Aging, Sexing, and Molt

Identification of birds not only means identifying the species of an individual, but also can include identifying its subspecies, sex, and age. Field identification of the age and sex of a bird can be important for studying many aspects of avian ecology and evolution, including life history evolution, reproductive ecology, and behavioral ecology. Ornithologists use a variety of characteristics to identify, sex, and age birds (Table 1).

Table 1. Features usefulful for identifying, aging, and sexing birds.

	Identification			
Character	**Species**	**Subspecies**	**Sex**	**Age**
Molt and Plumage Patterns				
Plumage coloration	•	•	•	•
Feather wear				•
Feather shape				•
Other Features				
Size (wing, tail, weight, leg, bill)	•	•	•	•
Skull ossification				•
Cloacal protuberance and brood patch			•	•
Gape	•			•
Iris color			•	•
Song	•		•	•
Geographic location	•	•		

Molt and Plumage Patterns

Feathers are not permanent structures, but are periodically shed and replaced. The process of shedding and replacing worn feathers is called molting, and the feather coats worn between molts are called plumages. Most birds in the Northern Hemisphere molt all flight and body feathers late in summer and undergo a second, more limited molt of body feathers in spring just before the breeding season. A complete understanding of the timing, sequence, and extent of molts is an essential aspect of the accurate aging and sexing of birds. Molt contributes to differences among individual birds in plumage color and patterns and feather shape and wear that can be used to identify the species, subspecies, sex, or age, depending on the taxon.

Molt

The exact schedule and number of molts varies for each species, depending on breeding cycle, habitat, and whether the species is migratory or sedentary. Birds molt their feathers for a variety of reasons: to replace worn feathers, to change colors for crypsis, to change colors for territorial or sexual displays. The importance of these factors to a bird's fitness will influence the frequency and extent of molts. A yearly molt is generally sufficient to offset normal rates of feather wear. Multiple molts in a year occur in birds using seasonal plumage displays (territorial defense or sexual attraction), in birds occupying harsh habitats (grasslands or deserts), or in birds that undertake long migrations.

In the temperate zone, the proximal cue for molt initiation is day length, which has an effect on the hormone levels that ultimately control molt progression. Molting is very costly. The bird replaces 25 – 40 percent of its dry mass, drawing on protein and energy reserves to synthesize feathers and to offset the effects of reduced insulation and flight ability. Because it is so costly, molt is often interrupted in order to begin breeding activities or for migration. Common white terns molt almost continuously to replace their easily worn, unpigmented feathers, but interrupt molt upon laying an egg. Some migratory birds interrupt molt to migrate and resume it at the end of migration (e.g. arctic Peregrine Falcon and American Golden Plover).

Many birds go through a quick series of plumages in their first months of life, and then cycle between a basic, or winter, plumage worn for most of the year and an alternate, or breeding, plumage worn only during spring and summer. Plumage sequence and molt terminology are shown in Table 2 and described in the text below.

Table 2. Molting schedule and plumage sequences.

Year of Life	Plumage Name	Molt Replacing Plumage	Extent of Molt
First (hatching year)	Natal down	Prejuvenal molt	complete
First (hatching year)	Juvenal plumage	1st prebasic molt	partial
First (hatching year)	1st basic plumage	1st prealternate molt	partial
First (hatching year)	1st alternate plumage	2nd prebasic molt	complete
Second	Adult basic plumage (2nd)	2nd prealternate molt	partial
Second	Adult alternate plumage (2nd)	Adult prebasic molt	complete
Third	Adult basic plumage	Adult prealternate molt	partial

After the second year, most birds cycle through the adult basic and adult alternate plumages.

Partial molt. Partial molts replace only some of the body contour feathers and rarely involve the flight feathers.

Complete molt. Complete molts replace all body and flight feathers.

Natal down. The natal down plumage may consist of a few scattered down feathers (as found on most hatchling landbirds) or it may be a dense, fuzzy covering (as found on ducklings and gallinaceous chicks). In birds with altricial young the natal down is generally replaced a week or two after hatching before fledging by the juvenal plumage. In loons, penguins, hawks, and waterfowl, the precocial chicks grow a second coat of down before the juvenal plumage.

Juvenal plumage. The juvenal plumage replaces natal down via a complete molt called the prejuvenal molt. The juvenal plumage generally differs substantially from subsequent adult plumages, allowing easy separation of first or hatch-year birds from adults. The juvenal plumage is often duller and more streaked or spotted than that of the adult, will often have wing bars where the adult has none, and is displayed on more loosely textured contour feathers. Examine the European starling and common grackle specimens and notice how the birds in juvenal plumage are duller and greyer compared to the adults. Notice how the American robin in juvenal plumage is extensively spotted in addition to being generally duller and browner than the adults. Replacement of the juvenal plumage via the first prebasic molt often occurs within three months of fledging and usually takes place on the breeding grounds (where the juvenile fledged). Birds in juvenal plumage are usually indistinguishable to sex.

Prebasic molt. In most north-temperate passerines, the first and adult prebasic molts usually take place from July–September, just after the breeding season. Prebasic molt usually takes place on the breeding grounds, but may take place during fall migration or on the winter grounds. In adults, the prebasic molt is usually complete and results in the adult basic plumage. In first or hatch-year birds, it is referred to as the first prebasic molt and results in the first prebasic plumage. The first prebasic molt is not complete, since the feathers of the primaries and tail are often not replaced. The second prebasic molt is complete, and results in the second basic plumage, which is generally the adult definitive plumage (adult basic plumage).

Molt sequence. Molting in birds usually follows a regular sequence within and among feather tracts. In many passerines, replacement of the remiges begins with the tertials and the innermost primaries (starting with the innermost primary and proceeding outward), followed by the secondaries (starting with the outermost secondary and proceeding inward). Tail feathers typically molt centrifugally from the innermost to the outermost pair (Figure 1). Regular and symmetrical sequences of flight feather replacement help maintain flight ability. In contrast, waterfowl (ducks, grebes, pelicans, auks) become flightless because they molt all of their flight feathers at the same time.

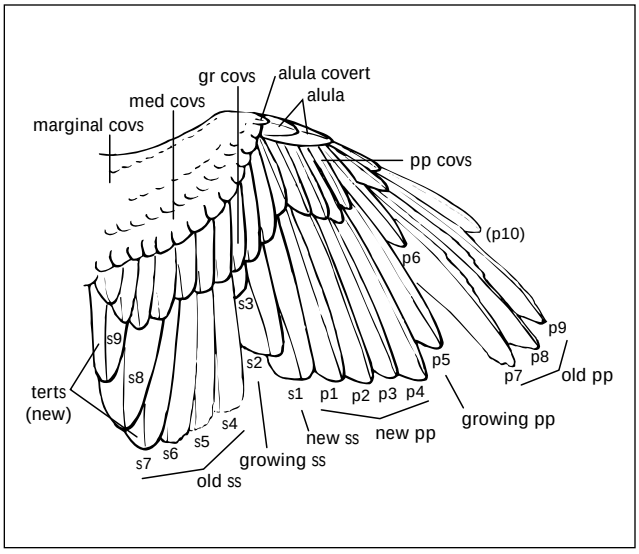

Figure 1. A wing during complete molt in typical sequence, including wing feather terminology.

Basic plumage. The basic plumage is generally worn during fall, winter, and early spring. In first or hatch-year birds, it is called the first basic plumage and is not the definitive (final adult) plumage, since the feathers of the wings and tail are generally not replaced in the first prebasic molt. These feathers retain qualities of the juvenal plumage, making birds in their first basic plumage generally distinguishable from those in their adult basic plumage. The adult basic plumage is the definitive plumage to which adults return after every breeding season. Juvenal passerines generally achieve the adult basic plumage by their second basic plumage. Some nonpasserines (gulls, eagles) and some passerines (orioles, manakins) take more than 2 years to reach the definitive plumage. In these

cases, the second, third, or fourth basic plumages differ from the definitive plumage, and an age can be assigned these subadult birds until they attain their adult basic plumage. This phenomenon is called delayed plumage maturation. Examine your field guide diagrams for ring-billed and herring gulls and note the changes in plumage for 1st, 2nd, and 3rd winter birds, compared to adult winter and breeding plumages.

Prealternate molt. In some birds, the prebasic molt is the only molt that occurs annually; thus, breeding occurs in the basic plumage for these species (e.g. American Robin and the woodpeckers). In most passerines, the prealternate molt causes the replacement of the basic plumage with the alternate plumage during winter or spring. In hatch-year birds, it is called the first prealternate molt and results in the first alternate plumage, whereas in adults, it is referred to as the adult prealternate molt and results in the adult prealternate plumage. Prealternate molts are generally partial, though the extent of the prealternate molt varies substantially among species and between sexes.

Alternate plumage. In adults, the alternate plumage is referred to as the adult alternate plumage, whereas in hatch-year birds, it is the first alternate plumage. In many passerines, the adult alternate plumages of males differ from their adult basic plumages, whereas in females, both plumages are similar. Birds in their first alternate plumage are generally duller than those in the adult alternate plumage.

Plumage Coloration

In many species of birds, differences in plumage coloration not only result from age and stage in the molt cycle, but also from sex or geographic location. Many birds have strong sexual dimorphism in plumage coloration. Examine the specimens of warblers, bobolink, American robin, tanagers, orioles, wood duck, and kestrel exemplifying sexual dimorphism in plumage. Since in many birds the female usually performs most or all of the incubation and brooding of the young, she is more cryptically colored and is less brightly colored than the adult male (e.g. many warblers and ducks). In species in which both parents sit on the nest, sexual dimorphism in plumage coloration may be little or absent (e.g. flycatchers and wrens). Some species exhibit reverse sexual dimorphism. In the phalaropes, the female is more brightly colored and defends breeding territories, and the male assumes the duties of incubation and parental care. Examine the belted kingfisher specimens and note how the female's breast is more brightly colored with rufous than is the male's.

Geographic variation in plumage coloration may result in species distinguished by subspecies or species with different "phases" of plumages. Eastern screech owls (see specimens) have two plumage types, red and gray phases, and their occurrence varies systematically with location. The plumages of many raptors (e.g. Red-tailed Hawk and Peregrine Falcon) also varies geographically, resulting in different subspecific designations regionally.

Feather wear and shape

As a result of physical abrasion, feathers wear at the edges and their shapes change. In birds in which the first prebasic molt is incomplete, the shape and amount of wear or fading of certain flight feathers or primary coverts can serve as clues for aging. The shapes of the rectrices, primaries, and primary coverts are aging criteria for birds that retain juvenal wing and tail feathers during the first prebasic molt. Generally, the outer two or three rectrices, the outer primaries, and the outer primary coverts are narrower and have more tapered inner webs in juvenal feathers, whereas the they are broader and more truncate in adults (Figure 2).

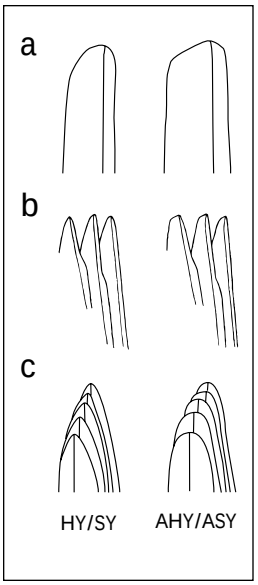

Figure 2. Examples of the shape of various feathers by age (a) outer rectrices (b) outer primaries (c) the outer primary coverts.

Differences in the amount of wear between juvenal and adult rectrices, primaries, and primary coverts can also provide useful clues for aging. Wear can result from abrasion to feather tips and degradation due to solar radiation. In the early fall, shortly after the prebasic molt, retained juvenal feathers are about one to three months older than the corresponding adult feathers and usually show signs of wear. Nicks in the outer webs of the feathers and a decrease in glossiness indicate feather wear. Adult feathers at this time should be glossy and lack nicks. Examine the baltimore oriole specimens. Compare the rectrices and remiges of the adult in basic plumage, which show little wear, with those of the specimen with first alternate plumage, showing extensive wear resulting from retention of these feathers from the juvenal plumage. Primary coverts, usually retained in the first prebasic molt, should be faded and worn, compared to the adjacent greater secondary coverts, which are generally replaced in the first prebasic molt and appear glossy.

Feather wear can also function in changing the plumage coloration or pattern. The plumage worn by the male snow bunting during summer breeding is not a separate plumage, but is actually just the worn feathers of the basic plumage. In the late summer, prebasic molt, the snow bunting male molts into a pale brown and gray basic plumage, with feathers having pale tips. Over the fall and winter, the pale white edges of feathers in the basic plumage wear off, revealing a bolder black and white pattern that is fully developed by the time the male has returned to his breeding grounds in spring. Such "wear plumage" is also evident in European starlings. Examine the starling specimens. The change from the speckled winter plumage to the non-speckled summer plumage results not from molt, but from the white tips wearing off of the contour feathers.

Anatomical Features

The anatomical features reviewed below are mostly useful for identifying, aging, and sexing birds in the hand, and aren't generally

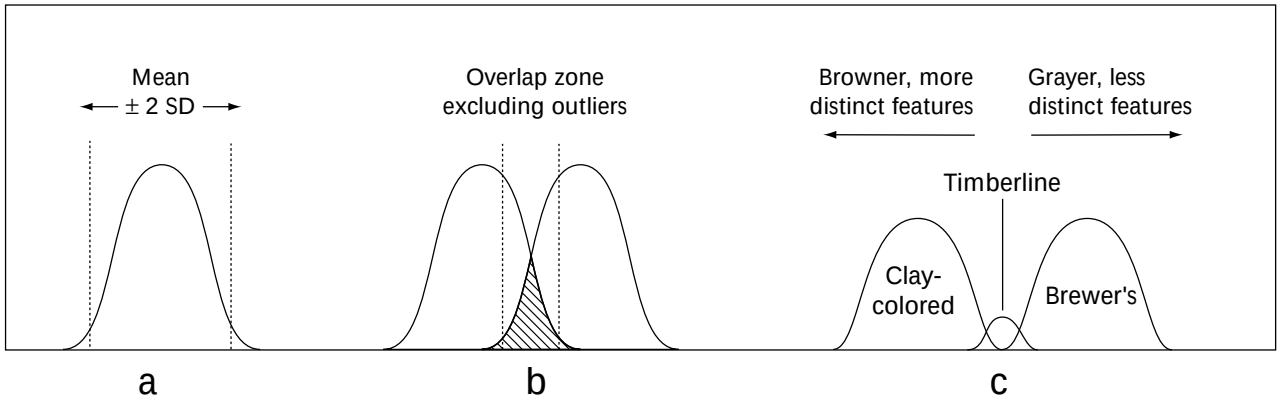

Figure 3. Normal (bell) curves including 95% confidence intervals (a) an example of an area of overlap between two similar populations (b) an example of its use in Spizella sparrows (c).

usefull as field marks. When birds can be captured for close inspection, however, theses features can prove invaluable, and are widely used iby ornithologists.

Size

Size can be a useful characteristic for the identification of species, subspecies, and sex, but is not reliable for determining age except in a few cases (e.g., certain blackbirds). Measurements can be particularly important for sexing live passerines in the hand and study skins in a museum collection.

In most passerines males are, on average, larger than females, but because this size difference is statistical, using size alone to determine the sex of an individual is often unreliable. In most North American passerines the sexes show a 60 – 80% overlap in many size measurements (e.g. the measurement of a large female may be similar to that of a small male): in these species wing cord length will reliably indicate sex in only 20 – 40% of the individuals measured (e.g. those lying in the extremes of the overall size distribution: Figure 3). Thus, for different species and individuals, various measurements of size may range from being nearly useless to being very informative. Remember that "reverse" sexual dimorphism (females larger than males) occurs in raptors and some other nonpasserines.

Some species and subspecies whose plumages are very similar (thus difficult to identify by plumage alone) can be identified using the measurement of several different anatomical features (e.g. flycatchers in the genus Empidonax and sandpipers in the genus Calidris). The combination of several measurements can also be used to reliably determine subspecies (e.g., Canada Goose, Savanna Sparrow).

Use of Size in the Field. Size can serve to identify some species whose plumages are very similar (e.g. Downy vs. Hairy Woodpecker, Lesser vs. Greater Yellowlegs, Snow vs. Ross's Goose, Virginia vs. King Rail, and Sharp-shinned vs. Cooper's Hawk) but the size difference between the species in question must be moderately large to allow for easy identification at a distance. In some species size can be used for sexing individuals in the field, but is largely unreliable except in certain situations (e.g. hawks). The use of plumage characteristics and song in conjunction with size is the most reliable technique for the determination of sex in the field.

Measurements. The size of a bird can be estimated using any number of parameters, but the primary measurements used are wing cord, tail length, bill length, tarsus length, and weight.

Wing Chord. Wing cord is the length of the wing from the wrist to the tip of the longest primary (as measured with a ruler), and is the most frequently used measurement (Figure 4a).

Tail length. Tail length is the distance from the tip of the longest rectrix to the insertion of the two central rectrices (Figure 4b). Tail length is the second most common size measurement used but is often difficult to estimate in live birds.

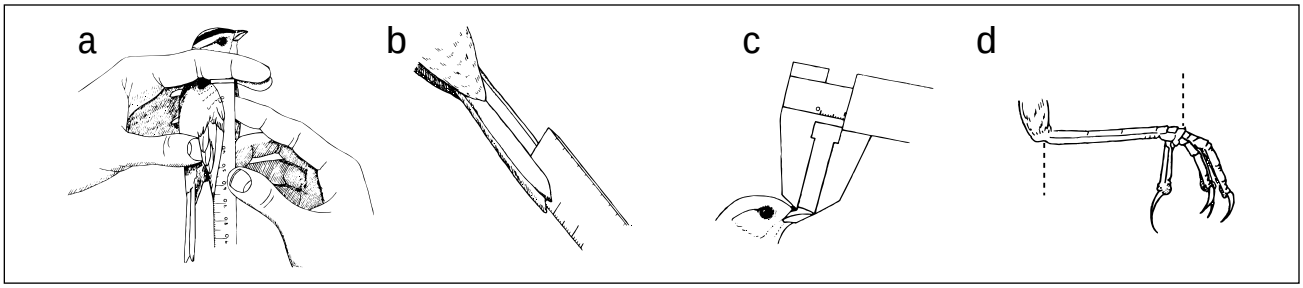

Figure 4. Measuring the wing chord (a), the tail between the central rectrices (b), the bill from nares to tip (c) and the tarsus (d).

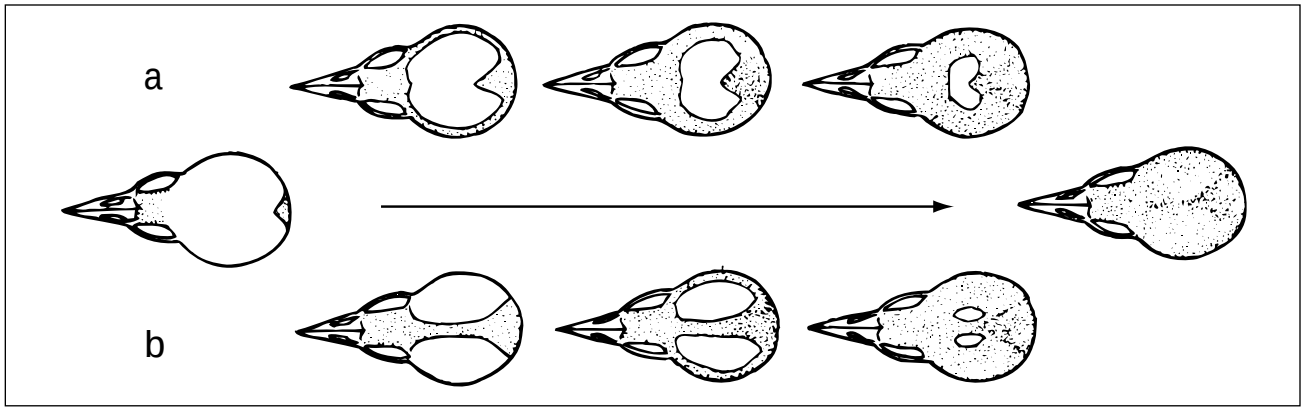

Figure 6. Two common sequence patterns of skull pneumaticization (a) periferal pattern (b) medial line pattern.

Bill length. Bill length is the distance from the anterior end of the nostril to the tip of the bill (Figure 4c). When measuring bill length it should be noted that slight variation in bill length occurs between seasons.

Tarsus length. Tarsus length is the length between the intertarsal joint and the last leg scale before the toes emerge (Figure 4d). Tarsus length is difficult to measure in live birds but can be helpful in sexing fledglings of certain species.

Weight. Weight is the mass of an individual. Many factors can effect weight, thus it is largely unreliable for determining age or sex.

Wing formula. Wing formula refers to three aspects of the primaries: the length and relative position of the primary tips, the occurrence and length of notches on the primaries, and the occurrence of emargination in the outer webs of the primaries (Figure 5). These three aspects of the wing can be used for determining the species, sex, and age of individuals. Feather wear can alter these features so the use of the wing formula is unreliable except when primaries are in good condition. The use of this technique is highly developed in Europe where it is used to identify a number of species with very similar outward appearances (especially among a group of Old World warblers).

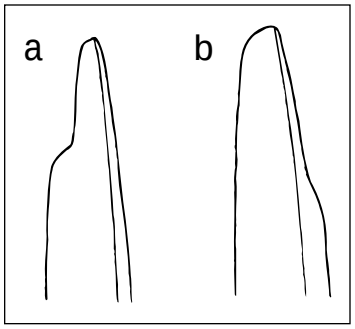

Figure 5. Examples of notched (a) and emarginate (b) primaries.

Skulling

Skulling is a technique used to age birds and is based on the extent of pneumatization in sections of the skull overlying the brain (the frontals and parietals). When a young bird fledges, the top of its skull consists of a single layer of bone: skull pneumatization is the gradual formation of a second layer of bone under the previous one, a process that takes four to twelve months depending on the species. Pneumatization produces recognizable patterns in the extent and distribution of air pockets and small visible columns of bone developing between the layers forming the top of the skull. These patterns are visible through the thin skin on the top of a bird's head. During certain times of the year the amount of skull pneumatization can be used to separate hatch-year birds from older individuals (the skulls of which are completely pneumatized) and is especially important for aging passerines, particularly in the late summer and the fall. The skulls of many passerines become completely pneumatized by late fall, at which time hatch-year birds are indistinguishable from older birds. Pneumatization takes several months in some groups of birds, so skulling these species can be productive into the late winter and very early spring.

In order to inspect the condition of the skull through the skin on the top of the bird's head, the crown feathers are brushed aside (this is usually done by wetting the feathers). Hatch-year birds (and, in some species, second-year birds through early spring) will have unpnuematized sections of the skull appearing pinkish white, contrasting with pneumatized areas which appear grayish, whitish, or pinkish white with small white dots (the columns of bone). The skulls of most after hatch-year birds will appear whitish with many scattered small white dots (Figure 6).

Cloacal Protuberance and Brood Patch

The most reliable technique for sexing species where males and females share similar plumages is the presence or absence of a cloacal protuberance or brood patch (for species with a long breeding season these features can also be used to identify adults and hatch-year birds). Cloacal protuberances and brood patches are only present on adults during the breeding season: during the non-breeding season other characteristics must be used.

Cloacal protuberance. Cloacal protuberances are developed by breeding male passerines to store sperm and assist in copulation (Figure 7). It results from the enlargement of the testes and associated ducts. A typical cloacal protuberance forms a right angle to the abdomen and is somewhat larger at the distal end than at the

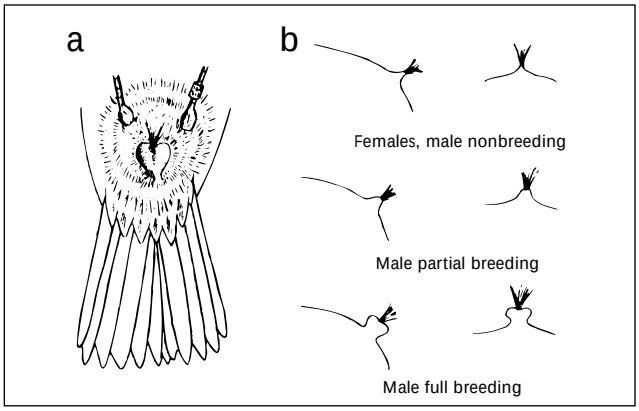

Figure 7. The cloacal protuberance at its peak (a) and profiles of passerine cloacal protuberances in different breeding conditions (b).

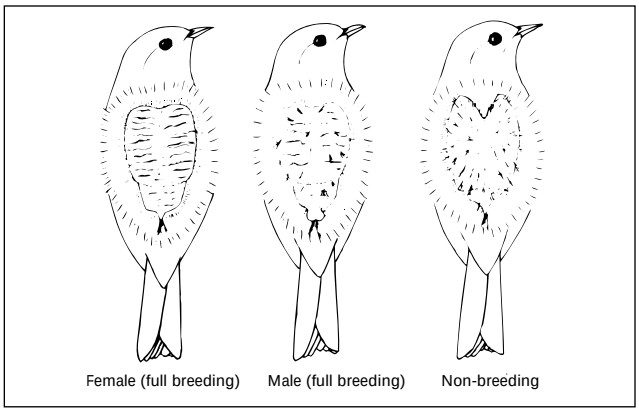

Figure 8. Brood patches at different stages of development.

proximal end. Some females will have a swollen cloaca but it will not be nearly as large as male's protuberance.

Brood patch. The brood patch is an area of bare skin on the breast developed by incubating females and serves to increase the transfer of body heat to the developing eggs (Figure 8). In the brood patch Blood vessels increase in size and skin becomes thicker and fluid-filled. The brood patch lasts through the breeding season until the prebasic molt (but may recede and redevelop between broods). Many North American passerine males do not form brood patches (they do not incubate) but in a few groups where the male will assist the female with incubation (e.g., vireos, mimids, Myiarchus flycatchers), an incomplete brood patch may develop.

Song

The production of song is a very reliable means for identifying and sexing birds. In most species only males sing, but in a few (e.g. Northern Cardinal and Eastern Wood Pewees) females will sing at least occasionally (a bird that is not singing is not necessarily a male, however). Age can not be reliably determined by song, although some second-year males may give incomplete or unusual songs. In addition to song, both sexes of most species produce a variety of other vocalizations that are often distinctive, and may be especially useful when no other techniques are available (e.g. American vs. Fish Crow, Eastern vs. Western Meadowlark, and Willow vs. Alder Flycatcher). The songs of many species vary with geographic range: these "dialects" are often associated with described subspecies, and is the most reliable identification characteristic for some(e.g. Red Crossbill).

Vocalizations are the primary means of identification used by avian researchers and in conjunction with visual identification allow researchers to conduct systematic population censuses.

Geographic Location

Geographic area can help to identify certain species whose plumages are nearly identical (e.g. Eastern and Western Wood Peewee, Eastern and Western Meadowlarks, Purple and Rock Sandpipers, and Carolina and Black-capped Chickadees: Figure 9).

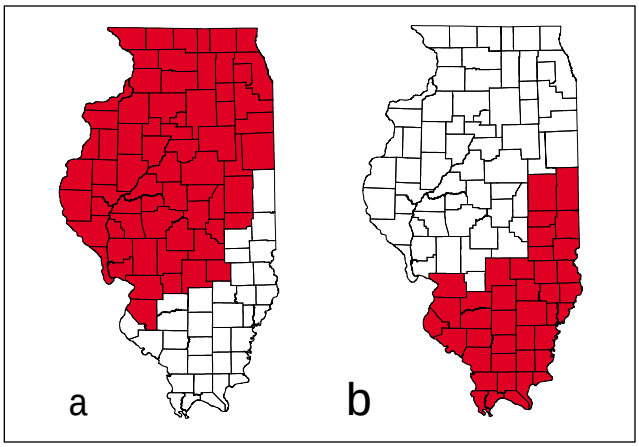

Figure 9. Range of the Black-capped Chickadee (a) and the Carolina Chickadee (b) in Illinois.