

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 successfully. Such costs are worthy of analyses 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 = $f(\text{weight})$, for example] as relationships are evaluated sequentially [forage requirements = $f(\text{weight}) = f(\text{metabolism})$, 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 |

31

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

| <u>type</u> | <u>publ</u> | <u>city</u> | <u>page</u> | <u>anim</u> | <u>kewo</u> | <u>auth/edit</u> | <u>year</u> |
|-------------|-------------|-------------|-------------|-------------|-----------------------------|--------------------|-------------|
| 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

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

| <u>CODEN</u> | <u>vo-nu</u> | <u>bepa</u> | <u>enpa</u> | <u>anim</u> | <u>kewo</u> | <u>auth</u> | <u>year</u> |
|--------------|--------------|-------------|-------------|-------------|----------------------------|-------------|-------------|
| 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 |

| <u>CODEN</u> | <u>vo-nu</u> | <u>bepa</u> | <u>enpa</u> | <u>anim</u> | <u>kewo</u> | <u>auth</u> | <u>year</u> |
|--------------|--------------|-------------|-------------|-------------|----------------------------|-------------------|-------------|
| 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 |

| <u>CODEN</u> | <u>vo-nu</u> | <u>bepa</u> | <u>enpa</u> | <u>anim</u> | <u>kewo</u> | <u>auth</u> | <u>year</u> |
|--------------|--------------|-------------|-------------|-------------|----------------------------|--------------|-------------|
| 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 |

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

| <u>CODEN</u> | <u>vo-nu</u> | <u>bepa</u> | <u>enpa</u> | <u>anim</u> | <u>kewo</u> | <u>auth</u> | <u>year</u> |
|--------------|--------------|-------------|-------------|-------------|----------------------------|-------------|-------------|
| 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 |

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

| <u>CODEN</u> | <u>vo-nu</u> | <u>bepa</u> | <u>enpa</u> | <u>anim</u> | <u>kewo</u> | <u>auth</u> | <u>year</u> |
|--------------|--------------|-------------|-------------|--------------|------------------|-------------|-------------|
| 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 |

| <u>CODEN</u> | <u>vo-nu</u> | <u>bepa</u> | <u>enpa</u> | <u>anim</u> | <u>kewo</u> | <u>auth</u> | <u>year</u> |
|--------------|--------------|-------------|-------------|-------------|------------------|-------------------|-------------|
| 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 Department | Concord, NH | conh |
| omcc | Olin Mathieson Chem. Corp. | E. Alton, IL | eail |
| oxup | Oxford University Press | London | loen |
| qupr | Queen's Printer | Ottawa, 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 Department 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 |

