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.

REFERENCES, UNIT 1.1

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:

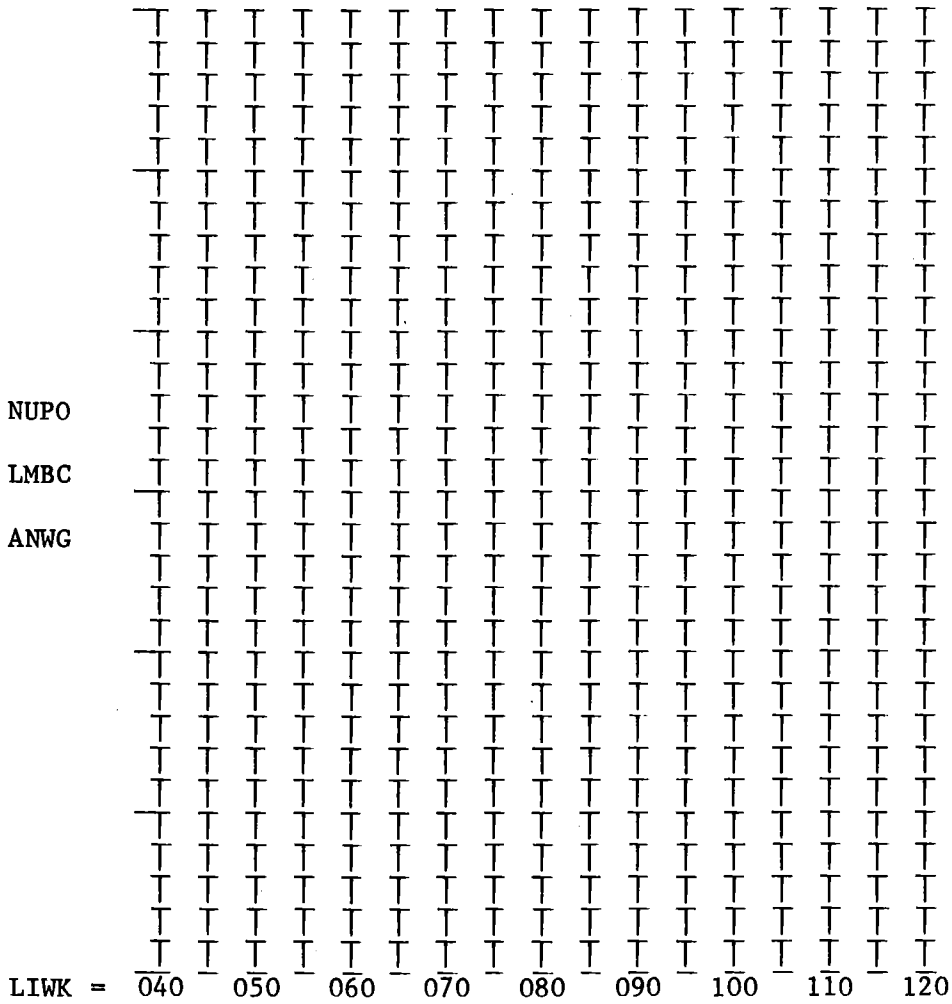
$$NUPO = 0.170\ LIWK - 5.66;\ r^2 = 0.71$$
$$LMBC = 0.655\ LIWK - 13.96;\ r^2 = 0.87$$

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

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)

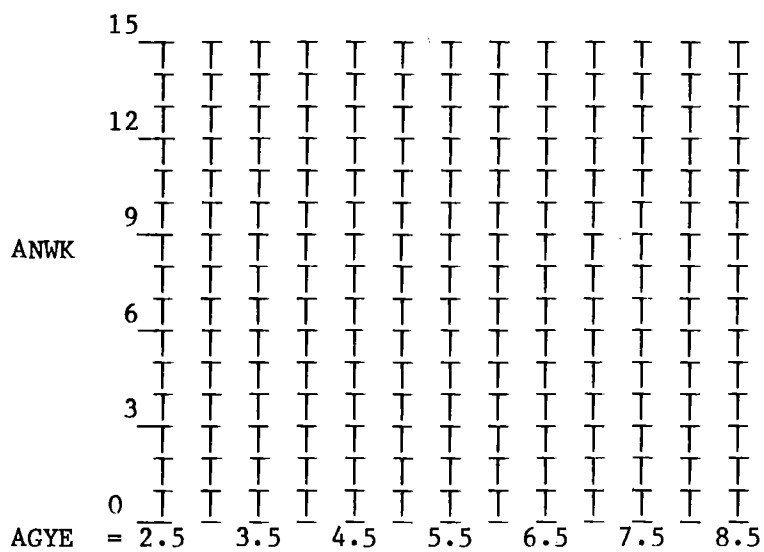
Ages and antler weights of 12 Manitoba elk have been given by Blood and Lovaas (1966). There is a general increase in weight with age, but with variations between years. Individual average weights for each age class in years (AGYE) are given below. Regression equations have been calculated. The a and 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 :

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

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:

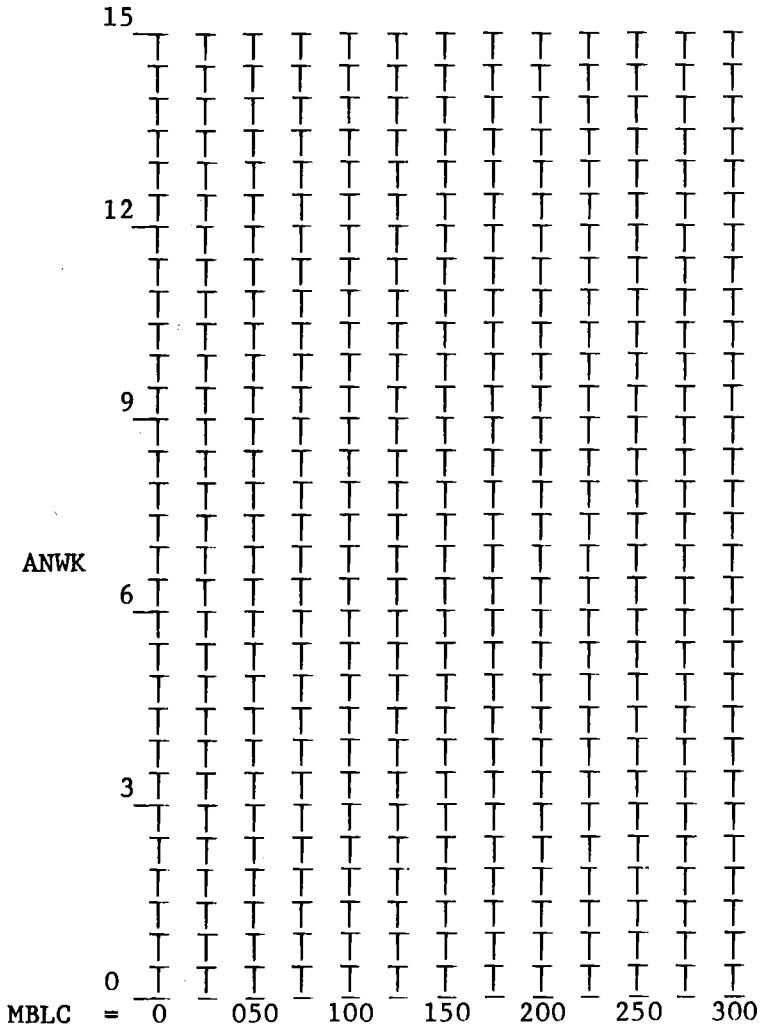
$$ANWK = a\ MBLC^b = 0.00001\ MBLC^{2.42660}$$

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

CHAPTER 2, WORKSHEET 1.3a

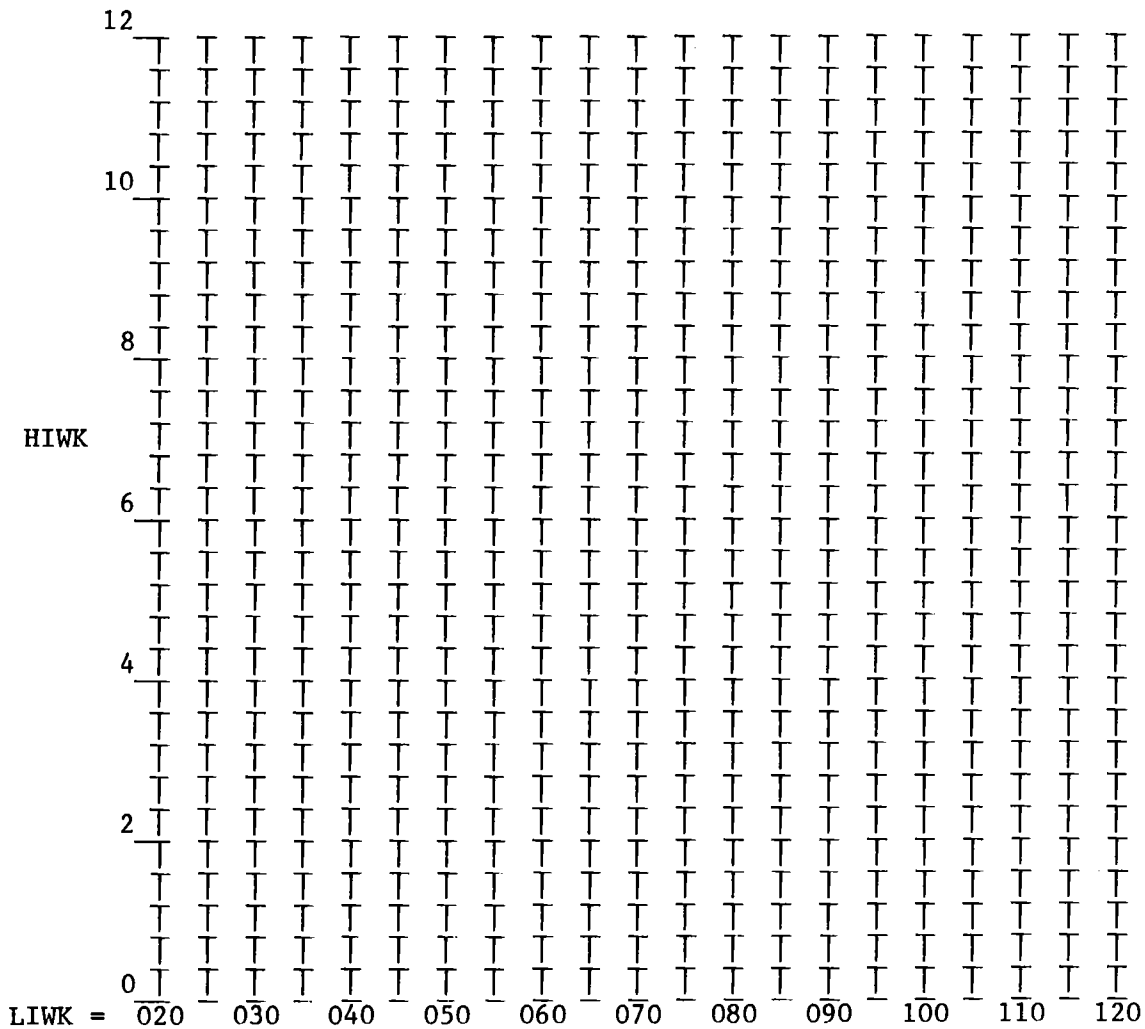
Live weight:hide weight relationships for white-tailed deer (odvi)

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.



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.

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

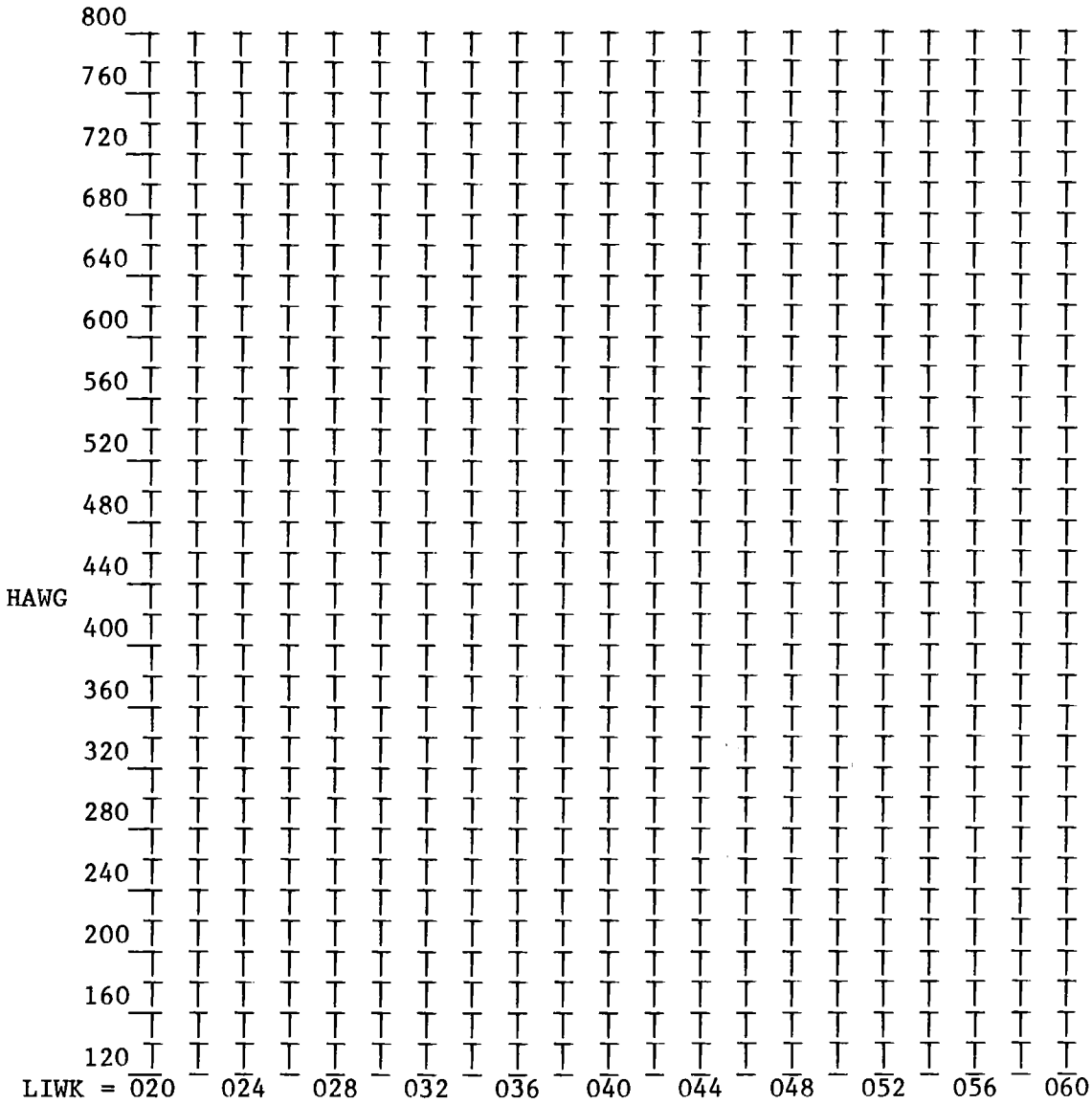
2. $121 < JDAY < 161$ $\quad HAWG = \dfrac{JDAY - 121}{50}\,(1.5)\,[-1406.51 + 542.33] \cdot \ln(IFWK)$

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

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

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).

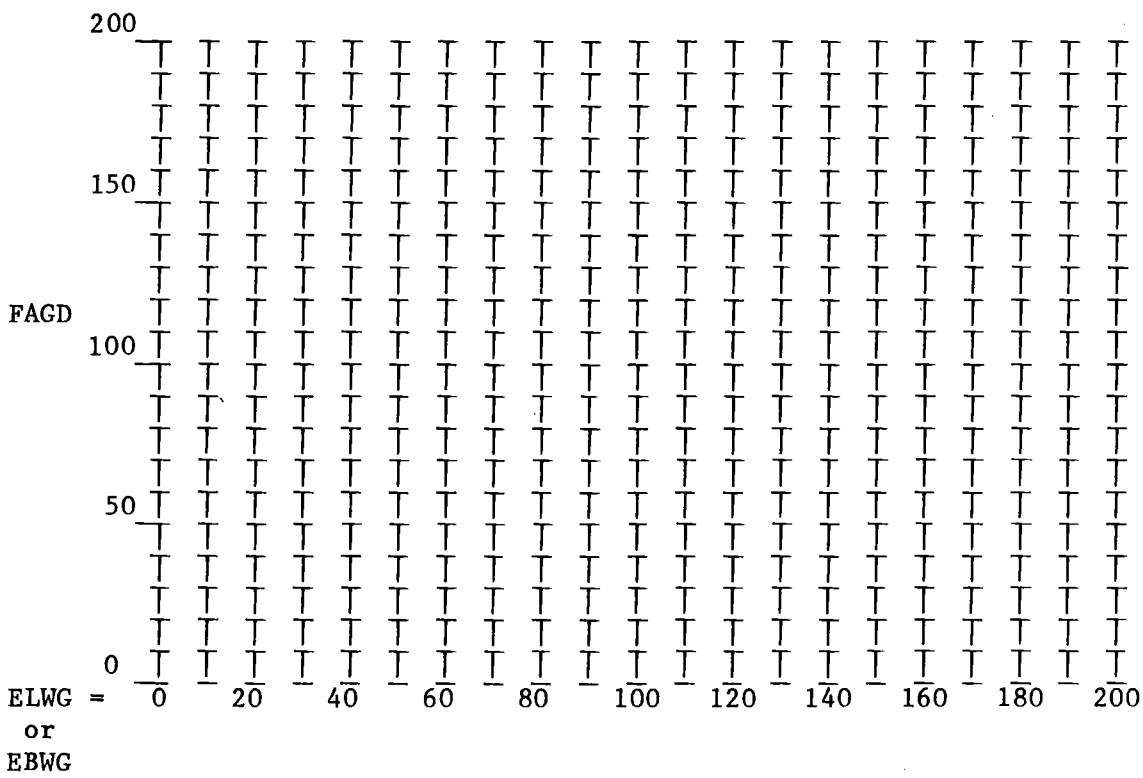
The equations for fetal age in days (FAGD) in relation to paired eye-lens weight in grams (ELWG) is:

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

The equation for fetal age in days (FAGD) in relation to paired eye-balls 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

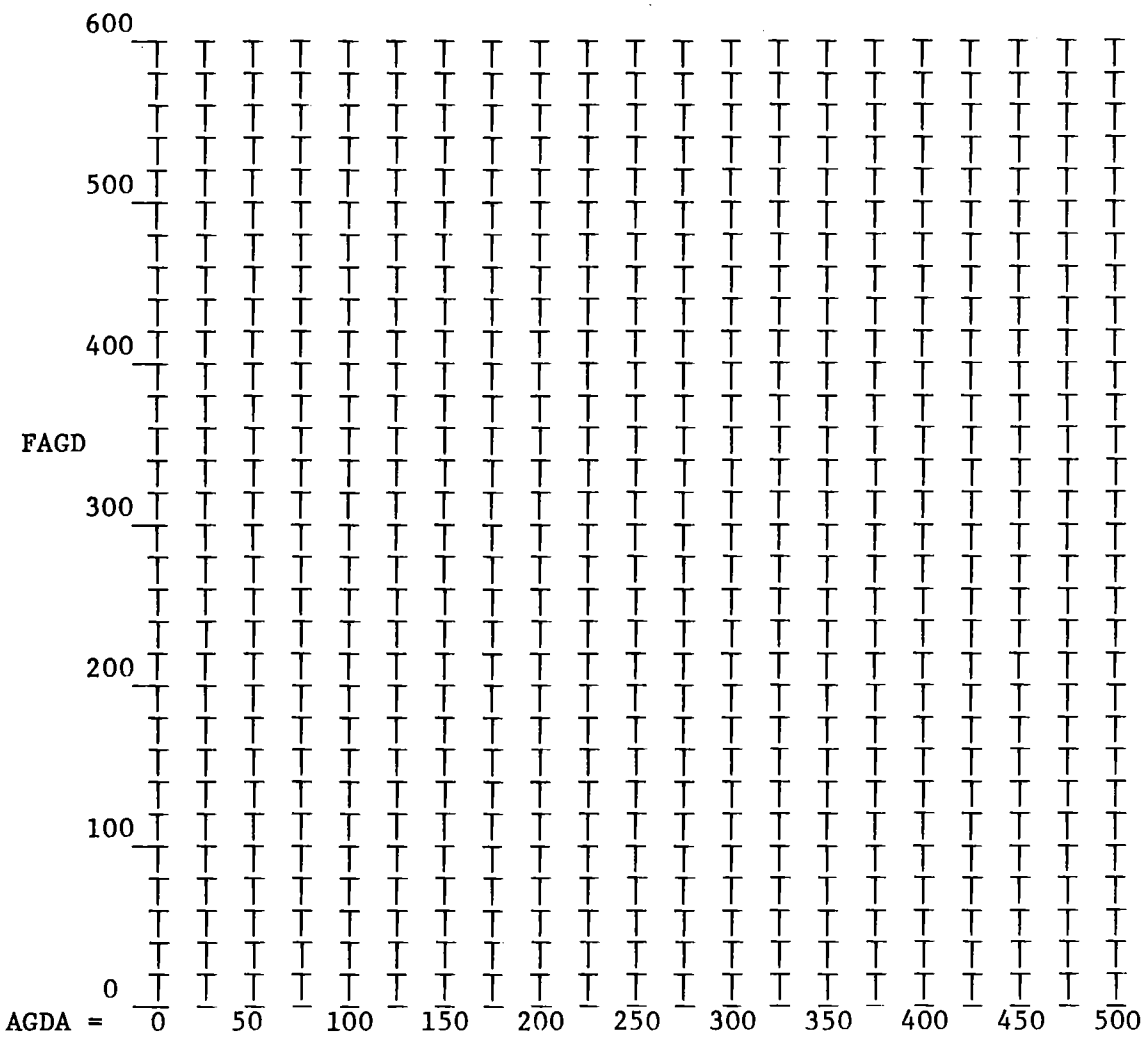
Ages 2 months to 7 years: $Y = 205.8 + 31.4X - 0.6\ X^2$, where Y = lens weight and X = age

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]	____

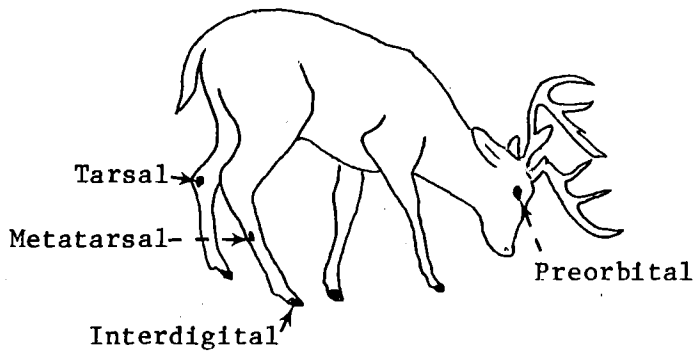


LITERATURE CITED

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.

LITERATURE CITED

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			

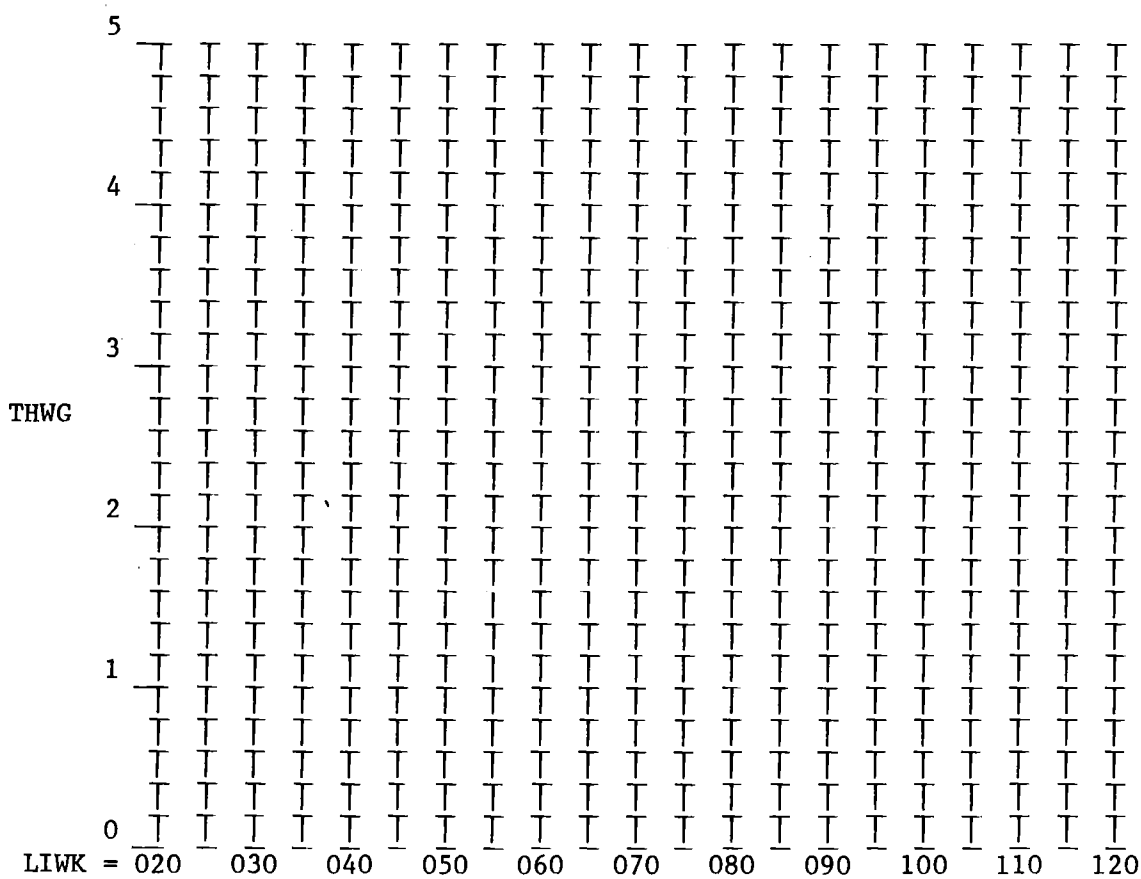
CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				dada			

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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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.