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CRITERIA FOR GENDER AND AGE

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INTRODUCTION

Accurate classification of an animal's gender and age is fundamental to wildlife research and management (Leopold 1933). Gender and age information is often used to establish harvest regulations and strategies, monitor a population's demographic structure, health, and viability, and provide an understanding of behavioral ecology.

In many situations identifying an animal's gender and age is relatively simple, especially for sexually dimorphic species and those with distinct age-specific patterns of appearance. However, accurate classification of an individual's gender and/or age may be more complicated for species that are monomorphic. Additionally, for many species, young-of-the-year are identifiable, but differentiation among older age classes is difficult. Moreover, in many situations only partial information and/or material, such as a wing, jaw, or tooth, is available for evaluating an individual's gender and/or age. This limitation can be exacerbated by the relatively short and/or sub-optimal time during which many samples are collected, such as during a hunting season.

One objective of this review is to describe basic techniques used to classify gender and age of birds and mammals that occur in North America. Techniques that have reduced subjectivity, improved accuracy, a wide range of applicability among numerous species, and a long history of standardized use are emphasized. The second objective is to identify techniques and resources used to examine particular species or groups of species. An exhaustive description of techniques used for evaluating gender and age for all species of interest cannot be achieved in this brief chapter. Consequently, we introduce some of the current techniques used and provide appropriate references for initiating detailed work.

TECHNIQUES FOR CLASSIFICATION OF GENDER AND AGE

The best techniques are those that are versatile and can be used throughout the year with live or dead animals, different body parts, and numerous age categories. In reality, development of particular techniques has often been affected by time of harvest and/or sampling methodology. For instance, widespread collection of waterfowl and gallinaceous bird wings following harvest has resulted in concentration on subtle differences in wing plumage as a key identifier of species, gender, and age, even though overall differences in plumage patterns among the species may be substantial. Although simple techniques are currently available to ascertain gender and basic age categories for most species, especially game animals, efforts to improve and expand the techniques will undoubtedly continue. These will likely include increased efforts to evaluate species that are endangered, threatened, and/or declining, and species that are indicators of habitat condition.

Behavior

Behavior for most species varies substantially among gender and age classes. Consequently, behavior can be important for identifying outwardly monomorphic species. Behavioral differences can include calls, songs (Fig. 1), visual displays, nest building, clutch incubation, nursing, and urination posture (Fig. 2). However, due to the complicated and species-specific nature of behavioral displays

Fig. 1. Many species of animals, including the sage sparrow (*Amphispiza belli*), exhibit gender-specific behavior. Male sage sparrows have a characteristic song that is not performed by females (photograph by W. M. Vander Haegen).

Fig. 2. Behavior is species-specific. Males of some species may stand and stretch while urinating and females may squat. Exceptions are common, as illustrated by male mule deer (*Odocoileus hemionus*) (Geist 1981) (photograph by V. Geist).

(Young 2004), with few exceptions, this chapter will focus on use of morphological characteristics for assessing an individual's gender and/or age.

General Morphology and Appearance

Body Size.—Gender and age categories for many species often differ substantially, thus making classification relatively straight forward with general field guides. For animals in hand, numerous physical characteristics can be measured, but body mass in all animals, forearm length in bats (Fig. 3), snout-vent length in lizards, frogs, and salamanders, and wing chord or wing notch-length in birds, are commonly used. Regardless of technique, care needs to be taken to ensure that measurements are standard and that results can be replicated (Nisbet et al. 1970). For example, in birds wing chord length is measured from, and including, the wrist to the tip of the longest primary. However wing chord can be measured in different ways: (1) unflattened, (2) flattened – normal camber of wing reduced with gentle pressure, or (3) maximally flattened – normal camber reduced and feathers gently straightened. Wing flattening and feather straightening can add 0.5 – 5% to the unflattened length; wing drying can reduce the length (Pyle 1997). Wing notch-length is measured from the notch in the wrist bend to the tip of the longest primary (Fig. 4); this measurement is not synonymous with the wing chord. For standardization, waterfowl wings are measured with wing notch-lengths (Carney 1992). Because waterfowl wings are usually dry when measured, the primaries are straightened, but the normal camber of the wing is not altered. Measurements of wing chord or wing notch-length will not be valid if the longest primary (or primaries) is missing, broken, or growing.

Fig. 3. The length of the forearm of bats is the most common measurement taken, in addition to mass. The slightly curved forearm of this fringed myotis (*Myotis thysanodes*) is measured as the straight-line distance from the end of the ulna to the base of the thumb, preferably using calipers (photograph by M. A. Schroeder).

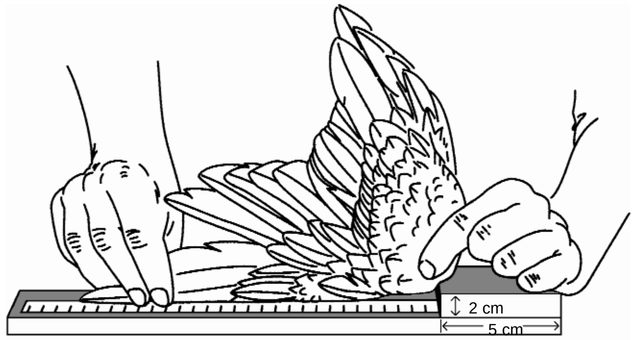

Fig. 4. Technique for measuring wing notch-length (modified from Carney 1992, original drawing from A. J. Godin). The measurement is taken from the notch in the wrist to the tip of the flattened primaries.

Many species display extensive variation in body size/mass associated with subspecies or race, region, and season. This variation often means there may be substantial overlap in the measurements of specific features. For example, even though the average male of many species may be heavier than the average female, there is a range in body mass where the gender could be either. This problem may be exacerbated in monomorphic species when the size of young males is similar to that of adult females.

Appearance.—Features of the head, body, tail, and/or shell of reptiles and amphibians can be used to assess gender and age. For example, the plastron (lower shell) of male turtles tends to be concave while in females the plastron is flat or slightly convex (Powell et al. 1998). The carapace (upper shell) tends to be more rounded with a pronounced median ridge in young turtles (Conant and Collins 1998, Stebbins 2003). Many amphibians have a distinct larval stage that is clearly distinguishable from either the juvenile or adult stages (Powell et al. 1998).

Birds typically have a natal plumage followed by a juvenile (or immature) plumage, and then an adult plumage. Although downy natal plumage is easily identifiable (e.g., chukar, *Alectoris chukar*) (Fig. 5), juvenile plumage can resemble adult plumage in basic appearance while differing in subtle ways such as notched tail feathers (Fig. 6), buffy or worn edges of wing coverts, and variation in color patterns. Most passerines can be separated into 2 age classes based on slight difference in the shape of outer tail feathers (Fig. 7) (Pyle 1997). Knowledge of feather type (Fig. 8) and molt patterns is extremely important for understanding which feathers offer the best clues to an individual's age and gen-

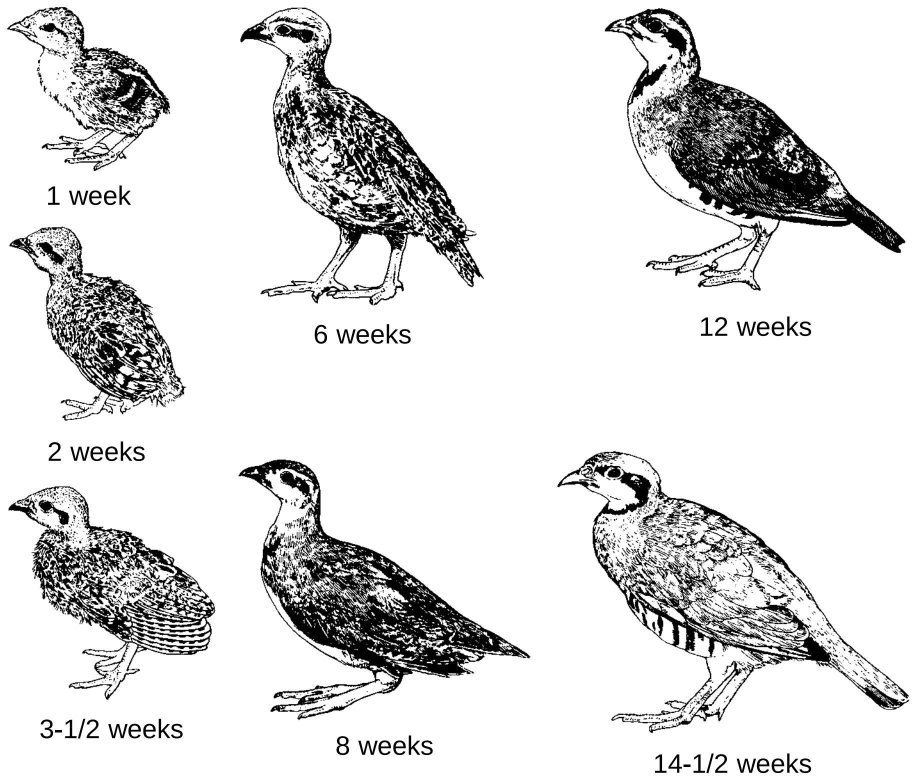

Fig. 5. Changes in appearance of juvenile chukars by age (Alkon 1982).

der. For example, the last juvenile feathers retained on many duck wings are some of the tertial coverts (Carney 1992). The first juvenile feathers to be replaced by adult feathers in spruce grouse (*Falcipennis canadensis*) are on the upper sides of the breast at about 30 days of age, thus permitting identification of gender (Boag and Schroeder 1992).

Males of many bird species have a distinct breeding plumage that can be used to identify gender. For example, male and female white-tailed ptarmigan (*Lagopus leucurus*) can be distinguished by plumage during spring, but not during winter (Braun et al. 1993). Females of most bird species develop a brood patch during the breeding season, a bare patch of skin on the abdomen that is critical during incubation; the presence or absence of a brood patch can be useful for assessing gender (Pyle 1997).

Most gallinaceous birds retain juvenile primaries 9 and 10 (numbered from P1 [inner] to P10 [outer]) through the first year and these primaries often differ in appearance from P9 and P10 of adults. Consequently, some gallinaceous birds can be reliably placed into 3 age classes (depending on time of year). These classes include HY (hatch year or juvenile), SY (second year or yearling, usually through the prebasic molt in late summer and early autumn), and ASY (after second year or adult). Later in the hunting season and/or following completion of the prebasic molt, SY birds are usually indistinguishable from ASY birds and, hence, both are referred to as AHY (after hatch year) birds. In this latter case, only 2 age classes are distinguishable (HY and AHY) (Fig. 9). Many other species of birds (except for a few species with intermediate plumage patterns) can only be differentiated into HY and AHY age classes, or in some cases, no differentiation at all (for example after the prebasic molt of mourning doves [*Zenaida macroura*]). Care should be taken when basing interpretations on the timing of molt. Zwickel and Dake (1977) found that reproductively successful female blue grouse tend to have a delayed molt when compared with unsuccessful females.

There can be substantial variation in plumage characteristics associated with region and subspecies. For example, ruffed grouse (*Bonasa umbellus*) in southern populations typically have longer tails than those in northern populations (Uhlig 1953, Davis 1969, Servello and Kirkpatrick 1986). Wild turkeys (*Meleagris gallopavo*) also show regional and subspecific variation (Healy and Nenno 1980). Many juvenile wild turkeys in Florida molt P9, and in some cases P10, in their first autumn (Williams and Austin 1970), in contrast to the normal pattern of gallina-

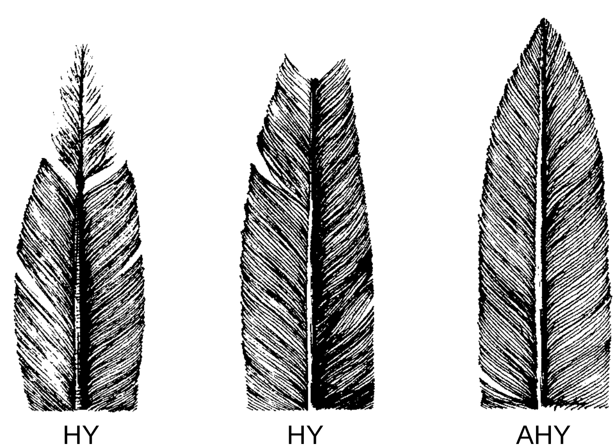

Fig. 6. Tail feathers of HY waterfowl may be notched or have a downy plume attached to the tip, while tail feathers of AHY birds are rounded or pointed (Godin 1960).

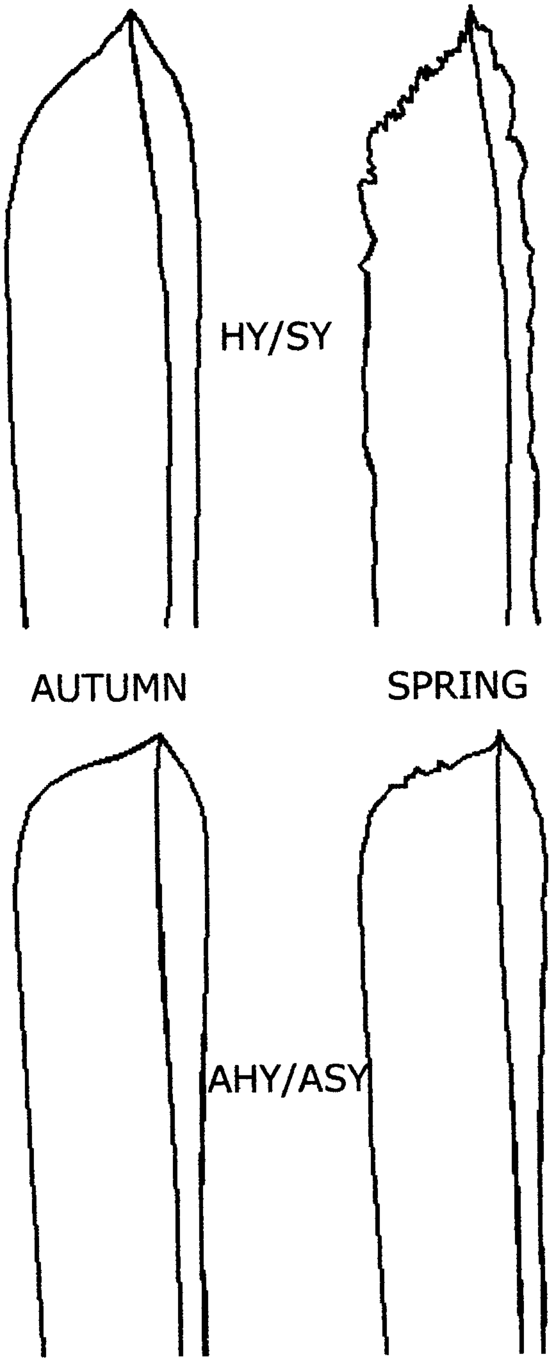

Fig. 7. Shape of outer rectrices of typical passerine during autumn and following spring for 2 age categories. Although feathers for each age category display wear in spring, feathers for HY/SY birds display considerably more (modified from Pyle 1997).

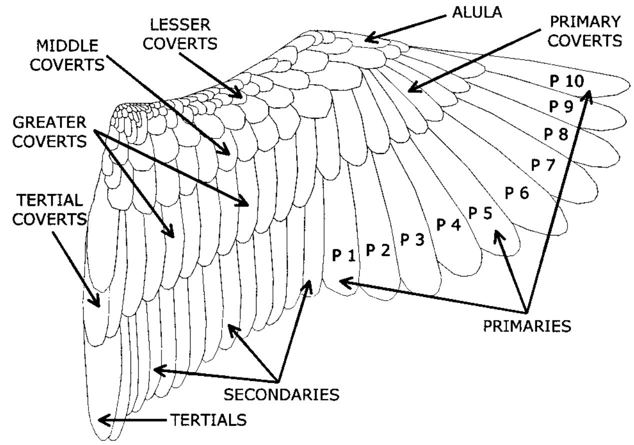

Fig. 8. Basic feather types on a typical wing. Primaries are numbered from proximal to distal (P1 through P10), and secondaries are numbered from distal to proximal (not individually labeled on figure).

ceous birds. The potential variation in appearance and pattern of molt associated with ecological region is not clearly understood, yet this factor may be a problem when samples are drawn from a broad geographic area and/or include multiple subspecies.

Mammals display much greater variation in size, longevity, productivity, and breeding cycles than birds. Many small mammals enter the breeding population in the same year they are born while large mammals can take many years to mature; for example, the house mouse (*Mus musculus*) is sexually mature 5-7 weeks after birth (Bronson 1979) while the gray whale (*Eschrichtius gibbosus*) reaches sexual maturity after at least 8 years (Burt and Grossenheider 1998). These differences add to the complications of assessing mammals, particularly with regard to age.

Ungulate fawns and calves tend to have relatively short head profiles when compared with yearlings and adults (Fig. 10). Other examples of variation include the vulval patches of female moose (*Alces alces*) (Roussel 1975) and caribou (*Rangifer tarandus*) (Bergerud 1978) and the black face patch of male pronghorn (*Antilocapra americana*) (Einarsen 1948). In an unusual example, the patterns on the undersurface of pelts are used to classify the age of muskrats (*Ondatra zibethicus*); juveniles have a symmetrical pattern whereas adults are blotchy (Moses and Boutin 1986) (Fig. 11). The fur on the tail of eastern gray squirrels (*Sciurus carolinensis*) also changes with age (Fig. 12).

Differences in physical features can often be used to assess gender and general age classes. For instance, males often have antlers while females do not and, in situations where females have antlers or horns, they are usually smaller. In addition, horns and antlers are usually larger for older animals (Fig. 13). Nevertheless, there is substantial variability and often too much overlap in the outward appearance of antlers and horns for this technique to be useful for several age categories (especially from a distance), and horns of females can sometimes resemble those of young males (Lawson and Johnson 1982).

Cloaca and Sex Organs.—In birds, the depth of the bursa of Fabricius (Fig. 14) decreases with age (Gower 1939). Hence, measurement of the bursa with a probe can be used to estimate age class (Wight 1956). However, because most birds display some age-specific variation in plumage, measurement of the bursa is not necessary. During the breeding season, the cloacal protuberance can be used to identify males in many species (particularly passerines), but the lack of a protuberance may not necessarily verify a female (Pyle 1997). Examination of the cloaca is usually not needed because most birds are dimorphic in appearance.

Examination of genitals is often important for classifying gender of mammals due to their monomorphic appearance. With large mammals, genitals often can be observed from a distance. However, careful palpation of many smaller species is needed to identify the testes and/or baculum.

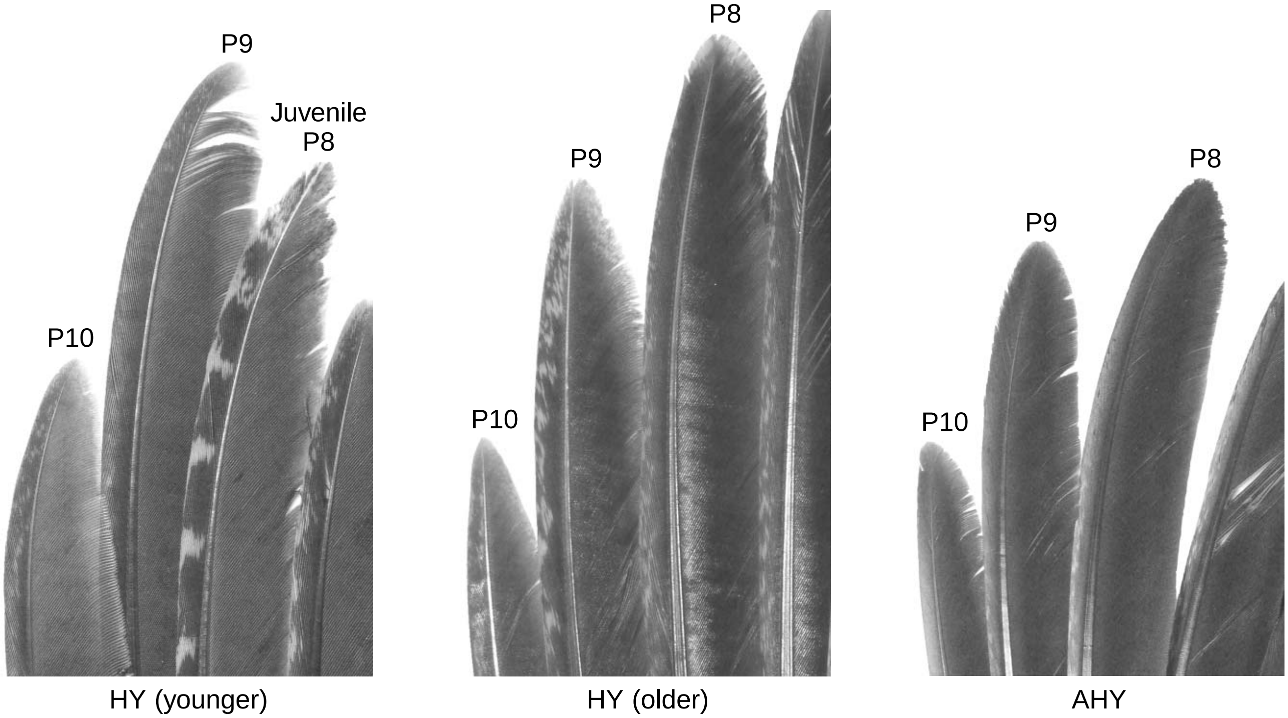

Fig. 9. Comparison of HY (hatch year or juvenile) and AHY (after hatch year) female blue grouse (*Dendragapus obscurus*) wings collected during the autumn harvest. In the wing on the left, the relatively short juvenile P8 has not yet molted and P9 and P10 are relatively pointed; the wing is clearly definable as HY. In the middle wing, juvenile P 8 has been replaced, and P9 and P10 are both relatively pointed; the wing is from an HY bird. On the right wing P9 and P10 are relatively rounded indicating the bird is AHY; because the bird has completed its molt, there is no possibility of differentiating between SY (second year) and ASY (after second year).

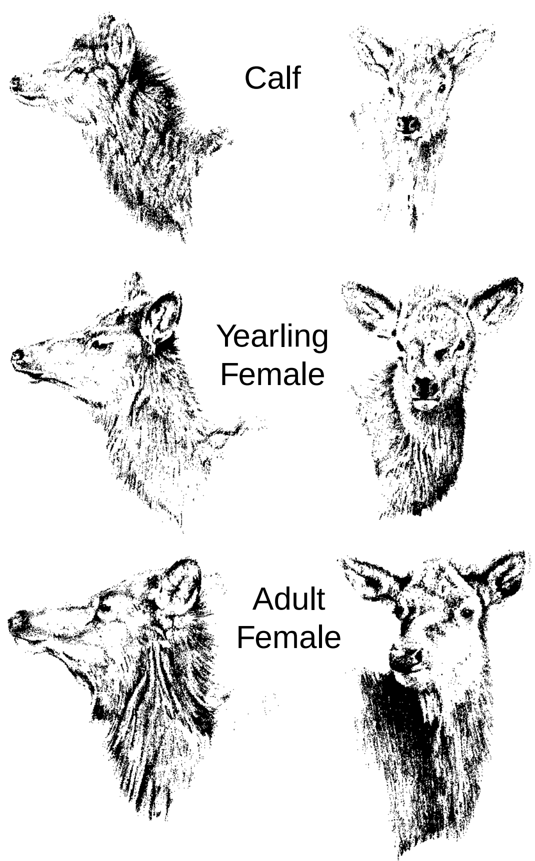

Fig. 10. Profile and frontal view of calf, yearling female, and adult female elk (*Cervus elaphus)* during late autumn–winter (Smith and McDonald 2002).

Changes in the appearance of the baculum are used as a technique for classifying age in many species including muskrat (Elder and Shanks 1962) (Fig. 15), mink (*Mustela vison*) (Lechleitner 1954), long-tailed weasel (*M. frenata*) (Wright 1947), striped skunk (*Mephitis mephitis*) (Petrides 1950*b*), American badger (*Taxidea taxus*) (Petrides 1950*b*), American marten (*Martes americana*) (Marshall 1951), and wolverine (*Gulo gulo*) (Wright and Rausch 1955). Schulte et al. (1995) also found that male American beaver (*Castor canadensis*) had a viscous anal gland secretion that was brown to sepia while the secretion of females tended to be paler and less viscous.

Reptiles exhibit internal fertilization via double-grooved hemipenes in lizards and snakes, and via a single-grooved

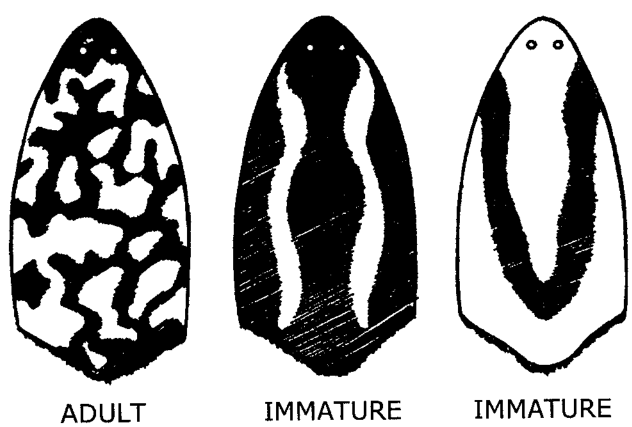

Fig. 11. The undersides of muskrat pelts have different patterns of light (prime) and dark (unprimed) fur that correspond with general age categories (Godin 1960).

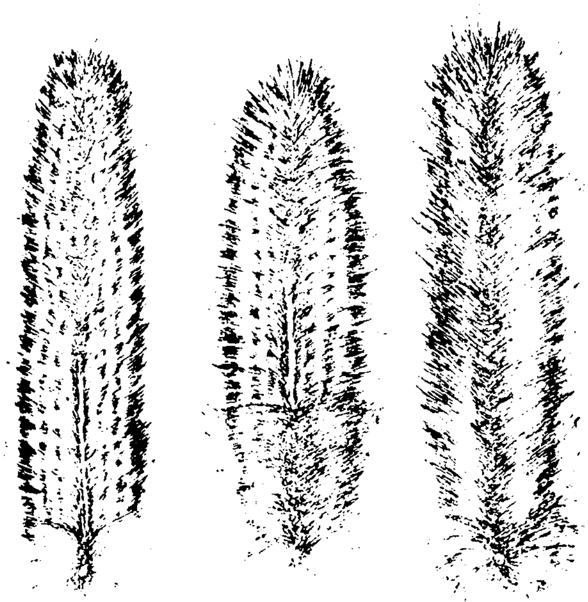

Fig. 12. Increased prevalence of short appressed hairs on the ventral surface of a gray squirrel's tail alters its age-related appearance (Godin 1960).

penis in turtles. The hemipenes of male lizards and snakes makes the base of their tail appear broader or swollen when compared with females (Gregory 1983). Gentle pressure may be used to evert the hemipenes. Some have recommended careful insertion of a blunt probe caudally at the lateral margins of the vent to confirm the presence or absence of the hemipenes (Schaefer 1934); Harlow (1996) used this technique effectively to ascertain gender of hatchling lizards. However, proper training for this technique is essential and care must be taken to avoid damaging reproductive organs (Gregory 1983). In turtles, the cloacal vent is positioned at or beyond the shell margin in males and inside the shell margin for females (Powell et al. 1998). Among amphibians, some salamanders exhibit internal fertilization while others, along with most anurans, fertilize egg masses externally. Male salamanders have a swollen cloaca, or vent, that is visibly lined with tubercles and conceals their copulatory organ (phallodeum); the female's vent does not have tubercles and is not swollen (Petranka 1998).

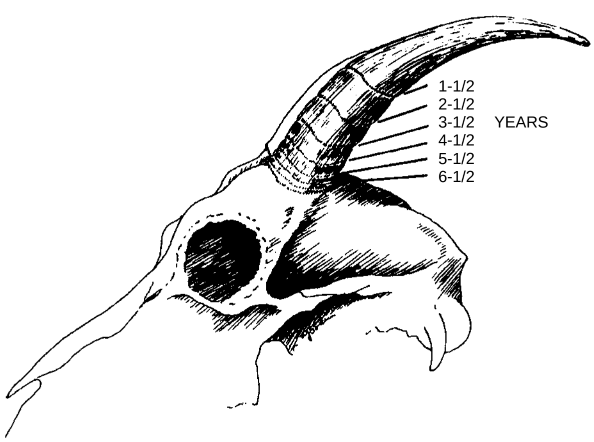

Fig. 13. The horns of mountain goats (*Oreamnos americanus*) may have rings that correspond to year class (Brandborg 1955).

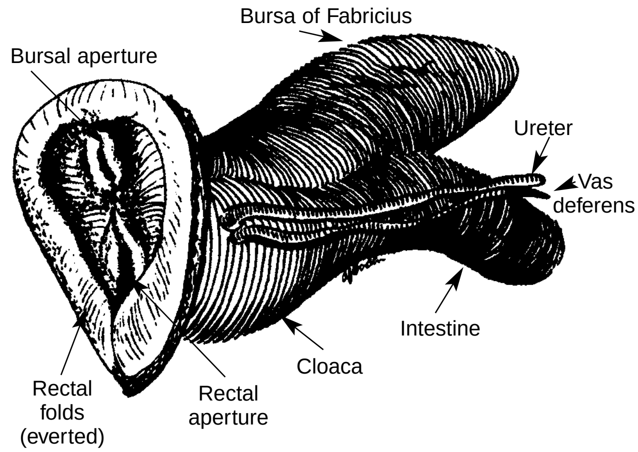

Fig. 14. Bursa of Fabricius in relation to other cloacal structures (from Godin 1960).

Internal examination of gonadal material, such as the ovaries in a female, is clearly useful for ascertaining gender and is often used to verify other techniques that are based on external characteristics. Other internal characteristics that are unique to a particular gender may be associated with secondary gender characteristics or directly with reproductive organs such as with suspensory tuberosities in white-tailed deer (*Odocoileus virginianus*) and mule deer (Taber 1956) (Fig. 16). Although suspensory tuberosities are observable in deer ≥2-1/2 years old, they are not obvious in deer as young as 1-1/2. In these cases, the ilio-pectineal

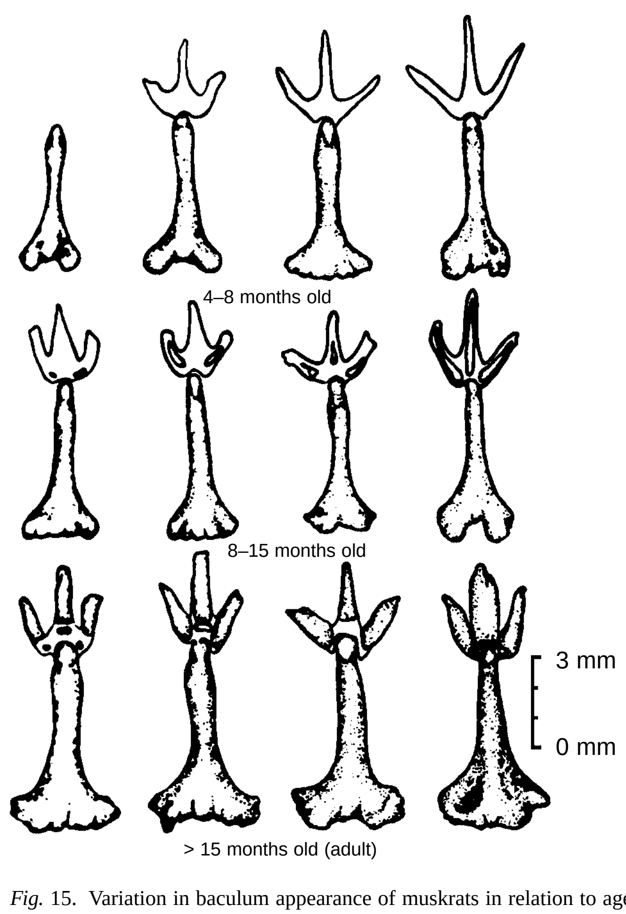

Fig. 15. Variation in baculum appearance of muskrats in relation to age (Elder and Shanks 1962).

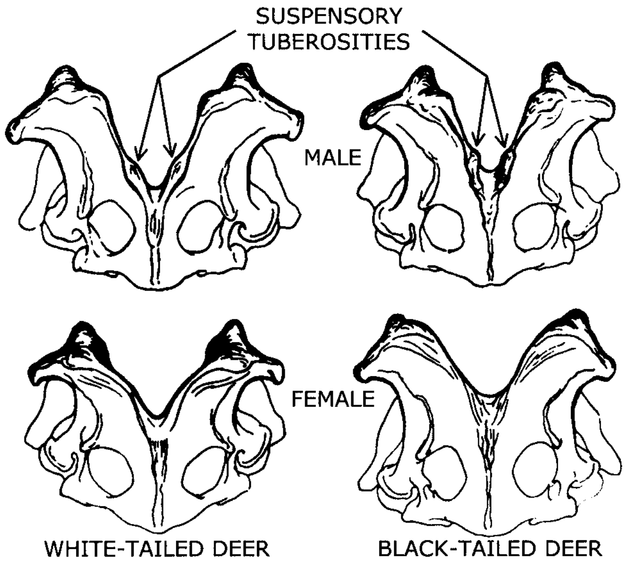

Fig. 16. Diagram of pelvic girdle of white-tailed deer (A) and black-tailed deer (*O. h. hemionus*) (B) ≥2-1/2 years of age showing suspensory tuberosities for the attachment of the penis ligaments (Taber 1956).

eminences can be used to ascertain gender (Edwards et al. 1982) (Fig. 17). Although internal characteristics are useful, they usually cannot be examined in live animals.

Dentition.—The structure and growth patterns of teeth are commonly used to classify age and gender of mammals (Fig. 18). General age classes of mammals can be identified by dental characteristics such as thin root walls, wide-open root tips, ratio of pulp width to tooth width, ratio of dentine to enamel, tooth shape, and the timing of tooth emergence (Severinghaus 1949; Jenks et al. 1984; Dix and Strickland 1986*a,b*; Johnston et al. 1987; Helldin 1997). Examination of teeth may also provide insight into gender for several species. For example, male elk grow an upper canine tooth whereas females do not (Greer and Yeager 1967). The lower canines in male black bear (*Ursus americanus*) (Sauer 1966), marten (Dix and Strickland 1986*b*), fisher (*Martes pennanti*) (Parsons et al. 1978, Jenks et al. 1984, Dix and Strickland 1986*a*), and bobcat (*Lynx rufus*) (Friedrich et al. 1983) tend to be larger than the lower canines of females.

In the maturing process of mammals, there is often a consistent pattern of tooth emergence and replacement. For example, in the lower jaw of ungulates there usually are 3 incisors (numbered from center to side, 1–3), 1 canine (incisorform), 3 premolars (numbered from front to back, 2–4), and 3 molars (number from front to back, 1–3); the first incisors, canine, and premolars are deciduous and are replaced by permanent teeth (Fig. 18). This evaluation of teeth is further enhanced by differences in appearance between the relatively small, deciduous teeth and their larger, permanent replacements. Three cusps characterize deciduous premolar 4 (third premolar from the front) in many North American ungulates, whereas permanent premolar 4 has only 2 cusps. The timing of these replacements and emergence of permanent molars can be used to estimate age (Table 1).

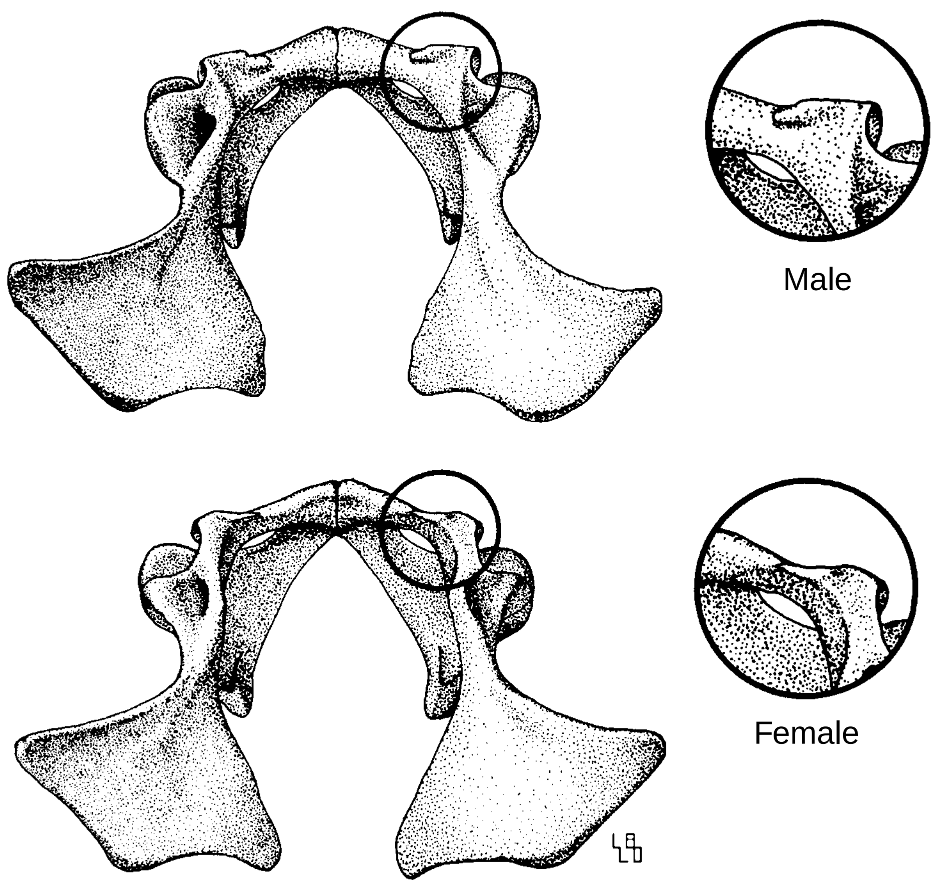

Fig. 17. Pelvic girdles of 1 ½ year-old white-tailed deer can be classified by gender based on the position of the ilio-pectineal eminences (IPE). The IPE is flattened and on the edge of the acetabular branch of the pubis in females, and rounded and above the edge of the acetabular branch of the pubis in males (Edwards et al. 1982).

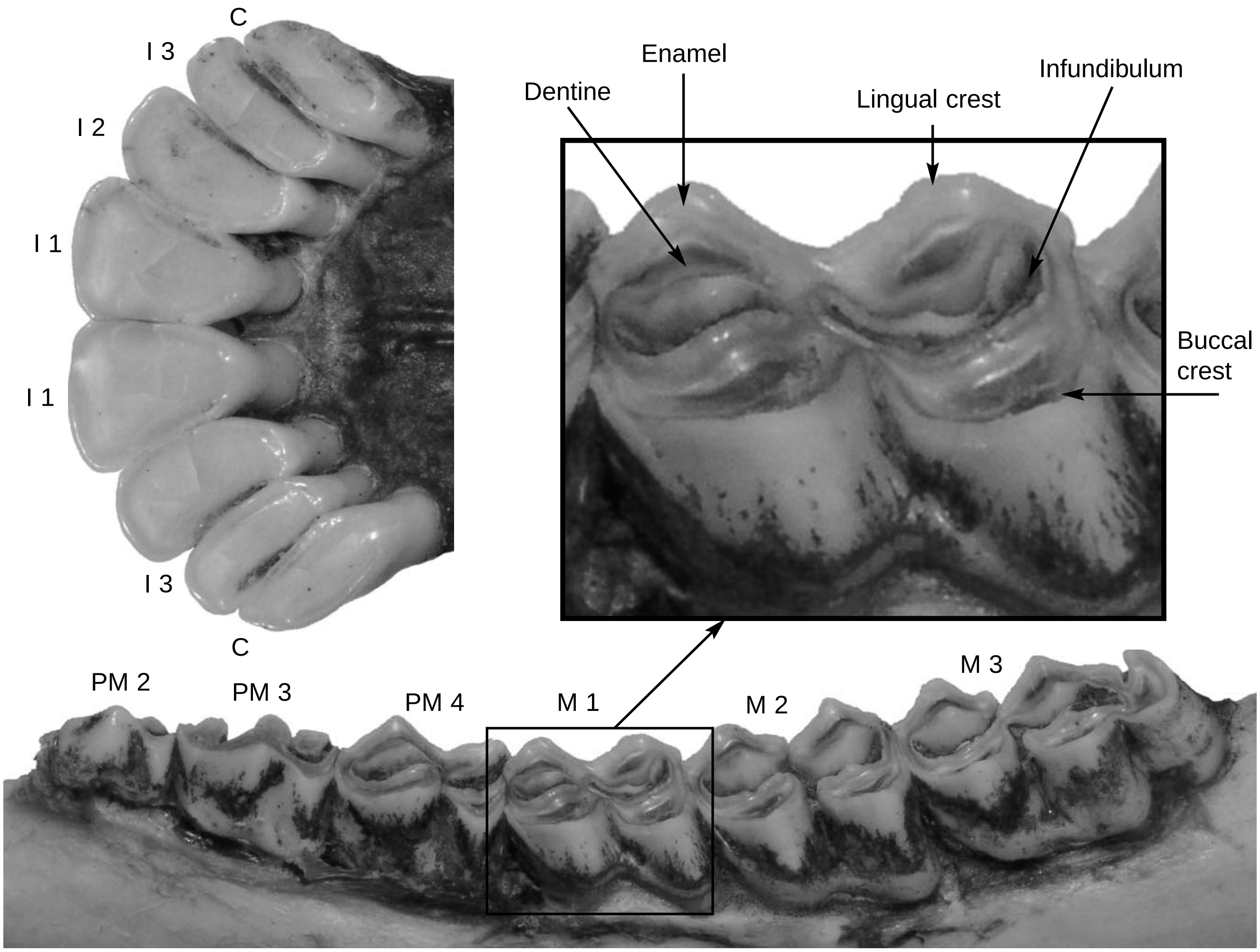

Fig. 18. Lateral view of lower left jaw of mule deer, facing the buccal crest (cheek side). The front of the lower jaw is also shown as well as an enlarged area illustrating the first molar. Teeth are labeled as I (incisor), C (canine), PM (premolar), and M (molar).

There has been substantial effort to use patterns of tooth wear, in addition to emergence and replacement of teeth, to classify older age categories such as for white-tailed deer (Severinghaus 1949) (Fig. 19) and gray wolf (*Canis lupus*) (Gipson et al. 2000) (Fig. 20). This effort has been accompanied by development of field techniques such as dental impressions (Flyger 1958, Barnes and Longhurst 1960, Clawson and Causey 1995) and reference sets of gender-specific mandibles (Thomas and Bandy 1975). However, research has often shown that tooth size and wear can vary by individual, subspecies, region, habitat, diet, and gender (Hesselton and Hesselton 1982, Erb et al. 1999, Van Deelen et al. 2000, Gee et al. 2002). Estimation of age of known-aged deer with tooth emergence and wear tech-

Table 1. Approximate age in months when permanent molars emerge or incisors, canines, and premolars replace deciduous teeth in the lower jaws of selected North American ungulates.

		Incisors			Canines	Premolars[a]			Molars		
Species	References	1	2	3	1	2	3	4	1	2	3
White-tailed deer	Severinghaus 1949	<6	<12	<12	<12	<18	~18	~12	2–6	~12	<18
Mule deer	Taber and Dasmann 1958	~12	~12	<18	<24	~24	~24	~24	2–6	6–12	18–24
Elk	Quimby and Gaab 1957	<18	~18	<30	<30	~30	~30	~30	~6	<18	<30
Caribou	Miller 1974*b*	10–13	12–15	12–15	12–17	22–29	22–29	22–29	<3	10–15	15–24
Pronghorn	Dow and Wright 1962	<15	<27	<39	39–41	<27	<27	<27	<2	<15	<15
Wild sheep (*Ovis canadensis*, *O. dalli*)	Lawson and Johnson 1982	12–16	24–28	33–36	45–48	24–32	24–30	24–30	1–6	8–16	22–40
Mountain goat	Brandborg 1955	15–16	26–29	38–40	~48	26–29	26–29	26–29	6–10	10–16	15–29

[a] Premolars are numbered from 2 through 4 due to the presumed evolutionary loss of premolar 1.

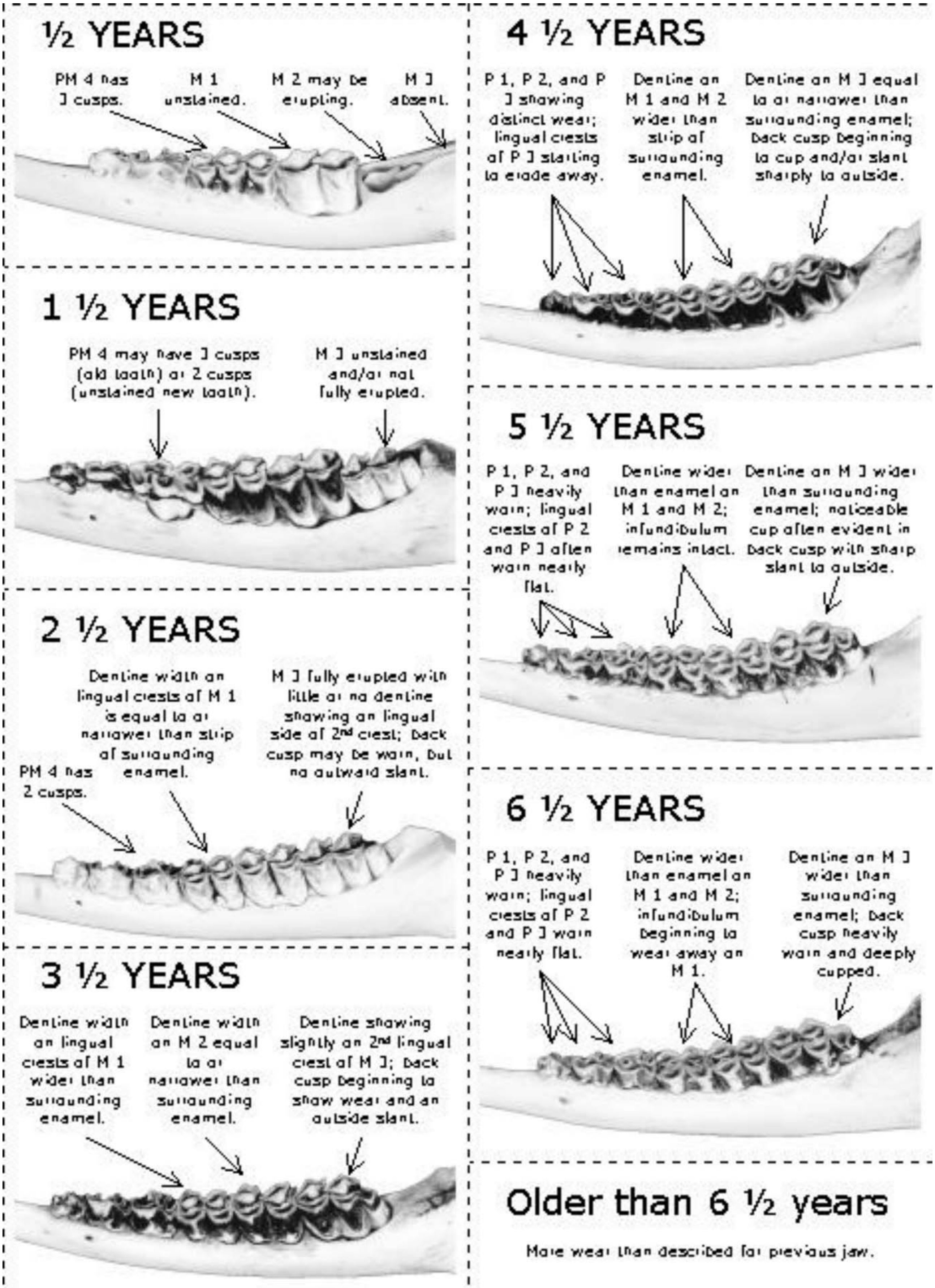

Fig. 19. Progressive age-related wear on premolars and molars (PM 2–4 and M 1–3 ,left-to-right) of lower left jaw (facing the cheek side) of white-tailed deer (Severinghaus 1949, Godin 1960, Dimmick and Pelton 1994).

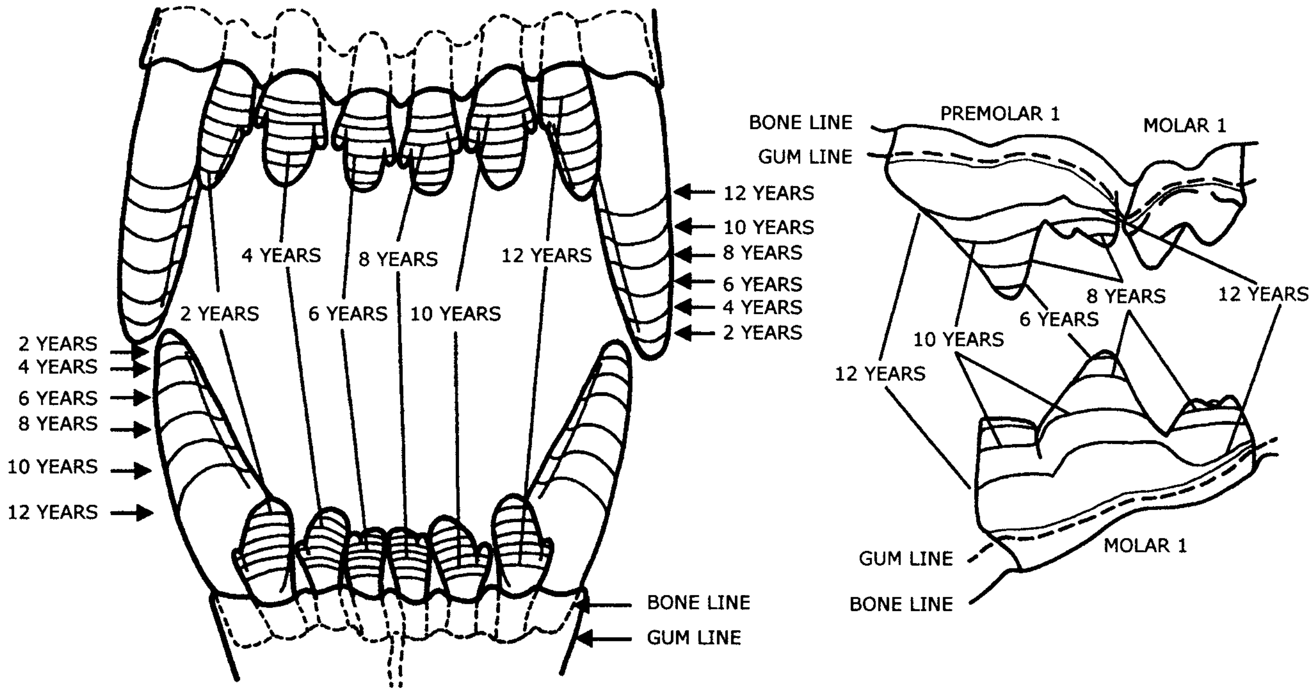

Fig. 20. Progressive wear on incisors and canines in 2-year increments for gray wolves. The lines represent averages for a study of known-aged wolves; errors of 1–3 years were observed using this technique (Gipson et al. 2000).

niques has been inaccurate, especially for older age categories (Hamlin et al. 2000, Gee et al. 2002).

Normal variation in tooth wear has been exacerbated by confusion in wear characteristics of teeth necessary to discriminate between age categories (Marchinton et al. 2003). For example, the relative width of dentine (dark-colored region) in relation to enamel (light-colored region) on the lingual crests (tongue side) of molars 1, 2, and 3 (Fig. 18) has been used to classify 2-1/2, 3-1/2, and older white-tailed deer. Severinghaus (1949) suggested that 2-1/2-year-old deer should have dentine narrower than enamel on molar 1, 3-1/2 year-old deer should have dentine wider than enamel on molar 1 and roughly equal to enamel on molars 2 and 3, and older deer should have dentine layers wider than enamel on all molars. Misinterpretation of these characteristics (3-1/2 year-old deer incorrectly described in Dimmick and Pelton 1994:193) (Fig. 19) can result in deer being misclassified (Marchinton et al. 2003).

For most species, collection of a tooth for cementum annuli analysis is the most accurate method used to estimate age among older age categories (Hamlin et al. 2000). Cementum is deposited annually on the roots of teeth so the layer closest to the dentine is from the earliest year and the layer of the current year lies closest to the root. Because gender, physiology, ecological region, and annual variation in weather appear to minimally influence the layers (Allen and Kohn 1976), the cementum of permanent teeth can indicate the number of years following tooth emergence (Klevezal and Mina 1973) (Fig. 21).

In teeth with distinct layers (e.g., beaver), grinding and polishing a section of the tooth is sufficient for evaluation of age (Van Nostrand and Stephenson 1964). In most sit-

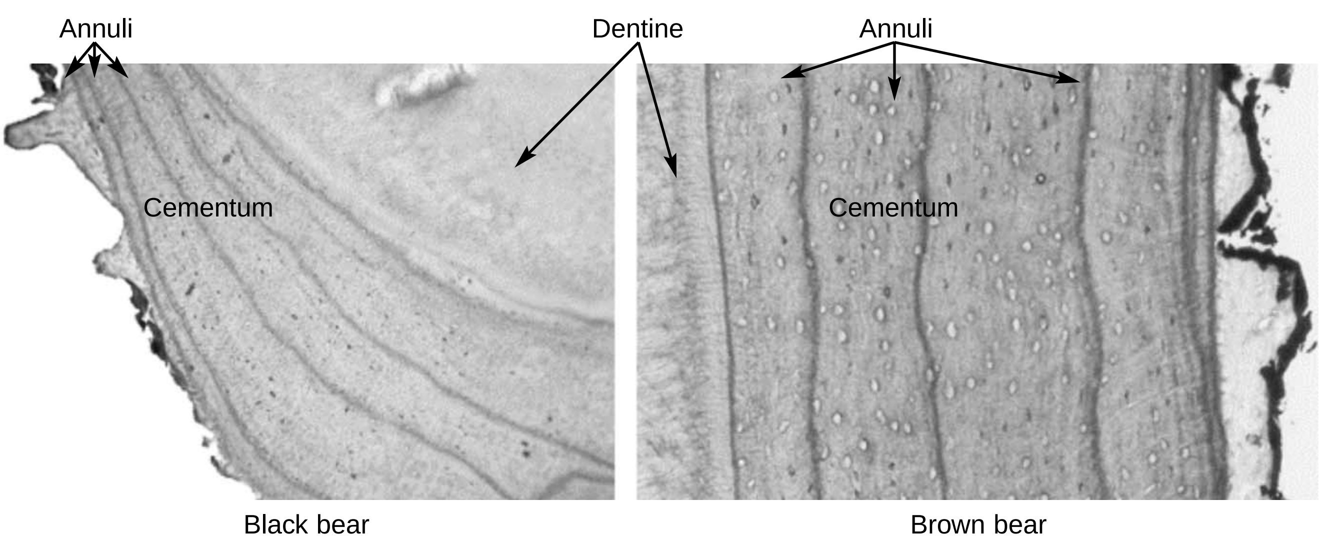

Fig. 21. Cementum annuli analysis of 4-year-old black and brown bears (*Ursus arctos*) (photographs by G. M. Matson).

uations, however, the tooth must be decalcified, cut into thin histological sections, and stained before evaluation. Techniques are also being expanded and developed to deal with other situations and tooth materials, including archaeological specimens (Lieberman et al. 1990, Beasley et al. 1992). All teeth have layers, but the tooth used to assess an animal's age varies among species and collecting conditions. Some teeth, such as incisors and premolars, are easier to extract and may be removed from live animals without obvious adverse effects (Nelson 2001, Bleich et al. 2003). Nevertheless, there is some debate about the ethics of tooth removal from live animals including arguments for (Nelson 2002) and against (Festa-Bianchet et al. 2002).

There are standard teeth and sections of teeth used for evaluation of cementum annuli. The standard tooth is the first incisor (central) for all ungulates, a lower canine or premolar 1 for most carnivores, and premolar 2 for cougar (*Puma concolor*) (Dimmick and Pelton 1994). Premolar 3 or 4 has also been used for martin, the lateral incisor for Canada lynx (*Lynx canadensis*) and bobcat, and an upper canine for bull elk. Standardization minimizes problems associated with differences in eruption time and interpretations of growth layers (Landon et al. 1998). If a nonstandard tooth type is selected for cementum age classification, the tooth must be identified, because differences in eruption time require different interpretations of growth layers. Errors of at least one year can result when an unidentified, nonstandard tooth is substituted for the standard. Techniques for tooth removal, mailing, storage, and processing should be selected before initiating research (Bergerud and Russell 1966, Erickson and Seliger 1969, Fancy 1980, Dimmick and Pelton 1994, Harshyne et al. 1998, Nelson 2001).

Use of cementum annuli for age classification appears to be more accurate than tooth wear for older mammals. In an experiment involving 120 known-aged samples from 12 species, exact agreement occurred between known and cementum age in 94 individuals; within 1 year for 21 individuals, and >1 year for 5 individuals (Dimmick and Pelton 1994). One reason for incorrect age classification using cementum annuli is the presence of double or uneven layers of cementum (Kolenosky 1987). This problem can result in errors, particularly the overestimation of age in younger animals and underestimation of age in older animals, such as with polar bears (*Ursus maritimus*) (Hensel and Sorensen 1980) and wolves (Landon et al. 1998, Gipson et al. 2000). It is likely that pulp cavities, and tooth eruption and replacement are more accurate for ascertaining younger age classes than cementum annuli; in these cases, use of cementum annuli is unnecessary (Johnston et al. 1987, Jacobson and Reiner 1989, Landon et al. 1998). These characteristics can be examined visually or with radiography (Kuehn and Berg 1981, 1983; Dix and Strickland 1986*a,b*; Nagorsen et al. 1988; Helldin 1997; Knowlton and Whittemore 2001).

Skeletochronology.—Skeletochronology is similar to cementum annuli analysis, but potentially has a wider array of applications. Adhesion lines or annual growth layers in bones can be examined to estimate age. Several studies have addressed this possibility in femur bones of sea turtles with substantial success (Zug et al.1986, Bjorndal et al. 1988, Klinger and Musick 1992, Klinger et al. 1997, Zug and Glor 1999, Zug et al. 2002). Examination of a known age interval following injection with oxytetracycline supported the accuracy of this technique (Coles 1999). Adhesion lines in the sectioned femurs of yellow-pine chipmunks (*Tamias amoenus*) also appear to accurately indicate age categories (Barker et al. 2003). The technique has been expanded to include toe-clipped samples of amphibians (Parham et al. 1996); a transverse histological section through the midpoint of the toe phalanx appears to be best (avoiding cartilaginous areas near the epiphyses).

Eye-lens Weight.—The crystalline eye lens of vertebrates is an indicator of age in mammal species because it grows without shedding cells (Lord 1959, Sanderson 1961*b*, Bloemendal 1977). In addition, an insoluble protein, tyrosine, accumulates in the eye lens and may also be useful (Dapson and Irland 1972, Birney et al. 1975, Ludwig and Dapson 1977). If properly preserved lens specimens are available, analysis of eye-lens weights can be accurate for younger age classes (Friend 1967, Hearn and Mercer 1988, Koubek 1993, Bruns Stockrahm et al. 1996). However, this technique is probably not as accurate as cementum annuli analysis for older age classes.

Development

Embryonic.—In birds altricial young are sparsely feathered and blind at hatching while precocial young are covered with down and have open eyes. Doves, pigeons, raptors, and most songbirds are altricial. Gallinaceous birds, waterfowl, shorebirds, and cranes are precocial. The incubation period is typically shorter for altricial young, but precocial young are able to leave the nest shortly after hatching. The morphological differences between the 2 types of development strategies can be observed using the developmental stages in the 14-day incubation period of the altricial mourning dove (Muller et al. 1984), the 23-day incubation period of the precocial northern bobwhite (*Colinus virginianus*) (Roseberry and Klimstra 1965), and the 26-day incubation period of the precocial wild turkey (Stoll and Clay 1975). When precocial embryos are approximately two-thirds of the way through their normal incubation period, they are similar to newly hatched altricial birds. Development of embryos can be examined in eggs with flotation techniques (Westerskov 1950, Barth 1953, Hays and LeCroy 1971, Dunn et al. 1979, Nol and Blokpoel 1983, Van Paassen et al. 1984, Alberico 1995) and candling (Westerskov 1950, Weller 1956, Young 1988) techniques. Some evidence suggests the age of early stage clutches may be overestimated while the age of late stage clutches may be underestimated with flotation (Walter and Rusch 1997).

Fetal development in mammals can be used to estimate age in days, conception date, and/or parturition date (Bookhout 1964). Prenatal development in white-tailed deer and mule deer are well described (Armstrong 1950, Hudson and Browman 1959, Salwasser and Holl 1979, Larson and Taber 1980, Hamilton et al. 1985) and may be examined using a portable radiography unit (Ozoga and Verme 1985).

Postnatal.—Altricial young remain in the nest until fledging; mourning dove chicks remain in the nest until about 14 days after hatch (Hanson and Kossack 1963). Age of precocial young can be classified in the field with pattern of down replacement or with measurements of primaries and/or their pattern of replacement, as illustrated with spruce grouse (McCourt and Keppie 1975, Towers 1988), blue grouse (Zwickel and Lance 1966, Schladweiler et al. 1970, Redfield and Zwickel 1976), greater sage-grouse (*Centrocercus urophasianus*) (Pyrah 1963), greater

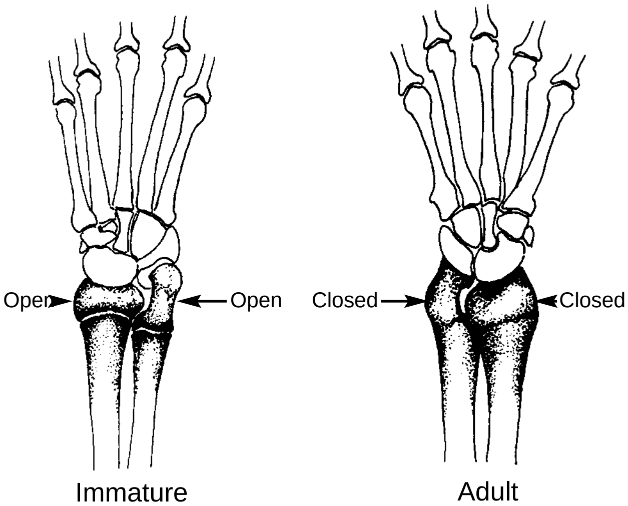

Fig. 22. Diagram of closure of epiphyses in raccoons (*Procyon lotor*) according to age (Sanderson 1961*a*).

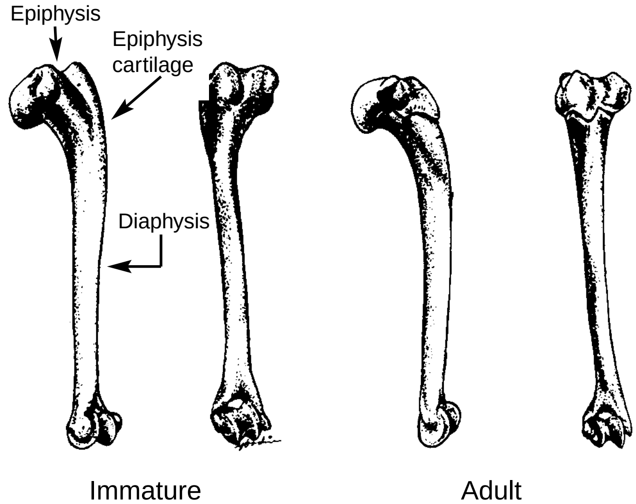

Fig. 24. Illustration of the epiphseal cartilage of the humerus in an immature and adult cottontail (*Sylvilagus* spp.) (Godin 1960).

prairie-chickens (*Tympanuchus cupido*) (Etter 1963), and northern bobwhite (Petrides and Nestler 1952).

Young mammals differ from adults in numerous ways such as body size, pelt appearance (Fig. 11), baculum shape (Fig. 15), closure of epiphyses (Fig. 22), ossification of sutures (Fig. 23), and the presence of epiphyseal cartilage (Fig. 24). There are also distinct patterns of tooth replacement that have been described for many species including white-tailed deer (Severinghaus 1949), mule deer (Rees et al. 1966), elk (Quimby and Gaab 1957), caribou (Bergerud 1970, Miller 1974*b*), muskox (*Ovibos moschatus*) (Tener 1965), bison (*Bison bison*) (Frison and Reher 1970), and pronghorn (Dow and Wright 1962) (Table 1).

Genetic Characteristics

Gender can be accurately ascertained from a variety of tissue samples using genetic techniques (Mittwoch 1963, Moore 1966, Schmid 1967, DeGraaf and Larson 1972, Amstrup et al. 1993, Oyler-McCance and Leberg 2004). These techniques may be especially important for species that are strongly monomorphic, in situations that require a noninvasive approach, and/or where only small amounts of tissue are available.

Gender can be ascertained with genetic material in a number of ways with new techniques being developed at a rapid pace (Oyler-McCance and Leberg 2004). Examination of general characteristics of the sex chromosomes (X and Y in mammals and W and Z in birds) was used in the past to evaluate gender in many species including whooping cranes (*Grus americana*) (Van Tuinen and Valentine 1987), white-tailed deer (Segelquist 1966, Crispens and Doutt 1970), and beaver (Larson and Knapp 1971). Techniques currently used are far superior in both their versatility and practicality. These newer techniques can test for the presence of specific genes (e.g., amelogenin) or gene sequences that are novel to a particular gender (Oyler-McCance and Leberg 2004). They can also be used on a variety of tissue samples including small amounts of blood (Hanaoka and Minaguchi 1996, Stacks and Witte 1996, Strom and Rechitsky 1998), teeth (Hanaoka and Minaguchi 1996, Murakami et al. 2000), dried tissue (Faerman et al. 1995, Lin et al. 1995), and fecal material (Reed et al. 1997, Yamauchi et al. 2000, Huber et al. 2002). Some of these techniques are successful with materials (such as teeth) stored at room temperature for more than 20 years (Hanaoka and Minaguchi 1996).

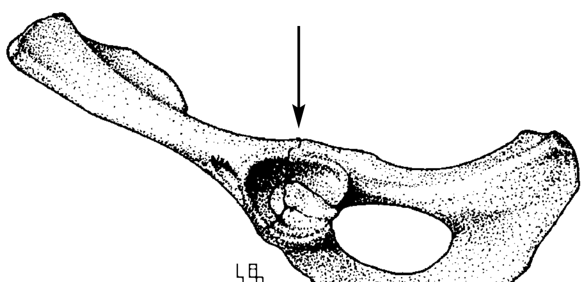

Fig. 23. Innominate bone of <1 year-old white-tailed deer. The arrow points at the area of incomplete ossification (Edwards et al. 1982).

GENDER AND AGE CHARACTERISTICS

Reptiles and Amphibians

The presence of the hemipenes and/or swollen base of the tail can be used to confirm a male lizard or snake (Gregory 1983). A pair of enlarged post-anal scales can be used to identify males in the genus *Sceloporous* (Fig. 25) and a

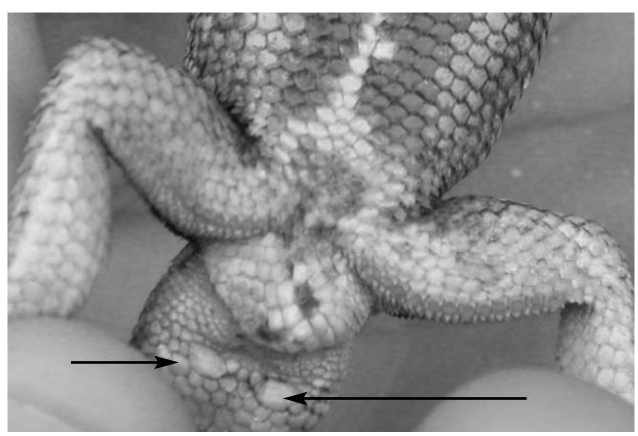

Fig. 25. Male sagebrush lizard (*Sceloporus graciosus*) illustrating the pair of enlarged post-anal scales that are characteristic of a male (photograph by S. S. Germaine).

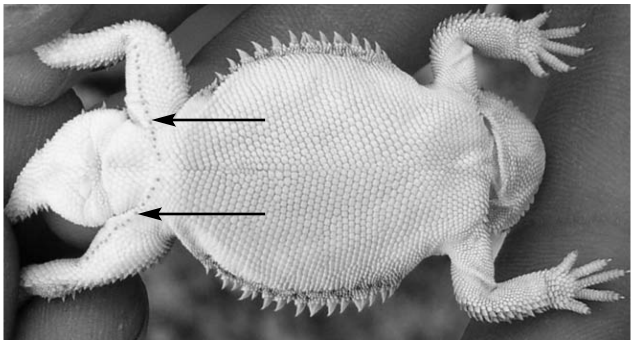

Fig. 26. Short-horned lizard (*Phrynosoma douglassii*) illustrating the femoral pores that extend down the inner thighs that are characteristic of a male (photograph by S. S. Germaine).

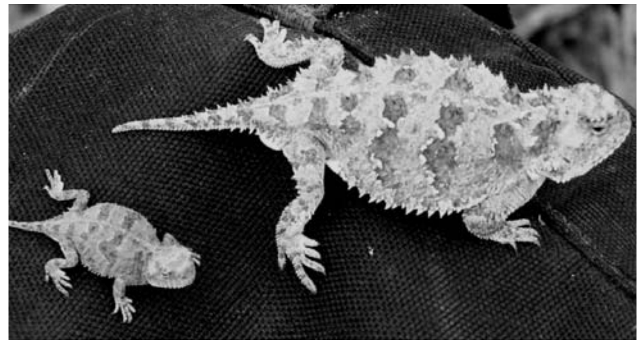

Fig. 27. Juvenile and adult short-horned lizards. Size is often a key characteristic in age classification of reptiles and amphibians (photograph by S. S. Germaine).

row of femoral pores on the ventral side of the thighs can be used to identify males in the genus *Phrynosoma* (Fig. 26). Breeding males of many lizard species can be identified by relatively bright coloration on the throat, armpits, belly, thighs, or tail (Stebbins 2003). The shape of the plastron and location of the vent can be used to ascertain gender in turtles. Gender in salamanders can be evaluated by the presence of the phallodeum and/or the appearance of the cloaca (Petranka 1998). Females also appear larger and plumper than males, and generally have shorter tails. Male frogs and toads generally are smaller than females, occasionally of different color, and have well-developed vocal sacs that appear as dark, loose skin along the throat when deflated. Breeding males also develop rough nuptial pads on the inner fingers of the forelimbs during the breeding season; the innermost digit may become enlarged (Fellers and Freel 1995). Male frogs and toads also chorus during the breeding season, while females generally are silent.

Young reptiles and amphibians are distinguishable from adults by size (Fig. 27) and or differences in their body appearance (Halliday and Verrel 1988). Neonate reptiles and terrestrial salamanders resemble adults in general body form, but are smaller and generally have relatively large eyes, head, and limbs (Stebbins 2003). The eggs of aquatic amphibians hatch into larvae bearing gills and tails, which are resorbed during metamorphosis into the juvenile stage, which is similar to adults but smaller (Powell et al. 1998). Some salamanders may be neotenous and attain sexual maturity while in the larval stage.

Growth in most reptile and amphibian species varies regionally, and can be influenced by temperature, food, water quality, population density, predation, and other environmental stressors (MaCartney et al. 1990, Rowe et al. 1992, Adolph and Porter 1996, Cogalniceanu and Miaud 2003). Turtles grow fastest during early years with sexual maturity correlated more with body size than age (Conant and Collins 1998, Stebbins 2003). Many freshwater turtles can live for over 50 years and some in the genus *Terrapene* may live considerably longer (Brown et al. 1995). In many lizard species, differences in size accurately represent distinct age classes until juveniles mature (Tinkle et al. 1993). Some lizards mature in the first year after hatch. In some species, size may continue to accurately indicate age after sexual maturation. In skinks, tails of young are often bright blue, but become duller or change color as they mature. Young snakes grow rapidly and often reach sexual maturity in 2–3 years. Skeletochronology or mark–recapture studies are reliable ways to assess age in reptiles and amphibians.

Birds

Variation in the molt patterns of birds, the material available for examination, and measurement techniques, have resulted in specific procedures for evaluating gender and age among species of birds. Timing of the observation (such as harvest) can be critical. It is easier to confirm a juvenile than an adult (lack of juvenile feathers may be a result of the timing of material collection rather than age). With few exceptions, there are no established techniques for reliably estimating age classes of older birds (≥2 years of age). Plumage characteristics (molt, plumage coloration, and feather wear and shape) of gallinaceous birds usually can be used to identify 3 classes (HY, SY, ASY) (Table 2). In swans and geese, gender is distinguishable

(continued on page 16)

Table 2. Age and gender characteristics for gallinaceous birds. The number of potential age classes is largely dependent on timing of examination relative to completion of prebasic molt. Primaries (P) are numbered from proximal to distal.

Species	Age	Gender
Spruce grouse	Chick age estimated by replacement and growth of primaries (McCourt and Keppie 1975, Quinn and Keppie 1981, Towers 1988). Bursa of Fabricius used (Ellison 1968), but rarely needed as a technique; pointed P9/P10 in HY/SY birds is reliable and easier (Zwickel and Martinsen 1967). P9 (McKinnon 1983) and P1 (Szuba et al. 1987) tend to have smaller shaft diameters in HY/SY birds.	Breast feathers solid black or black tipped with white in males and horizontally barred in females (Ellison 1968, Boag and Schroeder 1992). Rectrices mostly black in males or tipped with light brown and/or white depending on subspecies and age. Rectrices of females mottled black and brown and 1–2 cm shorter for given age category (Zwickel and Martinsen 1967, Boag and Schroeder 1992).

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Table 2. continued.

Species	Age	Gender
Ruffed grouse	Bursa of Fabricius length may be useful for ascertaining age, but not after January following hatch (Kalla 1991). HY birds tend to have pointed tips and less sheathing on P9/P10 than on P8, but this is less clear with aging (Hale et al. 1954, Dorney and Holzer 1957, Kalla 1991). HY/SY birds have a smaller P9 diameter or ratio of P9:P8 (Davis 1969, Rodgers 1979).	Males have longer "ruff" feathers on side of neck and 2–3 whitish dots on terminal ends of rump feathers while females have 1 whitish dot on terminal ends of rump feathers (Bump et al. 1947, Hale et al. 1954, Dorney 1966, Davis 1969, Roussel and Ouellet 1975). Starting at about 8 weeks of age, males can usually be distinguished from females by color of the bare patch above the eye; moderate to vivid reddish-orange in males and slight or no pigmentation in females (Palmer 1959). Males have distinct subterminal band on center 2 rectrices while females have indistinct subterminal band; female's tail is about 1 cm shorter for a given age category (Hale et al. 1954, Davis 1969, Rusch et al. 2000).
Blue grouse	Chick age estimated by replacement and growth of primaries (Zwickel and Lance 1966, Schladweiler et al. 1970, Redfield and Zwickel 1976, Zwickel 1992). P9 and P10 are pointed on HY/SY birds and rounded on ASY birds (Van Rossem 1925, Bendell 1955, Smith and Buss 1963, Braun 1971, Hoffman 1985).	Males have cervical apteria edged with white feathers and are 15–25% heavier than females (Caswell 1954, Boag 1965, Bunnell et al. 1977, Zwickel 1992). Males have primaries and rectrices 1–2 cm longer than females (Bendell 1955, Mussehl and Leik 1963, Boag 1965, Braun 1971, Hoffman 1983, Zwickel et al. 1991, Zwickel 1992). Rectrices of males mostly black or black with terminal band of gray, depending on subspecies. Sexual variation appears as early as 6 weeks (Nietfield and Zwickel 1983).
Sharp-tailed grouse (*Tympanuchus pedioecetes*)	P9 and P10 tend to be more pointed and worn in HY/SY than ASY birds (Hillman and Jackson 1973).	Male crown feathers are dark with buff-colored edge while female crown feathers are barred (Henderson et al. 1967, Connelly et al. 1998). Central 2 rectrices of male are longitudinally striped and comparable feathers in female are horizontally barred (Henderson et al. 1967).
Lesser (*T. phasianellus*) and greater prairie-chicken	Chick age estimated by replacement and growth of primaries (Etter 1963), and from descriptive photographs (Baker 1953). P9 and P10 in HY/SY birds tend to be more pointed and worn, and have more spotting on their anterior portions (Campbell 1972).	Male undertail coverts are solid with a terminal round spot; crown feathers are dark with a buff-colored edge. Female undertail coverts and crown feathers are barred (Copelin 1963, Henderson et al. 1967, Schroeder and Robb 1993, Giesen 1998). Tails of males are solid or lightly barred while those of females are entirely or partially barred (Copelin 1963).
Gunnison (*Centrocercus minimus*) and greater sage-grouse	Chick age estimated based on replacement and growth of primaries (Pyrah 1963). The pointedness of P9 and P10 in juveniles is distinct; examination of the bursa of Fabricius (Eng 1955) provides little addition information. Primaries tend to be longer in ASY than in HY/SY birds, especially P1 which can differ by about 1.5 cm (Crunden 1963, Schroeder et al. 1999).	Males have black chin, white breast, filoplumes, and white tipped undertail coverts. Females have mottled grayish brown breast and undertail coverts, and are 35–50% smaller for a given age category (Dalke et al. 1963, Schroeder et al.1999). Male primaries are 1.5–3.5 cm longer and rectrices are 7–10 cm longer for a given age category than for females (Crunden 1963, Schroeder et al. 1999).
White-tailed ptarmigan	Chick age estimated by replacement and growth of primaries (Giesen and Braun 1979). HY/SY birds have dusky brown flecking on P9/P10; this pigmentation is absent in ASY birds (Braun et al. 1993).	Male has prominent eye combs during the breeding season; upper breast, neck, and head feathers are buff and tipped with blackish gray to dark brown. Female breast feathers are coarsely barred. Gender difficult to distinguish from plumage during autumn and winter (Braun and Rogers 1967, Braun et al. 1993).
Rock ptarmigan (*Lagopus mutus*)	HY/SY birds have more dark pigmentation and less gloss on P9 than on P8; pigmentation tends to be equal or greater on P8 and gloss tends to be equal on ASY birds (Weeden and Watson 1967).	Male has distinct red eye combs and blackish brown breast during breeding season; female has mostly brown breast. Gender difficult to distinguish from plumage during autumn and winter (Holder and Montgomerie 1993).

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Table 2. continued.

Species	Age	Gender
Willow ptarmigan (*L. lagopus*)	Chick age estimated by replacement and growth of primaries (Bergerud et al. 1963, Parr 1975). HY/SY birds have more dark pigmentation and less gloss on P9 than on P8; in ASY birds pigmentation tends to be equal or greater on P8 and gloss tends to be equal (Bergerud et al. 1963, Weeden and Watson 1967).	Feathers on the neck and breast of male are distinctly rufous to chestnut and eye combs are red during the breeding season. Gender difficult to distinguish during autumn and winter (Hannon et al. 1998). Male has long, black rectrices and black central upper tail coverts. Female has shorter and dark brown rectrices and central upper tail coverts (Bergerud et al. 1963).
Wild turkey	In HY/SY birds the central 3 pairs of rectrices are longer than the outer rectrices, P9/P10 tend to be pointed with no bars in distal portions, and the upper secondary covert patch is narrower and duller (Petrides 1942, Williams 1961, Williams and Austin 1970). Spur and beard length increase with age (Kelly 1975), but overlap is large (Steffen et al. 1990). Tarsometatarsus length used with about 75% accuracy (Wakeling et al. 1997).	Skin on side of neck bare and pink-reddish in male; beard present in older males. Skin on side of neck lightly feathered and grayish-blue in female; shorter beards are occasionally present (Edminster 1954). Tarsometatarsus measurements larger in males and have been used to predict gender with about 96% accuracy (Wakeling et al. 1997). Primaries and rectrices longer in males than females for a given age category (Wallin 1982).
Montezuma quail (*Cyrtonyx montezumae*)	Greater upper primary coverts edged with buff or buffy bars near base in HY birds, or spotted or barred with white in AHY birds (Johnsgard 1973).	Face and throat of male marked with bold black and white pattern; face and throat of female mottled with brown, buff, and white (Leopold 1959).
Northern bobwhite	Chick age estimated based on growth of primaries (Petrides and Nestler 1952). Upper greater primary coverts buffy and tapered in HY birds, and gray-brown and rounded in AHY birds. P9/P10 pointed and dull brown in HY/SY birds, and rounded and grayish in ASY birds (Stoddard 1931, Dimmick 1992).	Male has white chin and eyestripe, except masked bobwhite that is mostly rufous with black head; female has buffy chin and eyestripe (Dimmick 1992). Base of lower mandible black in males and yellow in females. Middle wing coverts have fine, black, sharply pointed undulations in males whereas those in females are wide and dull gray (Thomas 1969, Brennan 1999).
Scaled quail (*Callipepla squamata*)	Primary coverts tipped, edged, or mottled with white in HY/SY birds and uniformly gray in ASY birds (Wallmo 1956).	Side of male's face is uniform gray with a brownish ear patch. Side of female's face is dirty gray streaked with black (Wallmo 1956).
Gambel's and California quail (*C. gambelii*, *C. californica*)	Greater upper primary coverts are mostly buff-tipped and pointed in HY birds, and uniformly gray and rounded in AHY birds. P9/P10 also more pointed and frayed in HY/SY birds (Calkins et al. 1999).	Male has black throat and crest; female has pale or buffy throat and small, brown crest (Calkins et al. 1999).
Mountain quail (*Oreortyx pictus*)	HY birds have buff-tipped primary coverts and AHY birds have uniform gray coverts. HY/SY birds also have pointed/frayed P9/P10 (Gutiérrez and Delehanty 1999).	Back of neck is gray and plume generally long and black in males. Back of neck is brown and plume shorter and browner in females (Johnsgard 1975, Brennan and Block 1985, Gutiérrez and Delehanty 1999).
Ring-necked pheasant (*Phasianus colchicus*)	Length of P10 may be useful for estimating age of chicks (Etter et al. 1970). Depth of bursa of Fabricius ≤8 or ≤6 mm for AHY males and females, respectively (Johnsgard 1975, Larson and Taber 1980). P1 of ASY birds tend to be longer and thicker than HY/SY birds (Wishart 1969, Greenberg et al. 1972). Spur length and eye-lens weight have not been useful (Stokes 1957, Dahlgren et al. 1965, Gates 1966, Koubek 1993).	Males large and brightly colored throughout with distinct leg spur and longer tail; females mottled brown with no spur and shorter tail (Oats et al. 1985, Rodgers 1985). Day-old males distinguishable from females due to an infantile wattle just below eye (Woehler and Gates 1970). Field-dressed males distinct due to their larger sternum (Oates et al. 1985). Bars on male primaries meet rachi at sharp angles except on unbarred tips. Bars on female primaries meet rachi at right angles (Linder et al. 1971).

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Table 2. continued.

Species	Age	Gender
Chukar	Growth of juveniles described and illustrated in detail (Alkon 1982, Fig. 5). Primary covert 9 <29 mm in HY and ≥29 mm in AHY birds. P9/P10 pointed in HY/SY and rounded in ASY birds (Weaver and Haskell 1968).	Primary measurements generally greater for males than females (Weaver and Haskell 1968, Cramp and Simmons 1980), but gender difficult to distinguish (Christensen 1996).
Gray partridge (*Perdix perdix*)	P9 covert pointed in HY and rounded in AHY birds. P9/P10 pointed in HY/SY and rounded in ASY birds (Petrides 1942).	Throat and eye stripe buffy-orange for males and buffy for females. Scapulars and median wing coverts lack crossbars in males and have 2–4 crossbars in females (Carroll 1993).

(from page 13)
with cloacal examination (Hanson 1962). General patterns of plumage in swans and geese usually can be used for age only (Table 3). Wing characteristics of ducks are particularly important, because wings from many species are collected simultaneously during the harvest; most provide an adequate indication of species (Carney 1992), gender, and age (Table 4). There also is substantial information on classification of gender and age in many other species including shorebirds, pigeons and doves, cranes, rails, and raptors (Table 5). In addition to numerous field guides of birds (e.g., Peterson 1998, 2002; Sibley 2000), there are detailed guides for identifying the gender, age, and subspecies of birds (Pyle et al. 1987, Pyle 1997). Pyle (1997) provides particularly useful information for evaluating birds in the hand. Additionally, each species in North America has been extensively reviewed in individual species accounts produced by the American Ornithologists' Union, 716 accounts in total (Poole and Gill, 1992–2003).

Mammals

Many species of mammals are outwardly monomorphic. Consequently, examination of genitals, patterns of dentition, and cementum annuli in teeth may be essential for classification of gender and age. Such procedures usually require collection or capture of the animal and/or collection of tissue samples. Because field guides (e.g., Hall 1981) are necessarily general in nature, species accounts for individual mammal species produced by the American Society of Mammalogists (first account produced in 1969) may be an essential resource for detailed information (e.g., dentition). These accounts are particularly useful for species receiving little research and management attention. Despite the difficulty of capture and/or collection, current techniques for estimating age of mammals, particularly older mammals, are more effective than comparable techniques for estimating age in birds (Table 6).

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Table 3. Age characteristics for swans and geese (abbreviated and summarized from Bellrose 1980 and other references noted below). Birds are classified as HY (before completion of the prebasic molt) and AHY (after completion of the prebasic molt). All HY swans and geese may have tail notched feathers early in hunting season. Plumage is similar in both genders for all species, with small differences in measurements. Only the male AHY mute swan (*Cygnus olor*) has a fleshy knob on its forehead.

Species	Age
Swans	HY birds usually dull with light gray patches whereas AHY birds are solid white.
Greater white-fronted goose (*Anser albifrons*)	HY birds have grayish body plumage, yellow legs and bill, and lack a white face patch. AHY birds have white face patch, orange legs, and pink bill (Ely and Dzubin 1994).
Snow goose (*Chen caerulescens*)	HY blue phase birds may have brownish-gray patches on head, body, legs, and bills. AHY blue phase birds have slate gray body plumage with white head. HY white phase birds may have patches of sooty gray on otherwise white plumage and grayish brown legs and bill. AHY white phase birds white with black wing tips, red legs, and a pink bill (Mowbray et al. 2000).
Ross' goose (*C. rossii*)	HY birds may have patches of pale gray on otherwise white plumage and AHY birds are white with black wing tips (Ryder and Alisauskas 1995).
Emperor goose (*C. canagica*)	HY birds may have patches of black-brown on head and neck; their legs and bill are black. AHY birds have a white head and upper neck, yellow legs, and a pink bill (Petersen et al. 1994).
Canada goose (*Branta canadensis*)	Tail feathers may be notched, breast feathers relatively narrow, and outer primaries more pointed in HY than AHY birds (Caithamer et al. 1993, Mowbray et al. 2002).
Brant (*B. bernicla*)	HY birds (Atlantic subspecies) have no white on necks until mid-winter; greater and middle wing coverts may be tipped with white. AHY birds have a white crescent on side of neck and the greater and middle coverts are dark brown. HY birds of the "black form" may have dark plumage with white undertail coverts and light gray edging of wing coverts. AHY birds have barred gray and white flanks with dark wing coverts (Reed et al. 1998).

Table 4. Age and gender characteristics of duck wings collected during the autumn hunting season (information abbreviated and summarized from Carney 1992). The number of potential age classes is largely dependent on timing of harvest in relation to completion of the prebasic molt. Other than common (*Somateria mollissima*) and king eider (*S. spectabilis*) with 3 age classes in males (HY, SY, ASY), only 2 age classes are identifiable for most species (HY, AHY). Primaries (P) are numbered from proximal to distal.

Species	Age	Gender
Mallard (*Anas platyrhynchos*)	Tertials frayed or faded, middle coverts narrow and trapezoidal, and inner edge of outer primary coverts relatively light in HY birds; tertials not frayed, middle coverts rounded, and inner edge of outer primary coverts lightly edged or not edged in AHY birds.	White bar on leading edge of speculum extends onto tertials in females, but not males. Males more likely to have vermiculated scapulars.
Am. black duck (*A. rubripes*)	Tertials frayed or faded, middle coverts anterior to tertials more trapezoidal in shape, and inner edge of outer primary coverts relatively light in HY birds; tertials not frayed, middle coverts rounded, and inner edge of outer primary coverts not edged in AHY birds.	Tertials of HY males >88 mm from tip of longest tertial covert and wing notch-length >273 mm; measurements smaller for AHY females. AHY separation is with tertial-tertial covert measurement of 90 mm and wing notch-length of 281 mm.
Mottled duck (*A. fulvigula*)	Tertials frayed or faded if any HY feathers present; tertials not frayed, middle coverts rounded, and inner edge of outer primary coverts lightly edged or not edged in AHY birds.	Birds with ≥3 non-iridescent secondaries likely female and iridescence on all secondaries likely male. Wing notch-length usually ≥251 mm for HY males and ≥255 mm for AHY males; length usually shorter for females.
Am. wigeon (*A. americana*)	Tertials and tertial coverts small and brownish in HY birds. Teritals have black outerwebs in AHY males and sharp white edging in AHY females.	HY males have mottled upperwing patch of mostly white, while HY female may have little white. AHY males have large white upperwing patch whereas patch is small and/or less distinct in AHY females.
Gadwall (*A. strepera*)	Tertials and tertial coverts may be pointed, frayed, and faded in HY birds; same feathers rounded and not frayed or faded in AHY birds.	Coverts mostly either black or cinnamon in AHY males; black and cinnamon restricted to ≤4 rows of coverts in females. Black or cinnamon occurs in ≥3 rows of coverts in HY males; females have little cinnamon in 2 rows. Wing notch-length usually ≥262 mm for AHY males, ≥255 mm for HY males; shorter in females.
Green-winged teal (*A. crecca*)	HY tertials small, narrow, and frayed; AHY tertials rounded and not frayed.	Vermiculated scapulars only occur on males. The outer black or dark brown strip on the most distal tertial sharply divided from the remaining portion of the feather in males and blended somewhat on females. Wing notch-length ≥183 mm characterizes males and ≤175 mm females.
Blue-winged and cinnamon teal (*A. discors,* A. *cyanoptera*)	Tertials and tertial coverts may be pointed, frayed, or faded in HY birds; same feathers rounded and not frayed or faded in AHY birds (see also Hohman et al. 1995).	Green on speculum iridescent in males and rarely iridescent in females. Greater secondary coverts mostly white in males and heavily spotted with dark brown in females.
Northern shoveler (*A. clypeata*)	Tertials and tertial coverts may be pointed, frayed, or faded, often with light edging in HY birds; same feathers rounded and not frayed or faded in AHY birds (Hohman et al. 1995).	All males and a few females have iridescent green speculum. Females typically have cream edging on lesser and middle coverts.
Northern pintail (*A. acuta*)	Tertials coverts may be pointed, frayed, or faded, often with light edging in HY birds; these feathers rounded and not frayed or faded in AHY birds (see also Esler and Grand 1994).	Speculum at least partly iridescent green in males; when green is occasionally present in females, it is not iridescent.
Wood duck (*Aix sponsa*)	HY tertials pale bronze with pointed, frayed tips and tertial coverts narrow, yellow-green; same feathers in AHY birds dark blue (male) or purplish red (female) and not frayed (Harvey et al. 1989).	White trailing edge of the secondaries is wider on the outer webs for females and approximately equal for males.

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Table 4. continued.

Species	Age	Gender
Harlequin duck (*Histrionicus histrionicus*)	HY tertials, greater coverts, middle coverts, and lesser coverts dark brown and often frayed at their tips; colors vary in AHY birds depending on gender and feather type, but feathers not frayed.	Males have 3 distal tertials with white on outer webs and secondaries have dark iridescent blue.
Steller's eider (*Polysticta stelleri*)	HY tertials slightly curved, tertials and tertial coverts dark brown, frayed; faded, and secondaries with 0.5 cm white band on trailing edge. AHY birds have strongly curved tertials and 1 cm white band on trailing edge of secondaries.	Greater secondary coverts completely white on AHY males and brown with 1 cm wide tip on AHY females.
Redhead (*Aythya americana*)	HY tertials and tertial coverts narrow and frayed; same feathers rounded and not frayed in AHY birds (Sayler 1995).	Vermiculation on tertials, greater tertial coverts, and middle and lesser coverts only present on male.
Canvasback (*A. valisineria*)	HY tertials and coverts narrow and frayed, middle and lesser secondary coverts have trapezoidal shape; same feathers rounded and not frayed in AHY birds.	Heavy vermiculation on tertials, greater tertial coverts, and middle and lesser secondary coverts of males.
Greater and lesser scaup (*A. marila, A. affinis*)	HY tertials and coverts pointed, frayed, and faded; same feathers rounded and not frayed or faded in AHY birds.	AHY males have scapulars, and middle and lesser coverts heavily vermiculated and tertials flecked with white near the tips. HY males have white flecking on middle coverts recessed 0.3 cm from edge. AHY females have flecking near edge of covert; flecking mostly absent from HY females.
Ring-necked duck (*A. collaris*)	HY tertials, tertial coverts, and middle and lesser coverts narrow and frayed; same feathers in AHY birds rounded and not frayed.	Wing notch-length usually >193 mm for AHY males and >189 mm for HY males; length usually shorter for females, but with overlap in 185–195 mm range, depending on age. AHY males have slightly shinier tertials than AHY females and occasional flecking on underwing.
Common goldeneye (*Bucephala clangula*)	Coverts of HY birds are a mixture of white, black, and gray-white, and often frayed; coverts of AHY birds solid white or terminally banded with black, and not frayed.	Wing notch-length separation point for males vs. females 218 mm for AHY and 210 mm for HY birds (males longer). AHY females have black band on tips of greater secondary coverts whereas coverts are solid white in AHY males.
Barrow's goldeneye (*B. islandica*)	Coverts of HY birds are a mixture of white, black, and gray-white, and often frayed; coverts of AHY birds solid white or terminally banded with black, and not frayed.	Wing notch-length separation point for males vs. females 222 mm for AHY birds and 217 mm for HY birds (males longer). AHY females have black band on tips of greater secondary coverts whereas coverts are distally white with occasional black tips for AHY males.
Bufflehead (*B. albeola*)	Tertials and greater coverts often frayed and pointed in HY birds; same feathers rounded and not frayed in AHY birds.	AHY males have entirely white greater, middle, and lesser coverts; same feathers dark brown or black in other age and gender categories. HY males usually have wing notch-length >160 mm; length shorter in HY females.
Hooded merganser (*Lophodytes cucullatus*)	Tertials and middle and greater coverts often frayed, faded, and pointed in HY birds; same feathers rounded and not frayed or faded in AHY birds.	AHY males have longitudinal white stripes on tertials and light gray middle and lesser coverts; white stripes absent in AHY females and middle and lesser coverts are dark brown. HY birds difficult to differentiate until AHY feathers appear.
Red-breasted merganser (*Mergus serrator*)	Greater tertial coverts dark gray-black, pointed, and frayed in HY birds; same feathers not frayed, rounded, and white in AHY males or shiny black in AHY females.	Distal tertials in AHY males mostly white with black margin on outer web; greater tertial coverts and middle and lesser secondary coverts mostly white. HY birds difficult to differentiate until AHY feathers appear.

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Table 4. continued.

Species	Age	Gender
Common merganser (*M. merganser*)	Tertials and coverts dark gray with pointed and frayed tips in HY birds; same feathers rounded and not frayed in AHY birds.	Distal tertials in AHY males mostly white with black margin on outer web and greater tertial coverts; middle and lesser secondary coverts mostly white. Wing notch-length separation point 260 mm for AHY males vs. females and 254 mm for HY males vs. females (males longer).
Long-tailed duck (*Clangula hyemalis*)	Tertials and coverts dark gray-brown, frayed, and faded at tips in HY birds; same feathers not frayed or faded in AHY birds and black (males) or dark brown with traces of tan (females).	AHY male tertials, tertial coverts, greater secondary coverts, and middle and lesser coverts black; same feathers in AHY females dark brown with some tan on the tips. HY birds difficult to differentiate until AHY feathers appear.
Black scoter (*Melanitta nigra*)	Tertials and coverts dark brown, pointed, frayed, and faded in HY birds; same feathers rounded, not frayed or faded, and shiny black (males) or dark brown (females) in AHY birds.	AHY males have P10 deeply attenuated for 55–60 mm from the tip and coverts usually shiny black; P10 not attenuated in other age and gender categories. HY birds difficult to differentiate until AHY feathers appear.
Surf scoter (*M. perspicillata*)	Tertials and coverts dark brown, pointed, frayed, and faded in HY birds; same feathers rounded, not frayed or faded, and shiny black (males) or blackish brown (females) in AHY birds.	Outer webs of primaries black and tertials and coverts are shiny black in AHY males and dark blackish brown in other categories. HY birds difficult to differentiate until AHY feathers appear.
White-winged scoter (*M. fusca*)	Tertials and coverts dark brown, faded and frayed at tips in HY birds; same feathers rounded, not frayed or faded, and shiny black (males) or dark brown (females) in AHY birds.	Overall wing is black in AHY males and dark brown in females; black-white interface has a "saw-toothed" appearance in males. HY birds difficult to differentiate until AHY feathers appear.
Common eider	Tertials and coverts faded and frayed in HY birds; same feathers not faded and frayed in AHY birds. SY males distinguishable from ASY and HY males by presence of white mottled tertials and coverts.	HY birds difficult to differentiate until AHY feathers appear (usually white). SY and ASY males distinguishable from females by presence of substantial white on tertials and coverts.
King eider	Tertials and coverts faded and frayed at tips in HY birds; same feathers not faded or frayed in AHY birds. SY males distinguishable from ASY and HY males by presence of mottled white on middle and lesser coverts.	HY birds difficult to differentiate. SY and ASY males distinguishable from females by presence of white on middle and lesser coverts, and blacker coloration of wing.
Ruddy duck (*Oxyura jamaicensis*)	Tertials, tertial coverts, and middle coverts somewhat frayed and slightly trapezoidal in HY birds; same feathers rounded and not frayed in AHY birds.	Gender not distinguishable from wings.
Fulvous whistling duck (*Dendrocygna bicolor*)	Tertials, greater coverts, and lesser coverts somewhat frayed and faded at tips in HY birds; same feathers not frayed or faded in AHY birds.	Gender not distinguishable from wings.
Black-bellied whistling duck (*D. autumnalis*)	Greater coverts slightly mottled near pointed tips in HY birds and entirely white with rounded tips in AHY birds.	Gender not distinguishable from wings.

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SUMMARY

Effective wildlife research and management depends on accurate assessment of gender and age in amphibians, reptiles, birds, and mammals. These assessments often can be conducted using long-established techniques that are relatively simple to perform including visual examinations of general appearance and/or sex organs. Information also can be gathered through examinations of dentition and/or partial samples such as wings or teeth. Although some species may appear monomorphic, the vast majority readily can be classified to gender and basic age categories. However, newer techniques are constantly being developed and evaluated because there often is a need to obtain better estimates of age or to make assessments using limited material, These techniques include improved cementum annuli analysis, skeletochronol-
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Table 5. Age and gender characteristics for miscellaneous species of birds. The number of potential age classes is largely dependent on timing of examination in relation to completion of the prebasic molt. Primaries (P) are numbered from proximal to distal and secondaries (S) from distal to proximal.

Species	Age	Gender
American woodcock (*Scolopax minor*)	Depending on time of year, 3 age classes can be recognized (because of retention of juvenal secondaries during second year, (Sheldon et al. 1958, Martin 1964). Juvenal secondaries have light tips and distinct dark subterminal bars; adult secondaries lack a distinct bar (Petrides 1950*a*, Martin 1964, Roberts 1988). Coloration of neck, foot, and bill also useful (Shissler et al. 1981).	Females heavier than males with overlap in the 160–190 g range (Owen et al. 1977). Bill length >72 mm, combined width of outer 3 primaries ≥12.6 mm, and wing chord (to tip of P 6 or P 7) ≥134 mm characterizes female. Measurements <64 mm, ≤12.4 mm, and ≤133 mm, respectively, characterize males (Artmann and Schroeder 1976, Keppie and Whiting 1994). The combination of characteristics minimizes overlap.
Wilson's snipe (*Gallinago gallinago*)	Juveniles may have a faint black tip on some lesser and median secondary coverts; adults have wide dark terminal shaft line (Dwyer and Dobell 1979). Multivariate analysis with feathers useful, but 20% overlap (McCloskey and Thompson 2000).	Not easily distinguishable by plumage or cloacal characteristics (Fogarty et al. 1977, U.S. Department of Interior and Canadian Wildlife Service 1977). Females have shorter outer rectrices and longer bills than males (Mueller 1999); 10% unclassifiable with multivariate analysis of skeletal and feather measurements (McCloskey and Thompson 2000).
White-winged dove (*Zenaida asiatica*)	Primary coverts of juveniles have pale tips and primaries may be edged with white or buff (Cottam and Trefethen 1968); juveniles lack black cheek-patch of adults (Schwertner et al. 2002).	Males larger than females with brighter plumage on crown, nape, and hind neck (Cottam and Trefethen 1968)
Mourning dove	Juveniles have white or buffy tipped primary coverts, or buffy edge on P9/P10 (Petrides 1950*a*, Swank 1955, Wight et al. 1967, Haas and Amend 1976, Cannell 1984). Long breeding season can complicate age classification (Schultz et al. 1995).	Females have tan breast and throat with a brown or brownish-gray crown; males blue or blue-gray with a slightly pink crown (Petrides 1950*a*, Cannell 1984, Mirarchi and Baskett 1994). Accuracy not perfect (Menasco and Perry 1978, Schultz et al. 1995).
Band-tailed pigeon (*Patagioenas fasciata*)	Juvenile growth has been described in detail (White and Braun 1990. Juveniles have buffy edged primaries, worn outer tips of P9/P10, and no wear on tips of S6 and S7. They retain secondary coverts up to 340 days of age (Silovsky et al. 1968, White and Braun 1978).	Breast and crown dull brown-gray in females and purplish to vinaceous in males (White and Braun 1978, Keppie and Braun 2000). This technique is useful as early as 45 days post hatch.
Sandhill crane (*Grus canadensis*)	Juvenal plumage brownish; the same plumage of adults grayish (Walkinshaw 1949). Rusty staining can make separation difficult. Forehead of juveniles may be tawny; adults may be pale gray with a red crown (Lewis 1979).	Plumage differences insignificant; males usually heavier than females (Tacha et al. 1992). Cloacal examination only 66% accurate (Tacha and Lewis 1978).
Whooping crane	Juveniles have brownish patches or buff-tipped feathers; adults are white with black wing tips and a red crown (Lewis 1995).	Gender not distinguishable based on plumage (Walkinshaw 1973), but males tend to be heavier (Lewis 1995).
Rails	Presence of bursa of Fabricius used to classify age of clapper rails (*Rallus longirostris*) (Adams and Quay 1958); juveniles also have paler bill (Eddleman and Conway 1998). The black throat patch of adult soras (*Porzana carolina*) absent in immatures (Melvin and Gibbs 1996). Juvenile black rails (*Laterallus jamaicensis*) slightly duller in plumage than adults (Eddleman et al. 1994).	Male clapper rail brighter on sides and base of bill (Eddleman and Conway 1998), male sora has lighter-colored bill (Melvin and Gibbs 1996), male king rail (*R. elegans*) slightly brighter in coloration (Odom 1977), male black rail has darker throat (Eddleman et al. 1994), and male yellow rail (*Coturnicops noveboracensis*) has distinct yellow bill during the breeding season (Bookhout 1995). Males generally heavier than females, although differences can be small.

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Table 5. continued.

Species	Age	Gender
Purple gallinule (*Porphyrula marinica*) and common moorhen (*Gallinula chloropus*)	Juveniles brownish or grayish with white feathers in throat region; bills and/or frontal shields lack red and yellow of adults (Bannor and Kiviat 2002, West and Hess 2002). Evidence of juvenile age class may persist until spring (Holliman 1977).	Gender not distinguishable based on plumage, but males slightly heavier than females in purple gallinule (West and Hess 2002) and up to 100 g heavier in common moorhen (Bannor and Kiviat 2002).
American coot (*Fulica americana*)	Juveniles paler than adults with lighter tipped feathers (Brisbin and Mowbray (2002).	Females smaller than males but overlap large (Fredrickson 1968, Eddleman and Knopf 1985).
Raptors	Most raptors have distinct juvenal plumage that is only slightly worn in first autumn (Dunne 1987). Eye color changes with age in accipiters from yellow (juveniles) to red, orange, or brown (adults) (Dunne 1987). Bald eagles (*Haliaeetus leucocephalus*) can be differentiated into multiple age categories based on increasing whiteness of the tail and head (McCollough 1989).	Wing chord often larger for females than males (U.S. Department of the Interior and Canadian Wildlife Service 1977, Dunne 1987, Pyle 1997). Some raptors clearly dimorphic in appearance; male northern harrier (*Circus cyaneus*) is gray while the female is brown (MacWhirter and Bildstein 1996), and the male American kestrel (*Falco sparverius*) has blue-gray wings while the female's are rusty (Smallwood and Bird 2002). Bald eagles do not differ in plumage coloration (Bortolotti 1984), but females tend to be larger (Buehler 2000).

Table 6. Age and gender characteristics for selected mammals. Appearance of external genitalia is sufficient for classification of gender for most species and, in the case of large ungulates, from a distance.

Species	Age	Gender
White-tailed deer	Fawns spotted in summer and smaller with relatively short nose in winter with innominate bone incompletely ossified (Edwards et al. 1982, Fig. 23). Tooth eruption and wear (Severinghaus 1949, Fig. 19) used to estimate age, but results mixed for older deer (Gilbert and Stolt 1970, DeYoung 1989, Jacobson and Reiner 1989, Gee et al. 2002). Examination of tooth replacement and wear should be used for 3 age classes (fawn, yearling, and adult) (Gee et al. 2002), unless reduced accuracy is acceptable. Cementum annuli analysis effective for older animals (Gilbert 1966, Ransom 1966, Lockard 1972, McCullough and Beier 1986).	With rare exceptions, only males have antlers. First year antlers usually small and referred to as "buttons." Presence of tuberosities on the pelvic girdle distinguishes adult males (≥2-1/2 years-of-age) from females (Taber 1956, Fig. 16). Specific differences in the ilio-pectineal eminence of the pelvic girdle can be used to identify gender in animals about 1-1/2 years old (Edwards et al. 1982, Fig. 17).
Mule and black-tailed deer	Fawns spotted in summer and smaller with a relatively short nose in winter. A general analysis of morphology is complicated by habitat type and/or region (Strickland and Demarais 2000). Pattern of tooth eruption used to estimate age of fawns and yearlings (Rees et al. 1966). For deer >2 years old, tooth-wear, eye-lens weight, and molar tooth-ratio techniques are imprecise (Robinette et al. 1957, Connolly et al. 1969*a*, Erickson et al. 1970, Van Deelen et al. 2000). Counts of cementum annuli from incisors accurate for older ages (Low and Cowan 1963; Thomas and Bandy 1973, 1975; Hamlin et al. 2000).	With rare exceptions, only males have antlers. Tracks of adult and larger yearling males distinguishable from females by their larger arc width (McCullough 1965). Presence of tuberosities on pelvic girdle distinguishes adult males (≥2-1/2 years-of-age) from females (Taber 1956, Fig. 16).

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Table 6. continued.

Species	Age	Gender
Elk	Head profile and presence/shape of antlers used to identify calves, yearlings, and adults (≥2 years old) (Taber et al. 1982, Smith and McDonald 2002, Fig. 10). Head profile quantifiable with significant variation in rostral length, interorbital width, and ear length for female age classes; yearlings larger than calves and adults larger than yearlings (Smith and McDonald 2002). Yearling males lack brow tines on antlers whereas antlers of adult males have brow tines and are branched (Taber et al. 1982). Pattern of tooth eruption used to estimate age through about 3 years (Quimby and Gaab 1957, Peek 1982); accurate estimation of older animals with cementum annuli analysis (Keiss 1969, Hamlin et al. 2000).	Only males have antlers and upper canines (Greer and Yeager 1967). Antler scars may also be visible following antler drop.
Moose	Calves identifiable by size. Tooth wear considered for aging (Passmore et al. 1955), but cementum annuli analysis of incisors or molars valid indication of year class (Sergeant and Pimlott 1959, Wolfe 1969, Gasaway et al. 1978, Haagenrud 1978).	Only males have antlers and only females have a white vulval patch (Roussel 1975). Differences in gender detectable with dimensions of fecal pellets (MacCracken and Van Ballenberghe 1987).
Caribou	Calves identifiable by small size and relatively short head profile (Bergerud 1978). Antlers usually larger for adults than yearlings. Tooth eruption pattern useful to classify age to about 2 years (Bergerud 1970; Miller 1974*a*,*b*; 1982). Cementum annuli analysis best technique for older animals (McEwan 1963, Bergerud and Russell 1966).	Antlers of males larger than those of females (Miller 1982). Presence of dark vulval patch in females most consistent characteristic (Bergerud 1978). Mandible lengths larger for males than females for a given age category (Bergerud 1964, Miller and McClure 1973).
Muskox	Calves are small, yearling males small with straight horn projections of ~ 100 mm, yearling females small with horns ~ 66 mm, and adults larger. Tooth emergence useful for animals to 6 years old; cementum annuli analysis more accurate for older animals. Basal depressions of horns in 4-year-old females maximally developed; bulls maximally developed by year 6 when horns completely cover their forehead (Tener 1965).	Horns of yearlings longer in males than in females (100 vs. 66 mm). In 2-year-olds, horns of males tend to be whiter and project straighter from the head (Tener 1965).
Bison	Cranial fusion used for 2 age classes (Shackleton et al. 1975, Duffield 1973), horn development used for 4 female and 5 male age classes (Fuller 1959, Reynolds et al. 1982), and tooth replacement and wear used for 5–7 age classes (Skinner and Kaisen 1947, Fuller 1959, Frison and Reher 1970). Cementum annuli analysis most reliable for estimating older age classes (Novakowski 1965, Moffitt 1998).	Horns of females more slender and inwardly curved than those of males (Reynolds et al. 1982). Numerous differences in horn cores, burrs, and skeletal measurements (Skinner and Kaisen 1947, Duffield 1973).
Wild sheep	Lambs distinguishable by small size. Because horn size increases with age, yearling rams can be classified based on size of curl (Jones et al. 1954). Horns segments used for older age classes (Geist 1966). Tooth eruption and replacement used to estimate age to 4 years (Hemming 1969, Lawson and Johnson 1982). Cementum annuli analysis reliable for older ages (Turner 1977).	Gender difficult to evaluate for lambs, but males of other age class have larger horns (Lawson and Johnson 1982). Yearling rams difficult to differentiate from adult ewes unless scrotum is detected.
Mountain goat	Kids distinguishable by size of body and horns (<1/2 ear length in autumn), yearlings have horns about ear length, and adults have longer horns. Replacement of teeth used to estimate ages through ~ 3 and rings on the horn used for all ages (Brandborg 1955, Fig. 13). Cementum annuli analysis presumably would work, but success of horn rings usually makes it unnecessary.	Males stand or stretch while urinating and females squat. Yearling males may have visible scrotum and yearling females may have visible vulval patch under tail. Horns of males generally thicker than those of females but field interpretation difficult (Wigal and Coggins 1982).

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Table 6. continued.

Species	Age	Gender
Pronghorn	Animals with horns longer than the ears usually adult males; maximum horn measurements from 2- and 3-year-old males (Mitchell and Maher 2001). Sequence of tooth eruption, replacement, and wear used to estimate age (Dow and Wright 1962, Jensen 1998), but cementum annuli analysis of first permanent incisor used for older age classes (McCutchen 1969, Kerwin and Mitchell 1971).	Horns of females average 42 mm in length and have unsubstantial prongs; horns of yearling males larger (O'Gara 1969). Adult males have black face to horns and black cheek patch; females have black nose area only (Einarsen 1948, Yoakum 1978).
Collared peccary (*Pecari tajacu*)	Tooth emergence and replacement used to estimate age to 21.5 months (Kirkpatrick and Sowls 1962). Eye-lens weights of limited value (Richardson 1966).	External dimorphism limited to genitals. Suspensory tuberosities on pelvic girdle prominent in males (Lochmiller et al. 1984).
Gray wolf	Pups identifiable by small size to 8 months (Carbyn 1987). Tooth eruption, replacement, and size useful to 26 weeks (Schonberner 1965, Van Ballenberghe and Mech 1975). Fusion of epiphyses of radius and ulna occurs at 12–14 months (Rausch 1967); fully grown at 18 months (Young and Goldman 1944). Cementum annuli analysis of teeth useful for estimating age of older animals (Goodwin and Ballard 1985, Landon et al. 1998, Gipson et al. 2000); tooth wear (Landon et al. 1998, Gipson et al. 2000, Fig. 20), cranial sutures, and pulp cavity measurements (Landon et al. 1998) have been considered, but are less versatile.	Urination posture used to identify gender (Carbyn 1987). Examination of nipples, penal scar/opening, and testicles used to identify gender in live wolves or pelts.
Coyote (*Canis latrans*)	Pups classified by size (Barnum et al. 1979, Bekoff 1982). Permanent canines emerge at 4–5 months and complete at 8–12 months (Voigt and Berg 1987); width of canine pulp cavity may be useful for estimating age (Root and Payne 1984, Tumlison and McDaniel 1984, Knowlton and Whittemore 2001). Cementum annuli useful for estimating age >20 months (Linhart and Knowlton 1967, Allen and Kohn 1976, Nellis et al. 1978, Bowen 1982, Root and Payne 1984), particularly for canine teeth (Roberts 1978).	Examination of nipples, penal scar/opening, and testicles used to identify gender in live coyotes or pelts (Voigt and Berg 1987). Sagittal crest of males more developed than females (Gier 1968, Bekoff 1982).
Fox	Canine teeth replacement complete at ~1 year (Geiger et al. 1977); roots (Voigt 1987) and pulp cavities (Bradley et al. 1981, Tumlison and McDaniel 1984) used to estimate age. Cementum annuli analysis also used (Grue and Jensen 1973, Allen 1974, Grue and Jensen 1976, Johnston et al. 1987), but accuracy decreases with number of annuli (Geiger et al. 1977). Eye-lens weight, baculum, body and skull measurements, and cranial sutures used but reliability not high (Sullivan and Haugen 1956, Wood 1958, Lord 1961, Geiger et al. 1977, Harris 1978).	Examination of nipples, penal scar/opening, and testicles used to identify gender in live foxes or pelts (Fritzell 1987). The baculum in males can be detected by palpating.
Black, brown, and polar bear	Eruption of canines used to estimate age to 3–4 years in black bears (Marks and Erickson 1966, Kolenosky and Strathearn 1987) and 2 years in brown bears (Rausch 1969). Cementum annuli analysis (Fig. 21) is preferred method for estimating age in black bears (Stoneberg and Jonkel 1966, Willey 1974, Carrel 1994, Keay 1995), brown bears (Craighead et al. 1970), and polar bears (Hensel and Sorensen 1980, Calvert and Ramsay 1998), but there are occasional errors (Hensel and Sorensen 1980, Kolenosky 1987, Harshyne et al. 1998). Baculum weight also used in brown bears (Pearson 1975). A multivariate approach has been used for black bear cubs including hair length, total length, skull width, and ear length (Bridges et al. 2002).	Males larger than females but substantial overlap in size (Pearson 1975, Craighead and Mitchell 1982). Lower canines of black bears used for gender identification (Sauer 1966). Length of the mandibular canine alveolus and width of the second mandibular molar also used (Gordon and Morejohn 1975).

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Table 6. continued.

Species	Age	Gender
Raccoon	Bacula of juvenile males porous at base with cartilaginous tip, <1.2 g in mass and <90 mm in length (Sanderson 1961*a*, Kaufmann 1982). Uterine horns of juvenile females translucent and 1–3 mm in diameter with no placental scars (Sanderson 1950); opaque and 4–7 mm with placental scars in adults. Tooth eruption useful to 110 days (Montgomery 1964), disappearance of cranial sutures and closure of epiphyses at ~12 months (Sanderson 1961*a*, Junge and Hoffmeister 1980, Fig. 22), and cementum annuli analysis for 4 age classes, including older animals (Grau et al. 1970, Johnson 1970).	Males slightly larger than females, but overlap makes characteristic difficult to use. Palpation used to detect baculum and testes in males (Stuewer 1943, Sanderson 1950, Kramer et al. 1999). Penal scars or nipples can be located on pelts.
American marten	Tooth replacement useful for estimating age to 18 weeks (Brassard and Bernard 1939). Radiographs of canine pulp cavities permit separation of juveniles from adults (Dix and Strickland 1986*b*). Cementum annuli analysis used to estimate age for older animals (Strickland et al. 1982, Archibald and Jessup 1984). Suprafabellar tubercle on femur used to separate juveniles from adults (Leach et al. 1982), but fusion of the distal femoral epiphysis not reliable (Dagg et al. 1975). Juvenile males have bacula weighing <0.1 g (Marshall 1951, Brown 1983).	Presence of baculum, preputial orifice on pelt, and larger size of head confirm male and vulva confirms female (Strickland and Douglas 1987). Characteristics of teeth and skull used to identify gender (Strickland et al. 1982, Brown 1983), but regional variation is large (Nagorsen et al. 1988). Tracks may be useful, although there is overlap (Zalewski 1999).
Northern river and sea otters (*Lontra canadensis*, *Enhydra lutris*)	Radiographs of teeth (Kuehn and Berg 1983, Melquist and Dronkert 1987) and closure of long bone epiphyses (Hamilton and Eadie 1964) useful to classify general ages. Cementum annuli analysis most reliable (Stephenson 1977, Bodkin et al. 1997). Eye-lens weight, baculum and skull characteristics, development of testes, and body size used with less success (Toweill and Tabor 1982, Melquist and Hornocker 1983).	Relative position of anus and urogenital openings used to ascertain gender; baculum detectable with palpation (Thompson 1958).
Wolverine	Genitalia and bone fusion used to separate young-of-the-year from adults (Wright and Rausch 1955, Rausch and Pearson 1972). Body weight, tooth wear, and physiological condition used to estimate age (Whitman et al. 1986). Best assessment for animals >1 year-of-age based on cementum annuli analysis (Rausch and Pearson 1972).	Nipples and genitalia (also scars and holes) used for classifying gender of live animals and pelts (Hash 1987). Females weigh 30% less than males (Hall 1981) with smaller skull condylobasal length (Magoun 1985).
Fisher	Suprafabellar tubercle present only on adult femur (Leach et al. 1982). Adults have prominent sagittal crest (Douglas and Strickland 1987) while young can be identified with bone epiphyses and pulp cavities (Dagg et al. 1975; Kuehn and Berg 1981; Jenks et al. 1984, 1986; Dix and Strickland 1986*a*). Tooth emergence useful through 7 months. Cementum annuli analysis of the first premolar used for estimating age of adults (Douglas and Strickland 1987, Arthur et al. 1992).	Males twice as large as females with larger bones (Leach 1977, Leach and de Kleer 1978). External genitalia or nipples readily apparent on live animals or pelts. Lower canines of males have root widths >5.64 mm (Parsons et al. 1978) and are longer (Kuehn and Berg 1981, Jenks et al. 1984, Dix and Strickland 1986*a*).
Mink and other mustelids	Tooth eruption useful for estimating age to 3 months in mink (Aulerich and Swindler 1968). Cementum annuli analysis useful for older animals (Klevezaµ and Kleinenberg 1967, Birney and Fleharty 1968). Baculum mass in mink averages 172 mg in juveniles and 398 mg in adults (Lechleitner 1954, Greer 1957, Godin 1960). Head of baculum is distinctly ridged in adult mink (Lechleitner 1954) or expanded in long-tailed weasel (Wright 1947).	Testes or penis scar identifies male and nipples female (Birney and Fleharty 1966, Eagle and Whitman 1987).
American badger	Techniques used include bone sutures, sagittal crest (Messick 1987), and baculum characteristics (Messick and Hornocker 1981). Cementum annuli analysis best indicator of adult year classes (Crowe and Strickland 1975, Messick and Hornocker 1981).	Body and skull measurements useful, but are overlapping (Messick and Hornocker 1981, Messick 1987). Testes, penis, or penis scar used to classify males and vulva or nipples used to classify females (Petrides 1950*b*).

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Table 6. continued.

Species	Age	Gender
Skunks	Cementum annuli analysis good estimator of adult year classes (Nicholson and Hill 1981). Other less effective techniques include bone ossification, tooth wear, and eye-lens weight (Allen 1939, Petrides 1950*b*, Mead 1967, Verts 1967, Bailey 1971, Leach et al. 1982).	Testes, penis, or penis scar used to identify males and vulva or nipples used to identify females. Lower canines may also be indicative of gender (Fuller et al. 1984).
Felids	Tooth emergence and replacement useful for estimating age to 240 days (Crowe 1975, McCord and Cardoza 1982, Lindzey 1987). Cementum annuli analysis useful for estimating age in older animals (Crowe 1972, Nellis et al. 1972); technique less successful with cougar. The foramen of the canine tooth closes at 13–18 months in lynx and bobcat (Saunders 1964, Crowe 1972, Johnson et al. 1981). Gum line recession used to estimate age in older cougar (Laundré et al. 2000), mass, body length, and tail length used to estimate age in younger cougar (Laundré and Hernández 2002); growth rate may vary by population (Maehr and Moore 1992).	Male genitalia detectable but less obvious than in other carnivores (McCord and Cardoza 1982, Lindzey 1987, Rolley 1987). Lower canine size useful to identify gender in bobcat (Friedrich et al. 1983). Body mass differs between male and female cougars, but there is overlap (Lindzey 1987, Laundré and Hernández 2002).
Pinnipedia	Patterns of tooth eruption and body size useful for estimating age (Spalding 1966), but cementum annuli analysis of canines best technique for older animals (Scheffer 1950, Laws 1962, Kenyon and Fiscus 1963, Anas 1970). Eye-lens weights useful in limited situations (Bauer et al. 1964).	Northern fur seal (*Callorhinus ursinus*), Steller sea lion (*Eumetopias jubatus*), California sea lion (*Zalophus californianus*), northern elephant seal (*Mirounga angustirostris*), walrus (*Odobenus rosmarus*), and gray seal (*Halichoerus grypus*) males substantially larger than females (King 1983, Riedman 1990). Harp seal (*Phoca groenlandica*) males only slightly larger than females, but black markings tend to be larger and more distinct. Harbor seal (*P. vitulina*) is exception as it is outwardly monomorphic. Canine teeth larger for males than females in every age category in northern fur seals (Huber 1994) and for animals >5 months in California sea lions (Lowry and Folk 1990).
Lagomorphs	Epiphyseal grooves on bones used to classify age to 14 months (Hale 1949, Godin 1960, Tiemeier and Plenert 1964, Bothma et al. 1972, Kauhala and Soveri 2001, Fig. 24); periosteal layers in mandibles may also be useful (Sullins et al. 1976). Skull length useful for estimating days after birth (Bray et al. 2002). Eye lens weights used to separate juveniles and adults (Lord 1959, Tiemeier and Plenert 1964, Rongstad 1966, Connolly et al. 1969*b*, Pelton 1970, Keith and Cary 1979, Hearn and Mercer 1988, Kauhala and Soveri 2001).	Careful examination can reveal the penis (cylindrical organ) or clitoris (flattened posteriorly); young rabbits and hares difficult to evaluate (Fox and Crary 1972).
Muskrat	Pelt primeness varies substantially between adults and juveniles; the underside of the pelt tends to be mottled in adults and broadly patterned in juveniles (Dozier 1942, Kellogg 1946, Applegate and Predmore 1947, Shanks 1948, Godin 1960, Doude Van Trootswijk 1976, Fig. 11). Adults have less fluting on first upper molar than juveniles (Olsen 1959, Proulx and Gilbert 1988) but pelt primeness appears more useful for classifying age (Moses and Boutin 1986). Adults have lower ratio of crown length to total length of first upper molar than juveniles, but regional variation should be considered (Pankakoski 1980, Erb et al. 1999). Additional characteristics include ossification of the baculum (Elder and Shanks 1962) (Fig. 15), and zygomatic breadth (Alexander 1951, 1960).	Careful examination can reveal the penis or nipples (Dozier 1942, Baumgartner and Bellrose 1943, Schofield 1955, Godin 1960). Sexual dimorphism in teeth not detectable (Lewis et al. 2002).

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Table 6. continued.

Species	Age	Gender
American beaver	Acceptable accuracy with a small number of age classes can be achieved with radiography of jaws of live or dead animals (Hartman 1992); cementum annuli analysis useful for additional age classes (Van Nostrand and Stephenson 1964, Larson and Van Nostrand 1968). Evaluation of anal-urogenital opening in females useful for classifying adults and juveniles (Thompson 1958). Skull characteristics (Buckley and Libby 1955) and tooth-root closure (Van Nostrand and Stephenson 1964) useful for classifying juveniles and adults of both genders.	Males generally larger and heavier than females (Payne 1979). Careful palpation can identify the testes and baculum (Osborn 1955). Color and viscosity of anal gland secretion is reliable indicator (Schulte et al. 1995).
Tree squirrels	Development of fox (*Sciurus niger*) and eastern gray squirrels can be estimated with basic morphology up to 6 weeks (Uhlig 1955). The fur on the lateral rump of adult eastern gray squirrels has a distinct yellowish streak near the base that is absent in juveniles (Barrier and Barkalow 1967); age-specific patterns in tail pelage also noted (Sharp 1958, Fig. 12). Teats are inconspicuous and hidden by hair in juvenile females and large and noticeable in adults. Cementum annuli analysis useful to estimate age class (Lemnell 1974, Fogl and Mosby 1978). Other techniques include epiphyseal lines in long bones (Petrides 1951, Carson 1961, Nellis 1969), epiphyseal lines in the foot (McCloskey 1977), and eye-lens weight (Beale 1962, Fisher and Perry 1970).	Gender classified by examination of external genitalia, but skulls also useful (Nellis 1969).
Woodchuck (*Marmota monax*)	Juveniles weigh 300–450 g by ~15 May and have eye-lens weights that average 12.3 mg, yearlings have narrow and pointed incisors and eye-lens weights that average 21.8 mg, adults have broad incisors and eye-lens weights that average 28.53 mg (Davis 1964).	Careful examination used to reveal the os penis; testes are often regressed (Kwiecinski 1998).
Virginia opossum (*Didelphis virginiana*)	The pouch is white, shallow, or insignificant in size in juvenile females; it is flabby, fatty, and dark in adults (Petrides 1949). Tooth eruption and emergence is useful characteristic (Lowrance 1949, Petrides 1949, McManus 1974, Tyndale-Biscoe and Mackenzie 1976).	Canines of males longer and heavier than those of females (Gardner 1982). Males have scrotum and females have pouch (McManus 1974, Gardner 1982).
Bats	Cartilaginous epiphyseal plates in the finger bones of juveniles makes joints look "tapered" and less 'knobby' than joints of adults (Anthony 1988).	External genitalia are visible in males; testes are relatively large when male is in breeding condition (Racey 1988).
Small mammals (insectivores, other rodents)	Eye-lens weights are used (Birney et al. 1975, Gourley and Jannett 1975) with mixed success (Dapson and Irland 1972, Barker et al. 2003); tyrosine content in lens may be more accurate (Dapson and Irland 1972). Tooth eruption (Mitchell and Carsen 1967, Beg and Hoffmann 1977), tail collagen strength (Sherman et al. 1985), adhesion lines in the lower jaw (Millar and Zwickel 1972) and femur (Barker et al. 2003), and cementum annuli analysis (Adams and Watkins 1967, Montgomery et al. 1971) also have been used.	Careful examination of genitals in live animals can be useful with most species. Shape of pelvic girdle can be used when only bones are available (Dunmire 1955).

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ogy, and genetic analysis of small tissue samples. It is likely these techniques will provide a foundation for evaluation of population demography, establishment of harvest regulations and strategies, and development of protocols to monitor population and ecosystem health.

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