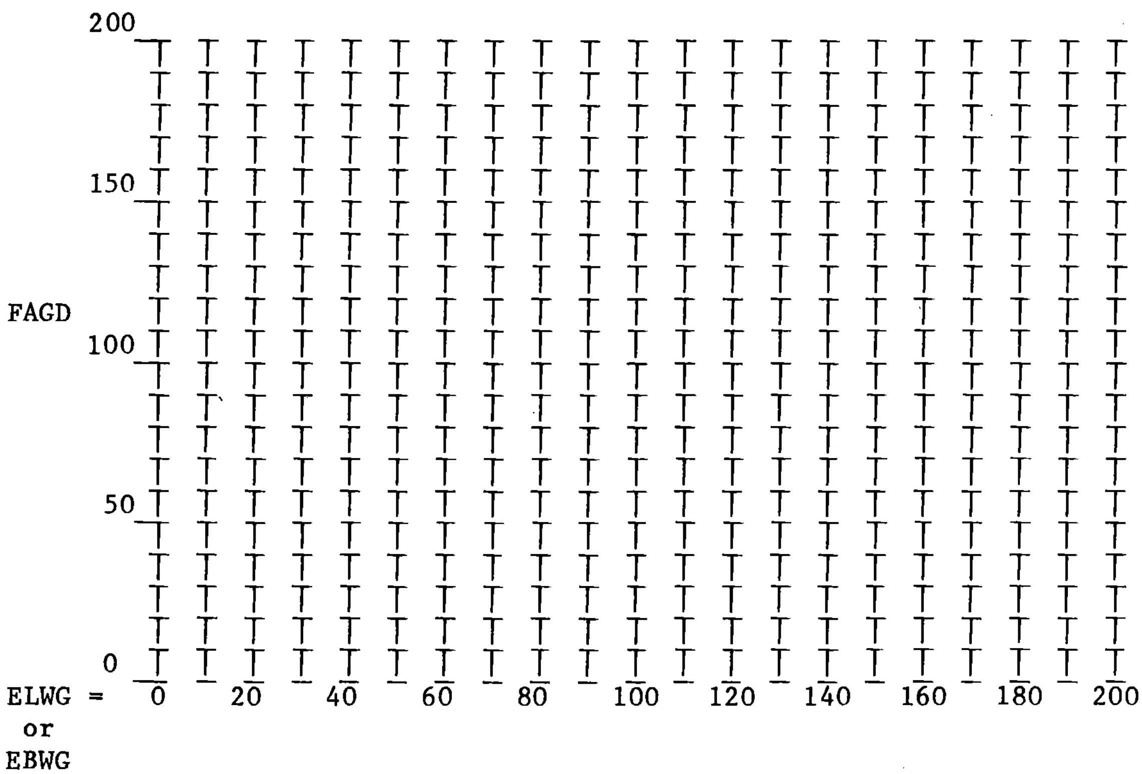
The equations for fetal age in days (FAGD) in relation to paired eyelens weight in grams (ELWG) is:

$$FAGD = 64.98 + 521.11\ ELWG\ (R^2 = 0.99)$$

The equation for fetal age in days (FAGD) in relation to paired eyeballs weight in grams (EBWG) is:

$$FAGD = 61.85 + 13.42\ EBWG\ (R^2 = 0.97)$$

Measured weights of these organs are not given by Short, so trials of different weights (X values) that result in FAGD up to 200 days should be made to complete the labeling of the X-axis below.



LITERATURE CITED

Short, C. 1970. Morphological development and aging of mule and white-tailed deer fetuses. J. Wildl. Manage. 34(2):383-388.

Dry weight of the lenses of white-tailed deer as a function of age (odvi)

Changes in dry weight (mg) of the lenses of white-tailed deer as a function of age are given by Hoffman and Robinson (1966), with linear regression equations expressing the relationship between lens weight and fetal age, a linear regression equation in the first year, and a parabolic equation for ages 2 months to 7 years. The equations are:

Fetal: $Y = 165.5 + 33.6X$, where Y = lens weight and X = age in months

First year: $Y = 205.8 + 31.4X$, where Y = lens weight and X = age in 2-month increments

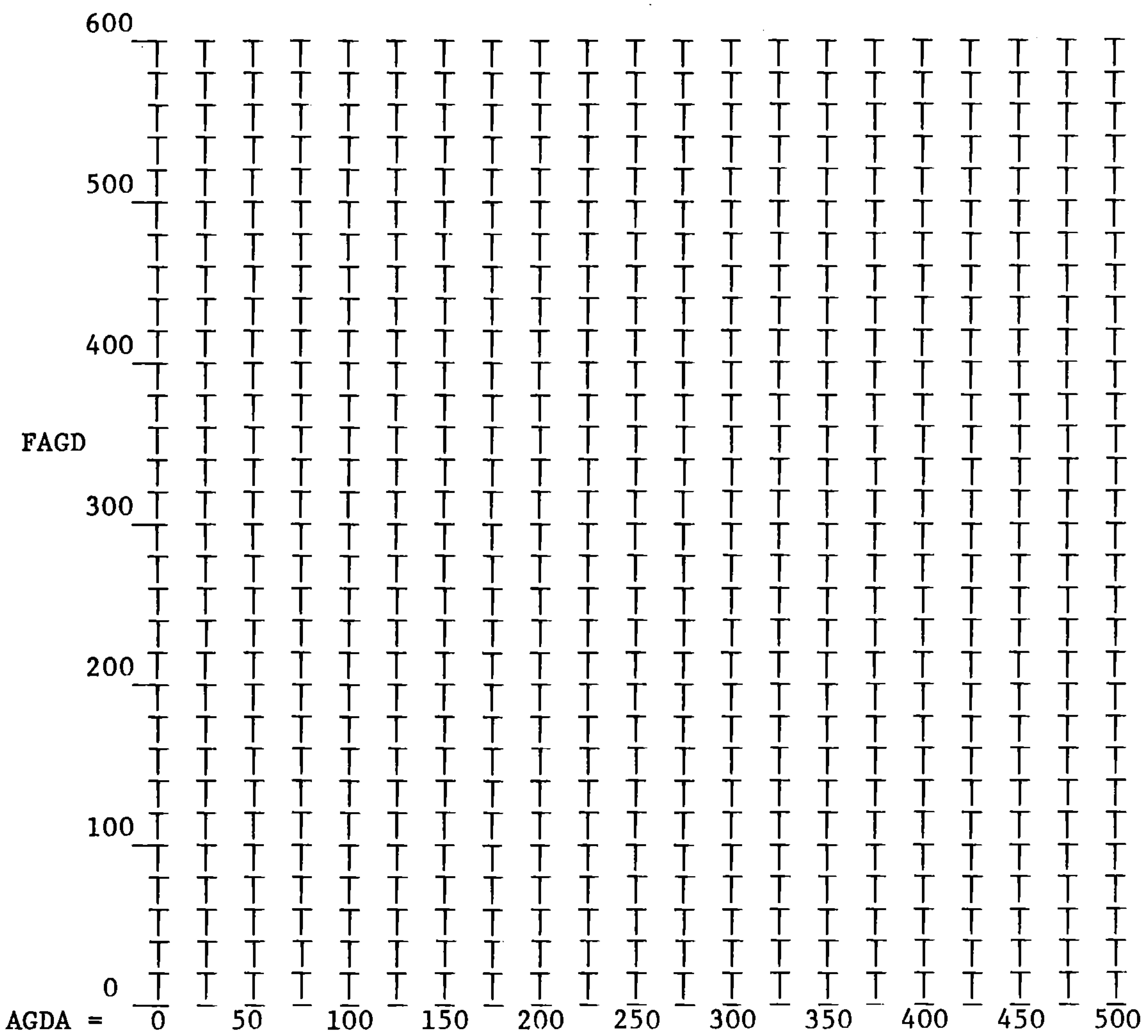
Ages 2 months to 7 years: $Y = 205.8 + 31.4X - 0.6\,X^2$, where Y = lens weight and X = age

The disjointed and overlapping lines (second and third equations) representing lens weights over these 3 time periods do not represent the continuous increase in lens weights characteristic of an individual. These data provide a good opportunity for converting 3 separate equations to a single equation by tabulating calculated values and curve-fitting with logarithmic, power, and exponential regression equations and then choosing the best fit.

WORKSHEET 1.5b is continued on the next page

Tabulate the AGDA and LWMG (lens weight in milligrams) below. Note that fetal ages are represented by negative values, where FAGD = LEGP - DIGE.

FAGD	LWMG	AGDA	LWMG
-150	____	50	____
-100	____	100	____
-50	____	150	____
0	____	200	____
		250	____
		.	____
		.	____
		[7 years]	____

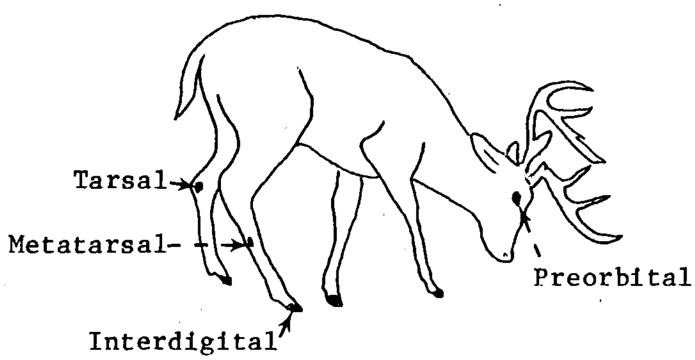


LITERATURE CITED

Hoffman, R., A. and Paul F. Robinson. 1966. Changes in some endocrine glands of white-tailed deer affected by season, sex, and age. J. of Mamal. 47(2):266-279.

UNIT 1.6: SKIN GLANDS

Wild ruminants have scent-producing skin glands that are likely important in communications between individuals of a population. Four specialized skin glands are listed by Cowan (1956; 549) for the mule deer. They are the preorbital glands, located in a shallow pit in the lacrimal bone just in front of the eye; the tarsal gland, located in the inside of the heel joint; the metatarsal gland located on the outside of the hind shank; and the interdigital glands, located between the hooves of each foot.



Preorbital gland. This gland, also called the lachrymal gland, is well-developed in elk (Murie 1951; 108) and mule deer, but reduced or absent in white-tailed deer (Cowan 1956). Cowan reports that the gland is actively opened and shut by female [mule] deer advancing to attack another individual, but not by males.

Tarsal glands. These glands, present in both white-tailed and mule deer, are marked by tufts of hair on the inside of the heel joints. It may be quite odoriferous, especially because deer of all ages and both sexes sometimes urinate on the glands. This is called rub-urinating. This has been observed in white-tailed fawns at the Wildlife Ecology Laboratory, where a buck, a doe, and two fawns occupy a 2.5 hectare enclosure. On one occasion, the fawns, a male and a female, were standing within twenty feet of each other when the male began to rub-urinate. The female began rub-urinating shortly after the male finished. Muller-Schwarze (1971) observed rub-urinating in orphan black-tail fawns in captivity but not in wild fawns with dams. He believes that the tarsal scent identifies sex, age, or type of individual. The tarsal gland is absent in elk (Murie 1951; 108).

Metatarsal glands. These glands, located on the outside of the hind shanks, are present in mule deer (Cowan 1956), elk (Murie 1951), and white-tailed deer. Its scent serves as an alarm pheromone in black-tailed deer over moderately large distances (Muller-Schwarze 1971).

Interdigital glands. These glands, located between the hooves of each foot, have hairs projecting away from the openings of these glands to carry the secretions between the hooves (Cowan 1956; 550). The scent may then be left in each hoof-print. Elk do not have interdigital glands (Murie 1951).

Other skin glands. A glandular brownish mass, somewhat divided into two lobes, one on each side of the tail, is described by Murie (1951; 108) for elk. Quay and Muller-Schwarze (1971) describe the condal glands of mule deer and black-tailed deer. Muller-Schwarze (1971) refers to forehead glands in black-tailed deer. Glands are undoubtedly present on other species that have not been studied well yet; some of these anatomical characteristics are taken for granted and not described in the literature yet.

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Cowan, I. M. 1956. In The deer of North America, W. P. Taylor, Ed. The Stackpole Company, Harrisburg, PA. 668 p.

Muller-Schwarze, S. D. 1971. Pheromones in black-tailed deer (*Odocoileus hemionus columbionus*). Anim. Behav. 19:141-152.

Murie, O. J. 1951. The elk of North America. The Stackpole Company, Harrisburg, PA. 376 p.

Quay, W. B. and D. Muller-Schwarze. 1971. Relations of age and sex to integumentary glandular regions in Rocky Mountain mule deer (*Odocoileus hemionus hemionus*). J. Mammal 52(4):670-685.

REFERENCES, UNIT 1.6

SKIN GLANDS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
SSBLA	7---3	401	407	cerv	morph chng glandular appar	katsy,gd	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	22--3	247	367	od	distr,var, pacif coast reg	cowan,imt	1936

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	40--1	114	128	odvi	micr struct, var, cutan gl	quay,wb	1959
JOMAA	52--1	1	11	odvi	geogr var, metatarsal glan	quay,wb	1971
MAMLA	22--4	537	546	odvi	metatars glands, neotropic	hershkovitz,p	1958

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AMZOA	7----	807	807	odhe	soc odors, young mule deer	muller-schwarze,	1967
AMZOA	9----	570	570	odhe	pheromone func, deer urine	muller-schwarze	1967

odhe continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ANBEA	19--1	141	152	odhe	*pheromones in black-tailed	mueller-schwarze,	1971
ANBEA	20--4	788	797	odhe	soc signif,forehead rubbng	mueller-schwarze,	1972
JOMAA	30--1	76	77	odhe	external measurements, mul	halloran,af; kenn	1949
JOMAA	45--1	48	53	odhe	comp 3 morph attrib, n mex	anderson,ae; frav	1964
JOMAA	51--4	675	694	odhe	funct histol integu gl reg	quay,wb; mueller	1970
JOMAA	52--4	670	685	odhe	rel age, sex, integ gl reg	quay,wb; mueller	1971
JULRA	59--3	223	230	odhe	specialized scent hair, dr	mueller-schwarze	1972
NATUA	223--	525	526	odhe	complexity, specificity,	mueller-schwarze	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ACATA	99--1	116	116	ceel	adreno, mela pituitar cell	simic,m; pantic,v	1971
AJPHA	223-3	604	607	ceel	sweat gland functn, red de	johnson,kg; malo/	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				alal			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	36--2	187	201	rata	histol, cytochem, skin gla	quay,wb	1955
JCECD	1---2	275	281	rata	volat comp from tarsal scl	andersson, q;/	1975
JCECD	3---5	591	601	rata	caudal gland, histol, chem	mueller-schwarze/	1977
KPSUA	5----	644	645	rata	chem comp, interdigi gland	sokolv, ve; brun/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJANA	129--	65	88	anam	histol subauric, rumpgland	may, rf	1970
JOMAA	52--2	441	446	anam	histol interdig, median gl	moy,rf	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				bibi			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ZOOLA	58--2	55	57	maam	scent marking, red brocket	volkman,n; ralls	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JBOMA	63--3	629	734	axax	the axis deer in hawaii	graf,w; nichols,l	1967

UNIT 1.7: ENDOCRINE GLANDS

Endocrine glands are organs of secretion, releasing hormones into the blood stream via the vascular beds in the glands themselves. Hormones are chemical "messengers" which have specific effects on other cell types. Many of the several endocrine glands scattered through the body have specific target organs which respond in predictable ways to particular hormones. Some function directly with a clearly-defined system (ovaries with reproduction, for example) and some have more diffuse effects, functioning as general regulators of body functions (thyroid of metabolism, for example) (McCauley 1971; 379). A list of the endocrine glands and synopses of their roles summarized from detailed information in McCauley (1971) and Romer and Parsons (1977) follows.

Hypophysis (Pituitary gland): regulates water balance, renal function, and protein synthesis, stimulates the thyroid gland, influences naturation of the gonads and production of sex hormones, and is involved in storing and releasing hormones synthesized elsewhere.

Thyroid gland: very important in regulating the metabolic rate, also influences development of the nervous system, behavior, and has roles in growth and reproductive functions.

Parathyroid glands: regulates the metabolism of calcium and phosphorous.

Islets of Langerhans: partial regulator of carbohydrate metabolism.

Adrenal glands: aid the body in meeting environmental stresses.

Testes: produce male sex hormones called androgens.

Ovaries: produce female sex hormones called estrogens.

The endocrine gland functions listed indicate that they are very important regulators of critical body functions such as metabolism, growth, and reproduction. Understanding of their roles in the ecology of free-ranging animals has not yet been achieved. Recent books on several species of wild ruminants do not even mention endocrine glands, even though they, as regulators of body functions, probably play more important roles in the ecology of these animals than any other single group of organs.

LITERATURE CITED

McCauley, W. J. 1971. Vertebrate physiology. W. B. Saunders Company, Philadelphia. 422 p.

Romer, A. S. and T. S. Parsons. 1977. The vertebrate body. W. B. Saunders Company, Philadelphia. 624 p.

REFERENCES, UNIT 1.7

ENDOCRINE SYSTEM CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JBLPA	4	31	41	cerv	[endocr gl, antlr develop]	[pantic,v	1966

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
HLTPA	9	1235	1239	od	n amer, thyroid radioiodin	hanson,wc; dahl,/	1963

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CPSCA	7---4	217	218	odvi	*organ:body weight relation	robinson,pf	1966
JOMAA	31--1	5	17	odvi	*weight relations, georg re	hamerstrom,fm,j/	1950
JOMAA	41--1	23	29	odvi	respon bucks, artifi light	french,ce; mcew/	1960
JOMAA	47--2	266	280	odvi	*endocrine glands,seas chan	hoffman,ra; robi	1966
JOMAA	55--3	656	659	odvi	antler shedding in midwest	zagata,md; moen,	1974
JWMAA	34--4	407	417	odvi	reprod, grow, resid, dield	murphy, da; kors	1970
JWMAA	36--4	1041	1052	odvi	nutrit effec, thyroid acti	seal,us; verme /	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ANREA	169-2	387	387	odhe	morpho acidophils, hypophy	nicolls,ke	1971
CAFGA	44--2	191	196	odhe	relat adren cortex, condit	hughes,e; mall,r	1958
CJZOA	54-11	1969	1978	odhe	cytolgy anterior pituitary	west,no; nordan	1976
JOMAA	52--3	628	630	odhe	*tiss, organs, tota body ma	hakonson,te; whic	1971
JOMAA	52--4	670	685	odhe	integumentary glandul regi	quay,wb; Muller-s	1971
JWMAA	30--4	781	785	odhe	ceel,radioiodine, thyroids	whicker,fw; farr/	1966
JWMAA	35--3	461	468	odhe	radio iodine uptake, reten	gist,cs; whicker	1971
JWMAA	35--4	689	697	odhe	/adrenal wt in popula, colo	anderson,ae; med/	1971
PAARA	209--	1	11	odvi	feed, season, antler devel	long,ta; cowan,c/	1959
PNDAA	30--1	35	35	odhe	pituatary, photoper, antlr	nicolls,ke	1976
PSEBA	93--1	161	162	odhe	cyclic var, thymus, mule d	browman,lg; sears	1956
SCIEA	140--	801	802	odhe	odvi,rata, iodin-132, n am	hanson,wc; whick/	1963
WLMOA	39---	1	122	odhe	*carcas, bone, organ, gland	anderson,ae; med/	1974
ZZAHA	115-3	314	326	odhe	/pituitar glnd, photoperiod	nicolls,ke	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ACATA	63--4	580	590	ceel	caca, investigatn, thyroid	pantic,v; stosic,	1966
VESMA	4	199	201	ceel	[antl devel, intern secre]	frankenberge, z	1955

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	27--1	90	91	alal	weights of minnesota moose	brechinridge,wj	1946

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ANANA	119-1	99	103	rata	subcommissural organ, secr	talanti,s	1966
AZOSA	58--2	61	63	rata	testost level, neck muscle	lund-larsen,tr	1977
CAFNA	90--4	449	463	rata	annual antler cycle, newfo	bergerud,at	1976
CBPAB	40a-2	495	501	rata	seas chang, hydro-corti se	yousef,mk; camer/	1971
CBPAB	40a	789	795	rata	thyroxi, sex, age seas	yousef,mk; luick,	1971
CJZOA	51--6	651	658	rata	seas varia, plasma testost	whitehead,pe; mce	1973
CJZOA	55--/	1692	1697	rata	produc,testos,time of year	whitehead,pe; wes	1977
FMFUB	6---4	373	381	rata	antlers, asymmetry, reinde	davis,ta	1973
JANSA	33--1	260	260	rata	thyroxine secre rate, calv	luick,jr; white,/	1971
PASCC	19---	71	72	rata	thyroxine secretion rate	yousef,mk	1968

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	56--4	829	846	anam	growth, casting horns, exf	o'gara,bw; matso	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				bibi			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

odva

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

obmo

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

oram

CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

dada

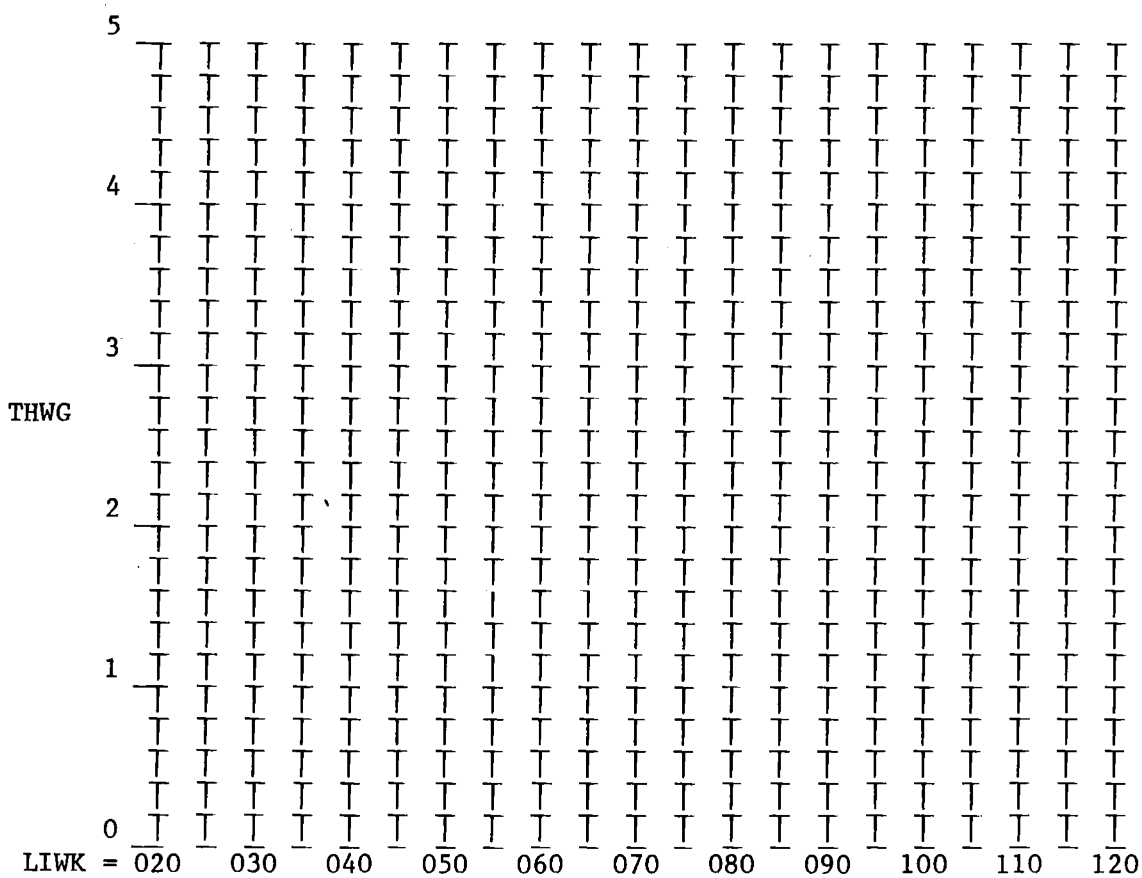
CODEN vo-nu bepa enpa anim kewo ______________________ auth ______________ year

JOMAA 27--4 308 323 many mammals of northern idaho rust,hg 1946

Seasonal changes in thyroid gland weights of white-tailed deer (odvi)

The graphic display of seasonal changes in relative weights of the thyroid glands, in grams per kg body weight, shows increases in thyroid weights when animals are gaining weight and decreases when they are losing (Hoffman and Robinson 1966). The increases and decreases also coincide with the increases and decreases in metabolism (Moen 1978).

The high relative weight shown in Hoffman and Robinson (1966) is about 0.08 and the low about 0.04 gms/kg. The high occurs in May-June and the low in January-February. The graphed data may be smoothed out by fitting a sine wave as described in CHAPTER 1, UNIT 1.4, using the example of 40 $\pm$ 20. In the data above, it is 0.06 $\pm$ 0.02. Primary and secondary phase corrections are necessary since the time periods between May-June (use JDAY 151) and January-February (use JDAY 30) are not equal. These too are discussed in CHAPTER 1, UNIT 1.4. Derive the equation for thyroid weight/kg and plot the results below. Then, multiply these results by LIWK over the annual cycle to predict thyroid weights in gms (THWG).



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Hoffman, R. A. and P. F. Robinson. 1966. Changes in some endocrine glands of white-tailed deer as affected by season, sex and age. J. of Mammal. 47(2):266-279.

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.

TOPIC 2. CHEMICAL CHARACTERISTICS

The chemical composition of an animal is an important consideration when determining nutrient requirements, since requirements are equal to the sum of nutrients deposted plus the nutrients necessary for metabolism but not incorporated into body tissue. If, for example, each kg of fat in a ruminant's body has an energy content of 9000 kcal kg^{-1}, then at least 9000 kcal of energy were ingested chemically in a kg of tissue. Since the deposition of fat or any other tissue is not a 100% efficient process, the energy required to deposit a kg of fat with an energy content of 9000 kcal is 9000 plus the energy for nutrient metabolism. The energy required for this deposition is analogous to overhead, or operating costs in a business.

Some of the tissue energy, especially fat, serves as a reservoir of stored energy that may be critical for survival. Fat tissue can be almost totally depleted before death occurs, but other tissues, such as protein, cannot be mobilized to a large extent without causing weakness and deterioration of life functions. Some tissues, such as bones, contain minerals that may be mobilized for antler growth, and the amount of antler growth is dependent on the amount of minerals mobilized plus the amount ingested, within the framework of genetic limitations, of course. The former is indicative of the nutrient quality of the range over a time span of a year or more, the latter of the quality of the range during the period of antlerogenesis.

Chemical composition varies through the year in relation to growth and reproduction. It is a function of several variables through time, and may be expressed in relation to live or ingesta-free weight. Weight varies seasonally however; calculations of seasonal variations in chemical composition in relation to seasonally-variable weights result in estimates of the absolute quantities of different chemical components of the body.

The chemical composition of milk varies through lactation as the nutrient requirements of the suckling young change, and their diet includes relatively less milk and more forage as the rumen and reticulum develops. Changes in milk composition through the lactation period are not well documented in most species, nor are seasonal changes in overall body composition. The UNITS that follow provide some insights into the ecological roles of chemical changes, indicating the usefulness of this information in evaluating survival and production potentials.

UNIT 2.1: BODY COMPOSITION

Knowledge of the body composition of an animal is essential for understanding and predicting energy, protein, and mineral requirements for maintenance and growth. The net requirements for these three categories of nutrients are dependent on the energy content and composition of the tissue replaced and new tissue deposited. Relationships between chemical composition and nutrition in cattle were studied many years ago (See Reid et al. 1955), and general relationships between animal condition and visible fat have been observed for wild ruminants for years. Published data on the chemical composition of whole animals and on some body parts are available for domesstic ruminants. Few data are available on wild ruminants paper s on body composition have been more descriptive than quantitative, with emphases on "fat condition indexes" and similar approaches.

Fat tissue indices have been derived for some species of wild ruminants because they provide indications of the status of indiviuduals through the winter for general comparisons between ranges and between winters. Such indices are not useful for quantifying the metabolic contributions of stored fat for survival, however, and the expediency with which they may be determined should not replace basic investigations of the chemical composition of the body. Basic investigations result in the background knowledge and understanding necessary for quantifying animal-range relationships, resulting in better interpretation of condition indices based on fat and other tissue characteristics.

Fat. Fat is a high-energy reservoir--one gram of fat contains 9.0 to 9.5 calories of energy--that is mobilized when energy intake falls below energy requirements. It is necessary to know what metabolically-available quantities are present in the body throughout the year in order to analyze the ecological contributions of fat to seasonally-variable metabolic energy requirements. Then, weight changes and body composition can be combined to derive an equation for calculating the fat contribution to daily metabolism. This is done in Chapter 7.

Protein. The total energy content of an animal is equal to the actual amounts of protein and fat times the caloric values of each. The estimated caloric contents of body protein and fat were 5.413 and 9.490 kcal/g, respectively (Robbins et al. 1974). Protein tissue, while containing stored energy in the chemical bonds holding protein molecules together (about 5 calories per gram), cannot be mobilized to a large extent without the loss of body condition. When the fat reserve is gone and protein is catabolized to maintain the energy balance, the animal is in a very precarious state of existence. This is characteristic of animals that die in a long winter. Protein deficiencies may occur in the summer too; nursing females must supply a relatively large amount of protein via milk for their rapidly-growing offspring. Lactating wild ruminants are often quite thin, especially through the first half of the lactation period. The high protein requirement at that time should be mostly met by the high-quality forage on the range, but protein in maternal tissue may supplement that ingested in the forage.

Minerals. Minerals are essential components of most body tissue, and the major component of the skelton. The minerals that are a part of the whole body composition are not known for wild ruminants, however. Ash--the solid residue left after complete tissue combustion--has been measured for both domestic and wild species, but this general category does not reveal the amounts of specific minerals present or required. Feeding trials with various levels of different minerals in the diets are used to determine requirements, but interpretations of the results are often difficult to make because of interactions between minerals, and especially trace elements.

Water. There is a water component of living tissue that, for whole organisms, represents about 2/3 of the mass of most species. Water is a required nutrient that is "turned over," and thus needs to be replenished regularly. Some African species of wild ruminants have special adaptations for conserving water, with different physiological and behavioral adaptive strategies. North American ruminants are, for the most part, not particularly specialized in their use and conservation of water, and most species live in habitats that are not water-limited.

The amount of body water in adult ruminants is quite closely related to their fat content. Fat tissue contains only about 10% water, much less than the average of all body tissue, so as the adult ruminant puts on large quantities of fat in the fall, the water fraction goes down. Body composition of white-tailed deer show this clearly as fat and water were inversely related, with protein remaining fairly constant and ash being a minor component of the total body (Robbins et al. 1974).

The total body composition, expressed as decimal fractions, is:

$$FATF + WATF + PROF + ASHR = 1.00$$

where the ..F is fraction of the preceeding chemical group. This illustrates the fact that only four major chemical groups make up the body composition, yet there are few data even on these four major groups for wild ruminants.

The most ideal kind of data on chemical composition of wild ruminants would include variations due to sex, age, and time of year. Such data would provide the background material for interpreting the changes in weights and nutrient requirements over the annual cycle. Body composition analyses are being done on white-tailed deer at the Wildlife Ecology Laboratory, but results are not yet available.

LITERATURE CITED

Reid, J. T., G. H. Wellington, and H. D. Dunn. 1955. Some relationships among the major chemical components of the bovine body and their application to nutritional investigations. J. Dairy Sci. 38:1344.

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

REFERENCES, UNIT 2.1

BODY COMPOSITION

BOOKS

type	publ	city	page	anim	kewo	auth	year
edbo	acpr	nyny	1		mineral metabolism, vol. 2	comar,cl; bronner	1964
edbo	acpr	nyny			compar nutrit, wild animal	crawford,ma,ed	1968
aubo	nasc	wadc	19	anim	bdy comp in animls and man	reid,jt; bensado/	1968
edbo	erda	spva	536	odvi	min cyclng in se ecosystem	howell,fg; gentr/	1975
edbo	erda	spva	542	odvi	min cyclng in se ecosystem	howell,fg; gentr/	1975

SERIAL PUBLICATIONS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	49--8	1159	1162	cerv	composition adipose tissue	garton,ga; dunca/	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	38--4	871	876	odvi*	body composition, white-ta	robbins,ct; moen	1974
JWMAA	29--2	397	398	odvi	kidney, marrow fat, condit	ransom,ab	1965
JWMAA	29--4	717	723	odvi	naturl vari blood proteins	miller,wj; hauge/	1965
JWMAA	37--1	103	105	odvi	reag dry assay, marrow fat	verme,lj; holland	1973
JWMAA	39--2	346	354	odvi/	chng blood prot, gest, suc	hartsook,ew; whel	1975
NFGJA	21--1	67	72	odvi/	riney vs kidney fat techni	monson,ra; stone/	1974
NYCOA	3---5	19	22	odvi	bone marrw index of malnut	cheatum,el	1949
PAABA	600-1		50	odvi	nutri req, growth, ant dev	french,ce; mcewa/	1955
PAABA	628-1		21	odvi	nutri req, growth, ant dev	magruder,nd; fre/	1957
PCGFA	26---	57	68	odvi	var fat levl, mandib cavit	nichols,rg; pelt	1972
WSCBA	5---6	42	42	odvi	chemi anal of deer antlers	chaddock,tt	1940

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJVRA	31--4	673	677	odhe	total body water, turnover	longurst,wm; bak/	1970
JANSA	36--6	1201	1201	odhe	plasma prot, lipid lev,nev	hunter,ve; lespe/	1973
JOMAA	45--2	252	259	odhe	density studies, body fat	whicker,fw	1964

odhe continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	33--2	389	393	odhe/water	turnover in mule dee	knox,kl; nagy,jg/	1969
JWMAA	36--2	579	594	odhe/indice,	carc fat, colo pop	anderson,ae; me/	1972
JWMAA	41--1	81	86	odhe	exp starva, recovery, does	decalesta,ds; na/	1977
PCZOA	16---	46	46	odhe	chang, plasma lipids, th y	stewart,sf; nord/	1963
WAEBA	589--	1	6	odhe	the mule deer carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JSFAA	22--1	29	33	ceel	fatty-acid compos, adipose	garton,ga; dunca	1971
JWMAA	32--4	747	751	ceel	fat content, femur marrow	greer,kr	1968
JWMAA				ceel	milk comp and consump,capt	robbins,ct; podb/	inpr
MAMLA	35--3	369	383	ceel	demog,fat res,body size,nz	caughley,g	1971
WAEBA	594--	1	8	ceel	the elk carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AZOFA	12--2	148	155	alal	fatty-acid compos, org fat	tanhuanpaa,e; pul	1975
CBPAB	57--3	299	306	alal/hair	elemnt val,var, alask	franzmann,aw; fl/	1977
JWMAA	40--2	336	339	alal	marrow fat, mortali, alask	franzmann,aw; arn	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBCPA	30--1	187	191	rata	fatty acid comp bone marow	meng,ms; west,gc/	1969
CBPAB	55--2	187	193	rata/serum	enz, blood constitue	bjarghov,rs; fje/	1976
CBPAB	56--3	337	341	rata	liver, bone, bone marrow	bjarghov,rs; jac/	1977
CJZOA	50--1	107	116	rata	seas, body h2o, blood volu	cameron,rd; luic	1972
CJZOA	54--6	857	862	rata	tritium wat dilut wat flux	cameron,rd; whit/	1976
FUNAA	23	106	107	rata	fat deposits, svalbard dee	oritsland,na	1971
JWMAA	34--4	904	907	rata	wt, dried marrow,femur fat	neilans, ka	1970
NJZOA	24--4	407	417	rata*morph,	fat stor, org weigh	krog,j; wika,m; /	1976
PASCC	19---	17	18	rata	total body water, turnover	cameron,rd	1968
PASCC	22---	14	14	rata	water flux, climate, nutri	cameron,rd; luic/	1971
TNWSD	28---	91	108	rata	phys var, condit, b g cari	dauphine,tc,jr	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	33--1	309	309	anam	carbonyl analysis of fat	booren,a; field,/	1971
JANSA	36--6	1195	1195	anam	collagen character,muscle	kruggel,wg; field	1973
JDSCA	38---	1344	1344	anam	maj chem comp bovine	reid, jt; wellin/	1955
JOMAA	52--3	583	589	anam*seas	tren in fat lev, colo	bear,gd	1971
JWMAA	34--4	908	912	anam/energy	flux, water kinetic	wesley,de; knox,/	1970
WAEBA	575--	1	6	anam	pronghorn antelope carcass	field,ra; smith,/	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	36--2	305	308	bibi	the lipids in bison bison	wilbur,dg; gorski	1955

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJBSA	24--3	515	524	ovca	ovmu, sp diff hair protein	darskus,rl; gille	1971
BECTA	19--1	23	31	ovca	chlor hydrocarb resid, fat	turner,jc	1978

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBCPA	50b-4	599	601	ovda	fatty acid comp bone marrw	west,gc; shaw,dl	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	49--8	1159	1162	many	comp, adipose tiss triglyc	garton,ga; dunca/	1971
VEZOA	71--5	60	64	many	hyaluronic acid, synovi fl	kuprikova,vm	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	18-11	209	222	caca	drssng %, body comp, calor	weiner,j	1973

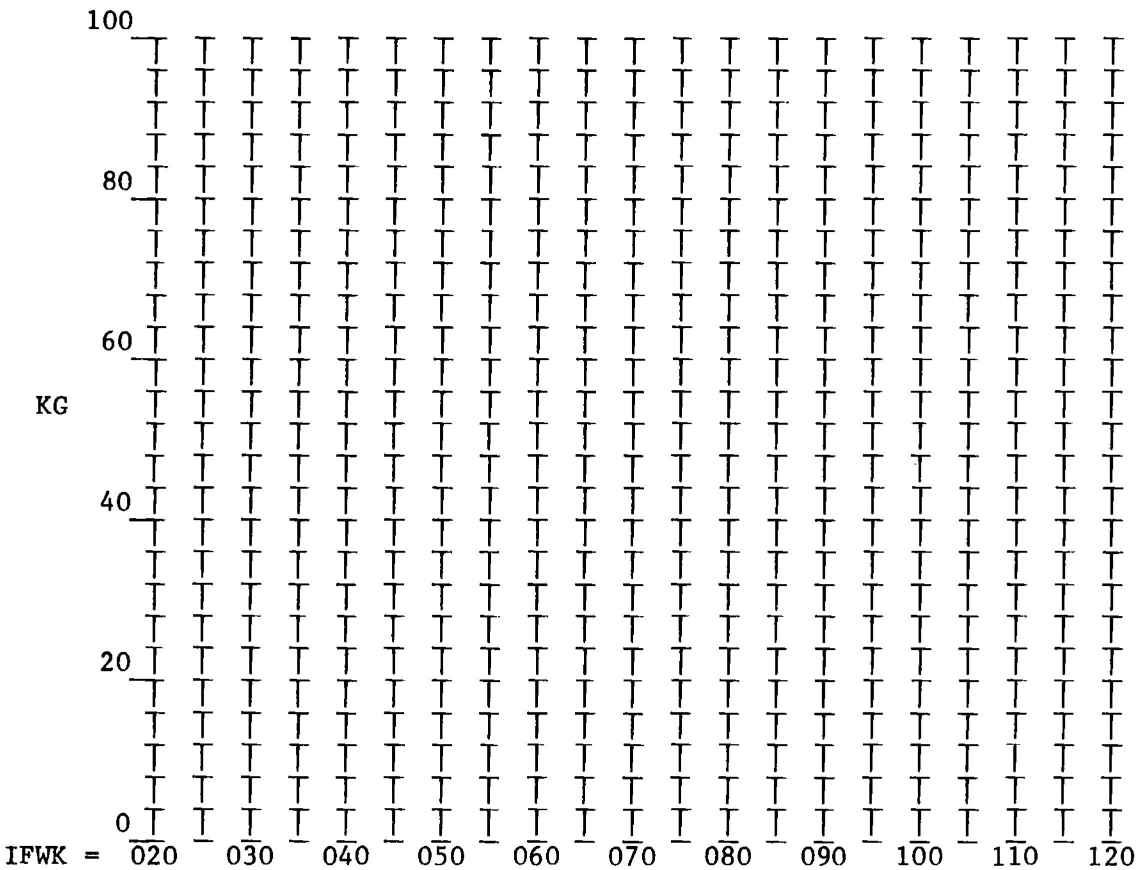
CHAPTER 2, WORKSHEET 2.1a

Body composition of white-taiiled deer (odvi)

The body composition of white-tailed deer may be predicted from ingesta-free weight in kg (IFWK). Equations for males, females, and both sexes combined are given by Robbins et al. (1974). The sex differences are very slight when composition is expressed on a per kg basis. The equations for both sexes combined are:

$$WATK = e^{(0.8982 \ln IFWK - 0.0827)}$$
$$FATK = e^{(2.1345 \ln IFWK - 6.3944)}$$
$$PRTK = e^{(1.0091 \ln IFWK = 1.6267)}$$
$$ASHK = e^{(0.9480 \ln IFWK - 2.9008)}$$

Complete the calculations and plot the relationships below. Note that the sum of the weights should equal the ingesta-free weight used in the calculations; deviations are due to experimental error. What is the sum when weights characteristic of moose (500 kg) are used in the calculations? Are these equations realistic when extrapolated beyond deer weights?



LITERATURE CITED

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

CHAPTER 2, WORKSHEET 2.1b

Relative body compositions of wild ruminants

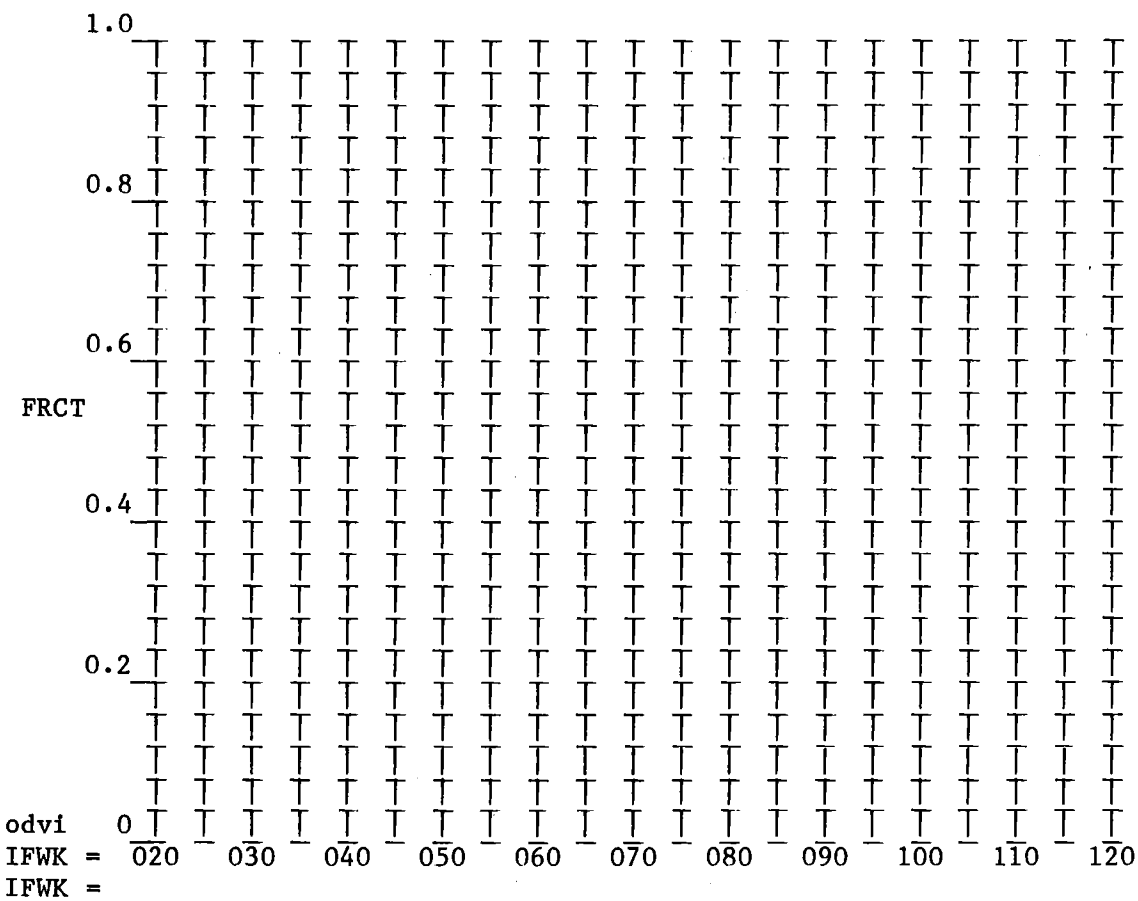
The lack of data on the body compositions of different species of wild ruminants makes it necessary to derive first approximations based on other species. Extrapolation of the equations in WORKSHEET 2.1a to moose (500 kg) does not work. How, then, can the body composition of moose be estimated?

If the assumption that water, fat, protein, and ash fractions of moose and other wild ruminants are propotional to those of white-tailed deer, then the weights of these fractions can be expressed as a fraction of the total and that fraction multiplied by the weight of the new species. Illustrating with the equation for water:

$$\mathrm{WATF} = e^{(0.8982 \ln \mathrm{IFWK} - 0.0827)}/\mathrm{IFWK}$$

where WATF = water fraction. The result is a decimal fraction.

Calculate the fractions for 20, 30, 40 . . . kg for deer for each of the four chemical groups and curve-fit the results. Then, use the resulting equations by making the weights of the new species proportional to the weight of white-tailed deer and complete the first approximations for different species. Relabel the x-axis with IFWK for the species considered.



UNIT 2.2: CHEMICAL COMPOSTION OF MILK

Milk is produced by the epithelial cells lining alveoli of the mammary glands. Production is stimulated primarily by a lactogenic hormone, prolactin, from the anterior pituitary gland (Pantelouris 1967). The sucking stimulus plays a part in the continuation of production; lactation diminishes rapidly if the milk is not removed from the udder.

The chemical composition of milk changes during the lactation period. Few measurements have been made of the composition of milk of any wild ruminant for the entire lactation period, however. The references listed usually contain chemical composition data at one point or for only a small part of the lactation period.

The chemical composition of milk changes during the lactation period. Few measurements have been made of the composition of milk of any wild ruminant for the entire lactation period, however. The references listed usually contain chemical composition data at one point or for only a small part of the lactation period.

Fat and energy. The fat content of milk is the major determinant of the caloric energy in milk. A formula for determining the kcal/kg of milk is in Blaxter (1962:171), with the caloric energy content a direct function of percent fat. The equation given is:

$$\text{Kcal/kg milk} = 304.8 + 114.1(f)$$

where f is the percentage of fat in the milk. The equation was derived from "many thousands" of samples from dairy cows milks varying in composition from 2.8 to 6.2% fat. Calculations of the caloric content of milks from different species of wild ruminants are explained in WORKSHEET 2.2b.

Protein. Milk is relatively high in protein, a biological necessity when it is the main or only source of nutrients for the neonate. Wild ruminant neonates begin grazing a few days after birth and extract proportionately more of their nutrient requirements from plants as their rumens develop. Since their total protein requirement is increasing as they grow rapidly during the suckling period, the contribution of milk proteins is significant. The chemical breakdown of milk protein can be quite extensive and is beyond the intent of this UNIT and available data on wild ruminant milk. Total nitrogen, which may be determined with the Kjeldahl method, is a good indicator of the total protein content of milk as only about 5% of total nitrogen is milk is present as non-protein materials (Lampert 1975:47).

Lactose. Lactose is the main carbohydrate found in milk. Called milk sugar, it is a disaccharide that can be hydrolyzed into two other sugars, glucose and galactose (Lampert 1975:49). The lactose in normal cow's milk ranges from 4.4 to 5.8% (Nicherson 1965:225). A table of composition of milk of 23 mammals in Nicherson lists reindeer as having 2.4% carbohydrate [lactose] which is only 1/2 of the amount in cow's milk. Such single numbers may be misleading because changes in the chemical composition of milk over the entire lactation period are certain to occur and probably have not been considered since milk collections of free-ranging animals are difficult to make over the entire lactation period.

Minerals. Minerals, collectively referred to as the ash content, make up 1% or less of the total content of milk. The minerals are not abundant, but they are important in neonate nutrition since skeletal growth is rapid early in life. The percents of seven minerals in milk and their percents in the ash of milk are listed by Lampert (1975:51). The seven minerals are potassium, calcium, chlorine, phosphorous, sodium, magnesium, and sulfur. There are also several minerals found in very small, or trace amounts.

Vitamins. Milk contains vitamins A, B, D, and E all necessary for metabolic processes.

Water. Milk is composed of nearly 90% water, which carries the lactose, minerals, salts, and water-soluble vitamins in solution.

LITERATURE CITED

Blaxter, K. L. 1962. The energy metabolism of ruminants. Hutchinson & Co., London. 327 p.

Lampert, L. M. 1975. Modern Dairy Products. Chemical Publishing Co., New York. 437 p.

Nicherson, T. P. 1965. Chapter 6 In Webb B. H. and A. H. Johnson, Editors. Fundamentals of dairy chemistry. The Avi Publishing Company, Inc., Westport, Connecticut. 827 p.

Pantelouris, G. M. 1967. Introduction to animal physiology and physiological genetics. Pergamon Press, Oxford. 497 p.

REFERENCES, UNIT 2.2

CHEMICAL COMPOSITION OF MILK

BOOKS

type	publ	city	page	anim	kewo	auth	year
aubo	isup	amia	291	dome	secretion of milk (4th ed)	espe, w; smith, v	1952
edbo	saco	phpa	584		handbook of biological dat	spector, ws	1956
aubo	isup	amia	291	dome	physiology of lactation	smith,vr	1959
aubo	hutc	loen	307	dome	energy metabol of ruminant	blaxter, kl	1962
aubo	jblc	phpa	273		nutrition, compos of milk	kirchgessner,m; /	1967
aubo	pepr	oxen	497		anim physiol, physiol gene	pantelouris, gm	1967
edbo	acpr	nyny			milk protein; chem, molecu	mckenzie,ha	1970
aubo	whfr	sfca	317	dome	biology of lactation	schmidt,gh	1971
edbo	butt	loen	467	many	lactation	falconer,ir,ed	1971
edbo	acpr	nyny			lactation	larson,bl; smith,	1974

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JRPFA	37--1	67	84	cerv	composi milk, cerv species	arman,p; kay,rnb/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	24--4	439	441	odvi	rearing, breedi fawns, cap	murphy,da	1960
JWMAA	25--1	66	70	odvi	deer milk, substitute milk	silver,h	1961
JWMAA	29--1	79	84	odvi/comp	milk,bld nursng doe,f	youatt,wg; verme/	1965

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	37--2	217	218	odhe	composit, deer milk, calif	hagen,hl	1951
JOMAA	36--3	473	474	odhe	mule deer milk	browman,lg; sears	1955
JOMAA	58--3	420	423	odhe	changes nutri compos, milk	mueller,cc; sadle	1977
JWMAA	20--2	212	214	odhe	postnat grow, comp of milk	kitts,wd; cowan,/	1956
JWMAA	44--2	472	478	odhe	milk yield, black-tailed d	sadleir,rmfs	1980

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BIJOA	153-3	647	655	ceel	whey proteins, red de milk	mcdougall,ei; ste	1976
JRPFA	37--1	67	84	ceel/comp,	yield of milk, red d	arman,p; kay,rnb/	1974
ZTTFA	31--5	227	238	ceel	comp, milk, red deer, pt 1	brueggemann,j; d/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	48--2	213	215	alal	gros comp milk, fat, minrl	cook,hw; rausch,/	1970
JWIDA	12--2	202	207	alal/	milk, hair, element relati	franzmann,aw; fl/	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	45--6	1101	1106	rata	milk, gros comp, fat, prot	hatcher,vb; mcew/	1967
JDSCA	57-11	1325	1333	rata/	milk comp chang, grazing r	luick,jr; white,/	1974
ZOBIA	32--6	746	750	rata	alal, electroph, milk prot	shubin,pn; turub/	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	37--2	217	218	anam	odhe, compos milk, compars	hagen,hl	1951

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	36--2	305	308	bibi	the lipids in bison bison	wilbur,cg; gorski	1955

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	41--2	131	143	ovca	rearing lambs in captivity	deming,ov	1955
CJZOA	43--5	885	888	ovca	milk, gross comp, fat cons	chen,ech; blood,/	1965

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	48--4	629	633	ovda*	milk, stage lact, composit	cook,hw; perarso/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	34--6	569	571	obmo	gross composition of milk	tener,js	1956
CJZOA	48--6	1345	1347	obmo	gros comp,ftty acid, minrl	baker,be; cook,h/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	47--1	5	8	oram	gross compos, fat acid con	lauer,bh; blood,/	1969
CJZOA	47--2	185	187	oram	miner const, milk, arctic	luer,bh; baker,b	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBCPA	42b-2	323	328	many	electrophesis milk casins	lauer,bh; baker,b	1972
CJZOA	49--4	551	554	many	carbohydra content, casein	baker,be; lauer,b	1971
CJZOA	55--1	231	236	many	amin acid comp casein milk	lauer,bh; baker,b	1977

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
IZYBA	4----	333	342	many	composit milk wild animals	ben shaul,dm	1962

CHAPTER 2, WORKSHEET 2.2a

Chemical composition of milk

The chemical composition of milk changes as the lactation period progresses. The data on chemical composition should be evaluated in relation to both the days into lactation (DILA) and the fraction of the lactation period (FRLP) that has passed. The format suggested below may be useful for tabulating chemical compositions and evaluating changes through the lactation period.

			CHEMICALS					
spec	DILA	FRLP	FAT-	PRTN	MNRL	WATR	LCTS	reference

spec = species
FAT- = fat
PRTN = protein
MNRL = mineral
WATR = water
LCTS = lactose

CHAPTER 2, WORKSHEET 2.2b

Energy content of milk

The amount of energy in milk depends on the chemical composition of the milk. Milk with a high fraction fat fraction contains more energy than milk with a low fat fraction. The equation given by Blaxter (1962:171) based on research by Overman and Gaines (1933) and Gaines and Overman (1938) for calculating kcal/kg milk as a function of the percentage of fat in the milk. The equation, with letter symbols modified, is:

$$ECPK = 304.8 + 114.1\ FATP$$

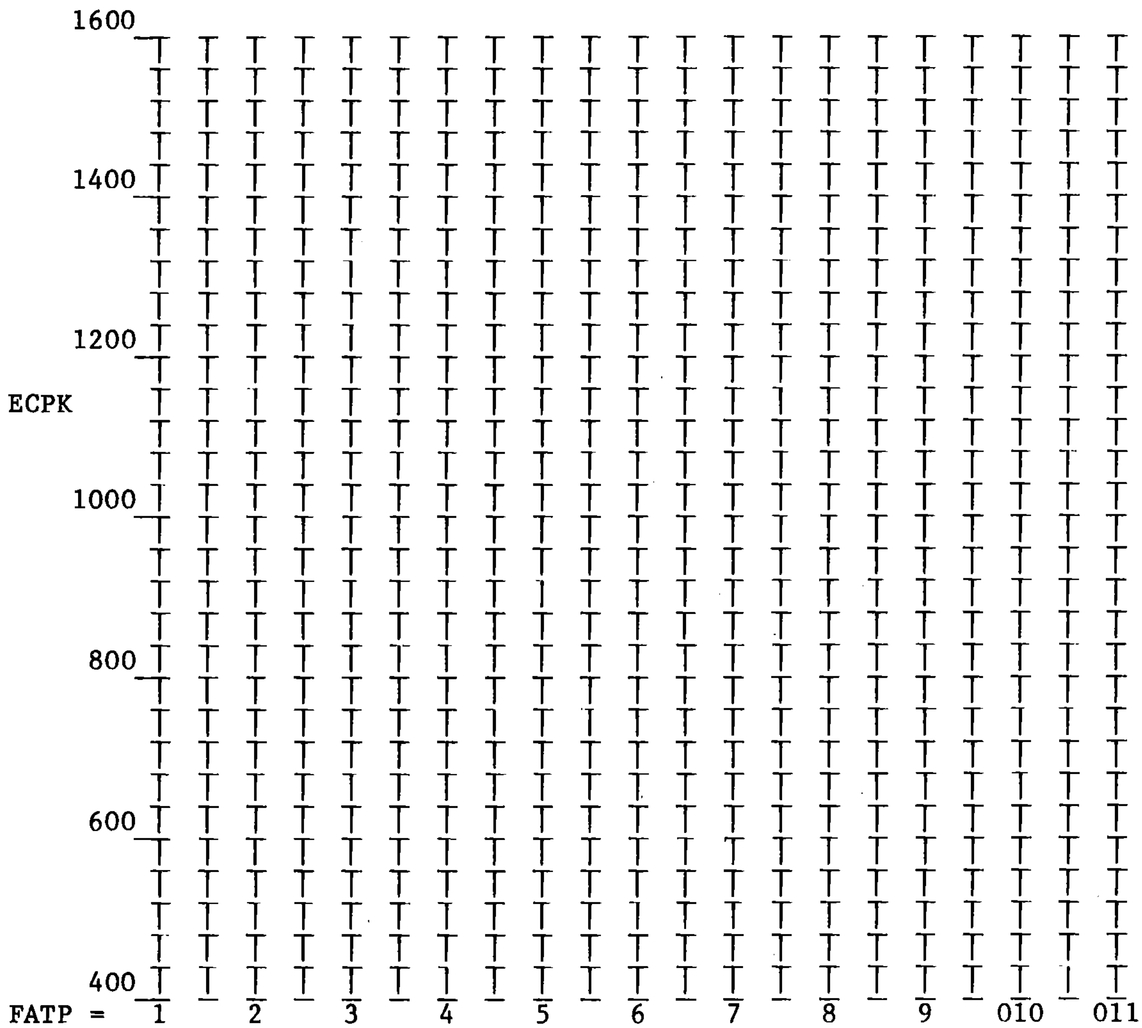
where ECPK = energy content per kg, and
FATP = fat percent.

Note that FATP is percent and not fraction. Milk with FATP = 4.0 has an energy content of 761 kcal/kg.

The equation has been derived from data on dairy cattle with milk varying from 2.8 to 6.2% fat. It should provide reasonable estimates when used for wild ruminants whose milk may contain more than 6.2% fat.

Lactation is a costly process. The use of this equation along with equations in CHAPTER 7 for calculating milk production results in estimates of the energy cost of milk, which is a significant part of the total cost of the ecological metabolism of free-ranging females.

Calculate ECPK and plot the line on the graph on the next page.



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Blaxter, K. L. 1962. The energy metabolism of ruminants. Hutchinson & Co., Ltd., London. 329 pp.

Gaines, W. L. and O. R. Overman. 1938. Inter-relations of milk fat, milk protein, and milk energy yield. J. Dairy Science 21(6):261-271.

Overman, O. R. and W. L. Gaines. 1933. Milk-energy formulae for various breeds of cattle. J. Agric. Res. 46(12):1109-1120.

TOPIC 3. GENETIC CHARACTERISTICS

Biological inheritance depends on chemical messengers called genes which are arranged on chromosomes, with the hereditary information in the deoxyribonucleic acids (DNA) of the genes (Hoar 1966; 663). Thus genetic characteristics are chemical characteristics with the unique role of transferring information from one individual to its offspring, from one generation to the next.

Each species has a given number of pairs of chromosomes, and genetic information is transmitted from both male and female when the sperm and egg unite in fertilization. The new individual is similar but not identical to its parents, with many, but not all, of the characteristics inherited by the offspring in ways suggesting Mendelian ratios (Pantelouris 1967; 423).

The spectrum of individual genetic characteristics comprises the genetic characteristics of populations. Some of the characteristics of populations that have been isolated for some time are visible and obvious (Svalbard reindeer, for example), and there is growing evidence that there are more subtle differences present too, differences which affect basic physiological functions that are of importance ecologically. It is very difficult, of course, to attribute such differences in wild ruminant populations to genetics or environment since controlled experiments are very difficult and expensive. Well-prepared physiologists interested in free-ranging animals have many interesting problems to investigate, but only with considerable expense and difficulty.

LITERATURE CITED

Hoar, W. S. 1966. General and comparative physisology. Prentice-Hall, Inc., Englewood Cliffs, N.J. 815 p.

Pantelouris, E. M. 1967. Introduction to animal physiology and physiological genetics. Pergamon Press, Oxford. 497 p.

REFERENCES, TOPIC 3

GENETIC CHARACTERISTICS

BOOKS

type	publ	city	page	anim	kewo	auth	year
edbo	haro	nyny	397		readings, ecologi genetics	connell,jh; mert/	1970

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
EVOLA	24--1	220	229	odvi	anal div skull morph, mich	rees,jw	1970
PCGFA	29---	392	403	odvi	starch gel, popul genetics	manlove,mn; avis/	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
GENTA	83---	s12	s12	ceel	genetic studi, yellowstone	cameron,dg; vyse,	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
IZYBA	17---	77	81	obmo	gene pool conserva, analys	flesness,nr	1977

UNIT 3.1: INDIVIDUAL CHARACTERISTICS

Individual wild ruminants inherit genetic potentials for growth, maximum body sizes, antler and horn development, and other physical characteristics, and likely behavioral characteristics as well. The physical characteristics actually attained are dependent on range characteristics, including nutrient abundance and chemical quality, and on factors influencing productivity, such as weather and thermal exchange.

The role of the range in determining body size was demonstrated experimentally for white-tailed deer by Severinghaus (1964) when deer from the Adirondacks, small in size and with low reproductive rates were held in captivity and fed adequate diets. They then attained large body sizes and reproductive rates characteristic of deer on good range.

Experiments at Penn State University have demonstrated that antler patterns of white-tailed deer are inherited, but antler size is determined by the quality of diet (French et al. 1955 and Magruder et al. 1957). This seems biologically reasonable, and is likely to be true for other species of wild ruminants as well. The effects of range quality are especially evident in yearly differences in antler growth, and annual increments to horns are also related to range conditions.

LITERATURE CITED

French, C. E., L. C. McEwen, N. D. Magruder, R. H. Ingram, and R. W. Swift. 1955. Nutritional requirements of white-tailed deer for growth and antler development. Pennsylvania Agricultural Experiment Station Bulletin 600.

Magruder, N. D., C. E. French, L. C. McEwen, and R. W. Swift. 1957. Nutritional requirements of white-tailed deer for growth and antler development II. Pennsylvania Agricultural Experiment Station Bulletin 628.

Severinghaus, C. W. 1964. Productivity and growth of white-tailed deer from the Adirondack region of New York. New York Fish and Game Journal. 11(1):13-27.

REFERENCES, UNIT 3.1

INDIVIDUAL CHARACTERISTICS

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BLOOA	29--6	867	877	odvi	hemmoglobin polymorphism	kitchen,h; putna/	1967
CBCPA	30--4	695	713	odvi	hemat,bld chem,prot polymo	seal,us; erickson	1969
JBCHA	247--	7320	7324	odvi	heterogen hemoglob-a chain	taylor,wj; easle/	1972
JOMAA	38-3	421	422	odvi	possible identical twins	mccullough,ra	1957
JWMAA	34--3	642	644	odvi	studies, the sex chromatin	crispens,cg jr; d	1970
JWMMA	37--3	422	423	odvi	sex chrom in antlered fema	crispens,cg,jr; d	1973
NFGJA	11-1	13	27	odvi	product, growth, adirondac	severinghaus,cw;	1964
PAABA	600--	1	50	odvi	nutrit req, grow, antl dev	french,ce; mcewa/	1955
PAABA	628--	1	21	odvi	nutr req, growth, antl dev	magruder,nd; fre/	1957

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	40--1	96	108	odhe	antler anomalies of mule d	robinette,wl; jon	1959

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ZEJAA	2---3	142	148	ceel	[biostatist stud, breedng]	bubenik,a; lochm/	1956

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
RIJUA	7	52	59	alal	moose popu palmated, type	voipio,p	1952

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AVCSA	10--1	44	47	rata	somatic y chromosome, rein	gustavsson,i; sun	1969
EXPEA	33--7	875	876	rata	rate,sister chromat exchng	pathak,s; ward,o/	1977
GNKAA	7---2	171	173	rata	alleles, transferrin locus	turabanov,mn; shu	1971
HEREA	88--1	113	115	rata	genetic markers, spitzberg	storset,a; olais/	1978
TGANA	7---4	303	305	rata	[polymorph, liver esteras]	shubin,pn; mongal	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	43--1	219	219	bovi	g, c bandng char, 4 specie	kieffer,nm; patha	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	55-10	1759	1762	bibi	chrom homol wood,plain bis	ying,kl; peden,dg	1977

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOHEA	69--2	77	80	ov	fundamn karyotyp, wild,dom	bunch,td	1978

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBCPA	40b-2	567	570	ovca	ovda,ovmu,transferrin,hemo	nadler,cf; woolf/	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	52--2	461	463	ovda	chromosomes,the dall sheep	nadler,cf	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ZEJAA	3---2	53	63	caca	[heterogeneity, europe]	lehmann,e	1957

UNIT 3.2: POPULATION CHARACTERISTICS

Genetic differences between populations have been recognized for some time, and external characteristics of isolated populations may be quite different from those of populations that have no natural barriers to immigration and emigration. The Svalbard reindeer population, isolated on Svalbard Island, is a striking example of external differences compared to continental populations of reindeer and caribou. Their legs are shorter, bodies more compact, hair is longer, etc. than other populations of Rangifer tarandus.

Research on genetic characteristics of populations has begun recently, especially on caribou and reindeer. Several studies were published in the 1970's, and more research is in progress. Reindeer are good subjects for such studies because of husbandry that has identified more or less discrete herded populations, with the wild caribou also divided into more or less distinct herds due to its behavior and natural barriers.

REFERENCES, UNIT 3.2

POPULATION CHARACTERISTICS

BOOKS

type	publ	city	page	anim	kewo	auth	year
edbo	acpr	nyny	105	many	population genetics,ecolog	karlin,s; eviatar	1976

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	22--3	155	246	od	distr,var, pacif coast reg	cowan,i mct	1936
JOMAA	39--3	347	367	od	mammals, guerrero, mexico	davis,wb; lukens,	1958
JWMAA	43--1	136	142	od	biochem var, heterog,s car	ramsey,pr; avise/	1979

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ABBIA	127--	711	717	odvi	hemoglob hetergeneity, w-t	huisman,thj; doz/	1968
JOMOA	128--	95	112	odvi	morph var, cranium, mandib	rees,jw	1969
JOMOA	128--	113	130	odvi	morph var, mandibl, skelet	rees,jw	1969
JWMAA	34--3	642	644	odvi	studies, the sex chromatin	crispens,cg jr; d	1970
PCGFA	25---	65	69	odvi	blk-t, crossbrd study tenn	whitehead,cj,jr	1971
PCGFA	29---	392	403	odvi	strch gel eletroph,pop gen	manlove,mn; avis/	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMMA	43--4	539	541	odhe	black-tail,wt-tail hybrids	cowan,imt	1962
NOSCA	48--1	66	71	odhe	subsp overlap, north washi	nellis,ch; fairb/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
IRFOA	30	64	78	ceel	hybrd amng deer,impl for c	harrington,r	1973
JZOOA	174-2	185	201	ceel	reexam of subsp, red deer	lowe,vpw; gardine	1974
JZOOA	177-4	553	566	ceel	hybrid, red deer,sika deer	lowe,vpw; gardine	1975
SWNAA	23--1	63	70	ceel	taxonomi status, merriam's	anderson,s; barlo	1978
ZEJAA	2---3	142	148	ceel	[biostatist stud, breedng]	bubenik,a; lochm/	1956

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
RIJUA	7	52	59	alal	moose popu palmated, type	voipio,p	1952

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
EXPEA	33--7	875	876	rata	sister chromatid exchnges	pathak,s; ward,o/	1977
GNKAA	7---2	171	173	rata	alleles, transferrin locus	turubanov,mn; shu	1971
HEREA	88--1	113	115	rata	genetic markers, spitzberg	storset,a; olais/	1978

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				anam			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				bibi			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovca			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				ovda			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ZEJAA	3---2	53	63	caca	[heterogeneity, europe]	lehmann,ev	1957

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	40--5	1009	1015	many	wild, domes,dev new genoty	spillett,jj; bun/	1975

CLOSING COMMENTS

Characteristics of organs and glands, chemical composition, and genetic characteristics have been introduced in CHAPTER 2. Characteristics of organs and glands are used in analyses of metabolic and behavioral functions in later CHAPTERS. Chemical compositions of the body and of milk are especially important in PART III. PHYSIOLOGY and METABOLISM OF WILD RUMINANTS.

All of the remaining CHAPTERS include direct or indirect references to CHAPTERS 1 and 2. The interdependence of material in all CHAPTERS will become more clear as the comprehensive concept of carrying capacity is evaluated.

Users of these CHAPTERS are urged to add WORKSHEETS on specific biological functions of different species. The design of this publication lends itself to such additions as both problem-solving examples and lists of published literature on other species are included. The ecological picture will become more complete in direct proportion to the number of analyses completed and biological functions related.

GLOSSARY OF SYMBOLS USED - CHAPTER TWO

AGDA = Age in days
AGYE = Age class in years
ANWG = Antler weight in gms
ANWK = Antler weight in kg
ASHK = Ash content in kg
ASHR = Fraction of ash

CLWK = Calculated live weight in kg

DILA = Days into lactation

EBWG = Eyeball weight in gms
ECPK = Energy content per kg
ELWG = Eye lens weight in gms

FAGD = Fetal age in days
FAT- = Fat
FATF = Fat fraction
FATK = Fat content in kg
FATP = Fat percent
FRCT = Fraction
FRLP = Fraction of the lactation period

HAWG = Hair weight in gms
HIWK = Hide weight in kg
HLLK = Heart, lung, liver weights in kg

IFWK = Ingesta-free weight in kg

JDAY = Julian day

LAPE = Lactation period
LBLC = Left beam length in cm
LCTS = Lactose
LIWK = Live weight in kg
LWMG = Lens weight in milligrams

MBLC = Main beam length in cm
MNRL = Mineral

PROF = Protein fraction
PRTK = Protein content in kg
PRTN = Protein

RBLC = Right beam length in cm

THWG = Thyroid weight in gms

WATF = Water fraction
WATK = Water content in kg
WATR = Water

GLOSSARY OF CODE NAMES - CHAPTER TWO

CODEN	
ACATA	Acta Anatomica
AIPAD	Anales del Instituto de la Patagonia
AJANA	American Journal of Anatomy
AJBSA	Australian Journal of Biological Sciences
AJPHA	American Journal of Physiology
AJVRA	American Journal of Veterinary Research
AMZOA	American Zoologist
ANANA	Anatomischer Anzieger
ANBEA	Animal Behaviour
ANREA	Anatomical Record
ATRLA	Acta Theriologica
AVCSA	Acta Veterinaria Scandinavica
AZOFA	Annales Zoologici Fennici
AZOSA	Acta Zoologica
BAPBA	Bulletin de l'Academie Polonaise des Sciences Serie de Sciences
BECTA	Bulletin of Environmental Contamination and Toxicology Biologiques
BGTEA	Bulletin de Groupe de Travail pour l'Etude de l'Equilibre Foret-Gibier
BIJOA	Biochemical Journal
BJLSB	Biological Journal of the Linnean Society
BJNUA	British Journal of Nutrition
BLOOA	Blood
CAFGA	California Fish and Game
CAFNA	Canadian Field Naturalist
CATRB	Calcified Tissue Research
CBCPA	Comparative Biochemistry and Physiology
CBPAB	Comparative Biochemistry and Physiology - A comparative physiology
CJPPA	Canadian Journal of Physiology and Pharmacology
CJZOA	Canadian Journal of Zoology
CPSCA	Chesapeake Science
EVOLA	Evolution
EXPEA	Experientia
FEPRA	Federation Proceedings
FMFUB	Forma et Functio
FOBGA	Folia Biologica
FUNAA	Fauna
GCENA	General and Comparative Endocrinology
GENTA	Genetics
GNKAA	Genetika
HEREA	Hereditas

HLTPA	Health Physics
IZYBA	International Zoo Year Book
JAASA	Journal of the Alabama Academy of Science
JAECA	Journal of Animal Ecology
JANSA	Journal of Animal Science
JBCHA	Journal of Biological Chemistry
JBLPA	Jelen
JBOMA	Journal of the Bombay Natural History Society
JCECD	Journal of Chemical Ecology
JCOQA	Journal of the Colorado-Wyoming Academy of Sciences
JDSCA	Journal of Dairy Science
JDREA	Journal of Dental Research
JEEMA	Journal of Embryology and Experimental Morphology
JEZOA	Journal of Experimental Zoology
JOHEA	Journal of Heredity
JOMAA	Journal of Mammalogy
JOMOA	Journal of Morphology
JRPFA	Journal of Reproduction and Fertility
JSFAA	Journal of the Science of Food and Agricuture
JULRA	Journal of Ultrastructure Research
JWIDA	Journal of Wildlife Diseases
JWMAA	Journal of Wildlife Management
JZOAA	Journal of Zoology
KPSUA	Khimiya Prirodnykh Soedinii
MAMLA	Mammalia
MMRLA	Mammal Review
MRLTA	Murrelet, The
NATUA	Nature
NAWTA	North American Wildlife and Natural Resources Conference, Transactions of the,
NCANA	Naturaliste Canadien, Le
NYCOA	New York State Conservationist
NFGJA	New York Fish and Game Journal
NJZOA	Norwegian Journal of Zoology
NZJSA	New Zealand Journal of Science
OFWRA	Ontario Fish and Wildlife Review
PAABA	Pennsylvania Agricultural Experiment Station Bulletin
PAANA	Proceedings of the Australian Society of Animal Production
PAARA	Pennsylvania State University College of Agriculture Agricultural Experiment Station Progress Report
PASCC	Proceedings of the Alaskan Scientific Conference
PCGFA	Proceedings of the Southeastern Association of Game and Fish Commissioners
PCZOA	Proceedings of the International Congress of Zoology
PIAIA	Proceedings of the Iowa Academy of Science

PLNAA	Plains Anthropologist
PMACA	Papers of the Michigan Academy of Sciences, Arts and Letters
PMASA	Proceedings of the Montana Academy of Sciences
PNDAA	Proceedings of the North Dakota Academy of Science
POASA	Proceedings of the Oklahoma Academy of Science
PSEBA	Proceedings of the Society for Experimental Biology and Medicine
PZSLA	Proceedings of the Zoological Society of London
RIJUA	Riistatieteellisia Julkaisuja
SAGCA	Science in Agriculture
SCAMA	Scientific American
SCIEA	Science
SOVEA	Southwestern Veterinarian
SSBLA	Seliskokhozyaistvennaya Biologiya
SWNAA	Southwestern Naturalist
TGANA	Tsitologiya I Genetika
TISAA	Transactions of the Illinois State Academy of Science
TKASA	Transactions of the Kentucky Academy of Science
TNWSD	Transactions of the Northeast Section, The Wildlife Society
TRNZA	Transactions of the Royal Society of New Zealand
VCSZA	Vestnik Ceskoslovenske Spolecnosti Zoologicke
VESMA	Vesmir
VEZOA	Vestnik Zoologii
VILTA	Viltrevy
VIWIA	Virginia Wildlife
VJSCA	Virginia Journal of Science
WAEBA	Wyoming Agricultural Experiment Station Bulletin
WLMOA	Wildlife Monographs
WSCBA	Wisconsin Conservation Bulletin
ZASMA	Zoologisch Abbandlungen
ZEJAA	Zeitschrift fuer Jagdwissenschaft
ZETIA	Zeitschrift fuer TierpsychologieAe
ZOBIA	Zhurnal Obshchei Biologii
ZOLZA	Zoologicheskii Zhurnal
ZOOLA	Zoologica
ZSAEA	Zeitschrift fuer Saeugetierkunde
ZTTFA	Zeitschrift fuer Tierphysiologie Tierernaehrung und Futtermittelkunde
ZZAHA	Zeitschrift fuer Zellforschung und Mikroskopisch Anatomie

LIST OF PUBLISHERS - CHAPTER TWO

acpr	Academic Press	New York	nyny
butt	Butterworth	Washington, D.C.	wadc
edar	Edward Arnold	London	loen
haro	Harper and Row	New York	nyny
hutc	Hutchinson	London	loen
isup	Iowa State University Press	Ames, IO	amia
jblc	J. B. Lippincott Co.	Philadelphia, PA	phpa
nasc	National Academy of Science	Washington, D.C.	wadc
pepr	Pergamon Press	Oxford, England	oxen
saco	Saunders Publishing Co.	Philadelphia, PA	phpa
whfr	W. H. Freeman Co.	San Francisco, CA	sfca

LIST OF WORKSHEETS - CHAPTER TWO