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Moult, ageing and sexing of European Hoopoe, Bee-eater, Kingfisher and woodpeckers

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ABSTRACT

The moults of the smaller non-passerine landbirds differ substantially from those of most passerines, and so do the ageing criteria based on plumage characters. Sexing criteria may apply before the post-juvenile moult or appear only after. Again, knowing their moults is important. Here we describe the moults of the Eurasian Hoopoe *Upupa epops*, European Bee-eater *Merops apiaster*, Common Kingfisher *Alcedo atthis ispida* and *A. a. atthis*, Eurasian Wryneck *Jynx torquilla*, Great Spotted Woodpecker *Dendrocopos major*, White-backed Woodpecker *Dendrocopos leucotos*, European Green Woodpecker *Picus viridis*, and Grey-headed Woodpecker *Picus canus*. For these species and some more woodpecker species (Eurasian Three-toed Woodpecker *Picoides tridactylus*, Middle Spotted Woodpecker *Dendrocoptes medius*, Lesser Spotted Woodpecker *Dryobates minor*, Black Woodpecker *Dryocopus martius*) we provide plumage criteria for ageing and sexing, illustrated with graphs and photos. A particular feature of these species is the delayed moult of the primary coverts which provides reliable ageing criteria, and even the opportunity to age birds beyond the second year of life.

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Ageing birds in the hand relies on features which can be observed by eye, such as the colour of bare parts and the iris, but mainly on plumage characters; as far as is known, skull pneumatisation is not applicable in non-passerines. Most plumage characters indicative of age relate to differences between feathers of the juvenile plumage and those of subsequent feather generations or on differences in the extent of moult. Hence it is important to understand the inter- and intraspecific extents and variations of the moults leading from the juvenile plumage to subsequent plumages.

The moults of the smaller non-passerine landbirds of the Coraciimorph group (*sensu* Prum *et al* 2015) differ substantially from those of most passerines, and so do the ageing criteria based on plumage characters. Sexing criteria may be present before the post-juvenile moult (e.g. Grey-headed Woodpecker *Picus canus*) or appear only afterwards (e.g. European Green Woodpecker *Picus viridis*).

The first aim of this paper is to describe the moult patterns of some smaller non-passerine landbird species that may be caught along with passerines at ringing sites, or for which many population studies are ongoing. In particular, we provide quantitative data on the variation in the extent of moult, which is important for ageing.

The second aim is to derive plumage criteria for ageing and sexing, and to present them in photographs, much as we did previously for passerines (Jenni & Winkler 2020a). Ageing and sexing criteria of the species covered here have been presented in several guides for ringers (Demongin 2013, Baker 2016, Demongin 2016, 2020, Blasco-Zumeta & Heinze 2023). However, ringers have reported that some of these are difficult to apply or are misleading. Here we explain the moults of 12 species in more depth, provide new quantitative data on the extent of the moults, and detail and rectify some ageing criteria.

A particular feature of many species of the Coraciimorphs is the delayed moult of the primary coverts, which provides reliable ageing criteria, and the opportunity to age birds beyond the second year of life. According to our findings, every species treated

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here does not moult the primary coverts during the post-juvenile moult, although woodpeckers, including the Eurasian Wryneck *Jynx torquilla*, do moult the primaries themselves then. Eurasian Hoopoe *Upupa epops* and European Bee-eater *Merops apiaster* moult primary coverts together with the corresponding primary during the first post-breeding moult. However, true woodpeckers often do not moult their primary coverts completely during the first post-breeding moult, and Eurasian Wryneck and Common Kingfisher *Alcedo atthis* never completely (Laesser & van Wijk 2017, Bunzel-Drüke & Zimball 2024). This corresponds with the observation that the moult of primary coverts in European Coraciimorphs often is not synchronised with the moult of the corresponding primary. In Eurasian Wryneck and Common Kingfisher, the primary-covert moult is often incomplete also during later moults, so that most of these short-lived birds die before they have moulted all their juvenile primary coverts (Laesser & van Wijk 2017, Bunzel-Drüke & Zimball 2024). Hence the moult of primary coverts does not follow a cyclic moult regime.

Whether the delayed moult of the primary coverts is an ancient feature of the Coraciimorphs remains to be studied, since the primary-covert moult of their tropical families is virtually undocumented. Alternatively, not moulting primary coverts – apparently not a substantial disadvantage for flight – may save energy, and hence speed up primary moult, as suggested by Kiat & Izhaki (2017). This would be important in time-constrained species and populations of the northern hemisphere, where the species occur that have been investigated so far for primary-covert moult. Time pressure is particularly evident in migratory Eurasian Wrynecks and in the Common Kingfisher, with its very long breeding season, both retaining primary coverts for up to five years (Laesser & van Wijk 2017, Bunzel-Drüke & Zimball 2024). Time pressure in Common Kingfishers is apparently so strong that they regularly also retain unmoulted remiges, one of the smallest species to do this (Bunzel-Drüke & Zimball 2024). These peculiar moult patterns of the Coraciimorphs deserve further study.

Terms and material

Feathers and their numbering

As before (Jenni & Winkler 2020a, 2020b), we number the primaries (**P**) from inside to outside, and the secondaries (**S**) from outside to inside (Figure 1). In contrast to for passerines, we do not use the term tertials and refer to these as innermost secondaries. Because the species treated here usually have more than nine secondaries, the differentiation of tertials according to their function (covering portions of the folded wing) and a particular moult sequence (Hickman 2008) is difficult, probably variable between species, and hence arbitrary.

The rectrices (**R**) are numbered from inside to outside. The marginal (**MaC**), lesser (**LeC**) and median (**MeC**) upper wing coverts are not numbered, while the greater coverts (**GC**) and primary coverts (**PC**) follow the numbering of their corresponding remiges.

In the legends to the photographs, we use the abbreviations **juv** for juvenile, **postjuv** for post-juvenile, **prebr** for pre-breeding and **postbr** for post-breeding when describing feather generations.

Age classes

We use the age classification which refers to the calendar year, i.e. **1cy** for birds hatched in the current calendar year (up to 31 December; Euring code 3), **2cy** for birds hatched in the previous calendar year and now in their second calendar year (from 1 January; Euring code 5), **3cy** for birds hatched two years ago, etc. The term **ad** is used to distinguish older birds from 1cy in summer–autumn, and for birds after their first post-breeding moult that cannot be aged more precisely. In some cases, we specify with **>2cy** (Euring code 6) and **>3cy** (Euring code 8) that they are older than a second- and third-calendar-year bird, respectively. We therefore avoid ambiguous notations such as '+2y'.

Note that ageing characters are based mainly on the extents of moults, and moults occur often in the

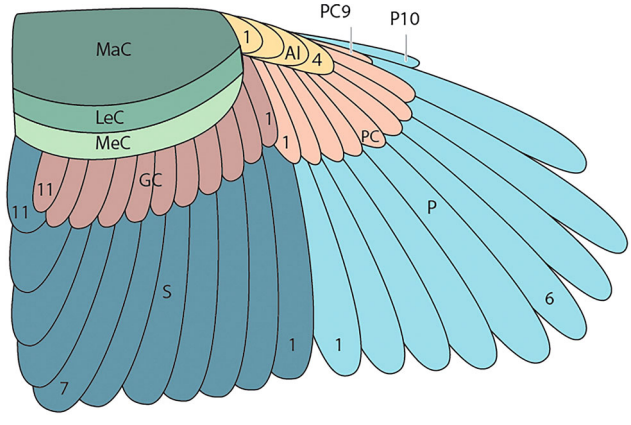


Figure 1. Abbreviations and numbering of the feathers on the wing, depicted for a Great Spotted Woodpecker: MaC, marginal coverts; LeC, lesser coverts; MeC, median coverts; GC, greater coverts 1–11; AI, alula feathers 1–4; PC, primary coverts 1–9; S, secondaries 1–11; P, primaries 1–10.

middle of the calendar year or, in the non-breeding area, across the turn of the calendar year. Therefore, the age classification based on calendar years (Euring codes) is often unsuited to our purpose, because ageing criteria are valid for only part of the calendar year (e.g. before or after the post-breeding moult), or across the turn of the calendar year. We therefore often describe ageing characters by referring to the period after a given moult, e.g. after the first post-breeding moult.

Material

For assessing the extent of moult, we used only birds which had completed moult. For all species, we examined specimens and wing preparations of the collection in the Natural History Museum of Basel. For most species, we used detailed moult protocols and photos of the wings taken by Raffael Winkler and collaborators at various sites in Switzerland, with some from Ventotene Island in Italy, Eilat in Israel, and Lake Ladoga near St Petersburg, Russia. We also used unpublished data on the moult of woodpeckers collected by the late Ernst Sutter, archived at the Natural History Museum of Basel, and we complemented our findings by descriptions and data from the literature. In particular we used the following sources:

Eurasian Hoopoe: Specimens of the Natural History Museum of Basel and moult protocols and photos taken in Switzerland, Ventotene Island and Eilat; biometrics from a breeding population in the Valais (south-west Switzerland), 2002–23.

European Bee-eater: Moult protocols and photos of birds caught at Ventotene Island. Photos and unpublished biometrics taken in the Czech Republic (Kauzál & Kauzálová 2021, 2024).

Common Kingfisher: Data from the large study by Bunzel-Drüke & Zimball (2023, 2024, 2025) on a breeding population in Westphalia, Germany, of the western subspecies *A. a. ispida*, complemented by findings from specimens of the Natural History Museum of Basel and moult protocols and photos taken in Switzerland; moult protocols of 134 birds of the eastern subspecies *A. a. atthis* examined by the late Werner Prünte in Manavgat, southern Turkey, in April on spring migration.

Eurasian Wryneck: Specimens of the Natural History Museum of Basel and moult protocols and photos taken in Switzerland, Ventotene Island and Eilat, complemented with a large data set including photos on the moult of primary coverts from a breeding population in the Valais collected by Anna Sandor and Irmi Zwahlen, 2017–24.

Great Spotted Woodpecker: Specimens in the Natural History Museum of Basel and moult protocols and photos taken in Switzerland; photos of wings taken from 217 captures of live birds at a winter ringing site at the Konrad Lorenz Institute of Ethology in Vienna examined for greater- and primary-covert moult, many of them retraps from previous years. From the same site in Vienna, we examined photos of 25 Middle Spotted Woodpeckers.

White-backed Woodpecker: Photos taken in the field from 54 individuals caught in the course of a project of the Swiss Ornithological Institute in eastern Switzerland, Liechtenstein and western Austria (see Ettwein *et al* 2025).

European Green Woodpecker: Specimens in the Natural History Museum of Basel and moult protocols and photos taken in Switzerland.

Grey-headed Woodpecker: 32 skins and wing preparations from the Natural History Museum of Basel and photos taken in the field from 39 individuals caught in the course of a project of the Swiss Ornithological Institute in Switzerland (see Gross *et al* 2023).

Most photos of wings were taken from live birds (for technique, see Jenni & Winkler 2020a) and from wing preparations by Raffael Winkler. For all other photos we indicate the contributor.

Eurasian Hoopoe *Upupa epops*

Wing and tail feathering

Eurasian Hoopoes have ten P and ten PC. P 10 is well developed, 40–50 mm long, with a white spot of variable size on the inner web, although this can be absent. PC 10 is minute (4 mm) and hidden under the MaC.

There are ten S, the innermost four covering the closed wing. S 10 is small; we could not find a reduced S 11 (as mentioned by Ginn & Melville 1983, Baker 2016, Demongin 2016, 2020). Above the S are eight well-developed GC plus a small GC 9, half of the size of GC 8, and no GC 10. Hoopoes have four Al and a carpal remex of about 28 mm (Stephan 1974) which is completely hidden under GC 1. The limit between P and S is not prominent at first sight, but recognisable by the fact that P 1 has only one white mark at the feather tip (the starting point of the white bar running across the P), and S 1 has four white marks on the inner web (the starting points of the four white bars across S 1–6). There are only five pairs of R.

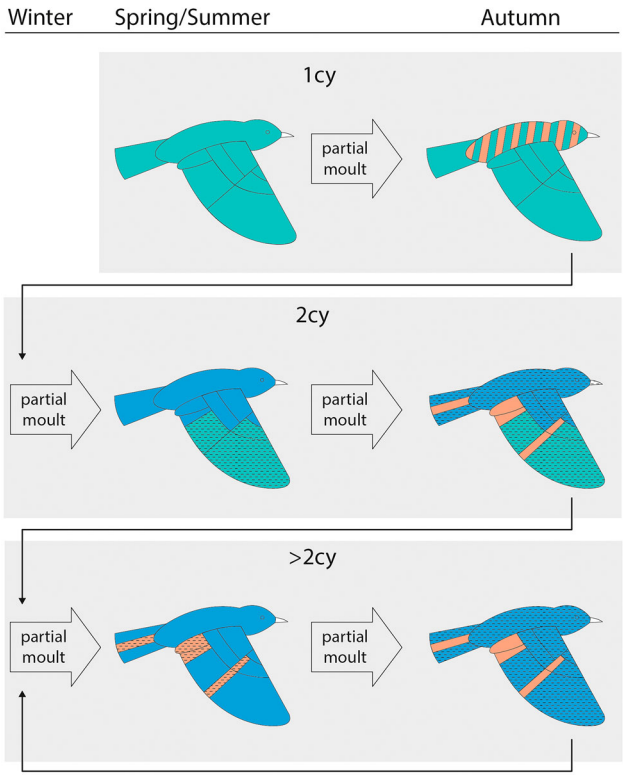


Figure 2. Schematic presentation of the moult of Eurasian Hoopoes. Adults undergo an extensive moult in the non-breeding area, while 1cy/2cy undergo a partial moult not including P and PC. All age classes may start moult in Europe before autumn migration and finish in the non-breeding area. In autumn, the P of adults are worn, the P of 1cy relatively fresh. In spring, it is the reverse, the P of adults being relatively fresh, those of 2cy worn. Colours indicate the feather generations acquired by a complete or partial moult: green, juvenile feathers; orange, feathers acquired during the post-juvenile/post-breeding moult in the breeding area; blue, feathers acquired during winter/spring in the non-breeding area (irrespective of whether they could be considered part of a continuation of the post-juvenile/post-breeding moult or a proper pre-breeding moult). Boxed arrows indicate moults. Worn feathers are indicated by hatched areas. The general ageing criteria for the various periods can be deduced by comparing the birds in the same column.

Moult

Sequence

P are moulted in the usual descendent order from P 1 to P 10. S are moulted from S 1 ascendently to S 6 and from S 7 in both directions; S 4 is the last to be moulted (according to Glutz von Blotzheim & Bauer 1980, C.S. Roselaar in Cramp 1985). However, our observations suggest that the post-juvenile moult starts at S 8 or 9 (see below). R moult starts with R 1 and then is irregular.

Post-juvenile moult

Before autumn migration, no wing and tail feathers are renewed in Europe, and probably only part of the body feathers (n = 12; Figure 2). However, two of five 1cy examined by us in Israel (on 27 September and 5 October) had all GC renewed, one of them with new S 7–10, the other with growing S 8–10, although these may be resident birds. We know of no data on the moult extent and possible moults limits within the wing coverts in 1cy birds before autumn migration.

In the non-breeding area, 1cy/2cy (n = 39) replace all wing coverts (except PC), S 7–10 and usually S 5 and 6. Not renewed are P, PC; and in most cases the outer S (Figures 2 & 3). The Al is difficult to judge but looks renewed in many cases. Most 1cy/2cy moult all R (n = 11, own data), or part or none (C.S. Roselaar in Cramp 1985).

The replacement of the S starts descending and ascending from S 8 or 9 (own obs.) and ends with S 4 (one example), S 5 (33), S 6 (four), or S 7 (one). S 9 is always replaced and S 10 in most cases (one example unmoulted). Two birds (5%) with renewed S 1–3 show that 1cy/2cy also can occasionally moult outer S. In these two cases the ascendent moult wave from S 1 inwards stopped with the retainment of juvenile S 4 and juvenile S 4–6, respectively.

Post-breeding moult

The post-breeding moult can start in August in Europe with inner S, central R and P 1–2 (n = 3; Figure 2) and then is suspended during autumn migration. The PC are moulted together with the P, this in contrast for instance

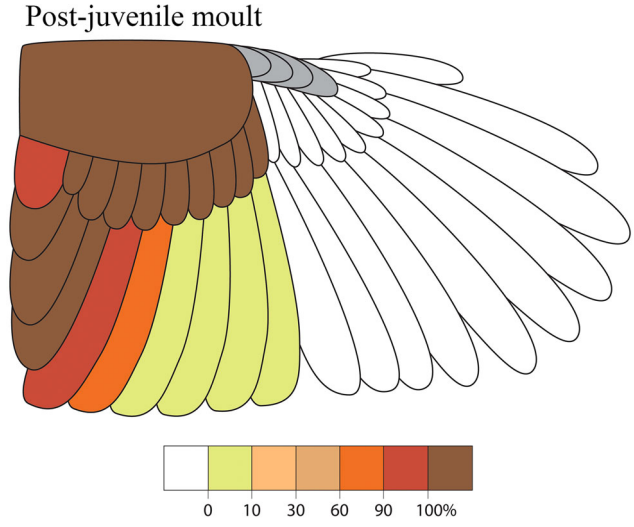


Figure 3. Extent of the post-juvenile moult performed in the breeding and non-breeding area on the wing of 1cy/2cy Eurasian Hoopoes, representing the moult extent of 2cy in spring/summer. The alula feathers, shaded grey, are not considered.

to the woodpeckers. Moult is resumed in Africa and the rest of the plumage renewed (n = 14) between November and January (February/March) (Stresemann 1944, Glutz von Blotzheim & Bauer 1980, C.S. Roselaar in Cramp 1985), or even starting in September (Stresemann & Stresemann 1966).

Pre-breeding moult

The existence and extent of a possible pre-breeding moult of head, neck and underparts are subject to debate (C.S. Roselaar in Cramp 1985). Blasco-Zumeta & Heinze (2023) make a case for such a moult in adults and some 2cy including only head and neck feathers.

Ageing criteria

Ageing Hoopoes is difficult because there is no characteristic in the patterning of the feathers that is unique to the juvenile or the post-juvenile plumage. Ageing mostly depends on the fact that in autumn the adult plumage is eight to nine months old and therefore more worn (especially the P) than the plumage of 1cy, which is only three to four months old. In spring it is the reverse, because the adults have renewed their P in Africa, whereas the 2cy have not (Figure 2). But even this characteristic may be ambiguous because the difference in wear between adults and 2cy is not distinct in all cases (Figure 9). The characteristics relating to the shape and pattern of the outermost tail feather (Baker 2016, Demongin 2016, 2020, Blasco-Zumeta & Heinze 2023) are often ambiguous, and even more so the shape of P (Baker 2016), which we therefore do not recommend for ageing.

In the breeding area before migration

1cy: The juvenile plumage resembles closely the adult plumage. Just after fledging, juveniles are darker in colour than adults, more rufous-brownish rather than pale orange-ochre, but the plumage fades rapidly (C.S. Roselaar in Cramp 1985, Corso 2000). 1cy have fresh P without signs of wear (Figure 5). It is not clear whether 1cy in autumn show any moult limits within the wing coverts, R, or S.

Ad (2cy and older): P are at least nine months old and therefore more worn than those of 1cy. Tips of P are bleached brownish, most prominent on P 4–5 (Figure 6). Some adults start P moult in Europe and in that case have innermost P fresh contrasting with the rest of the P (Figure 6). The same holds for inner S where moult limits can occur.

During and after spring migration (after the moult in the non-breeding area)

2cy: As P have not been renewed in the non-breeding area, they are worn and show bleached, brownish tips, especially on P 4–5. Their colour is usually not shiny jet-black but duller greyish-black. Moreover, there is very regularly a moult limit between inner and outer S, in most cases between old S 1–4 and new S 5–10. The moult of the inner S starts with S 8 ascendently to S 10 and descendently to S 5. This moult of the inner S proceeds probably very slowly or at two different times, as they often look differently worn; the newest is S 5, rarely S 4 or 6. The moult limit within the S is not evident because they are less exposed to abrasion than the P, so one needs to look carefully for it. For reliable ageing, both ageing criteria for 2cy (worn P and moult limit within S) must be present in combination (Figure 8). Figure 9 is an example of a tricky 2cy with deep-black and little abraded P, a hardly detectable, supposed moult limit between outer S 1–5 and inner S 6–10 as well as a seemingly old GC 1. We suppose that some 2cy can replace outer S and so look like adults in this respect. A detail to discover and to check is a possible moult limit within the GC. We observed eight of 39 2cy with possibly an old GC 1 or GC 1–2 (Figure 8). Are these seemingly old GC from the juvenile plumage or otherwise old looking?

Ad: The P of adults, freshly renewed during winter, are shiny jet-black without brownish tips (Figure 7). There are in general no moult limits within S. The S are probably moulted over a long time span and so are of different quality and should not be confused with a moult limit to be used for ageing. Often S 1–3 are a bit shorter than the inner ones (Figure 7). If inner S are replaced a second time during a supposed pre-breeding moult just before leaving Africa, a moult limit may develop resembling the one of the 2cy. Therefore, the two ageing criteria, jet-black P and no moult limits within S, must be present in combination for a secure ageing. However, breeding females of all ages often have P worn and dirty from spending time in the nest.

Sexing criteria

Not only ageing but also sexing Hoopoes is difficult. Adult males and females of a pair in direct comparison can be distinguished by the fact that males show, in general, a more intensely pinkish-grey-tinged head and breast than females, where these parts are less pink but more brownish-grey. Moreover, the streaking of the sides of the belly is more pronounced in females (C.S. Roselaar in Cramp 1985, Ericson 1997, Blasco-Zumeta & Heinze 2023).

The preen gland of females increases about eight-fold in size from the start of egg laying up to hatching, then decreases to pre-breeding size until the middle of the nestling period. During the entire period that females are in the nest incubating or brooding, the secretion is dark and pungent, not white and odourless as in males and non-breeding females (Martín-Vivaldi *et al* 2009).

On average, males are larger than females in all measures. Beware however when working with breeding birds that the female of a pair may sometimes be larger than her mate.

Wing length and bill length (measured from the distal end of the nostril to the tip of the upper mandible) are better suited for separating the sexes than the length of P 8 or R 1 (Table 1, Figure 4). When using 47.75 mm as a threshold value for bill length (smaller = female, larger = male), only 85% of birds are correctly sexed. When birds with a bill

Table 1. Descriptive statistics of bill length (measured from the distal end of the nostril to the tip of the upper mandible), wing length, length of P 8 and of R 1 (all in mm) in females (F) and males (M) of a breeding population of Eurasian Hoopoes in south-west Switzerland, measured by various ringers. The sex was determined from the size of the uropygial gland. Q values are the 10%, 25%, 75% and 90% quantiles.

	Bill		Wing		Primary 8		Rectrix1	
Statistics	F	M	F	M	F	M	F	M
Min	40.2	41.3	131.0	136.0	99.5	104.0	81.0	81.0
Q10	42.56	46.90	136.00	142.00	104.00	109.04	87.50	93.00
Q25	44.00	48.85	138.00	144.25	106.00	111.00	90.00	95.00
Median	45.40	50.35	140.50	146.83	108.00	113.50	92.50	98.00
Q75	46.90	52.10	142.50	149.50	110.91	116.00	95.50	100.50
Q90	48.25	53.64	144.13	151.17	112.50	118.00	98.00	103.00
Max	52.4	61.1	149.0	157.0	120.0	123.9	105.0	112.0
Mean	45.44	50.39	140.24	146.82	108.39	113.50	92.69	97.84
n	933	839	373	335	834	733	972	865

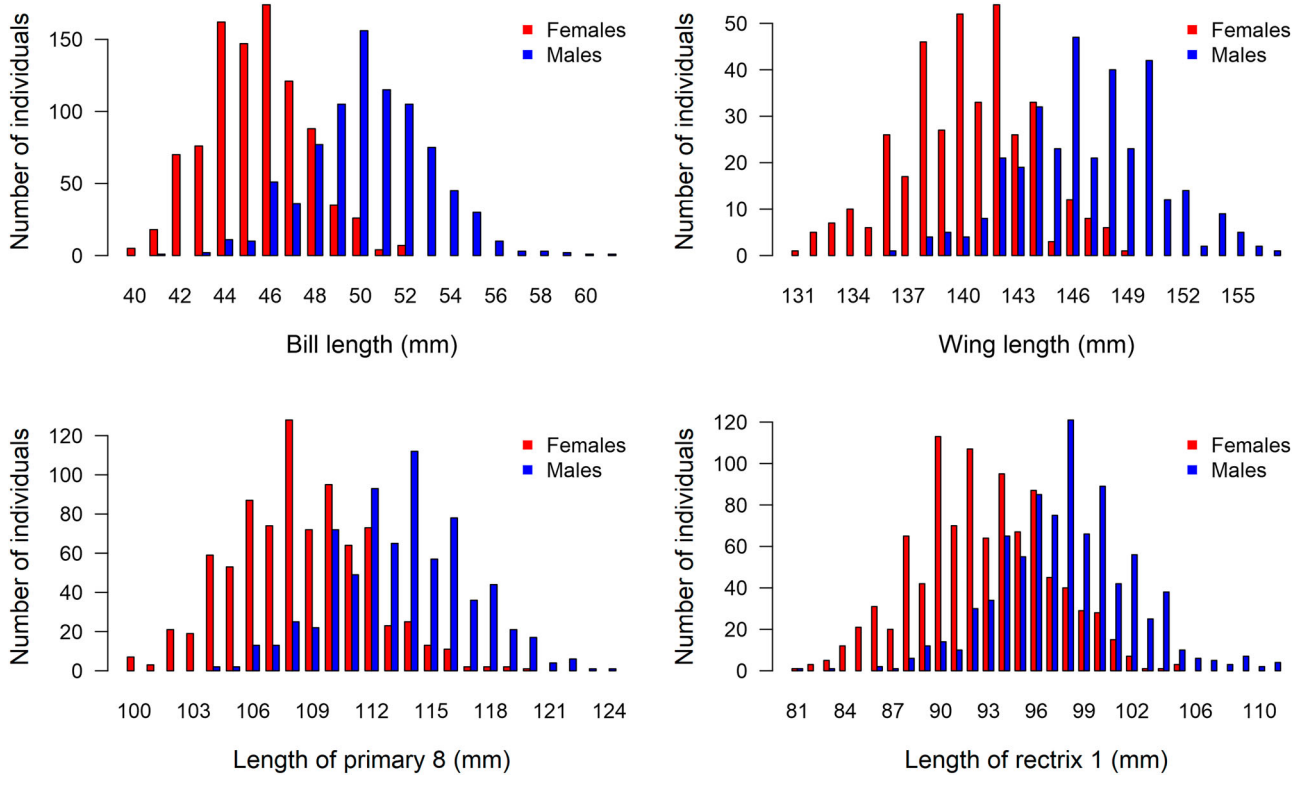


Figure 4. Frequency distributions of bill length, wing length, length of P 8 and of R 1 for male and female Eurasian Hoopoes (see also Table 1).

length shorter than 46.90 mm (or 45.40 mm) are considered as females, and birds >48.85 mm (or 50.35 mm) as males, 91% (96%) are correctly sexed, but 18% (48%) remain unsexed. Similarly, when using 143.0 mm as a threshold wing length (smaller = female, larger = male), only 81% of birds are correctly sexed. When birds with a wing length smaller than 142.5 mm (or 140.5 mm) are considered as females, and birds >144.5 mm (or 147.0 mm) as males, 88% (94%) are correctly sexed, but 17% (49%) remain unsexed.

When using both bill length and wing length in the discriminant formula D = 0.293 * bill + 0.160 * wing - 37.08, 90% of the individuals in a Swiss population can be sexed correctly, negative values of D indicating females and positive ones males. However, this formula may need to be adjusted, depending on population and on season as a proxy for primary wear.



Figure 5. 1cy Eurasian Hoopoe in juv plumage, 11 October. Entire wing juv. This bird apparently replaced no wing-feathers before departing to Africa.



Figure 6. Ad Eurasian Hoopoe after partial post-breeding moult, 27 September. P and PC 1–2 postbr. S 6 postbr, 7 growing, 8–9 postbr. Rest of wing from last winter or not assignable. Moult limit within P and S, with worn brownish tips to P 4–5, is typical for ad.



Figure 7. Ad Eurasian Hoopoe after complete moult in the non-breeding area, 23 April. Entire wing moulted last winter in the non-breeding area. Fresh, shiny jet-black wing feathers without moult limits within S safely indicate an ad. S 1–3 a touch shorter than S 4–6, as often seen in ad. Photo by Paul Mosimann.



Figure 8. 2cy Eurasian Hoopoe after partial moult in the non-breeding area, 27 April. P, PC, S 1–4 and probably GC 1 juv. Rest of wing from last winter or not assignable. Juv P and PC dull greyish-black, worn brownish tips to P 4–5 and moult limit in the S indicate a certain 2cy. Photo by Paul Mosimann.



Figure 9. Probably 2cy Eurasian Hoopoe after moult in the non-breeding area, 15 April. For a 2cy, the P are as jet-black as in ad (less so the PC), but the brownish tips on P 4 and P 5 are indicative of 2cy. GC 1 looks juv. There may be a moult limit between S 5 and 6 but it is far from clear. Photo by Thomas Degen.

European Bee-eater *Merops apiaster*

Wing and tail feathering

European Bee-eaters have ten P (the outermost is only 15 mm long and hidden under P 9), nine PC, 14 S, 15 GC, four Al, and a carpal covert (hidden under GC 1). There are six pairs of R.

Moult

Sequence

P are moulted in the usual descendent order from P 1 to P 10. S moult starts at S 13 in both directions and later at S 1 inwards, so that S 5 and 6 are last. Moult of R starts at R 1 and later at R 6, so that R 4 or R 5 is moulted last (Glutz von Blotzheim & Bauer 1980, C.S. Roselaar in Cramp 1985).

Post-juvenile moult

Some 1cy may moult some body feathers from August before autumn migration (these feathers are of the green non-breeding plumage type, as in adults; Figure 11b), but probably most migrate in full juvenile plumage (C.S. Roselaar in Cramp 1985, Kauzál & Kauzálová 2021). 1cy do not start P moult in the breeding area (Figure 10).

In the non-breeding area, 1cy moult almost completely from October/early November until February/March (C.S. Roselaar in Cramp 1985, Kauzál & Kauzálová 2021). Only the juvenile PC remain unmoulted (Figure 10; 15 2cy examined on Ventotene Island had all P renewed, but no PC; Winkler 2003). This has been largely overlooked in the literature, although the resulting difference in colour to adult PC had been used for ageing (e.g. Lessells & Krebs 1989, Baker 2016, Kauzál & Kauzálová 2021). The feathers acquired in the non-breeding area are of the colour of the breeding plumage.

Post-breeding moult

Most adults (2cy and older) start a limited moult in mid-June to July which involves part of the body feathers, followed in August by some P with their corresponding PC in most individuals (Figure 10; Glutz von Blotzheim & Bauer 1980, C.S. Roselaar in Cramp 1985, Kauzál & Kauzálová 2021). At least some of the birds which start moulting their P, moult also part of their LeC (own data). Whether other wing coverts are moulted is unknown.

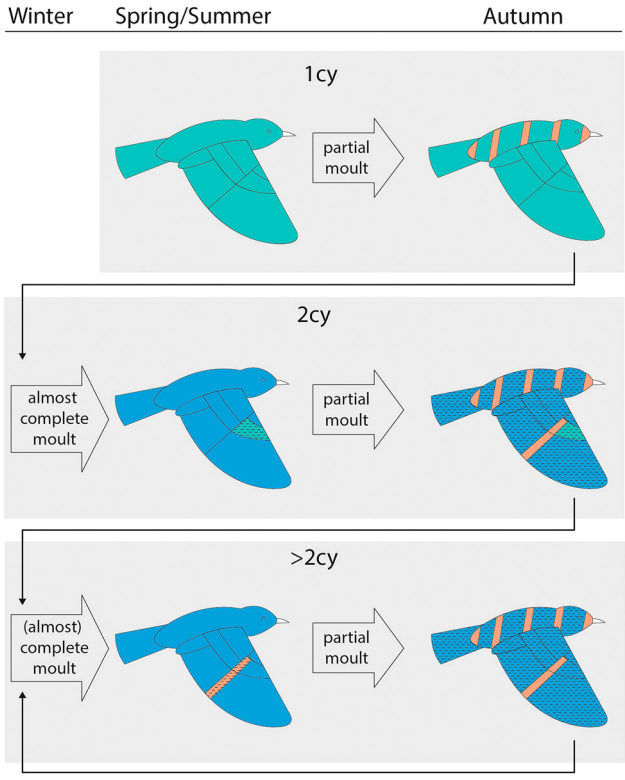


Figure 10. Schematic presentation of the moult of European Bee-eaters. Most adults start moult after breeding in summer, suspend moult during autumn migration, and moult the major part of the plumage in the non-breeding area. Before spring migration, they may undergo a partial pre-breeding moult of limited extent. Some 1cy birds may moult part of the body feathers before autumn migration, but most moult only in the non-breeding area. Here, moult is complete except for the PC. Key as in Figure 2.

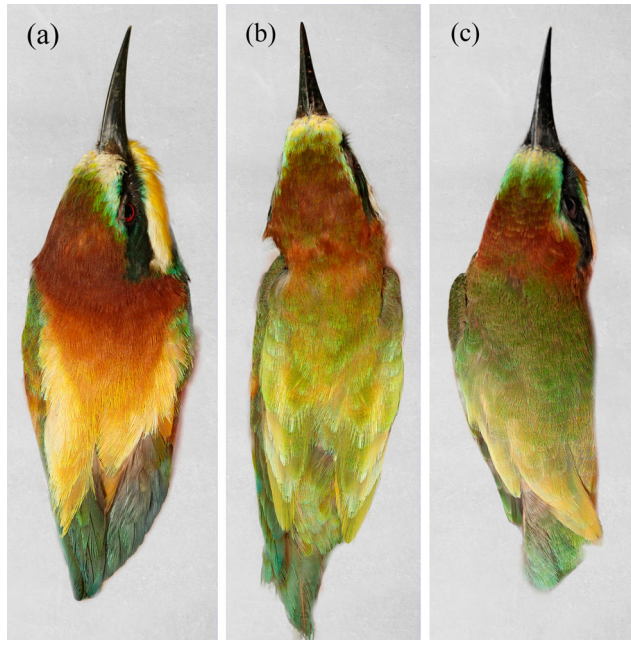


Figure 11. European Bee-eaters: (a) breeding plumage of a female, (b) non-breeding plumage of a female and (c) juv plumage. The photographers' hands were digitally removed from the pictures. Photos by Ondrej Kauzál and Tereza Kauzálová.

In a Czech population, 70% of adults in June–early August moult some feathers on back, neck and around the brood patch (own data; n = 267). The feathers on head and back acquired in the breeding area are greenish and form a non-breeding plumage carried for only two to three months (Figure 11b). 70–90% of adults moult one to four P before autumn migration: in south-eastern Czech Republic no P 5%, P 1 37%, P 1–2 57%, P 1–3 1% (n = 104 adults from the breeding seasons 2019–23 in the photo gallery by Kauzál & Kauzálová 2024); in Iberia no P 21%, P 1 8%, P 1–2 50%, P 1–3 17%, P 1–4 4% (n = 24, Mead & Watmough 1976); on Ventotene Island, Italy, no P 7%, P 1 10%, P 1–2 55%, P 1–3 28%, always together with the corresponding PC (n = 29, birds examined in spring, Winkler 2003); in Kazakhstan, 75% of the migrating adults in August/September had moulted some innermost P (up to P 4, n = 832; Y.G. Savin & A.P. Gistsov in Fry 1984); in southern France, a third of the adults had started P moult in August (n = 25; but possibly more will start later), and if P 3 is reached, also S 13 and S 14 may be moulted (Glutz von Blotzheim & Bauer 1980).

After suspension for autumn migration, the post-breeding moult is resumed in the non-breeding area from mid-October or November (Figure 10). The remaining remiges and all R are moulted, and the remaining body feathers and wing coverts are replaced by feathers of the breeding plumage. Moult is completed by February. The PC are moulted together with the corresponding P.

Pre-breeding moult

This moult occurs from December to March in the non-breeding area. It involves those parts of head, body and wing coverts which were replaced by non-breeding feathers during the post-breeding moult (C.S. Roselaar in Cramp 1985). Hence most 1cy/2cy birds probably have no pre-breeding moult, because most of them started the post-juvenile moult only in the non-breeding area. However, it remains an open question which feathers moulted in the non-breeding area are to be considered part of the (resumed) post-juvenile/post-breeding moult and which belong to the pre-breeding moult (see Jenni & Winkler 2020a).

Ageing criteria

In the breeding area

1cy: Birds in juvenile plumage (and after a possible restricted moult of body feathers) have all R of the same length, or R 1 only slightly longer (beware of adults with worn and broken streamers). The central pair R 1 are often slightly more intensely green and look less abraded than R 2–6, simulating a moult limit. Most 1cy have a dark-brown or reddish-brown iris, not red as in most adults (Figure 12). The body plumage is variable: some have dull-green feathers on the nape, upperparts (resembling the non-breeding plumage of adults, Figure 11c), and wing coverts (Figure 15), light-green back and rump (not yellow-golden), some have a yellowish back (Figure 13; Kapun *et al* 2011, Kauzál & Kauzálová 2021). Rarely, there are birds with a very green upper side, hardly any brown on forehead and lacking a black throat border, resembling juvenile Blue-cheeked Bee-eaters *Merops persicus* (Müller 2009, Kauzál & Kauzálová 2024).

2cy: PC still of the juvenile plumage with a bleached pale-blue outer vane, and progressively worn, contrasting with the green base of the renewed P and Al (Figures 21 & 22). No contrast in wear within P and PC. R1 elongated, as in >2cy (if not broken off).

>2cy: PC fresh and of the same colour as the base of the P. Most >2cy show innermost one to four P slightly older than the rest, because they had been moulted before autumn migration and are about two months older than the other P. This difference in wear in the corresponding PC is hardly visible. R 1 elongated, as in 2cy (if not broken off). For the rare adults with a dark-green mantle and a light-green back, see sexing.

During and after the post-breeding/post-juvenile moult in autumn in the breeding area

Because the post-juvenile and post-breeding moults in the breeding area do not affect R and all of the PC, the ageing criteria above still hold. In addition, birds with growing or freshly renewed innermost P are adults (Figures 16–18). In autumn, the renewed P are conspicuous (Figure 18). Birds without growing or renewed innermost P are mostly 1cy, but about 10–30% of adults also do not renew any P before arrival in the non-breeding area.

The feathers on head and back acquired during the post-breeding moult in the breeding area in 2cy and >2cy are greenish, resembling the juvenile plumage more (Figure 11b).

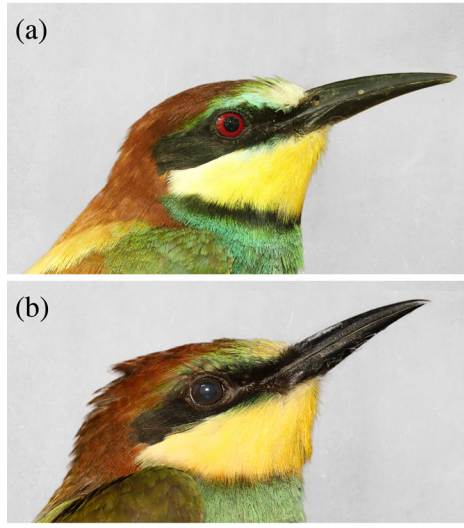


Figure 12. European Bee-eater iris colours: (a) ad male in July with red iris, (b) juv in August with dark-brown iris. Photos by Ondrej Kauzál and Tereza Kauzálová.

Sexing criteria

Many, but not all, birds can be sexed by plumage coloration (mainly after Kauzál & Kauzálová 2021, Bastian & Bastian 2022 and Blasco-Zumeta & Heinze 2023) and biometrics (see below). Both sexes have a brood patch.

Adults (2cy and older): Males have central GC, MeC and LeC rufous-chestnut on both feather vanes (Figure 19). Adult females have more greenish central GC, MeC and LeC without or with only little rufous-chestnut. Their central GC are rufous-chestnut only on outer vane (Figure 20), bordered by a bluish-green edge, inner vane greenish. The yellow throat is usually paler than in males and bordered by a narrower black ring (Todte & Harz 2003).

Not all birds can be sexed by plumage characters, there are intermediates, especially among 2cy (Costa *et al* 2020). In a Czech population, 9.3% of the adults were found to be incorrectly sexed on plumage characters when they were subsequently genetically sexed (own data; n = 208). Moreover, rarely birds with greenish upperparts, rather than brown and golden, have been observed during breeding (Todte & Harz 2003). These may be birds which skipped the pre-breeding moult.

Sexing from August onwards may become more difficult when the greenish body feathers have been acquired and the LeC and MeC are moulted together with the innermost P. However, GC seem to be moulted only in the non-breeding area and certainly help in sexing, but we advise caution in sexing birds with advanced wing-covert moult.

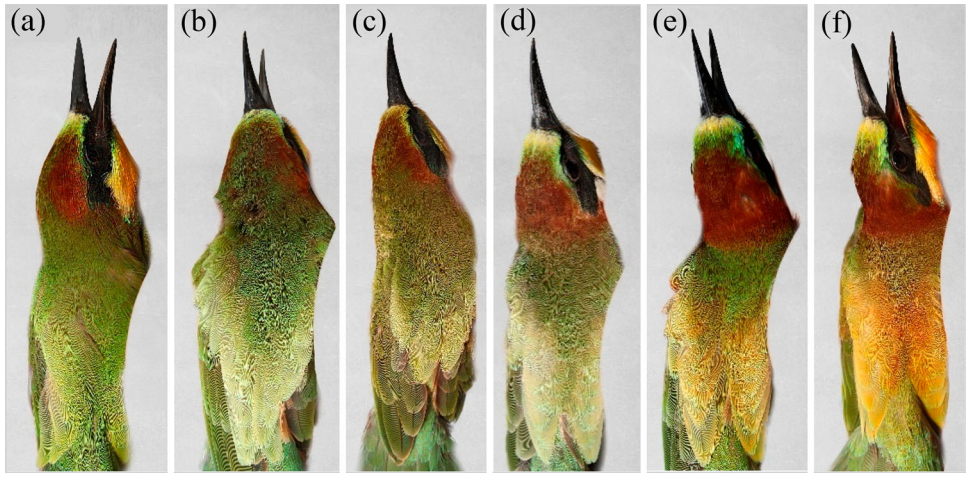


Figure 13. Colours of the back and scapulars of 1cy European Bee-eaters from the Czech Republic in July and August show a continuum from green to yellow. If categorised by two persons (OK, TK) into green (a–b) and yellow (d–f; c being scored both green and yellow), birds scored as green are mainly females (73–80%, 20–27% males), birds scored as yellow are mainly males (61–72%, 28–39% females). Overall, about 70% have been correctly sexed (n = 69, sex genetically determined). In these examples, a–d are females, e–f are males. The photographers' hands were digitally removed from the pictures. Photos by Ondrej Kauzál and Tereza Kauzálová.

Juvenile plumage: Birds in juvenile plumage cannot be sexed reliably because of a great overlap, except the typical ones: Typical males have GC and S tinged chestnut, more chestnut on crown and nape, and pale-golden upperparts. Typical females have GC and S tinged greenish, more greenish on the crown and nape, and greenish upperparts (Demongin 2016, Bastian & Bastian 2022, Blasco-Zumeta & Heinze 2023). Older nestlings and 1cy in summer show a variation in the colour of the back from green to yellow. While most (or all; Kapun *et al* 2011) can be categorised as green or yellow, we consider there are intermediate colours difficult to assign. The colour morphs correspond to males and females, respectively, in about 70% of cases (see Figure 13).

Biometrics

Adult males are generally larger than adult females in almost all measures (reviewed by Bastian & Bastian 2022), while 2cy and >2cy do not differ significantly in size (Costa *et al* 2020). Single measures show considerable overlap between the sexes (Table 2, Figure 14) Therefore using single measures to separate the sexes does not perform well. When birds of a Czech population (Table 2) with a wing length <146.5 mm (or <144.0 mm) are considered as females, and birds >151.5 mm (or >153.5 mm) as males, 94% (100%) are correctly sexed, but 48% (78%) remain unsexed. Similarly, when birds with a streamer length <18.0 mm (or <16.0 mm) are considered as females, and birds >24.0 mm (or >25.0 mm) as males, 92% (94%) are correctly sexed, but 45% (70%) remain unsexed.

However, two or three measures combined proved to separate the sexes correctly in about 90% of genetically

Table 2. Descriptive statistics of bill length (measured from skull to tip of bill), maximum wing length, tail length (length of R 1 measured with a ruler inserted between R and under-tail coverts), and length of the streamer (see Figure 14) in adult females (F) and males (M) of a Czech breeding population of European Bee-eaters, measured (in mm) and genetically sexed by OK and TK. Q values are 10%, 25%, 75% and 90% quantiles.

	Bill		Wing		Tail		Streamer	
Statistics	F	M	F	M	F	M	F	M
Min	30.9	35.6	140.5	145.5	90.0	90.5	0.0	0.0
Q10	36.46	38.08	143.00	148.50	102.00	109.70	13.30	19.00
Q25	38.55	39.45	144.00	150.00	105.00	112.00	16.00	21.00
Median	39.70	40.40	146.50	151.50	108.00	115.00	18.00	24.00
Q75	41.08	42.08	148.00	153.50	110.00	118.00	19.00	25.00
Q90	41.81	43.00	150.00	155.00	112.00	119.65	20.70	27.00
Max	44.4	48.3	153.0	159.5	116.0	129.0	22.0	32.0
Mean	39.51	40.68	146.37	151.61	107.45	114.24	17.30	23.09
n	74	87	81	88	76	88	74	85

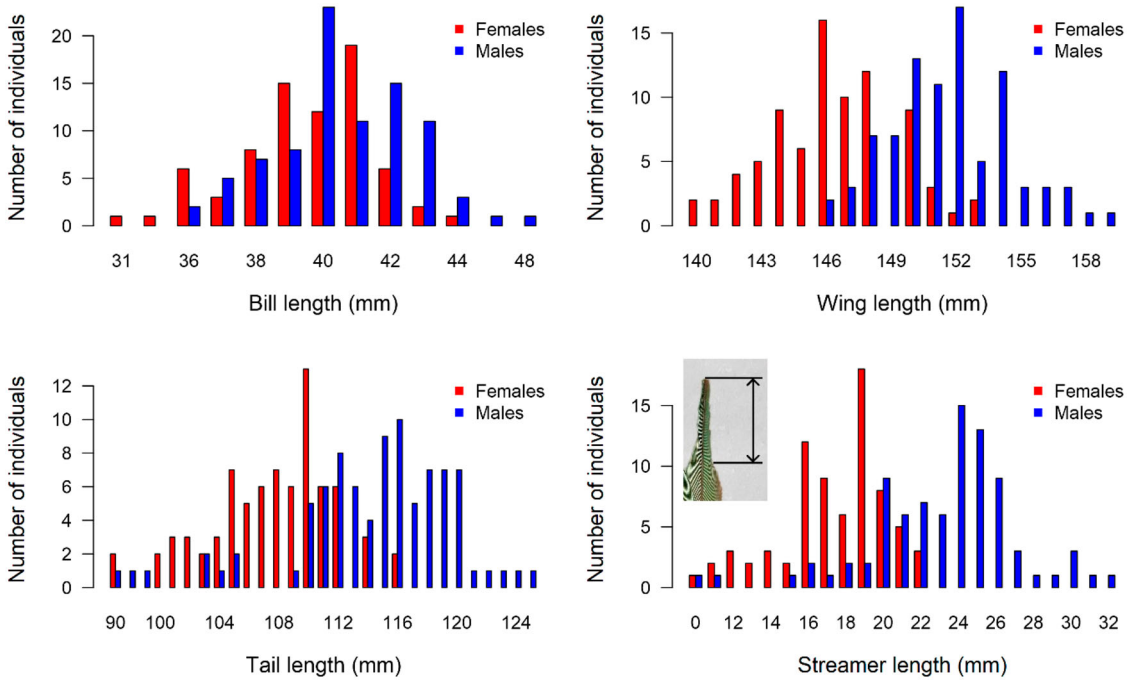


Figure 14. Frequency distributions of bill length, wing length, tail length and streamer length for adult European Bee-eaters (see also Table 2).

sexed birds. The sexes of German and Portuguese birds best separate using the discriminant formula: D = 0.200∗W + 0.239∗TT - 34.29, where W is maximum wing length and TT is tail-tip length (from the tip of the longest to the tip of the shortest tail feather); negative values indicate females, positive ones males; 93% correctly classified (Costa et al 2020, where other discriminant functions including head-and-bill length are also given).

The sexes of Czech birds could be separated with 89% accuracy using wing length and either tail or streamer length or combinations of three measures (wing with any two of tail, streamer and bill). Because tail length is more easily measured, we provide the discriminant formula D = 0.277 * W + 0.123 * T - 55.06, where T is tail length (see Table 2); negative values indicate females, positive ones males. However, the performance of these formulae may vary with population, the person measuring, and wear of wing and streamer.

In juveniles of the Czech population from August, when wing and tail feathers are fully grown, wing, bill and tail lengths are shorter than in adults (Table 3). While primaries and tail feathers get their adult size when moulted, the bill probably grows continuously, and hence is not suitable for sexing over a large period of time. The overlap between the sexes of juveniles is larger than in adults, and hence single measurements perform poorly. Sexes are separated with an 84% accuracy by the discriminant formula D = 0.626 * B + 0.139 * T - 36.04, where B is bill length measured from skull to bill tip. If bill length is to be avoided, the formula D = 0.121 * W + 0.062 * T - 21.92 separated the sexes of 73% of birds correctly.

Table 3. Descriptive statistics of biometrics for female (F) and male (M) 1cy European Bee-eaters, from August, with fully grown wing and tail feathers. Details as in Table 2.

	Bill		Wing		Tail	
Statistics	F	M	F	M	F	M
Min	33.3	35.3	133.5	137.0	78.0	83.0
Q10	35.21	36.20	135.00	140.00	79.30	84.10
Q25	36.13	38.05	138.75	141.00	83.00	86.25
Median	37.40	38.40	140.00	144.00	85.50	88.00
Q75	37.78	39.85	141.38	146.75	89.00	90.75
Q90	38.33	41.35	142.50	149.75	90.00	92.80
Max	39.5	42.2	145.0	151.5	91.0	96.0
Mean	37.00	38.75	139.68	144.22	85.52	88.55
n	18	16	14	16	27	22



Figure 15. 1cy European Bee-eater in juv plumage, August. Entire wing is juv. No bright colours; wing coverts dull brownish-green. Photo by Ondrej Kauzál and Tereza Kauzálová.



Figure 16. > 2cy male European Bee-eater, 12 August. Start of post-breeding moult in the breeding area with growing P 1. P and PC of the same colour, therefore >2cy. Photo by Ondrej Kauzál and Tereza Kauzálová.



Figure 17. 2cy male European Bee-eater, 18 August. Start of post-breeding moult in the breeding area with growing P 1 and 2. Note PC 2 (PC 1 not visible) growing together with its P, and growing LeC and MaC. PC very worn and different in colour to P, therefore 2cy. Photo by Ondrej Kauzál and Tereza Kauzálová.



Figure 18. 2cy female European Bee-eater after partial post-breeding moult, 10 September. P 1 and PC 1 renewed, PC 2–9 juv. Rest of wing renewed in the non-breeding area. This bird started P moult with P 1 in the breeding area and suspended it for autumn migration. PC 2–9 are very worn, hence juv, and indicate a 2cy. Photo by Irmi Zwahlen.



Figure 19. Ad male European Bee-eater after complete post-breeding moult, 1 May. P 1–3 with corresponding PC renewed before autumn migration, rest of wing after migration in the non-breeding area. Moult limit between older inner P and newer outer P is typical for ad birds in spring. Due to progressive bleaching, P 1–3 have light-blue outer vanes, not greenish-blue as in P 4–9. Male-type wing coverts with central MaC, LeC and MeC deep orange. Central GC orange on both vanes. Photo by Paul Mosimann.



Figure 20. Ad female European Bee-eater after complete post-breeding moult, 28 April. P 1–2 with corresponding PC renewed before autumn migration, rest of wing after migration and in the non-breeding area. Moult limit between older inner P and newer outer P typical for adults in spring. P 1–2 with light-blue outer vane, due to progressive bleaching, not greenish-blue as in P 3–9. Female-type wing coverts with most MaC, LeC and MeC greenish. Central GC with orange outer but brownish-green inner vane. Photo by Paul Mosimann.



Figure 21. 2cy male European Bee-eater after nearly complete post-juvenile moult, 1 May. Entire wing postjuv, except PC 1–9 juv. The unmoulted juv PC are light blue on the outer vane due to bleaching and contrast with the green bases of the renewed P. There is no moult limit between inner and outer P, because 1cy start their P moult only in the non-breeding area. Male-type wing coverts. Together with the basal parts of the S, they form a large, bright, continuous orange patch on the wing. Photo by Paul Mosimann.



Figure 22. 2cy female European Bee-eater after nearly complete post-juvenile moult, 29 April. Entire wing postjuv, except PC 1–9 juv. The colour difference between retained PC and renewed P not striking, but is visible at a second glance. No moult limit within inner P. Female-type wing coverts, with much green on MaC, LeC and MeC. Inner vanes of GC brownish-green. Photo by Paul Mosimann.

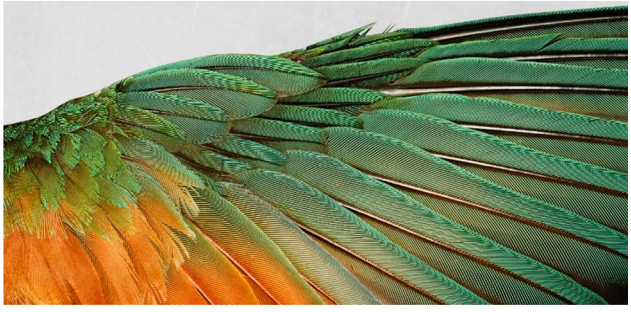


Figure 23. Ad male European Bee-eater after complete post-breeding moult, 1 May. Entire wing postbr. No colour difference between PC and the bases of P is typical for ad; base of P 1 slightly brighter because it had already been moulted before autumn migration; PC 1 hidden. Photo by Paul Mosimann.

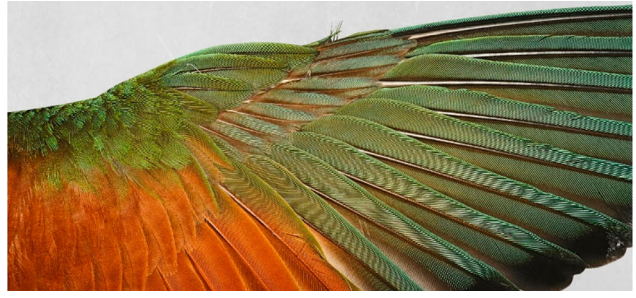


Figure 24. 2cy male European Bee-eater after nearly complete post-juvenile moult, 1 May. Entire wing postjuv except PC 1–9 juv. The unmoulted juv PC are light blue on the outer vane due to bleaching, and contrast with the green bases of the renewed P. This colour difference is typical for 2cy. Photo by Paul Mosimann.

Common Kingfisher *Alcedo atthis*

Wing and tail feathering

Common Kingfishers have ten P (P 10 is almost as long as P 9) and 13 S. S 13 is small (Figure 35); we could not find a reduced S 14 (as mentioned by Ginn & Melville 1983, Baker 2016 and Demongin 2016). 6% of *A. a. ispida* from Westphalia, Germany, had one supernumerary S (thus 14 S) on one or both wings (n = 2201; Bunzel-Drüke *et al* 2025). There is a carpal covert and four Al. PC 10 differs from PC 1–9 by being 3 mm shorter than PC 9 (which is 4 mm shorter than PC 8), narrower, more pointed and edged light blue, not greenish as the other PC. Furthermore, there is a 4–5-mm-long remicle which is attached to the tip of digit 2, hidden under P 10 and the underwing coverts. This feather, also known as minute P 11, was, strangely, ignored by Stresemann (1934), Glutz von Blotzheim & Bauer (1980) and C.S. Roselaar in Cramp (1985) but mentioned by Stephan (1970). There are normally six pairs of R; 6% of birds (2% males, 10% females) have 13 or 14 (15) R and 0.1–0.2% 11 or 10 R (n = 17 709 nestlings and 3165 fully grown birds; Bunzel-Drüke *et al* 2025; similarly Kotyukov 2016, Doucet 1971). For lengths and mass of remiges and rectrices, see Bunzel-Drüke *et al* (2023).

In the Common Kingfisher there is a tendency to have blue feathers on those parts of the wing that are fully visible in a sitting bird and to reduce blue colour and sparkling light-blue feather tips on parts that are covered on the folded wing. The GC, largely covered by each other and the MeC and LeC on the closed wing, have no sparkling blue tips, or only small ones, in contrast to the highly visible MeC and LeC and part of the MaC with their well-developed tips. However, the innermost two or three GC (GC 10–12) that cover the rest of the GC on the folded wing are more intensely blue, have sparkling tips and can, owing to this colour difference, simulate a moult limit (Figures 35, 36 & 39). P and S are blue only on the outer vane, but S 10–12, which cover the closed wing and are fully visible, are blue on both vanes. Also, the outermost R, covered by the rest of the tail, is less intensely blue. The colour of the distal part of the outermost PC 10 is not greenish as that of PC 1–9 but has the same light-blue colour as the outer vanes of P 1–9 (already in juvenile plumage). Conversely, P 10 is all dark-brown, without any blue. Since PC 10 lies exactly over the base of P 10, its light-blue colour compensates for the lack of light blue of the outer vane of P 10. It seems that the physiological costs of producing shining blue feathers are only worthwhile in plumage that is visible on the closed wing.

Moult of the Western Common Kingfisher Alcedo atthis ispida

This account is based mainly on the findings of Bunzel-Drüke & Zimball (2023, 2024, 2025) from 6040 captures, among them many retraps, of breeding birds in Westphalia, Germany, of the western subspecies *A. a. ispida*.

Sequence

The unusual sequence of the moult of remiges was discovered early (Stresemann 1921, Stresemann & Stresemann 1961). P moult starts from two centres, i.e. simultaneously from P 1 and P 7, each progressing descendently, and finishes with P 6 and P 10 (Figure 25). Moult is slow; the next P is shed only when the previous one has reached two thirds its full length. GC and most other wing coverts are moulted before the S (Martínez 1982, Kotyukov 2001). Together with P 1 and P 7, S moult starts with S 10 progressing both ascendently and descendently, and later with S 1 ascendently (Figure 25). The sequence of R moult is irregular. Moult is often asymmetrical between the wings, and increasingly so with age.

Unlike most other birds, kingfishers do not moult the primary coverts in sequence with the respective primaries (Doucet 1971). When P 7 is growing, PC moult starts with PC 10, and later with central PC, PC 9 is moulted last (Bunzel-Drüke & Zimball 2024).

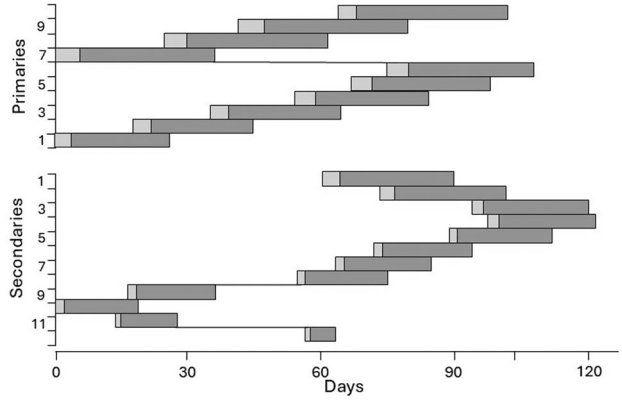


Figure 25. Sequence of the moult of the remiges and mean growth duration when all remiges are moulted in a complete moult (which is rare). The light section of a horizontal bar represents the part of the feather embedded in the skin; the dark section represents the visible part of the feather. Redrawn from Bunzel-Drüke & Zimball (2024).

Post-juvenile moult

Partial (Figure 26): All or part of body feathers, none or some R, mostly R 1 (–2–3(–4)). P, S and all wing coverts are retained until the first post-breeding moult (C.S. Roselaar in Cramp 1985, Bunzel-Drüke & Zimball 2024).

Timing and extent of the post-juvenile moult are variable due to the protracted fledging period (May–September); it starts in July/August or later, and ends in October–December. Early-fledged 1cy moult extensive parts or all of body feathers and some R, while some late-fledged ones are still in juvenile plumage in December (C.S. Roselaar in Cramp 1985, Bunzel-Drüke & Zimball 2024). The juvenile plumage is of a similar quality to later feather generations, reducing the pressure for renewal.

In Westphalia, Germany, 68.2% of males and 56.5% of females renew some R, preferably the central R. Only four of 1946 1cy birds moulted P 7 (and one S 10) in their first summer (Bunzel-Drüke & Zimball 2024).

The post-juvenile moult is arrested during winter, but some body-feather moult may occur throughout the year. Moult is resumed in spring (Figure 26; see pre-breeding moult). It remains unclear whether this is a continuation of the post-juvenile moult, a separate pre-breeding moult, or both (C.S. Roselaar in Cramp 1985).

Post-breeding moult

The breeding season with up to four broods is very long (end of March–August/September); moult of adults starts regularly after the first brood and hence frequently overlaps with breeding (Glutz von Blotzheim & Bauer 1980, Kotyukov 2001, Bunzel-Drüke & Zimball 2024).

The post-breeding moult of remiges can be complete, but is mostly only almost complete (Figure 26). It starts with body feathers and P in June–August, during breeding, and finishes mid-October–November/December (in migrants sometimes in the non-breeding area; Martínez 1982). However, some birds, especially females, may start moult of remiges as early as March (Bunzel-Drüke & Zimball 2024). Up to about August, moult of remiges is slow, and 20% of 2cy as well as 15% of >2cy temporarily halt moult, especially during chick rearing. From the second brood onwards, adults increasingly overlap moult with breeding (ca. 50% in July and 80% in August and September; Doucet 1971, Bunzel-Drüke & Zimball 2024).

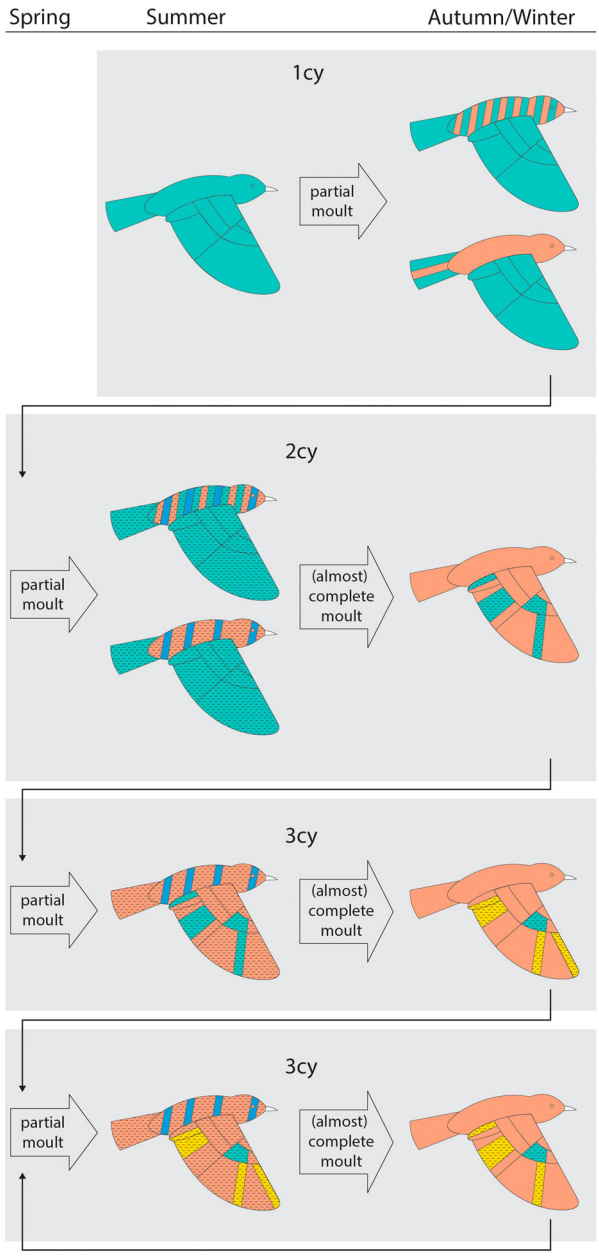


Figure 26. Schematic presentation of the moult of Western Common Kingfishers. The post-breeding moult of remiges is rarely complete; most adults suspend moult before winter. The unmoulted remiges are moulted before or during the next moult (rarely as early as spring). 1cy birds undergo a partial moult of variable extent. A pre-breeding moult occurs in spring. Colours indicate the feather generations acquired by a complete or partial moult: green, juvenile feathers; orange, feathers acquired during the post-juvenile/post-breeding moult; if these are not moulted during the subsequent post-breeding moult, they are coloured yellow; blue, feathers acquired during winter/spring. Boxed arrows indicate moults.

To maintain flight capability, the moult of remiges is slow, and an uninterrupted moult lasts about 120 days (Figure 25; Doucet 1971, Bunzel-Drüke & Zimball 2024).

For many birds, this is too long to accomplish before winter, despite an overlap with breeding, and moult is suspended in autumn to be continued in the following year from the point of interruption before or during the next moult.

2cy: In Westphalia, Germany, only 16% moult the remiges completely during the first post-breeding moult. 84% retain on average 8.5 remiges (range 1–31, sum of both wings; Bunzel-Drüke & Zimball 2024). Mostly S 2–5 and S 12, as well as P 6 remain unmoulted, i.e. those moulted last in a complete moult (Figure 27). In Belgium, more than 61% (possibly 83%) suspend moult of remiges (Doucet 1971).

In Westphalia, 61.5% moulted no PC, 38.5% moulted only PC 10 of at least one wing (mostly when P 7 was growing) (Bunzel-Drüke & Zimball 2024). PC 10 is moulted much earlier and more often than the other nine primary coverts.

3cy: The second post-breeding moult of remiges continues from the point where moult was suspended in the previous year (Figure 26). Particularly females with a high number of retained remiges may start as early as spring (Morgan 1998, Bunzel-Drüke & Zimball 2024). After the retained feathers are renewed, or sometimes simultaneously, a second moult cycle starts in the same way as the first (Doucet 1971, Bunzel-Drüke & Zimball 2024). If the second moult of remiges starts before the first is completed, three generations of remiges may be present for a short time (Glutz von Blotzheim & Bauer 1980). This would represent a serial moult, i.e. two concurrent waves of moult.

The second post-breeding moult of remiges is not a complete one in 73.8% of birds. Because the feathers retained during the first post-breeding moult have been renewed, the feathers retained during the second post-breeding moult are often those adjacent, i.e. often S 5–7 and sometimes P 5–6 and 10 (Figures 27 & 28; Bunzel-Drüke & Zimball 2024). However, if all remiges were moulted in the first post-breeding moult, and the second post-breeding moult is incomplete, the pattern of old and new remiges will be similar to the one after the first post-breeding moult. The number of retained remiges is higher in females than in males and decreases from the first to the second post-breeding moult (from 6.0 to 4.6 in males and from 9.7 to 6.1 in females, sum of both wings; Bunzel-Drüke & Zimball 2024). Fewer than 30% moult any of PC 1–9, these averaging only three or four across both wings (Figure 27; Bunzel-Drüke & Zimball 2024), while PC 10 is moulted by most 3cy.

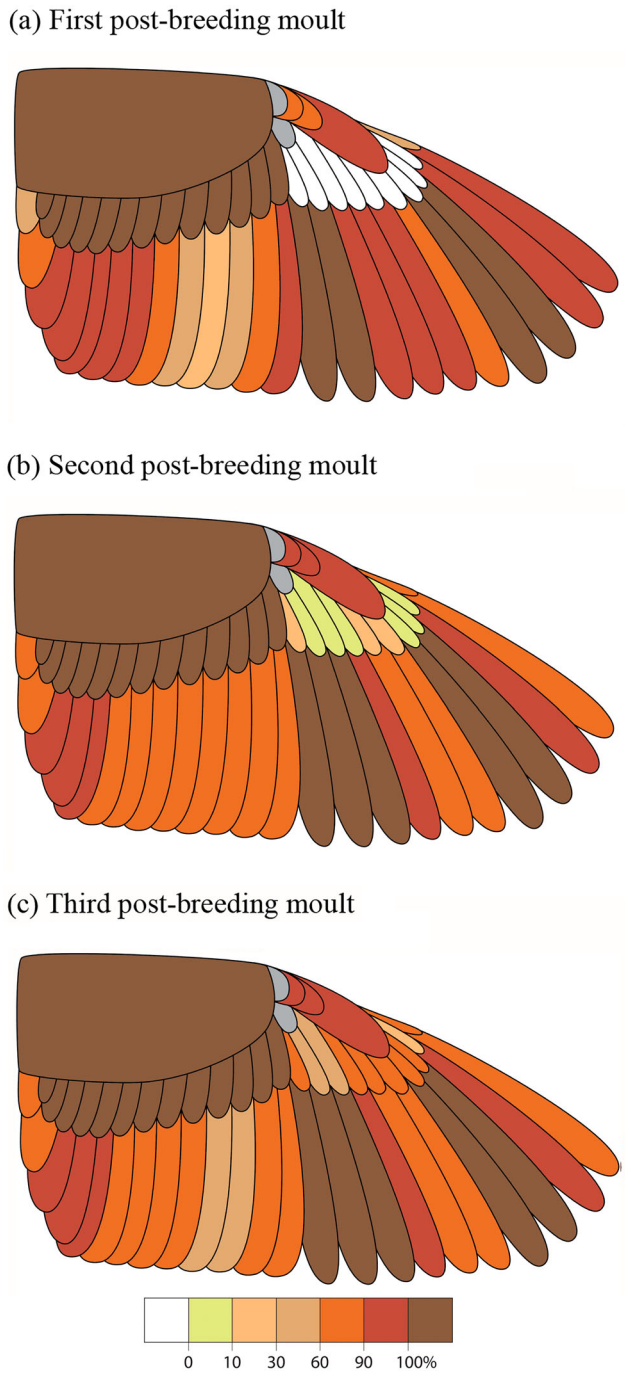


Figure 27. Extent of (a) the first, (b) second and (c) third post-breeding moult on the wing in the Westphalian population of Western Common Kingfisher. The carpal covert, shaded grey, is not considered. For the PC of the third post-breeding moult, the proportion of non-juvenile PC is given, which includes a few PC moulted only in the second and not the third post-breeding moult. Provisionally, we assigned all GC as renewed, although GC may exceptionally be retained (Figure 38); it remains unclear how often this occurs.

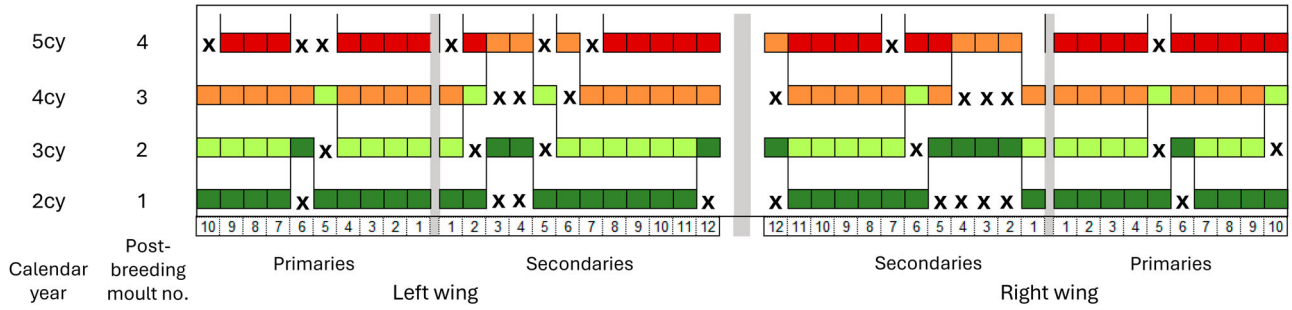


Figure 28. Pattern of renewed remiges in a male Western Common Kingfisher examined after four consecutive post-breeding moults. The remiges moulted during the first, second, third and fourth post-breeding moult are marked on the respective line with coloured squares, and those not moulted with a cross. The remiges of the same feather generation are marked with the same colour and are connected with lines. After the first post-breeding moult, the wing consists always of two feather generations. Note the different moult patterns on its left and right wings. Redrawn from Bunzel-Drüke & Zimball (2024).

>3cy: The third post-breeding moult of remiges starts with the retained feathers from last year. When again unmoulted feathers are left at the end of the third post-breeding moult (92.6% of birds; Figure 27), the pattern of old and new remiges is similar to the one after the first wing moult (Figure 28; Bunzel-Drüke & Zimball 2024).

Most 4cy birds (80%) renew some of PC 1–9 (Figure 27). PC 9 is the last to be renewed. PC 10 seems to be renewed by most. All seven 5cy bird examined, after their fourth post-breeding moult, renewed some PC 1–9. Moult of all juvenile PC on both wings is very rare and may happen during the third or fourth post-breeding moult as 4cy or 5cy, an age most kingfishers do not reach, or later (Bunzel-Drüke & Zimball 2024).

Pre-breeding moult

2cy and adults renew some body feathers in winter/early spring (mainly in March) before courtship, males with a slightly higher intensity than females (Figure 26; Glutz von Blotzheim & Bauer 1980, Bunzel-Drüke & Zimball 2024).

Moult of the Common Kingfisher of eastern Europe Alcedo atthis atthis

This subspecies is distinctly smaller and in eastern Europe mainly migrant compared to the German population of the western subspecies of which only about 10% migrate to the western Mediterranean (own data). While the moult sequence of the remiges is the same, birds from eastern Europe also moult extensively in the winter quarters. However, much of the seasonal timing and extents of the moults of the various age classes in the breeding and the wintering areas remain unknown. The following account therefore remains provisional. It refers to the eastern European populations and is mainly based on the reports by Kotyukov (2001, 2005, 2016) from Ryazan, south-west of Moscow, and 134 birds examined by the late Werner Prünte in Manavgat, southern Turkey, on spring migration in April.

Post-juvenile moult

Before autumn migration, as in *A. a. ispida*, part or all of the body feathers and none or central R (R 1–4) are moulted (Kotyukov 2005). In contrast to *A. a. ispida*, the nominate race frequently moults one to three S and one or two P before autumn migration or in the winter quarters (Figure 29; Kotyukov 2016). Among 99 2cy in Turkey on spring migration, 67% had no renewed P, 33% had P 7 renewed, one of these also P 8 (P 1 was never renewed); 16% had no S renewed, 43% one, 25% two and 15% three (Figure 29); 42% had all R new, 41% R 6 unmoulted, 9% R 5–6 unmoulted and 8% three or four R unmoulted. It is unclear when the renewal of P and S occurs. Four birds in Turkey in April had P 7 still in the last stages of growth. We examined a 1cy in Israel on 14 October with growing P 7, new S 10 and moulting MeC, LeC and MaC (Figure 36). Because the Common Kingfisher is not a breeding but a

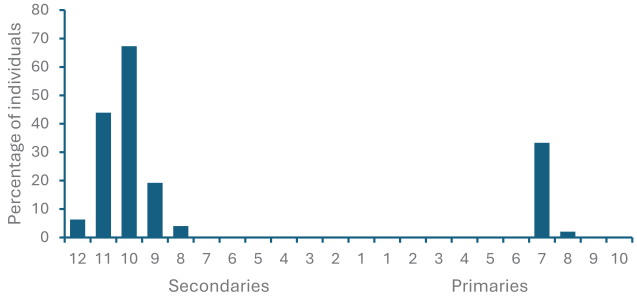


Figure 29. Extent of the post-juvenile moult of remiges in 2cy Eastern Common Kingfishers *A. a. atthis* in Turkey on spring migration (n = 99). The small S 13 was not considered.

wintering bird in Israel (Shirihai 1996), this bird was probably a migrant starting moult only after arriving at its winter quarters. Whether in spring central R and P 7 may be moulted a second time (Kotyukov 2005) remains to be verified.

Post-breeding moult

Adults near Moscow generally start moult during breeding between the first and second brood and interrupt moult before autumn migration in September. Before autumn migration they moult P 1–2 (3) + P 7–8 (9) and S (6–7) 8–12 and PC 10 (Kotyukov 2001, 2005). A 2cy after the first post-breeding moult from Israel suggests that P moult might continue with P 8, if P 7 was moulted during the post-juvenile moult (Figure 30).

By contrast to *A. a. ispida*, moult of the remiges regularly continues in the winter quarters, but records of actively moulting adults are few (Kiat 2015). Among 34 individuals identified as adults on spring migration in Turkey, 29 had all P and S fresh, while five had only one to seven P and one to eight S renewed (counted on one wing). These might be 3cy birds with only a limited first post-breeding moult. Hence, birds with only a few unmoulted remiges, as is typical for *A. a. ispida* (Figure 27), have not been found and might be rare or non-existent. Whether the moult of PC is as slow as in *A. a. ispida* has not been examined in detail.



Figure 30. 2cy Eastern Common Kingfisher, ringed as 1cy in October 2009, and photographed after its first post-breeding moult had been interrupted within P, 27 August 2010. P 1–2 and 8 postbr (renewed in summer 2010), P 3–6 and 9–10 juv (strongly worn), P 7 probably renewed during the post-juvenile moult in the preceding autumn/winter (slightly worn, tip not as bleached as on P 6). S 1–2 juv (worn). This bird is recognisable as ad because of the concurrent renewal of P 1–2 and 8, and as 2cy because of the renewal of P 7 in the preceding post-juvenile moult. Photo from Kiat (2010).

Ageing criteria for the Western Common Kingfisher Alcedo atthis ispida

This account is based mainly on the data collected by Bunzel-Drüke & Zimball (2025) for *A. a. ispida*, with additional own material and the findings of F. Guénat in Glutz von Blotzheim & Bauer (1980) and of Čech (2017, 2021). For more details see Bunzel-Drüke & Zimball (2025).

Note that moult limits are often difficult to ascertain, because some feathers within the same tract (e.g. Al, GC, PC) may differ in coloration, although of the same feather generation (see Wing and tail feathering).

Before and during moult (May–October)

1cy: The colour of the upper side of the toes, an infallible criterion until September, is more brown than orange (Figure 31; tarsus coloration is similar, but less reliable). No moult of P and S (Figure 35), though extremely rarely *A. a. ispida* may moult P 7 in the first autumn. Birds with bill length <28 mm (measured from the distal edge of the nostril to the tip of the bill) will have fledged during the previous month or two. Distinct breast-band of greenish or greyish feather tips (Figure 32) which disappears gradually from September in about 40% of 1cy due to wear and body-feather moult. Some 1cy do not moult their body feathers, or moult only some, while others may moult most together with some R.

Ad: Upper side of the toes is orange, or orange with some brown spots (Figure 31). Moult of P and S in (June–) August–October (–November) (Figure 25). Because only a few P and S are growing simultaneously, examine the remiges carefully for missing and growing ones. No greenish or greyish breast-band, but some 2cy birds, especially females, may still show a distinct breast-band or the remains of it.

After the moult (from about October until spring/summer)

1cy/2cy: All P, S and PC are of the same generation (juvenile; Figure 35) and the trailing edge of the S and P smooth and even. About half of the 1cy moult part of the R which are new and longer than the juvenile R (Figure 33). Birds in winter/spring with two generations of MaC or LeC are 1cy/2cy, while those with same-generation MaC or LeC give no indication of age.

Ad: 84% (n = 1072) retain some P and S, hence show two generations of P and S. The moult limits are not always easy to detect. The retained feathers are slightly more bleached on the outer vane and often slightly shorter

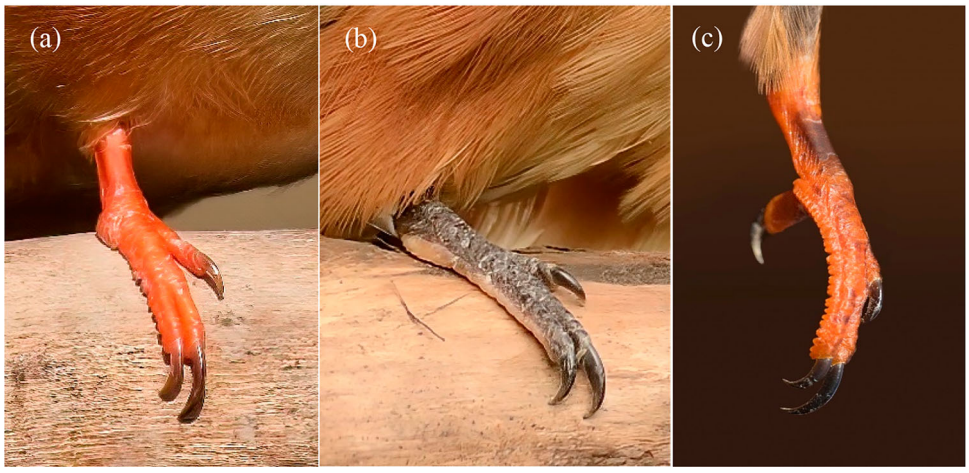


Figure 31. Toes of (a) ad Common Kingfisher in the breeding period, (b) a juv on 28 August, and (c) a 1cy on 26 October: in autumn and winter, the colour of the upper side of the toes becomes unsuitable as an ageing criterion. Photos by M. Bunzel-Drüke & O. Zimball (a, c) and Klaus Nigge (b).

(Figures 38 & 39). But there are also birds where the moult limits are prominent and highly visible (Figure 37). Adults moult most remiges (always more than half) and therefore can be distinguished from the extremely rare 1cy/2cy *A. a. ispida* individuals which may moult only one or a few S and/or P during the post-juvenile moult and have their moult limits around P7 and S10.

The 16% of adults with a complete moult of P and S can be recognised either by all of their PC being distinctly more worn than in 1cy/2cy or by having two generations of PC (Figure 40), and most of them by an uneven trailing edge of the S and P.

The colour of the upper side of the toes is no longer an infallible criterion, because 1cy birds' feet become more and more orange, and some adults increase the amount of brown during autumn and winter. However, birds with their feet all orange can be recognised as adults until November.

The degree of wear of P and S alone, and the shape of S, proposed as additional ageing criteria, are unsuitable. Whether differently coloured body feathers (most obvious on the head) are a suitable ageing criterion requires further study, because they may not only be due to juvenile and post-juvenile feathers but also to a partial pre-breeding moult in winter/spring.

Many adults can be aged further because the moult of PC 1–9 starts only after the second or third post-breeding moult and because the pattern of old S varies systematically with the number of post-breeding moults (details see Bunzel-Drüke & Zimball 2025). Note that these ageing criteria are based on the extents of consecutive post-breeding moults, and hence are valid for the period between two post-breeding moults, spanning parts of two calendar years and two different Euring age codes. Four patterns of retained PC and S can be distinguished that lead to two distinct age classes (2cy/3cy and 3cy/4cy) and two ranges of age classes (>2cy/3cy and >3cy/4cy):

- All PC 1–9 old and contrasting with the renewed P; the retained S comprise an uninterrupted block starting at S 1, 2, 3 or 4 and ending with S 4, 5, 6, 7, 8 or 9 (most often S 3–5; Figure 39); in only one wing may an additional new S within the block of old S occur. These can be aged as 2cy/3cy (after the first post-breeding moult, Euring code 5/7). Only 3.5% of birds with such a pattern were actually older than 2cy/3cy.
- All PC 1–9 old; in at least one wing, the retained S are split into two blocks of one or several S, or a single block of retained S starts at S 5, 6 or 7 and ends with S 6, 7 or 8; typically, S 6–8 are retained. These can be aged as 3cy/4cy (after the second post-breeding moult, Euring code 7/9). 9.4% of birds with such a pattern were actually younger or older than 3cy/4cy. These are probably birds with a complete moult of S and P in the first post-breeding moult.
- All PC 1–9 old; pattern of old S differs from above, or all P and S new. These can be aged as 2cy/3cy or older (after the first or a later post-breeding moult, Euring code 4/6).
- Some PC 1–9 new, or very rarely all. These can be aged as 3cy/4cy or older (after the second or a later post-breeding moult, Euring code 6/8). Because only <30% of 3cy start moulting some PC 1–9, while 80% of 4cy do, these are likely to be 4cy/5cy birds.

Ageing criteria for the Common Kingfisher of eastern Europe Alcedo atthis atthis

Before and during moult (May–September)

See Western Common Kingfisher.

After the moult (from about August/September until spring/summer)

1cy/2cy: All P, S and PC are of the same generation (juvenile) and trailing edge of the S and P is smooth and even, or P 7 (–8) and one to three inner S moulted. As far as known, P 1 is not renewed.



Figure 32. 1cy Western Common Kingfisher at the end of August, with distinct breast-band. Photo by Klaus Nigge.



Figure 33. Tail of a 2cy Western Common Kingfisher after the post-juvenile moult, 15 January. The five R marked 'n' have been renewed. Photo by M. Bunzel-Drüke & O. Zimball.

Ad: In contrast to 1cy, which do not moult P 1, adults seem to start moult almost simultaneously with P 7 and P 1 (Figure 25). How many P and S are moulted before migration or in the winter quarters, respectively, is unknown. In spring, most adults have renewed all P and S. Birds with two generations of PC are adults. Individuals with more than P 7 and one to three S moulted, but several P and S retained are probably adults. For colour of the upper side of the toes, see Western Common Kingfisher. Because the moult of PC and the exact moult extents of P and S are not known, we cannot propose criteria differentiating more age classes within adults.

Sexing criteria

The best sexing criterion is the colour of the lower mandible (Glutz von Blotzheim & Bauer 1980, Čech 2017, 2021, Bunzel-Drüke & Zimball 2025), as indicated in all guides. Both sexes fledge with a black bill tipped white; the bill grows rapidly during about 50 days after fledging, and slower thereafter. The sexually dimorphic coloration of the lower mandible is attained after 40–50 days at a bill length of >30 mm, as measured from the distal edge of the nostril to the tip of the bill. Only 1–2% of 1cy birds are wrongly sexed, while 2cy and older birds can be sexed reliably (0.2% error; Bunzel-Drüke & Zimball 2025). The maximum size of the light patch in males occurs in January–March and may rarely reach female-like dimensions.

Male: Lower mandible black with no or only a small light-brown to pale-orange patch close to the base of the bill. The light patch in side view is shorter than the black distal part of the mandible (Figure 34).

Female: Lower mandible mainly or completely pale-orange to bright-orange. The orange part in side view is longer than the black distal part of the mandible (Figure 34).

Although on average the plumage of males is more intensely coloured than that of females, and with a less distinct or absent breast-band, the overlap is large; thus plumage coloration is not a reliable criterion in 1cy birds. Nestlings with bright-blue body feathers on the upper side are mostly males (90%) while blue-green and greenish nestlings may be either sex (Bunzel-Drüke & Zimball 2025).

There is no typical brood patch to look for, and no difference between the shapes of the cloaca of breeding males and females (Bunzel-Drüke & Zimball 2025).

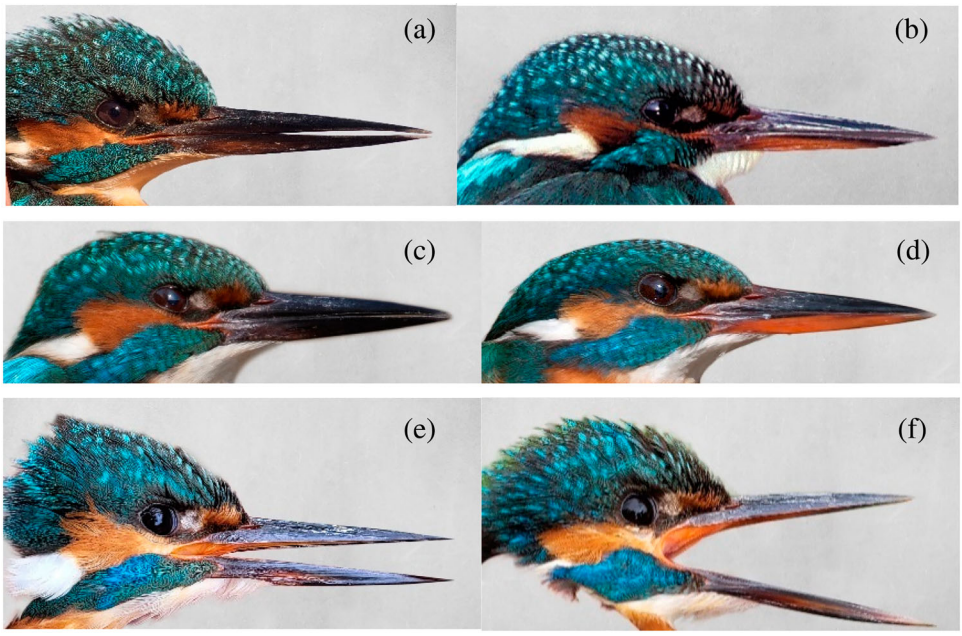


Figure 34. Bill colours in Common Kingfisher. The lower mandible of males (left column) is black, or almost so, while that of females (right column) is mainly or completely orange: (a) typical 1cy male and (b) female in October/November; (c) typical ad male and (d) female in April; (e, f) ad (2cy) breeding birds in May with atypical coloration of the lower mandible – (e) male with a rather large pale-orange patch and (f) female with a rather narrow pale-orange patch, probably due to a bill injury. Photos by M. Bunzel-Drüke & O. Zimball.



Figure 35. 1cy female Western Common Kingfisher with entire wing in juv plumage, 20 September. There are no moult limits in P or S and the trailing edge of the wing is even. On this wing S 13 is easily visible. GC 11–13 are a touch bluer than GC 1–10, and GC 11–12 have sparkling blue tips as MeC, LeC and MaC, simulating a non-existent moult limit.



Figure 36. 1cy Eastern Common Kingfisher, Eilat, Israel, 14 October. P 7 is half grown; MeC, LeC and MaC postjuv and growing, with some juv left; S 10 postjuv; rest of wing juv. This subspecies is reported to start wing moult in part already in its first calendar year (Kotyukov 2016). Note that the juv GC 11–12 (less so also GC 10) are the only ones to have a sparkling blue tip.



Figure 37. 2cy Western Common Kingfisher during its ongoing first post-breeding moult, 29 August. P 1 and 7 postbr, 2–6 and 8–10 juv. On the other wing P 2 and 8 are not juv but growing. S 1–8 and 12 juv, 9–11 postbr, 13 uncertain. GC 1–6 and 10–12 juv, 7–9 postbr, 13 uncertain. PC 1–10 juv. MeC and LeC mostly postbr, MaC postbr and juv. Al difficult to assign. This ad shows the start of moult with P 1 and 7 which is typical of *Alcedo* kingfishers. Because the old P 8–10 are strongly abraded, this is a 2cy.



Figure 38. Ad female Western Common Kingfisher after post-breeding moult, 17 December. P postbr. S 1–3 and 6–12 postbr (13?), 4–5 probably juv; PC 1–9 juv, 10 probably postbr; GC, LeC and MaC postbr; Al difficult to assign. Aged as ad because of the uneven trailing edge of P and the retained S 4–5. The old S are slightly shorter and a trace greener than the renewed ones, but the moult limit is not conspicuous and needs a close examination. Because PC 1–9 and S 4–5 are probably juv, this bird is a 2cy.

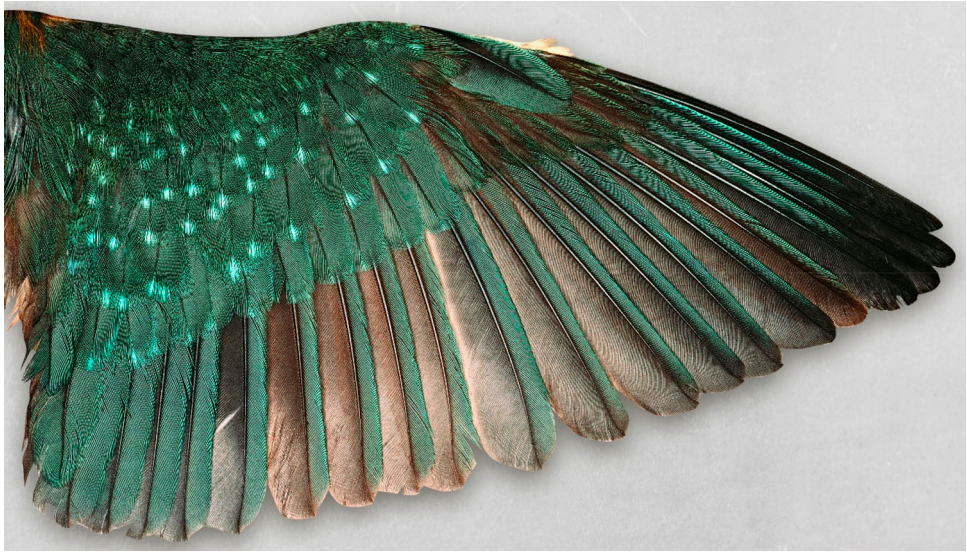


Figure 39. 2cy female Western Common Kingfisher, ringed as 1cy on 1 September 1999 and photographed after first post-breeding moult, 17 December 2000. P 6 juv, 1–5 and 7–10 postbr; S 2–5 juv, 1 and 6–12 postbr, 13 unclear; PC juv; GC 1 juv, 2–11 postbr; MeC, LeC and MaC postbr; Al 4 probably postbr, 1–3 unclear. Aged as ad because of the retained P 6 and S 2–5, which are slightly shorter and a touch greener than the renewed ones. Exceptionally also GC 1 has been retained from the juv plumage, but it is unclear how frequently such moult limits occur within the GC. Note that GC 10–11 show the same sparkling blue tips as MeC and LeC, but not GC 1–9.

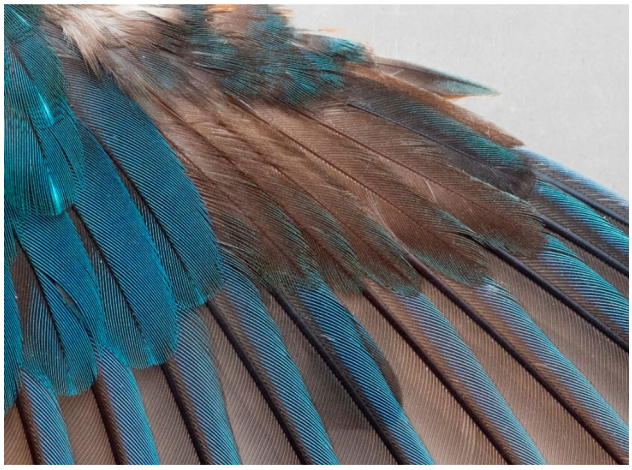


Figure 40. 3cy female Western Common Kingfisher during post-breeding moult, 30 September 2018, having been ringed as nestling in May 2016. PC 8 and 10 renewed, remaining PC juv, hence more than two years old (PC 1 hidden under GC); P 4 growing. The two generations of PC indicate a 3cy or older bird. Photo by M. Bunzel-Drüke & O. Zimball.

Eurasian Wryneck *Jynx torquilla*

Wing and tail feathering

Eurasian Wrynecks have ten P, nine PC, 11 S, 11 GC, four Al and no carpal covert nor carpal remex. There are six pairs of R but R 6 is reduced and hidden. For the lengths of the primaries and rectrices in juvenile and later plumages, see Figures 45 and 60 and 'Ageing criteria'.

Moult

Sequence

P are moulted in the usual descendent order from P 1 to P 10. Post-juvenile S moult usually starts at S 8 in both directions and, rarely, later at S 1 inwards. Moult of R in the post-juvenile moult starts after shedding P 5 and proceeds strictly from outside to inside, i.e. from R 6 to R 1 (Sutter 1941; unpubl. data). The sequence of the post-breeding moult has not been described in detail.

Timing of moult

The post-breeding and post-juvenile moults take place between July and September (Figure 41). In a breeding population in south-west Switzerland, the post-breeding moult starts in the second ten days of July (per M. Schaub). According to Sutter (1941), birds fledge at an age of 21 days after hatching and start moulting P at 22–24 days. P-moult duration of 1cy is around 80–85 days in hand-reared birds (Sutter 1941; unpubl. data). Iovchenko & Kovalev (2005) found that the post-juvenile P moult starts at the age of 19–23 days when young birds are still in the nest or a few days after leaving it, and they estimate the moult duration of a population in the south-eastern Ladoga area to be about 80 days and the individual duration 60–70 days.

Wrynecks apparently can moult during autumn migration. On the Col de Bretolet, a pass in the Swiss Alps, we observed moulting 1cy from mid-July until the beginning of September in all stages of P moult (seven 1cy in six different years), although most had finished moult. In the Ladoga area, 70% of passage birds in the main migration period (15 July to 10 August) were in advanced P moult (growing P among P 4–7). During the most intensive moult phase (growing P 7–10) migrants may interrupt migration and stop over for about a month. This behaviour allows birds from the far north to leave breeding sites before environmental conditions deteriorate (Iovchenko & Kovalev 2005).

The moult in the non-breeding area can start soon after arrival by completing the partial post-breeding and post-juvenile moult of the S (Figure 41). We have

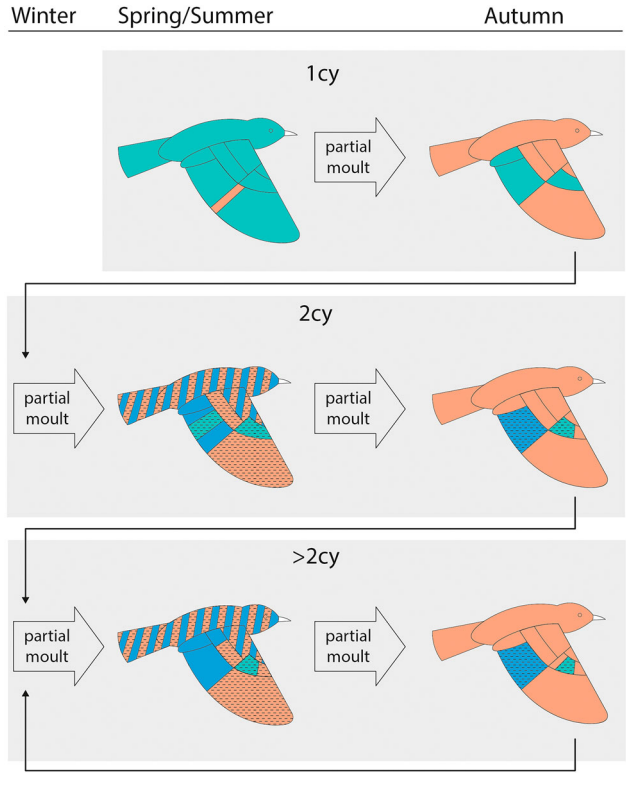


Figure 41. Schematic presentation of the moult of Eurasian Wrynecks. Adults moult almost completely after breeding in summer (not or partly renewed are PC and S 1–7). Moult is resumed in the non-breeding area and overlaps with an extensive pre-breeding moult. 1cy undergo a partial post-juvenile moult in the breeding area and, like the adults, resume it in the non-breeding area. The pre-breeding moult is less extensive than in >2cy. Key as in Figure 2.

an example of a 1cy from Cameroon from 8 November starting S moult with growing S 1–2 and S 8 as well as growing central R.

A pre-breeding moult is said to take place in February– March (–April) (Stresemann & Stresemann 1966, C.S. Roselaar in Cramp 1985, Demongin 2016, 2020).

Post-juvenile moult (in the breeding area)

Always moulted are body feathers, MaC, LeC, MeC, P and Al; occasionally scattered coverts may remain unmoulted (Figures 41 & 42a). PC are not renewed (n = 219 from Switzerland, mostly examined in spring, among them 15 birds which were ringed as nestlings in the previous year; see also Laesser & van Wijk 2017). Moult of GC: range 7–10, mean 9.9, mode 10, none 0%, all 95.5% (n = 66; including 39 spring birds). Moult of S 1–6: none 93%, two 1cy renewed S 1 and also had one to three renewed inner S (n = 28). Moult of S 7–10 (S11 not considered): none 82.1%, two 1cy with new S 8, two with new S 8 and 10, one with new S 7–9 (n = 28). Moult of R: all 75%, R 1 unmoulted 17%, R 1–2 unmoulted one 1cy (n = 24).

Post-breeding moult (in the breeding area)

Always moulted are body feathers, MaC, LeC, MeC, GC, Al, P, S 8–10 (S 11 not considered) and R. Not renewed, or only partly, are PC and S 1–7 (Figures 41 & 42b).

PC (data from a breeding population in south-west Switzerland): during the first post-breeding moult (2cy), 89% moulted PC 9 or PC 8–9 (Figures 44a & 55), while two birds moulted none (Figure 58), another bird PC 7–9, another PC 1 and 6–9 (n = 35 3cy birds examined in spring/summer of known age, either ringed as nestlings or as 2cy in summer, including the 16 birds in Laesser & van Wijk 2017). On average, only 1.4 PC are moulted (range zero to five).

During the second post-breeding moult (3cy), on average 2.8 PC (range one to five) are moulted (Figure 44b; n = 11 4cy birds examined in spring/summer of known age, either ringed as nestling or as 2cy in summer, including the three birds in Laesser & van Wijk 2017). These are often the outermost PC again and to some extent PC 1, while central PC are moulted rarely (by only one bird). Therefore, several juvenile PC, mainly among PC 2–6, remain unmoulted again (Figures 42b & 44b). Also, PC moulted in the first post-breeding moult may remain unmoulted, so that more than half of 3cy/4cy birds show three generations of PC (juvenile, moulted during the first and moulted during the second post-breeding moult; Figure 57).

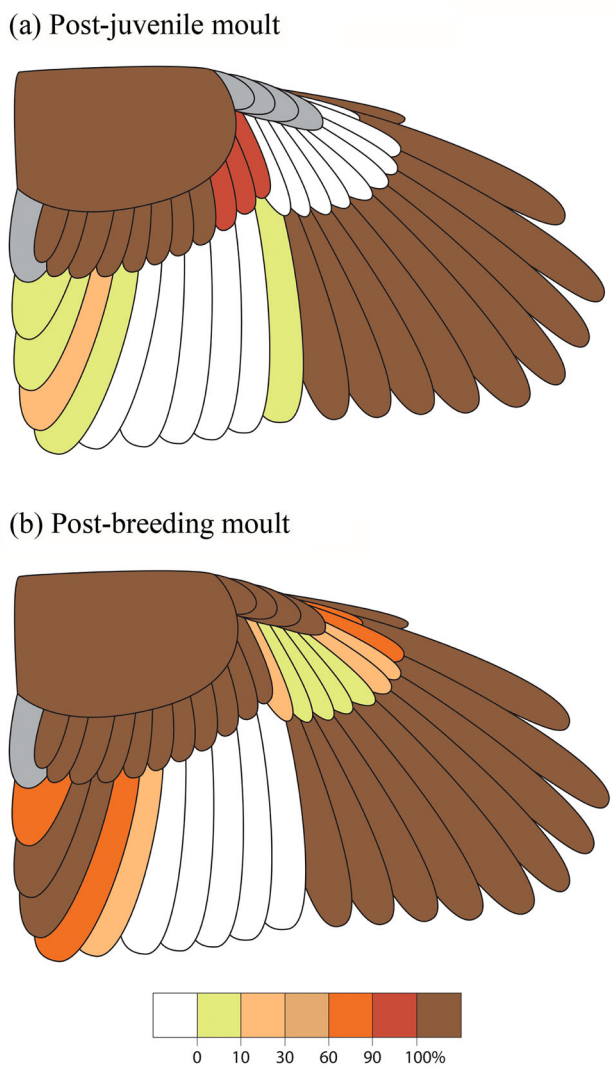


Figure 42. Extent of (a) the post-juvenile and (b) the post-breeding wing moult in the breeding area in the Eurasian Wryneck, representing the moult extent in autumn. Feathers shaded grey are not considered.

Four individuals of known age examined when 5cy–7cy (including one from Laesser & van Wijk 2017; one individual as 5cy and 6cy; Figure 59) have three to six PC moulted (mean 4.6, n = 5) and all had three generations of PC except one with two. Single juvenile PC can be retained until at least before the fifth post-breeding moult, so that these PC may be kept for five years (Laesser & van Wijk 2017). Because of the limited moult of PC, all adults (>2cy) show moult limits within their PC (Figure 42; n = 126; see also Laesser & van Wijk 2017).

Our limited sample (n = 5; Figure 42) shows that S 8–10 (S 11 not considered) were always renewed, S 1–5 remained unmoulted and S 6 and S 7 were replaced in one case each. However, individuals with more S moulted might appear in a larger sample. As

a result, S moult may be split between the breeding and non-breeding areas (C.S. Roselaar in Cramp 1985, Baker 2016, Demongin 2016, Gorman 2022).

Pre-breeding moult (in the non-breeding area)

During the moult in the non-breeding area, the renewal of the S is resumed, interpreted as completion of the post-breeding or post-juvenile moults, according to age, and several feather groups are renewed a second time, interpreted as pre-breeding moult (Figure 41). The assignment of the feather generations in spring birds returning from the non-breeding area is difficult, and hence the extent of the moult in the non-breeding area is beset with uncertainties. The extent is generally larger in >2cy than in 2cy.

In 2cy and >2cy, parts or all of the body feathers, MaC, LeC, MeC and Al are thought to be moulted again. P and PC remain unmoulted (Figure 43). Within the GC (1–10, GC 11 not considered), 64% of >2cy show a moult limit, generally within GC 6–8; 36% have renewed either all or none (n = 22). Among 2cy, only 23% have a moult limit within the GC, usually within GC 9–10; 77% have retained all their post-juvenile GC, among them two which even retained one or two juvenile GC (n = 39).

S 7–10 are usually renewed, although single ones may remain unmoulted (>2cy, n = 22; 2cy, n = 39). 73% of >2cy renew all S 1–6; 27% retain up to four, in most cases S 1 (n = 22). 51% of 2cy moult all S 1–6, 10% moult none and 39% between one and five; unmoulted S remain mostly around S 4 (n = 39).

31% of >2cy renew all R (1–5); 69% have a moult limit somewhere between R 2 and 5 (n = 13). R 1 is always moulted. Among 2cy, 10% renew all R, 32% none, and 58% have a moult limit; in birds with moult limit, R 1 is always moulted.

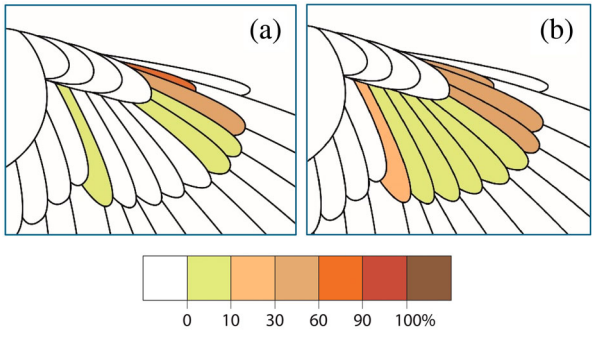


Figure 44. Extent of the PC moult during (a) the first (n = 35) and (b) the second post-breeding moult (n = 11) of Eurasian Wrynecks of known age, representing the PC pattern of 2cy/3cy and 3cy/4cy birds respectively.

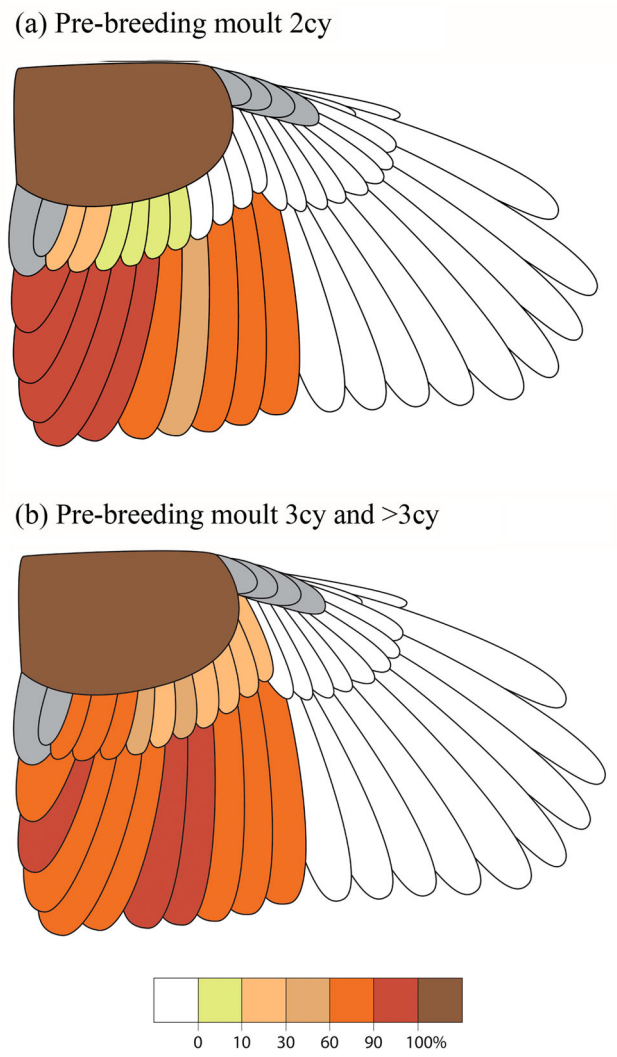


Figure 43. Extent of the pre-breeding moult (including the completion of the post-breeding and the post-juvenile moult in the non-breeding area) on the wing in (a) 2cy and (b) ad (3cy and >3cy combined) Eurasian Wrynecks, representing the moult extent in spring/summer. Feathers shaded grey are not considered. Note that age is determined mainly by assessing the PC, which are not moulted during the pre-breeding moult. Therefore, the pattern of PC moult in spring/summer is the same as after the post-juvenile and post-breeding moults shown in Figure 42.

Ageing criteria

Before and during the post-juvenile and post-breeding moult in summer

1cy: The juvenile plumage is greyer than the post-juvenile plumage and fluffy. Just after fledging the P are amazingly short compared to the S (Figures 47 & 60). The juvenile P 10 is prominent, about 30 mm long, and rounded. The juvenile tail is wedge-shaped; the post-juvenile tail is squarer (Figure 45). For as long as the juvenile P 10 is not replaced, its length is the best character for ageing.

Ad (2cy and older): P 10 is only about 12 mm long, hardly detectable, hidden under the PC, slim and pointed. The R are all of nearly the same length (except the minute R 6). See below for the distinction between 2cy and >2cy.

After the post-juvenile and post breeding moult in summer/autumn

1cy: The best ageing criterion is the condition of the PC (Laesser & van Wijk 2017, see also Gorman 2022). Because they are not moulted in 1cy (Figure 42), there is never a moult limit within the PC. In contrast, other authors claimed that some 1cy replace the outermost one or two PC (e.g. Baker 2016, Demongin 2016, corrected in Demongin 2020). The PC are of the same fresh colour as the P. Their pointedness and their pattern of light spots are individually variable and not helpful in ageing.

The juvenile S 7–10 often have a white spot at the tip of the outer vane (Figure 48), less obvious on the inner vane. This is not always the case and hence not an infallible character. 18% have a moult limit within S 7–10. The old juvenile inner S are more abraded, paler and often with the white patch mentioned above, the new inner S (mostly S 8) are fresh, more deeply coloured and with yellowish-brown tips (Figure 49). A small percentage (4.5%) have a moult limit within the outer GC, the juvenile GC being shorter and having a conspicuous white spot at the tip of the outer vane (Figures 50 & 52). Normally the whole tail is replaced during the post-juvenile moult, but around 17% retain R 1 or R 1–2. These retained R are shorter, narrower and more worn than the rest.

In juvenile birds, the iris is dark grey-brown without a reddish tinge (Mulhauser & Zimmermann 2014, Kauzál & Kauzálová 2021, Blasco-Zumeta & Heinze 2023), but 1cy in late summer and autumn typically have a light-grey or grey-brown iris well into autumn (own obs.; Figure 46). We do not know at what age the colour changes.

Ad (2cy and older): Almost all have a moult limit within the PC (Figure 51). Only rarely adults moult no PC during their first post-breeding moult (two birds of 35) and hence have no moult limit, but in these birds the PC are a year old and markedly worn (Figure 58). Moreover, adults may rarely renew S 1–5. Therefore, there is always a moult limit between the renewed P and the one-year-old S, as well as between the renewed inner S and the retained bleached S (Figure 51). Moult of inner S is less frequent in 1cy and concerns only single feathers, rather than all of S 8–10 as in adults.

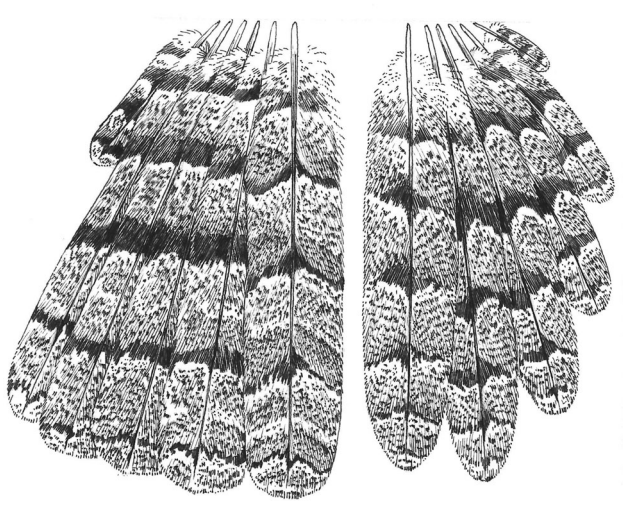


Figure 45. Eurasian Wryneck: the six rectrices of one side of the tail, left from the ad and right from the juv plumage. Drawing by Friedhelm Weick, reproduced from Glutz von Blotzheim & Bauer 1980 by permission of U.N. Glutz von Blotzheim.

Iris is darker than in 1cy, mahogany or dark-brown with a reddish tinge (Figure 46). Because PC are not renewed in the non-breeding area, 2cy and >2cy birds in autumn can be distinguished using the same criteria of the PC as for 3cy and >3cy birds in spring, described below.

After the pre-breeding moult

2cy (before the first post-breeding moult): All PC are of the same generation and of the same basic colour as the P. The light spots on the PC line up across the feather tract, having been grown simultaneously. 51% moult all S in the non-breeding area and therefore resemble >2cy in this regard (Figure 55), but 10% moult none and 39% only part of the S. These retained juvenile S (S 2–6, not S 1) are 1.5–2 mm longer than the renewed ones, more pointed and narrower, and hence stand out between the new feathers as an infallible feature (Figures 53 & 54).

Iris colour in spring of many 2cy is still light grey or grey-brown, but some already show some brown or reddish-brown and are darker, overlapping with 3cy (Figure 46).

>2cy: A straightforward character for >2cy is a moult limit within the PC. Many adults after the first post-breeding moult have moulted only PC 9, so look carefully for this hidden feather. Retained juvenile PC (mainly among PC 2–6) stand out by their abrasion and paleness (Figures 51, 56 & 57). There is no evidence of adults moulting all PC in one moult

(see above). So, even in the rare old birds that have replaced all juvenile PC, there still is a moult limit – though, because the moulted, non-juvenile PC deteriorate less quickly than the juvenile ones, this may be difficult to detect (Figure 59). In all cases of PC showing a moult limit, the light spots on the PC do not lie in an even line across the feather tract; instead, this line is interrupted, stepped or uneven, indicating that the feathers have not grown simultaneously (Figure 57).

Rarely, adults have no moult limit within the PC, and therefore can be mistaken for 2cy. These are 3cy birds that did not moult any PC during their first post-breeding moult. Their juvenile PC are 1.5 years old and therefore more bleached than the renewed P (Figure 58). Iris colour in spring is usually dark-brown or reddish-brown, but some 3cy are brown and lighter, overlapping with 2cy (Figure 46).

Some adults, but not all, can be aged further.

3cy: Birds with two generations of PC are mostly 3cy (for 3cy birds with only juvenile PC, see above). They most frequently have renewed only PC 9 or PC 8–9 (Figures 44a & 56). Because PC 9 is often hidden, look carefully. However, some >3cy (probably less than half) also have only two generations of PC, because the extents of the first and second post-breeding moults may overlap (Figure 44b). The juvenile PC are generally more worn in >3cy than in 3cy, but there is quite some overlap.

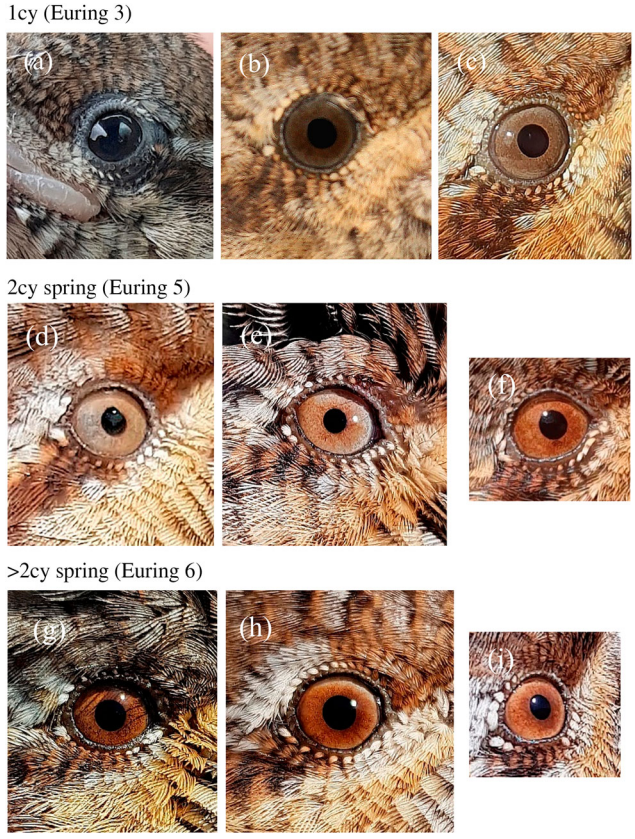


Figure 46. Eurasian Wryneck iris colour at various ages: (a) nestling 5 June; (b) 1cy 14 July; (c) 1cy 23 August; (d) 2cy 12 April; (e) 2cy 13 April; (f) 2cy 11 April; (g) > 2cy 14 April; (h) > 2cy 13 April; (i) > 2cy 6 April. Most pictures represent typical cases, but (f) and (i) are atypical or rarer examples. Photos by Irmi Zwahlen (a, c–i) and Ondrej Kauzál (b).



Figure 47. 1cy Eurasian Wryneck in juv plumage, 21 July. The juv P 1–4 have been shed shortly after fledging and are growing. P 5–10 and rest of the wing juv. Compared to the juv S, which have already reached their ad length, the juv P are amazingly short, except P 10 which is three times longer than the moulted postjuv feather.

>3cy: Adult birds retain juvenile PC at least until after the second post-breeding moult (4cy), possibly even until after the third and fourth (5cy and 6cy), but all moult a few PC in each post-breeding moult. Therefore, more than half of adults after the second post-breeding moult have three generations of PC (Figure 57) and can be aged as >3cy (Euring code 8).

Birds with no juvenile PC left are >4cy. Their moult limit within PC is harder to detect and iris colour helps to avoid confounding these cases with 2cy birds (Figure 59).

Sexing criteria

There are no differences in plumage between males and females. The species is sexually monomorphic.



Figure 48. 1cy Eurasian Wryneck after post-juvenile moult, 12 September. P, Al and wing coverts postjuv, except PC. PC and S juv. No moult limit within PC, which are of the same basic colour as P. White spots on the tips of the outer vanes of juv S 7–10. Photo by Thomas Degen.



Figure 49. 1cy Eurasian Wryneck after post-juvenile moult, 17 August. P, Al and wing coverts postjuv, except PC, which are juv. S 1–7 and 9 juv, 8 and 10 postjuv. No moult limit within PC, which are of the same basic colour as P. White spots on the tips of the outer vanes of juv S 7 and 9, these tips being yellow-brown on the postjuv S 8 and 10. Photo by Thomas Degen.



Figure 50. 1cy Eurasian Wryneck after post-juvenile moult, 21 September. P, Al, MaC, LeC and MeC postjuv. GC 1 juv, 2–10 postjuv. PC and S juv. No moult limit within PC, which are of the same basic colour as P. White spots on the tips of the outer vanes of juv S 7–10 are not very prominent in this bird. Juv GC 1 smaller and with a whitish spot on the tip of the outer vane. Photo by Thomas Degen.



Figure 51. Ad Eurasian Wryneck after post-breeding moult, 22 August. P postbr. PC 1 and 7–9 postbr, 2–6 old (probably juv). S 1–5 prebr, 6–10 postbr. Rest of wing postbr. Conspicuous moult limit within PC indicates ad. S 1–5 were not moulted, but will be renewed in the non-breeding area. Photo by Thomas Degen.



Figure 52. 2cy Eurasian Wryneck after prebr moult, 8 April. P postjuv. PC juv. GC 1–2 juv, 3–10 postjuv or prebr. S 1–6 and 8 prebr, 7 and 9–10 juv or postjuv. Rest of wing difficult to assign. Juv GC show white tips and are shorter than renewed GC. Juv PC of the same colour as P, not worn and bleached; light spots arranged in an even line; no moult limit. Photo by Thomas Degen.



Figure 53. 2cy Eurasian Wryneck after prebr moult, April. P postjuv. PC juv. S 4 juv, 1–3 and 5–7 prebr, 8–10 postjuv. Rest of wing difficult to assign. The juv S 4 protrudes from the prebr S and is a typical sign for 2cy, as well as the PC lacking a moult limit and being of similar colour and wear as the P.



Figure 54. 2cy Eurasian Wryneck after prebr moult, 27 April. This exceptional bird has 11 P. P postjuv. PC juv. S 1 probably postjuv, 2–3 prebr, 4 juv, 5–7 prebr, 8–10 postjuv. GC postjuv. Rest of wing difficult to assign. The juv S 4 protrudes from the prebr S and is a typical sign for 2cy, as well as the PC lacking a moult limit and being of similar colour and wear as the P. S 1 is a trace more worn than S 2–3 and 5–7 but not protruding nor as narrow as the juv S 4, thus probably one of the few cases of postjuv replacement. Photo by Paul Mosimann.



Figure 55. 2cy Eurasian Wryneck after prebr moult, 6 April. P postjuv. PC juv. S 1–10 prebr. Rest of wing difficult to assign. Typical case of a 2cy because there is no moult limit in the PC nor in the S. PC are not abraded or bleached and are of the same colour as the P.



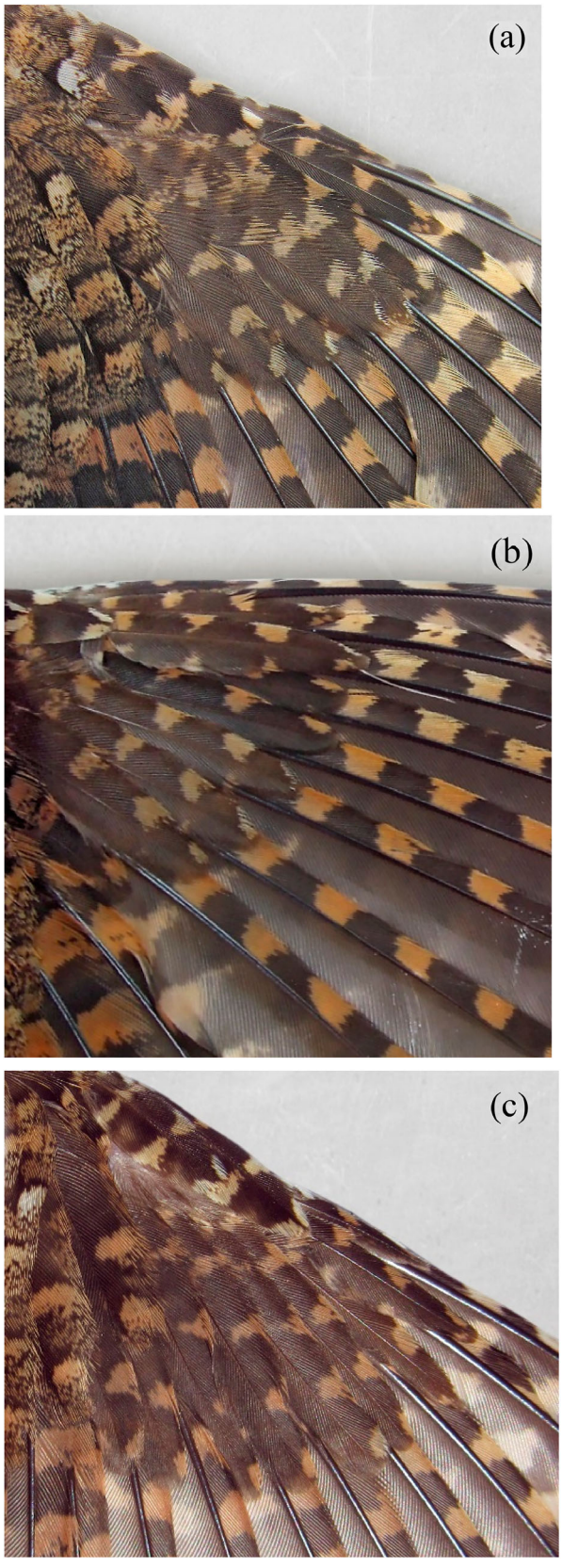
Figure 56. Ad after prebr moult, 3 April. P postbr. PC 1–7 juv, 8–9 postbr. S 1 and 6 postbr, 2–5 and 7–10 prebr. Rest of wing difficult to assign. The unmoulted PC are bleached, as is typical for PC older than half a year. The pattern of only two outermost replaced PC is a frequent one after the first post-breeding moult (hence 3cy bird) but also occurs in 4cy birds.



Figure 57. Ad Eurasian Wryneck after prebr moult, 12 April. PC 1 new, 2–5 very old, 6 new, 7 old, 8 new, 9 new but barely visible. Rest of wing not considered. This bird has three generations of PC. The oldest are PC 2–5 which are probably still juv. The old PC 7 was grown during a post-breeding moult two years ago. PC 1 and 8–9 are new and were moulted during the previous post-breeding moult. Therefore, this bird is in at least its fourth calendar year (4cy or older, Euring code 8). Photo by Irmi Zwahlen.



Figure 58. Ad Eurasian Wryneck after its first prebr moult, 11 April 2022. PC 1–9 juv. Rest of wing not considered. This bird was ringed as nestling in 2020, hence is a 3cy, one of the rare individuals that did not moult any PC in the first post-breeding moult. The bleached PC in contrast to the fresh P indicate 3cy, even without any moulted PC. Photo by Irmi Zwahlen.



True woodpeckers (Picinae)

Wing and tail feathering

True woodpeckers have ten P, the outermost P 10 being reduced in size, and nine clearly visible PC, a minuscule PC 10 is present but hidden under the MaC. There are 11 S in Middle Spotted, Lesser Spotted, White-backed and Great Spotted Woodpecker, and 12 S in Black, European Green, Grey-headed and Eurasian Three-toed Woodpecker. The innermost S is small and usually hidden under the innermost GC. Above each S is a GC (GC 1–11 or GC 1–12). The Al consists of four feathers, the innermost (Al 1) is sometimes longer than Al 2 and may cover it. There are no carpal remex and carpal covert, or only downy remains. Among the six pairs of rectrices, the outermost (R 6) is very small, hidden and inserts above R 5.

In Picinae in general, but especially in the Great Spotted Woodpecker, parts or all of the plumage may suffer from melanin-based colour deficiencies that lead to whitish (Figure 70) or reddish-brown feathers (Figure 71), rather than black ones. If such deficiencies occur in the juvenile but not in the subsequent plumage, moult limits are particularly distinct.

The juvenile primaries

In all European true woodpeckers, the lengths of the primaries differ considerably between the juvenile and later plumages. The innermost two juvenile primaries P 1–2 are reduced to less than half of their adult

← **Figure 59.** This Eurasian Wryneck was ringed as a nestling in 2013. (a) On 26 April 2016, as 4cy and after its second post-breeding moult, it had moulted PC 7–9 (PC 1 not visible) while PC 2–6 are juv. (b) On 5 June 2017, as 5cy, it had moulted PC 1, 5–6 and 9 during its third post-breeding moult. PC 7–8 remained from the second post-breeding moult, while PC 2–4 are still juv. Hence there are demonstrably three generations of PC present. However, PC 7–8 are only very slightly less bleached and of slightly firmer structure than the juv PC 2–4. (c) One year later, on 13 April 2018, as 6cy, it had moulted PC 1–4 and 8–9 during its fourth post-breeding moult; hence no more juv PC are left. PC 5–6 are from the third post-breeding moult, while PC 7 has not been renewed during the last two post-breeding moults and is very old, bringing it again to three PC generations. Note that the differences in wear between the PC generations are not striking. Photos by Anna Sandor.

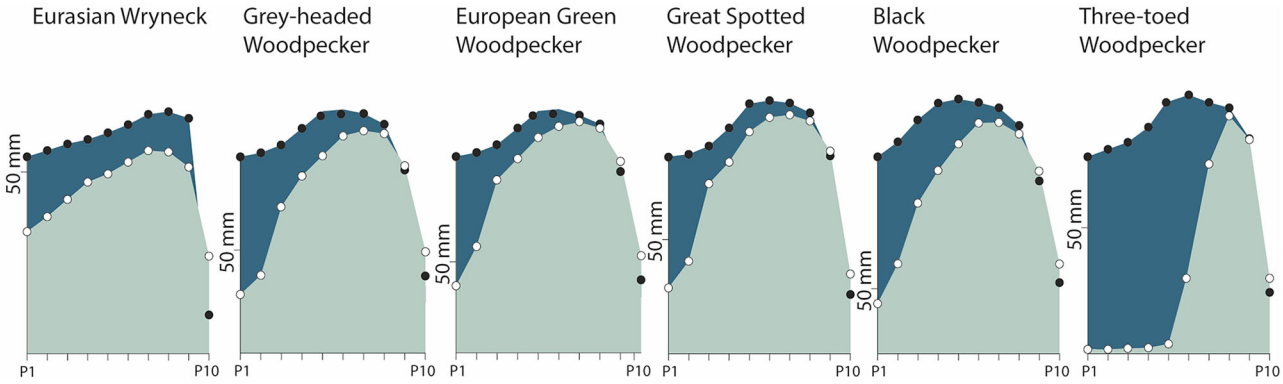


Figure 60. Comparison of the length of the juv (white symbols) and postjuv/postbr (black symbols) primaries in woodpeckers. The juv P 1–7 are shorter to varying degrees, P 8–9 are of approximately ad size, while the juv P10 is generally longer than in later generations. The schematic primary outlines from the innermost P 1 to the outermost P 10 have been scaled across species to a common length of P 1. The horizontal mark on each *y*-axis represents 50 mm. The difference between juv and ad primaries is shaded dark blue. Redrawn from Sutter (1974).

length. P 3–7 are notably shorter than after the post-juvenile moult, P 8–9 are approximately of adult size, while the small outermost juvenile primary P 10 is longer in the juvenile plumage than thereafter (Figure 60, Sutter 1974). Also, the juvenile R 2 and 3 are reduced in length compared with the post-juvenile feathers (Stresemann & Stresemann 1966). In the Eurasian Three-toed Woodpecker, the five innermost primaries P 1–5 are only a few mm long and P 6 is reduced to individually varying degrees (Figure 60; Ruge 1969, Sutter 1974).

The juvenile primaries reduced in size are the ones moulted first during the post-juvenile moult. In northerly latitudes, the time to renew all primaries and rectrices is short. Hence, it is an advantage to start moult early and not to invest energy in primaries that are to be moulted so soon.

Indeed, juveniles start P moult with the reduced P 1 and P 2 already a few days before or just after fledging, when the other juvenile P are still growing (Figure 61; Stresemann & Stresemann 1966, Sutter 1974). Eurasian Three-toed Woodpeckers start the post-juvenile moult with P 1–5 already at the age of 8–13 days in the nest (Figure 61), and thus have growing primaries of two different feather generations while still in the nest (Ruge 1969).

After fledging, P moult continues with the subsequent P dropped every 10–15 days so that P moult finishes at about four months of age in the Great Spotted Woodpecker (Figure 61). Moult of body feathers starts with the moult of P 4 but becomes intense only when juvenile P 6 or P 7 is dropped.

Moults

True woodpeckers moult once per year after the breeding season (Figure 62). The moult is protracted. There are generally only one or two (three) P growing concurrently on each wing (Figure 61).

Post-juvenile moult

Post-juvenile moult takes place between June and October, is partial and includes the body feathers, R and P (Figure 62). Because P 1 is dropped before or at fledging and the remaining P are still growing at fledging, birds in juvenile plumage always have growing P, but important renewal of the other juvenile feathers sets in only in the middle of P moult. PC are not moulted. As a general rule S 1–8 remain unmoulted, we have however observed irregular and one-sided replacement of odd S 4–7 in the Great Spotted Woodpecker. The moult extents of S 9–11/12, Al, MaC, LeC, MeC and GC vary between species and individuals. Species with a generally large moult extent are Grey-headed, European Green and Middle Spotted Woodpeckers, while Great Spotted and Lesser Spotted Woodpeckers have a variable, and Eurasian Three-toed and Black Woodpeckers a smaller moult extent.

In none of the woodpecker species examined by us, and in accordance with other authors (Miettinen *et al* 1986, Kovalev 1993, Pyle & Howell 1995, Kovalev 1996, Miettinen 2002), could we confirm reports of PC moulted during the post-juvenile moult (C.S. Roselaar in Cramp 1985, Baker 1993, 2016, Demongin 2016, 2020, Blasco-Zumeta & Heinze 2023). Specifically, we carefully examined 24 wing preparations of 1cy Great Spotted Woodpeckers

during various stages of active post-juvenile P moult, none had any PC growing. Also, all Great Spotted Woodpeckers with retained juvenile GC (hence certain 1cy/2cy) never had renewed PC (150 wing preparations, skins and photos). This also held for the 1cy/2cy of the Grey, European Green and White-backed Woodpeckers examined by us (for an exceptional case of a White-backed Woodpecker, see its species account).

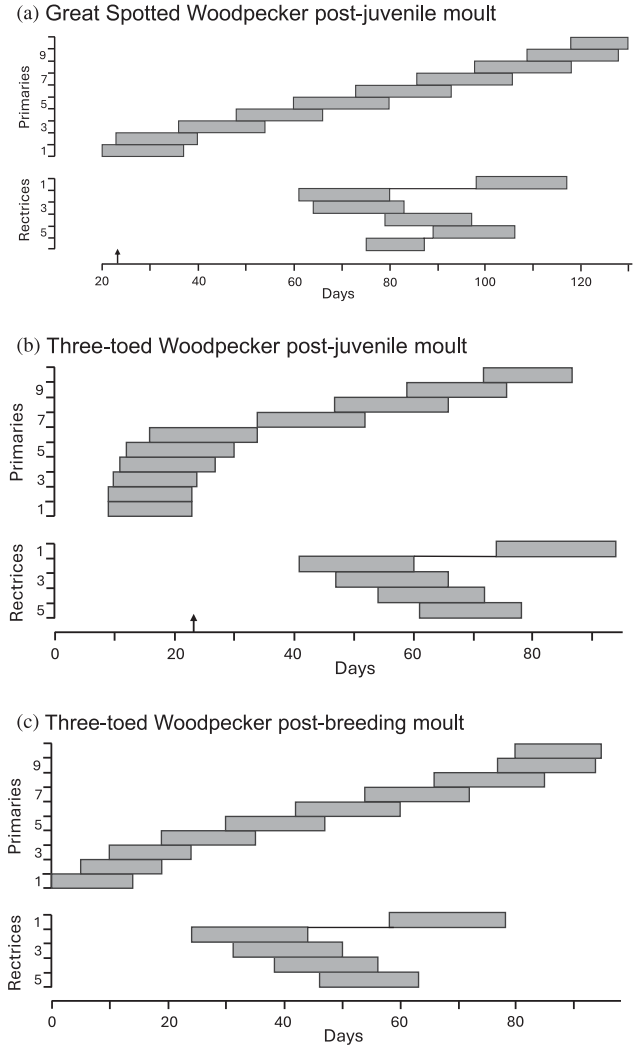


Figure 61. Sequence and duration of the moult of the primaries and rectrices in (a) a captive juv Great Spotted Woodpecker and (b) a juv and (c) an ad Three-toed Woodpecker. The bars indicate the duration of growth of individual feathers. The reduced outermost R 6 of the Three-toed Woodpecker is not considered. For the two juv birds, day 0 is the day of hatching and the arrow indicates the fledging date. Moult of the innermost primaries starts before fledging. For the ad bird, day 0 is the day of the shedding of P 1 (E. Sutter, unpubl. data).

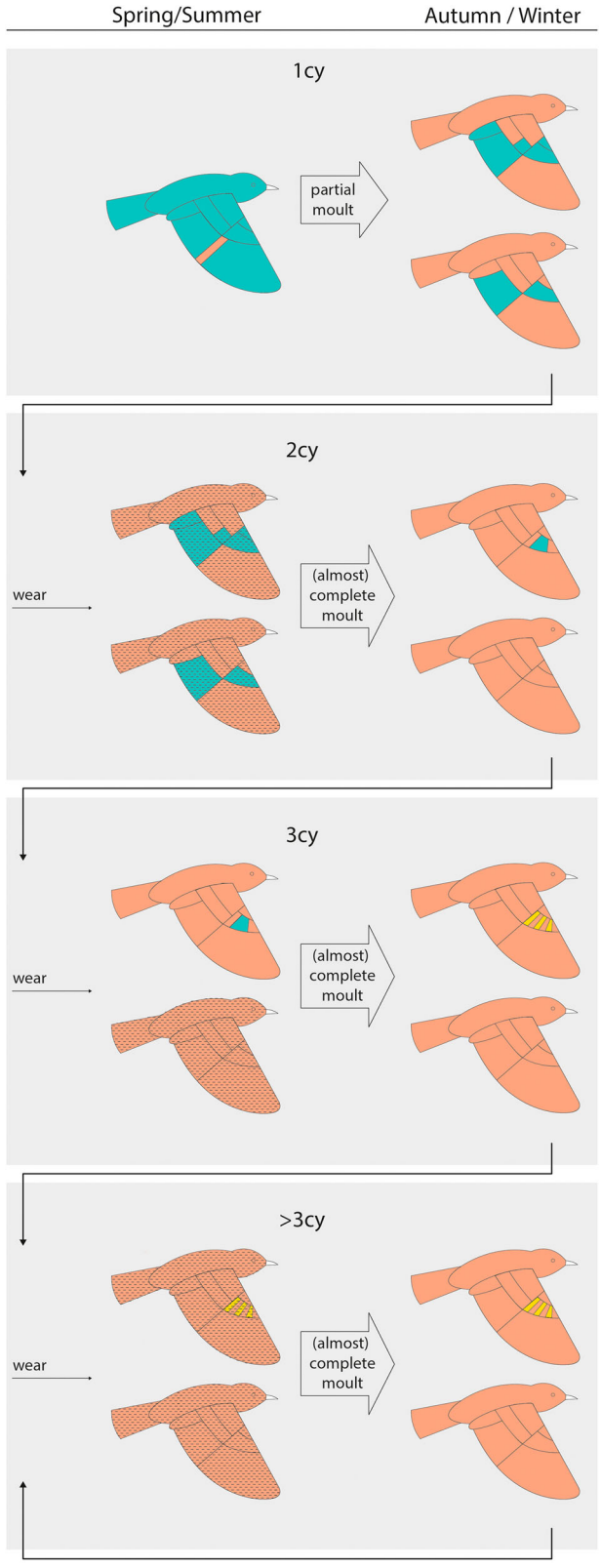


Figure 62. Schematic presentation of the moult of true woodpeckers. 1cy/2cy retain their juvenile PC and usually S 1–8, and often some GC, until the first post-breeding moult. After the post-juvenile moult, their plumage is composed of two feather generations. Adults moult completely or retain individual PC and/or, more rarely, S. For details and exceptions see species texts. Key as in Figure 26.

Post-breeding moult

Post-breeding moult takes place between June and October (November) and is complete or almost so (Figure 62). Depending on species and individual, some PC and/or S remain unmoulted.

P are moulted in the usual descendent sequence from P 1 to P 10 (Figure 61). PC often do not moult together with the corresponding P, or may remain unmoulted (e.g. Ginn & Melville 1983, Michalek & Miettinen 2003). S are moulted from two foci: from S 8 in both directions and from S 1 ascendently, approximately in the order S 8–9–7–1–10–6–2–11–5–3–4. Rectrices are moulted in the order R 2–3–4–5(–6)–1 (R6 sometimes earlier; Figure 61); thus the strong central pair supports the bird on vertical surfaces when the other R are growing, and vice versa (Glutz von Blotzheim & Bauer 1980, C.S. Roselaar in Cramp 1985; Figure 63).

General ageing criteria

Ageing before and during moult

1cy birds are recognisable by remaining juvenile head and body feathers, by the fact that the juvenile PC belonging to growing P are not renewed, and by the fact that no S 1–8 are growing. In adults, all or most S are moulted, as well as some or all PC, but not necessarily those of the corresponding P.

Ageing after the moult

1cy/2cy are recognisable by the unmoulted PC and (less conspicuously) the unmoulted S 1–8. In most 1cy/2cy, but not all, the light spots on the juvenile S are aligned and change shape gradually across the tract. Adults have all PC and S new or show a mixture of new and old PC and S. In many adults, the light spots on S are not aligned across the tract but show more or less abrupt changes in position and shape. According to our findings, moult limits within PC occur only in adults (see above).



Figure 63. In this Grey-headed Woodpecker from 25 August, the central R 1 are growing (the two blood quills) while R 2–5 have already been renewed. The renewal of R 1 after the other R is typical for all true woodpeckers. Photo by Lisa Eichler.

Great Spotted Woodpecker *Dendrocopos major*

Timing of moult

Post-juvenile and post-breeding moults take place mid-May–October (–mid-November), earlier in southern than in northern populations (Michalek & Miettinen 2003). The start of moult of an individual may vary between years by 20–25 days, probably depending on individual timing of breeding (Kovalev 1999). Some birds, especially males, start moult with P 1 or P 1–2 and corresponding PC when feeding nestlings. Duration of post-breeding primary moult in Russia is 100–110 d (Kovalev 1999) and in Great Britain 120 d (Ginn & Melville 1983). Duration of post-juvenile moult in Russia is 155–165 d (Kovalev 1996) and in Great Britain 145 d (Ginn & Melville 1983), and took 110 d in a captive bird (Figure 61). In Fennoscandian eruptive birds, adults slow down moult during migration, while 1cy may suspend post-juvenile moult and finish it only in December/January (Ree 1974, Vikberg 1974, 1975, C.S. Roselaar in Cramp 1985).

Extent of moult

Post-juvenile moult

This account is based on 82 1cy/2cy from Switzerland (Figure 64a). Always moulted are body feathers, P, R, MaC, LeC and MeC. Exceptionally, single juvenile MaC, LeC, MeC or red crown feathers may be retained. Outer S and PC are not moulted: (see True woodpeckers, Moults).

Moult of GC: range 2–11 feathers, mean 6.2, mode 5, none 0%, all GC 4.9%. From a further sample from Vienna (n = 79): range 3–11 GC, mean 7.0, mode 5, none 0%, all GC 8.9%. Moult of Al: none 8.5%, Al 1 7.3%, Al 1–2 11.0%, Al 1–3 15.9%, Al 1 and 4 2.4%, Al 1–2 and 4 2.4%, all four 52.5%. Moult of S: none 86.6%; 9.8% replaced single S among S 4–11, mostly on one wing only and some of them probably accidentally. Only two birds moulted S 9–11 (all GC moulted) and one bird S 11 on both wings. A further four birds from Vienna had moulted S 8, S 9, S 10 or S 8–9.

The extent of post-juvenile moult is correlated among GC, S and Al. Most renewed S were found in birds with at least eight GC moulted and these had all Al renewed.

The extent of the post-juvenile moult varies between regions and subspecies and is generally less extensive in the north than in the south (Kovalev 1996). In Russia (Lake Ladoga), the moult is less extensive than in birds from Switzerland and Vienna: 70.3% had no GC moulted and 0% all; 59.5% had no Al moulted and 0% all; S were not moulted; all MaC, LeC and MeC were moulted in only 24–54% of 1cy, while 40–59% showed a moult limit and 5–16% moulted no feathers among these tracts (n = 37; Kovalev 1996).

Post-breeding moult

Among 63 birds from Switzerland , 20% renewed the entire plumage, and 80% left individual PC (maximum five) and/or S (maximum four) unmoulted, often different ones on the left and right wings: 39% left only PC unmoulted, 13% only S unmoulted, and 27% both PC and S unmoulted (Figure 64b). Most often, some central PC (among PC 3–6) and S (among S 3–5) remained unmoulted. In a sample from Vienna (n = 69), 40.6% renewed all PC and 59.4% left one to five PC unmoulted, most often among PC 3–5. In British birds also, some central PC remain unmoulted (Ginn & Melville 1983).

The first post-breeding moult of birds from Vienna is less extensive than later moults. 33.3% moulted completely (all PC and S); 66.7% retained one to five PC, always as a block centred around PC 4–5 (Figure 65a; n = 24 1cy/2cy birds retrapped after the following first post-breeding moult). Single S may also be retained. The first post-breeding moult of Russian and Finnish birds is never complete (Miettinen *et al* 1986, Kovalev 1999, Miettinen 2002, Michalek & Miettinen 2003): some central PC (usually PC 3–6, minimum PC 3–5, maximum PC 2–7) and in 52% of birds some S are retained (S 4, S 3–4, S 3–5, rarely S 2–5). At Lake Ladoga, PC 2–7 (3%), 3–7 (6%), 2–6 (27%), 3–6 (52%), 2–5 (6%) or 3–5 (6%) remain unmoulted (n = 83; Kovalev 1995, 1999).

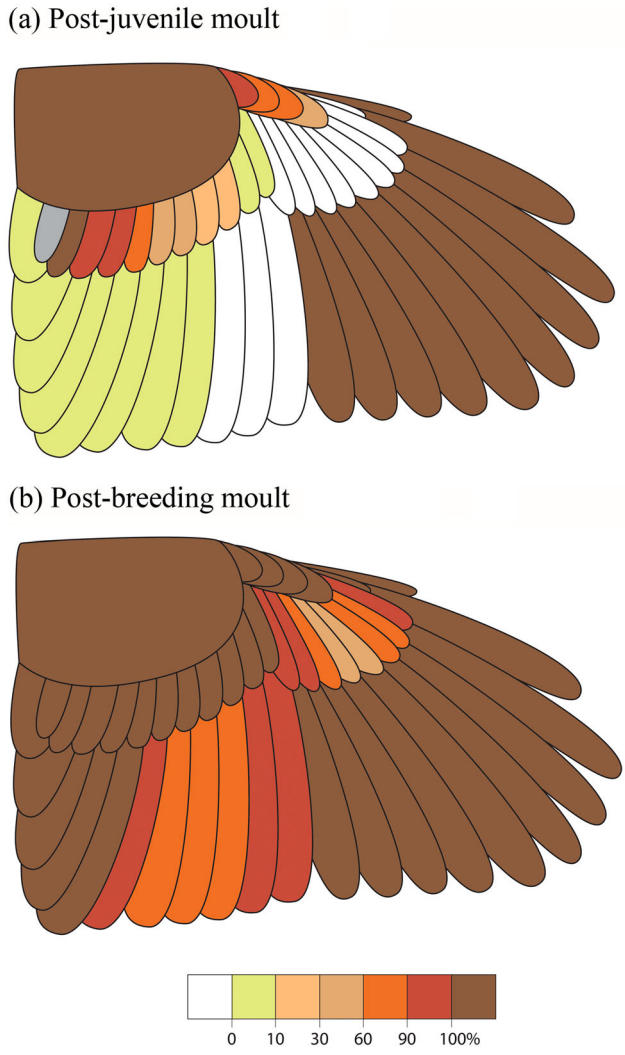


Figure 64. Extent of (a) the post-juvenile and (b) the post-breeding moult on the wing in Great Spotted Woodpeckers from Switzerland. For the post-juvenile moult, GC 11 (shaded grey) is not considered. Birds from Vienna renewed slightly more GC during the post-juvenile moult, but showed a very similar extent of PC moult during the post-breeding moult (see text).

The second and later post-breeding moults of birds from Vienna are more complete: 59% moulted all PC, 41% retained one to five PC (Figure 65b; n = 27 retraps). Again, some S may be retained. It seems that juvenile PC retained during the first post-breeding moult are usually moulted, often in a complete PC moult; if some PC are retained, they are now more dispersed (Figure 65b), often more distal and sometimes in two blocks (Kovalev 1999, see also Pyle & Howell 1995 for American species). Some birds retain individual PC during two subsequent post-breeding moults and hence may show three generations of PC (Figure 73; Miettinen 2002). It is to be expected that southern populations generally moult more PC and S, hence birds with three generations of PC might be rare or non-existent. Russian and Finnish birds usually retain some PC during the second and later post-breeding moults, but some may moult all PC (Kovalev 1995, 1999, Miettinen 2002).

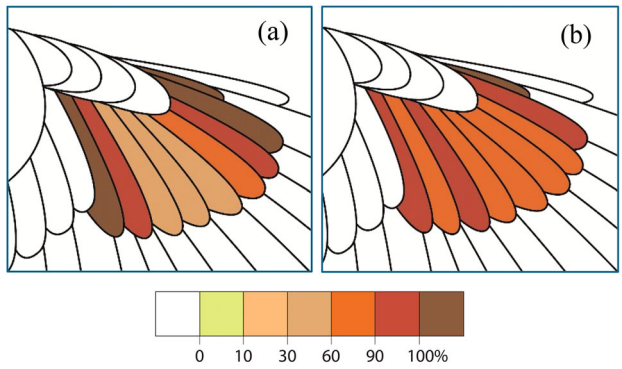


Figure 65. Extent of the moult of PC during (a) the first post-breeding moult (n = 24) and (b) the second or later post-breeding moults (n = 27) of Great Spotted Woodpeckers of known age from Vienna.

Ageing criteria

Before and during moult

1cy: In juvenile plumage, crown red, back of head black (Figure 66c, d). Innermost GC 8–11 mottled black and white (Figure 67), not pure white as in later plumages. Tips of P 8–9 white (P 7 can have a white tip also in later plumages). Undertail coverts dull red, not deep red. Outermost tail feathers tapered, not rounded, best visible on R 5. Juvenile P 10 longer than in adults: 31–42 mm (mean 34.4, n = 22; E. Sutter in Glutz von Blotzheim & Bauer 1980).

During moult, look for remaining juvenile red crown feathers and white tips on unmoulted outer P. PC and S 1–8 are not renewed. Intensive moult of body feathers (including the red crown) starts only when juvenile P 6 or 7 is dropped (Glutz von Blotzheim & Bauer 1980).

Ad have a black crown (in males back of head red; Figure 66a, b), P 8–9 without white tip, undertail coverts deep red, outermost R rounded (best seen on R 5). Adult P 10 shorter than in juveniles: 22–29 mm (mean 25.8, n = 25; E. Sutter in Glutz von Blotzheim & Bauer 1980). In contrast to 1cy, S are moulted, starting when P 2 or 3 is dropped (Glutz von Blotzheim & Bauer 1980). During the moult of P, generally some PC are moulted but not necessarily the associated ones.

After the moult

1cy/2cy: 91–95% show a moult limit within GC. To detect a moult limit, it is important to know that the juvenile GC 8–11 are black-and-white (Figure 67), but completely white when moulted (Figure 69), while GC 1–7 are dark in both plumages.

A moult limit within GC 1–7 (72% of birds) is easily detected: juvenile GC are brown-black, mat and shorter than the post-juvenile GC which are glossy black and longer (Figures 69 & 70). A moult limit between GC 7 and 8, between the white and dark GC (20% of birds), can be recognised by a difference in length and wear: the white GC are longer and fresh, while the juvenile GC are shorter and worn (Figure 71). A moult limit within the innermost GC 8–11 (4%) is easily detected because the juvenile GC are black-and-white and shorter, while the renewed GC are longer and mostly pure white; moreover, there is a contrast between the juvenile brown-black GC and the renewed glossy-black MeC.

If all GC are renewed (5–9%; Figure 68), the bird looks similar to an adult. But because adults always renew all S, they have no moult limit within S, whereas 1cy/2cy with a large moult extent are prone to renew also one or two S. Also, the moult limit between juvenile S and post-juvenile GC may be helpful. Moreover, 1y/2y have no moult limit within PC (contrary to Demongin 2020; see True woodpeckers, Moults).

Moult limits within Al occur in 39% of 1cy/2cy. Note that the innermost Al 1 (white on inner vane) often covers the black Al 2 completely. The largest Al 4 is slightly less black in both juvenile and later plumages than Al 1–3 and might thus simulate a moult limit.

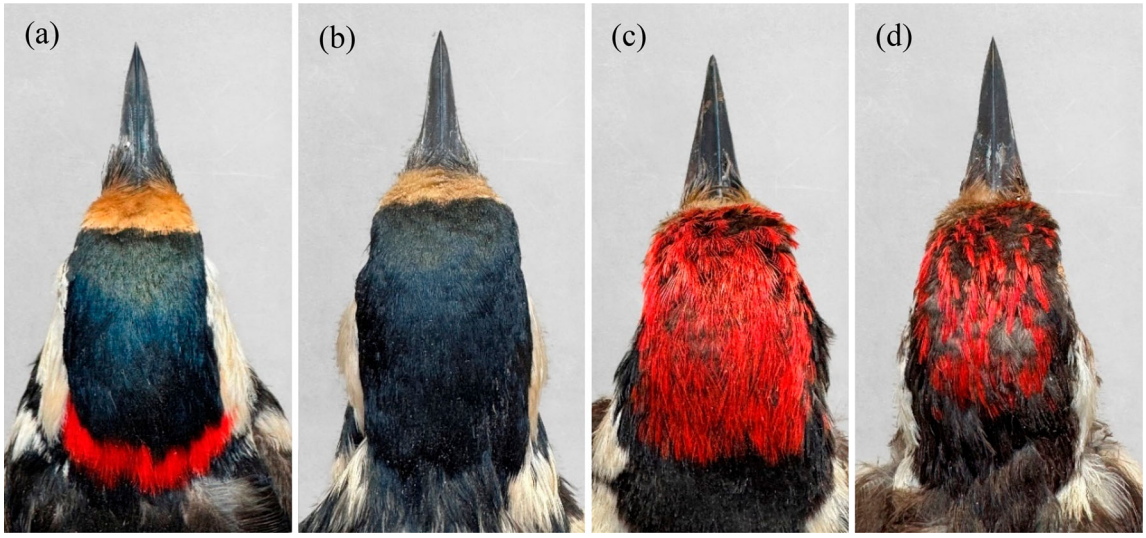


Figure 66. Crowns of Great Spotted Woodpeckers: (a) ad male, (b) ad female, (c) juv male, (d) juv female. Anatomically sexed specimens from the Natural History Museum of Basel (NMB 99-025, 2-091, 94-056, 92-075).

Therefore, moult limits are best detected when between Al 1 and 2 or between Al 2 and 3. Also note that Al can be renewed irregularly, e.g. often Al 1–2 and 4 (Al 3 unmoulted), or Al 1 and 4 (Al 2 and 3 unmoulted).

13% of 1cy/2cy renew one to three S, often only on one wing; new S can be recognised by being darker black and glossy.

Individual red-tipped crown feathers are not indicative of 1cy/2cy, because some adults can also grow a few red-tipped crown feathers (Baker 2016).

Iris is generally brown or reddish-brown in 1cy until March/April, turning red-brown to red later on (Demongin 2016, 2020), but iris colour cannot be used alone as an ageing criterion, as the overlap in colour between age classes is too broad (Baker 2016).

Ad: No moult limit within GC, Al and S, but 80% have a moult limit within PC and/or S 1–6 (60–66% within PC and 40% within S 1–6). Contrary to Demongin (2020), we consider birds with two generations of PC safely recognisable as adults.

With experience, some of those adults with a moult limit within PC can be aged further:

2cy/3cy (after the first post-breeding moult, Euring code 5/7): Birds with a clear contrast within PC in shape, wear and colour, indicating that the retained PC are from the juvenile plumage (mostly central PC), can be aged as 2cy/3cy (Miettinen 2002). Juvenile PC, now more than a year old, are browner and more worn than the replaced PC (Figure 72). The differences between juvenile and replaced PC are less obvious among outer PC, because here the replaced PC are also more pointed and worn. The contrast between retained juvenile and replaced S is generally more pronounced than in older birds. White spots on the outer vane of juvenile S are usually closer to the tip than in replaced feathers.

3cy/4cy and older (after the second post-breeding moult, Euring code 6/8): Moult limit within PC not conspicuous, because retained and moulted PC are similar in shape and differences in wear are slight (Figure 74). Also the contrast between retained and moulted S is very slight (Miettinen 2002). Some birds retain individual PC during two subsequent post-breeding moults and then may show three generations of PC (Figure 73; Miettinen 2002). If the oldest generation of PC is of juvenile type, the bird may be determined as a 3cy/4cy (Euring code 7/9). However, because outer PC wear faster and are more pointed than inner PC, the determination of juvenile PC versus later PC is not easy. Because southern populations are expected to moult more PC, birds with three generations of PC might be rare or non-existent.

Sexing criteria

After the post-juvenile moult, males have the back of head with a red band, females all glossy bluish-black, without red (Figure 66a, b).

Not all juveniles can be sexed. Both sexes have a red crown and the back of the head black (Figure 66c, d). Length of red crown 24–30 mm in males, 17–25 mm

in females. Black between red crown and eye averages narrower in males than females. In fresh plumage, on average hardly any grey or black feather bases visible on the red crown in males, in contrast to females which show more dark feather bases (C.S. Roselaar in Cramp 1985). Juveniles can be safely sexed as soon as some post-juvenile feathers appear on the back of the head (red in males, black in females).



Figure 67. 1cy male Great Spotted Woodpecker during post-juvenile moult, 9 July. P 1–2 postjuv, 3–4 growing. Rest of wing juv. Typically for juv plumage: innermost GC 8–11 mottled black and white; P 8–9 with white tips.



Figure 68. 2cy male Great Spotted Woodpecker after post-juvenile moult, 27 March. P, Al, GC, MaC, LeC, MeC postjuv. S 1–4 juv (despite uneven lengths), S 5–8 postjuv. Rest of wing juv. No moult limit within the GC, but between postjuv GC and juv PC, and between juv S 1–4 and postjuv S 5–8. Moult limit between postjuv S 8 and juv S 9–11 but not distinct. On the other wing this bird has S 7–8 postjuv and S 1–6 juv of even length, as well as GC 1 juv, all features corroborating a 2cy.



Figure 69. 2cy female Great Spotted Woodpecker after post-juvenile moult, 25 January. GC 1–5 juv, 6–11 postjuv. Al 1 and 3 postjuv, 2 and 4 juv. PC juv. P, MaC, LeC and MeC postjuv. Moult limit distinct within GC, but not well marked within the Al.



Figure 70. 2cy male Great Spotted Woodpecker after post-juvenile moult, 15 February. GC 1–4 juv, 5–11 postjuv; PC juv; P, Al, MaC, LeC and MeC postjuv. Example of a 2cy with light, discoloured juv wing coverts: juv GC 1–4 and PC light grey-brown, the remaining postjuv wing coverts and Al normally coloured. Moult limit within GC is particularly conspicuous.



Figure 71. 1cy female Great Spotted Woodpecker after post-juvenile moult, 25 November. GC 1–7 juv, 8–11 postjuv; PC juv; P postjuv; Al 2–3 juv, 1 and 4 postjuv; MaC, LeC and MeC postjuv; some MaC juv. Example of a 1cy with reddish-brown discoloured juv wing coverts: juv GC 1–7, PC, some MaC and Al 2–3 reddish-brown, postjuv rest of wing coverts and Al 1 and 4 normally coloured. Moult limit within GC is particularly conspicuous.

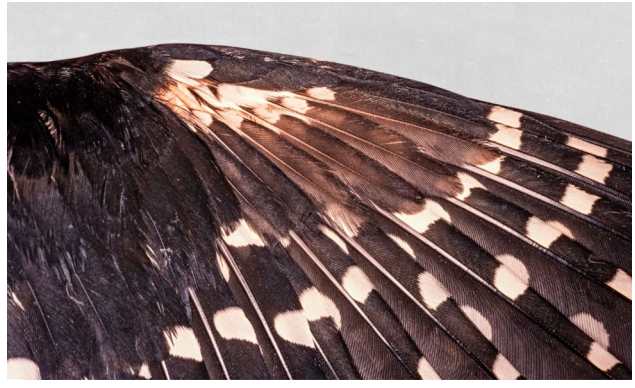


Figure 72. Ad female Great Spotted Woodpecker after post-breeding moult, 27 May. Entire wing renewed, except PC 3–6. The retained PC are bleached and worn, so probably of the juv generation: this indicates that this bird is probably a 3cy (Euring code 7) and has undergone its first post-breeding moult.

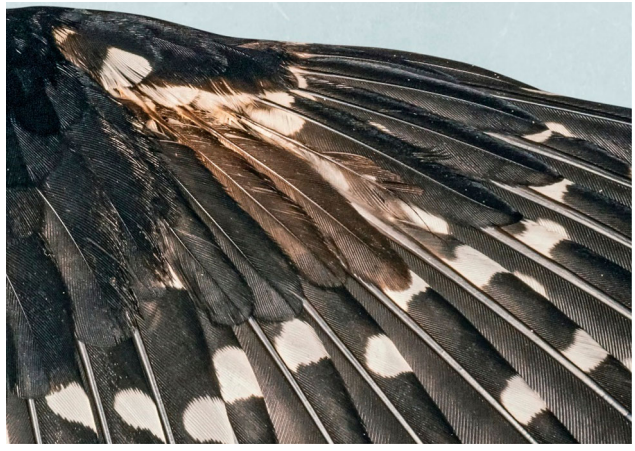


Figure 73. Ad male Great Spotted Woodpecker after post-breeding moult, 10 May. Entire wing renewed, except PC 3–5. The different wearing conditions of the PC suggests three generations of feathers. The oldest PC 5 is very much abraded and a remnant of the juv plumage. PC 3–4 are of better quality but clearly more bleached than PC 1–2 and 6–9 and so are of an intermediate generation. The newest PC are from the latest post-breeding moult. This bird has undergone two post-breeding moults and, as it is from spring, is a 4cy (Euring code 8) bird.



Figure 74. Ad female Great Spotted Woodpecker after post-breeding moult, early November. Entire wing renewed, except PC 3–5 and S 5. The old PC 3–5 are not particularly bleached and worn, so probably not from the juv generation. This would indicate that this bird has undergone at least two post-breeding moults, hence aged as >2cy (Euring code 6).



Figure 75. Ad female Great Spotted Woodpecker after post-breeding moult, winter (no date). Entire wing postbr. One of the 20% of ad without retained PC and in this respect similar to a 1cy/2cy with all PC from the juv plumage. But PC of ad jet-black as GC; no moult limit within GC. The white dots on the PC of this bird are particularly pronounced, but this is part of individual variability and not indicative of age.

White-backed Woodpecker *Dendrocopos leucotos*

Timing of moult

Because of its earlier breeding, moult starts and ends about two weeks earlier than in sympatric Great Spotted Woodpeckers, i.e. remiges from early May until end of September (C.S. Roselaar in Cramp 1985) or in the Pyrenees end of October (Purroy 1972, Urbina-Tobias & Grangé 2024).

Extent of moult

This account is based on photos from birds captured in the field in Switzerland, Liechtenstein and Austria, among them nine retraps in a later year. Some feather tracts could not be examined in detail (e.g. inner S) and findings are therefore preliminary.

Post-juvenile moult

Body feathers, MaC, LeC, MeC, P and R always moulted; S 1–6 and PC not moulted. 53% had all GC renewed, while 47% left one to eight outer GC unmoulted. Outer Al feathers can remain unmoulted. S 7–11 could not be assessed reliably (Figure 76a; n = 15).

Post-breeding moult

33.3% renewed the entire plumage; 43.6% left some PC unmoulted; 7.7% one or a few S among S 1–6; and 15.4% both some PC and one or a few S 1–6. On average 2.9 PC (range 1–6 feathers) remained unmoulted among PC 2–7. Mostly only one S was left unmoulted (twice two, once three) which could occur anywhere within S 1–6 (Figure 76b; n = 39).

The figures for retained S 1–6 must remain provisional, because S of probably the same feather generation differed slightly in gloss and in the shape and position of the white spots. As in Grey-headed Woodpecker, it seems that the S, which moult sequentially at different times, may acquire slightly different colour patterns. However, this needs further study.

Pyrenean White-backed Woodpeckers *D. l. lilfordi* showed a similar moult extent (Villanúa *et al* 2020, Urbina-Tobias & Grangé 2024): the post-juvenile moult, examined on eight birds in total, comprised all MaC, MeC, LeC, P and the innermost five to seven GC, but some single juvenile LeC and MeC may be retained. Al 4 is retained by about half of the birds. PC 8–10 sometimes seemed newer, but probably because they

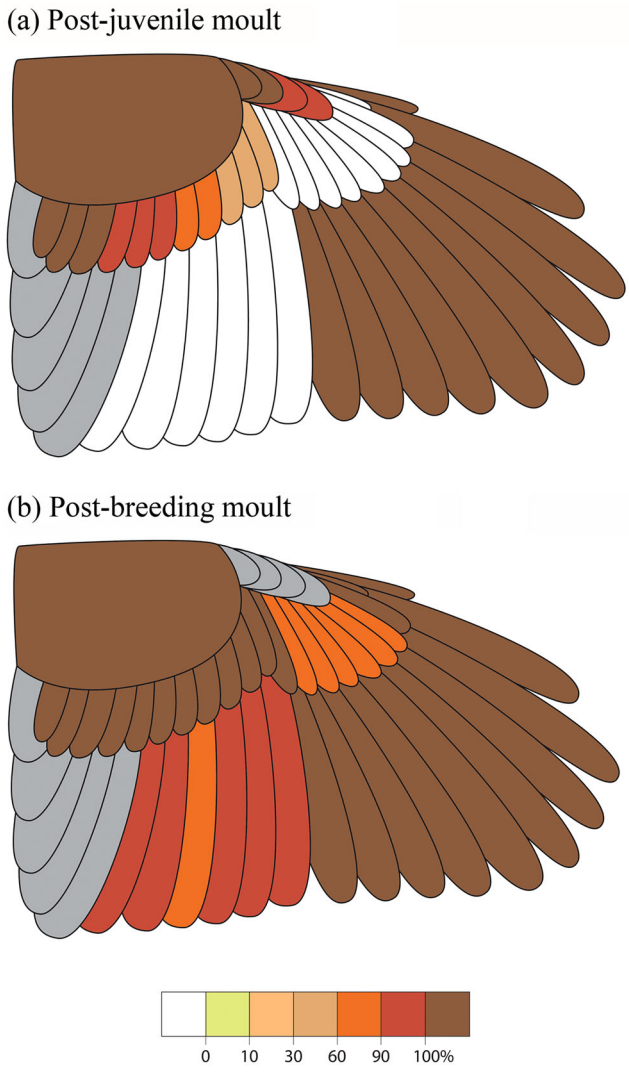


Figure 76. Extent of (a) the post-juvenile and (b) the post-breeding wing moult in White-backed Woodpeckers. Feathers shaded grey were not considered.

receive less wear. An exceptional case, allegedly a 2cy, has been reported with renewed PC 1 and 4 (Urbina-Tobias & Grangé 2024), but having seen the photos of both wings, we cannot interpret the moult pattern fully and therefore be sure about the age.

Fifteen 3cy or older birds had undergone a complete moult, among them <25% having a few S and PC unmoulted (S 1, 3 or 4, PC 5, 9, 10; Villanúa *et al* 2020). On the northern slope of the Pyrenees, four of the five adults had retained S 4 and 5 and three had retained at least one PC (Urbina-Tobias & Grangé 2024 and pers. comm.).

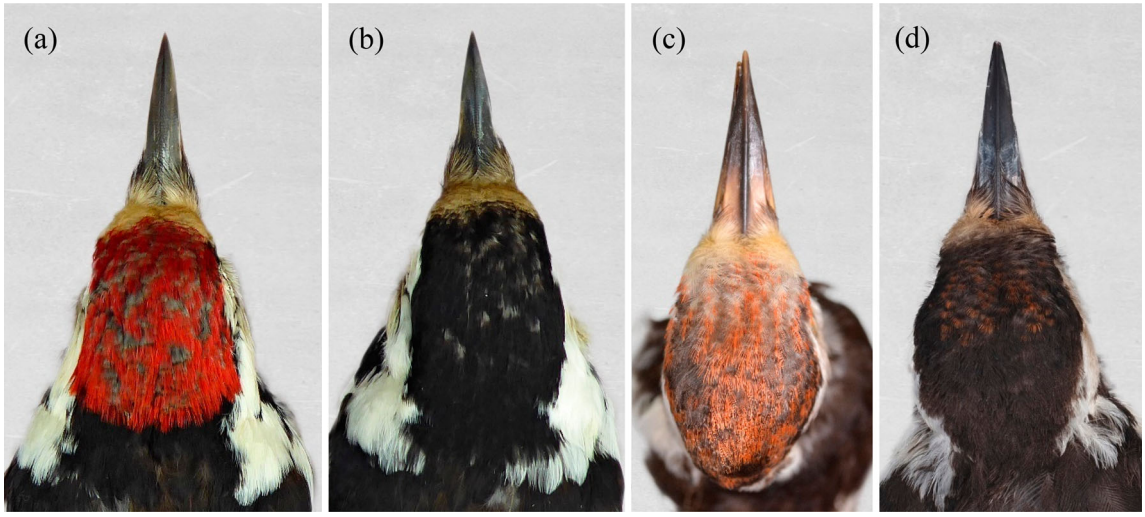


Figure 77. Crowns of White-backed Woodpeckers: (a) ad male, (b) ad female, (c) juv male, (d) juv female. The variation in the extent of the red crown in the juv plumage of males and females remains to be studied in more detail. Anatomically sexed specimens from the Museum Koenig Bonn (a, b, ZFMK_ORN E.I.5.h.λ, E.I.5.h.θ), the Natural History Museum at Tring (c, NHMUK 1879.4.5.1420), and the Finnish Museum of Natural History, Helsinki LUOMUS (d, http://id.luomus.fi/KS.KL31095).

Ageing criteria

Before and during moult

1cy: In juvenile plumage, the black parts are dull brownish-black. The red tips of the crown feathers of males are small so that the dark feather bases are visible, and the red crown appears mottled (Figure 77). The streaks on breast and flanks are less sharply defined, the underparts buff, the red tinge on underparts is restricted to vent and under-tail coverts, pale, or virtually absent. P 5–8 are tipped white on both vanes, not only on outer vane. P 10 is 6–10 mm longer than the longest PC (Glutz von Blotzheim & Bauer 1980, C.S. Roselaar in Cramp 1985, Grangé 2022, Urbina-Tobias & Grangé 2024).

During moult, look for remaining juvenile feathers (e.g. duller brownish-black MaC and LeC) and white tips on inner vane of unmoulted outer P. PC and S 1–6 are not renewed. Intense moult of body feathers (including the crown) starts only when juvenile P 6 or 7 is dropped (Glutz von Blotzheim & Bauer 1980).

Ad: The black parts of the plumage are jet-black. Crown is black or red. The streaks on breast and flanks are sharply defined, the underparts white, the red tinge on underparts extends to lower belly. P 5–8 are fringed white only on outer vane. P 10 is 5 mm longer to 3 mm shorter than the longest PC (Glutz von Blotzheim & Bauer 1980, C.S. Roselaar in Cramp 1985, Urbina-Tobias & Grangé 2024). In contrast to 1cy, S and at least some PC are moulted.

After the moult

1cy/2cy: About 50% show a moult limit within GC 1–8. Note that GC 1 and, less so, GC 2 are shorter than the other GC, and sometimes have no white spot; these differences may simulate a moult limit. Because S 1–6 are all juvenile, and hence grown at the same time, their white spots are aligned across the feather tract.

Ad: No moult limit within GC, Al and S 7–11. 66% have a moult limit within PC and/or S 1–6 (Figures 79–81). Moult limits within S are not easily detected, because S may vary in colour (see above). In some adults, but not all, white dots on S 1–6 are not all aligned. Some adults with a moult limit within PC can be aged further (Figures 79–82; see Great Spotted Woodpecker). Adults without retained PC and/or S are difficult to identify (Figure 81).

Sexing criteria

After the post-juvenile moult, males have crown and back of head red, and females black (Figure 77). In juvenile males, the red on the head is paler than in adults and restricted to the crown, with black and grey feather bases showing through, but extending to the white cheek. Red tips on crown feathers are 1.5–3 mm long. Juvenile females have markedly less red on the head than juvenile males, not extending to the white cheek. The red is often restricted to the forecrown or central crown, hardly visible, or even absent. If present, red tips on crown feathers are 0.5–1.5 mm long (Figure 77; C.S. Roselaar in Cramp 1985, Stenberg 1998, Grangé 2022).



Figure 78. 2cy male White-backed Woodpecker after post-juvenile moult, 30 March. MaC, LeC, MeC, GC, AI and P postjuv. PC and S juv. The juv PC are slightly browner than the renewed P. Photo by Antonia Ettwein.



Figure 79. Ad female White-backed Woodpecker after post-breeding moult, 19 April. Entire wing renewed, except PC 4–6 and S 1–2. Typical ad, with a moult limit within PC. The moult limit within S is harder to see. Because the old PC are considerably worn and pale, they are probably juv, and hence this bird can be aged as 3cy (Euring code 7). Photo by Antonia Ettwein.



Figure 80. Ad female White-backed Woodpecker after post-breeding moult, 13 October. Entire wing has been renewed, except for PC 3–4. Typical ad, with a moult limit within PC. Because the old PC are more similar to the renewed ones, they are probably not juv, but have been renewed during a previous post-breeding moult, and hence this bird can be aged >3cy (Euring code 8). Photo by Carolyn Nabholz.



Figure 81. Ad male White-backed Woodpecker after post-breeding moult, 3 April 2018. Entire wing postbr. All PC of the same generation. Difficult to age, but note that the white spots on S are not aligned. This bird was also caught the year before, on 14 March 2017, when it was aged ad because of a retained PC 7. Photo by Antonia Ettwein.



Figure 82. Ad female White-backed Woodpecker after post-breeding moult, 18 April. Entire wing has been renewed, except for PC 2–7. Typical ad, with a moult limit within PC. PC 6–7 are older than PC 2–5. PC 2–5 have not been renewed during the last post-breeding moult, while PC 6–7 are probably juv and had not been renewed during the last two post-breeding moults. Hence this bird can be aged >3cy (Euring code 8). Photo by Antonia Ettwein.

European Green Woodpecker *Picus viridis*

Timing of moult

The moult of adults starts after the young have fledged (May–July) and may last until November. 1cy start moult with P 1 a few days before fledging. Moult generally is earlier in southern regions than in northern areas and takes 120–130 days (Glutz von Blotzheim & Bauer 1980, Ginn & Melville 1983).

Extent of moult

Post-juvenile moult

Body feathers, P, R, MaC, LeC, MeC, GC and Al are always moulted; S 1–8 and PC not moulted. See also True woodpeckers, Moults. Among S 9–12, none moulted 51.4%, one feather 18.9%, two 18.9%, three 10.8%, most often S 12. S moult is often asymmetric between the wings (Figure 83a; n = 37).

Post-breeding moult

63% moult the entire plumage, 37% leave one to four PC among PC 2–7 unmoulted, mostly PC 4–5, often asymmetric between the wings (Figure 83b; n = 27). No unmoulted S were found in our sample, but this may occur in more northerly areas.

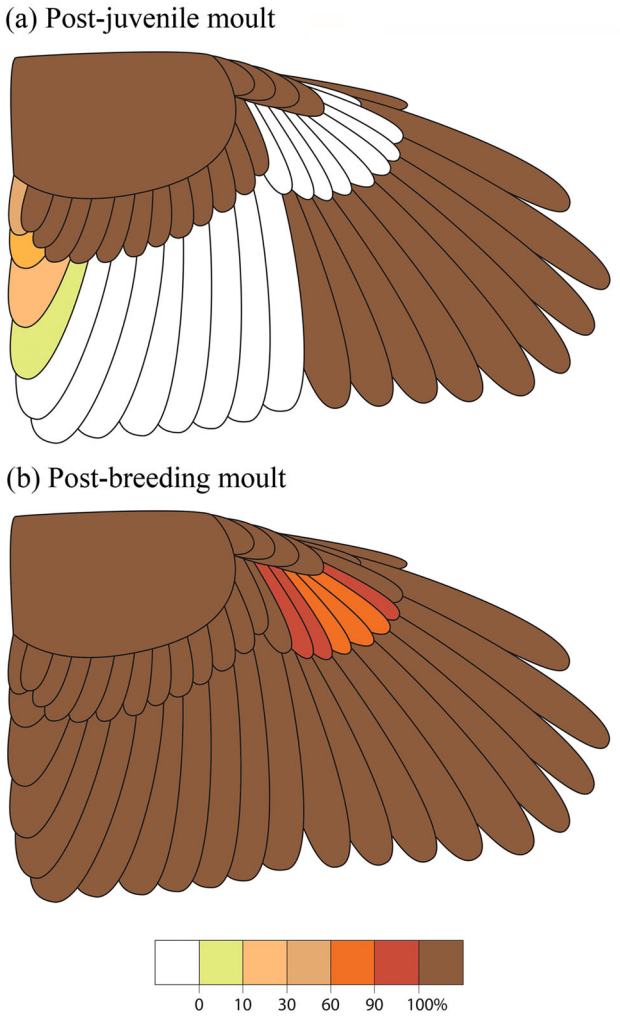


Figure 83. Extent of (a) the post-juvenile and (b) the post-breeding wing moults in the European Green Woodpecker.

Ageing criteria

Before and during moult

1cy: The juvenile plumage is very distinct with head, neck and underparts heavily spotted or mottled; green upperparts, GC, MeC, LeC and MaC with white spots (Figures 84 & 86), head lacks a black mask. P 10 longer than in later plumages: 46–58 mm (mean 51.5 mm; n = 24; E. Sutter in Glutz von Blotzheim & Bauer 1980).

During moult, look for remaining juvenile body feathers, MeC and MaC with their distinctive spots. PC and S 1–8 are not renewed. Body feathers are only renewed during the moult of the outer five P (Glutz von Blotzheim & Bauer 1980).



Figure 84. European Green Woodpecker in (a) juv and (b) ad plumage. In juv plumage, the underparts are fluffy and heavily spotted or mottled. Adults have unspotted underparts. Specimens from the Natural History Museum of Basel (NMB 18350, 15815).

Ad have unspotted body plumage (Figure 84) and a plain black mask. P 10 shorter than in juvenile plumage: 35–44 mm (mean 39.2 mm; n = 26; E. Sutter in Glutz von Blotzheim & Bauer 1980). During moult of P, all or some PC are moulted but not necessarily together with the associated P. The S are moulted.

After the moult

1cy/2cy: All PC juvenile (contrary to Demongin 2016, 2020; see True woodpeckers, Moults). Juvenile PC with distinct light spots (Figures 86–89). The duller-green juvenile S 1–8 contrast with the renewed green GC (Figure 88). Furthermore, look for moult limits within S 9–12 and the barring of S 12. Juvenile S 9–12 show individually variable barring (most distinct on the small innermost S 12; Figure 87), which, when faint, may resemble that of adults. About half of 1cy/2cy show a moult limit within S 9–12 (Figures 88 & 89). Juvenile S 9–12 have marked light bars, renewed S 9–12 only faint bars on the inner vane. Moreover, renewed S 9–12 stand out by their deeper green colour. If there is no moult limit within S 9–12, look for S 12. If S 12 is distinctly barred (juvenile), the bird is a 1cy/2cy (Figure 87).

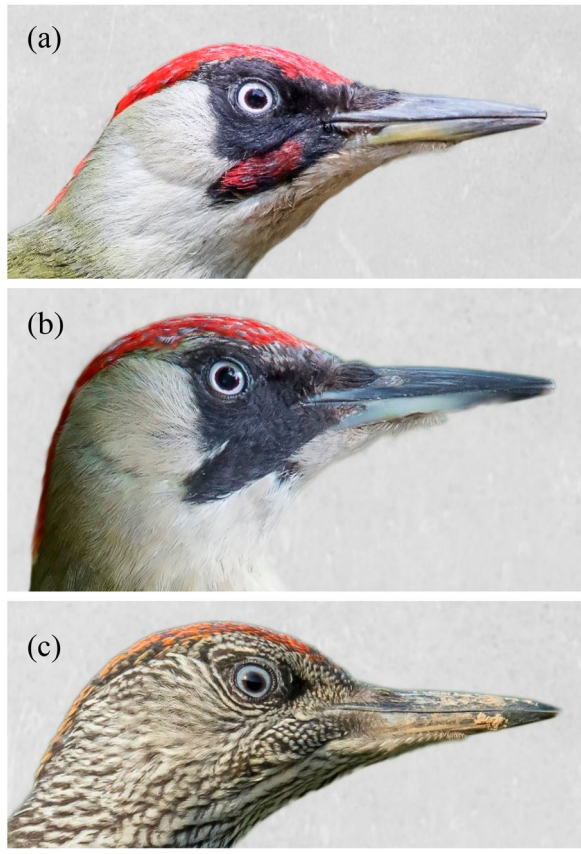


Figure 85. Head pattern of (a) male and (b) female European Green Woodpecker after the post-juvenile moult, and of (c) a juv of which the sex cannot be told from the plumage. Photos by Marcel Burkhardt.

Ad: PC with blurred spots which are less light (Figure 90). No distinct difference in colour between S and GC. No moult limit within S 9–12; S 9–12 without bars (Figure 90). Birds with a mixture of old and new PC are adults (Figure 91).

Sexing criteria

Males have a red malar stripe, bordered black; females have a black malar stripe without red (Figure 85).

Juveniles can be safely sexed as soon as some post-juvenile feathers appear in the malar stripe.

In complete juvenile plumage, males may or may not have some reddish or golden feathers in their faint malar stripe, while females do not have such coloured feather tips. Therefore the colour of the malar stripe is an unreliable criterion for sexing in complete juvenile plumage (Demongin 2016, Gorman 2023).



Figure 86. Juv female European Green Woodpecker (sexed anatomically) during post-juvenile moult, 1 August. P 1–4 postjuv, 5 growing. Rest of wing juv. All juv wing coverts strongly spotted. S 9–11 (S 12 hidden) distinctly barred.



Figure 87. 1cy European Green Woodpecker after post-juvenile moult, 6 December. MaC, LeC, MeC, GC, Al and P postjuv; rest of wing juv. Juv PC with prominent white spots. Moult limit between renewed GC and juv S very faint, not helpful for ageing. Juv S 9–12 with some barring, most apparent on S 11 and 12. About 50% of the 1cy have none of S 9–12 renewed and are more difficult to age than 1cy with partially replaced S 9–12. Look for prominence of the white spots in PC.



Figure 88. 1cy European Green Woodpecker after post-juvenile moult, 28 November. MaC, LeC, MeC, GC, Al, P and S 9 postjuv; rest of wing juv. Juv PC with prominent white spots, slight contrast in green tone between juv S and renewed GC. Easily recognised as 1cy by prominent moult limit between postjuv fully green S 9 and juv greyish-green adjacent S. P 3–7 with rusty tips, a colour deficiency occurring occasionally in true woodpeckers, independently of age.



Figure 89. 1cy European Green Woodpecker after post-juvenile moult, 14 November. MaC, LeC, MeC, GC, Al, P and S 9, 10 and 12 (barely visible) postjuv. S 11 and rest of wing juv. Prominent white spots on juv PC. Contrast between postjuv GC and juv S not marked, but easily recognised as 1cy by conspicuous moults limits within S 9–12.



Figure 90. Ad European Green Woodpecker after post-breeding moult, 5 May. Entire wing renewed, except PC 5. A moult limit within PC is an unmistakable sign for ad. Note also the spotting of the renewed PC which is blurred and not clear white as in juv PC. S 9–12 without any barring.



Figure 91. Ad European Green Woodpecker after post-breeding moult, 25 May. Entire wing renewed, except PC 3–5. Distinct moult limit within PC, typical for ad. Renewed PC with blurred, dirty white spots.

Grey-headed Woodpecker *Picus canus*

Timing of moult

The moult of adults starts after the young have fledged (June–July) and may last until November. 1cy start moult with P 1 a few days before fledging. Moult duration is probably 10–15 days shorter than in the European Green Woodpecker (Glutz von Blotzheim & Bauer 1980).

Extent of moult

Post-juvenile moult

Body feathers, P, R, MaC, LeC, MeC, GC and mostly all Al (one bird with Al 4 unmoulted) are always moulted; PC and S 1–8 not moulted; 10.0% moult one or two S among S 9–11, usually only on one wing (S 9–10, S 10–11, S 11; the small S 12 not systematically taken into account, but S 12 was found to be moulted in 2 of 32 birds) (Figure 92a; n = 52). As Miettinen (2002), we could not confirm reports of the renewal of some PC (C.S. Roselaar in Cramp 1985, Demongin 2016). We think these are probably 3cy birds (see True woodpeckers, Moults).

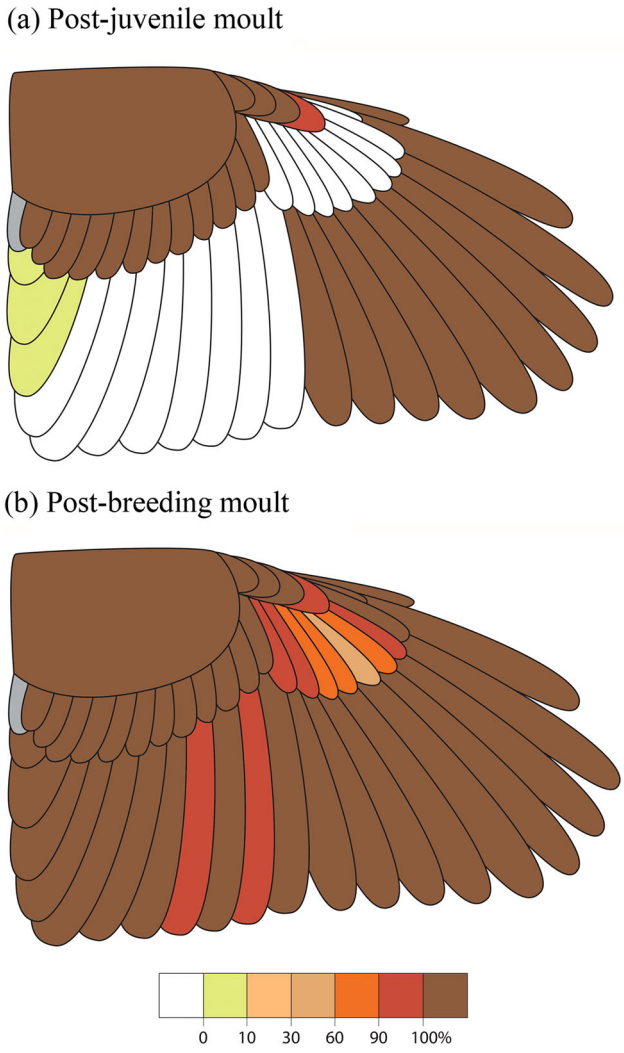


Figure 92. Extent of (a) the post-juvenile and (b) the post-breeding moult on the wing in the Grey-headed Woodpecker. S 12, shaded grey, is not considered.

Post-breeding moult

Only 32.6% moult the entire plumage; 58.1% leave one to five PC unmoulted (mean 2.0 feathers, mostly one or two) (Figure 92b; n = 43). Independent of the age, the unmoulted PC occur mostly as a block within PC 3–6, but may occur within PC 1–7, and in only two cases in two separate blocks.

Two birds (4.7%) left one S unmoulted (S 2, S 4; no old PC present), and two other birds (4.7%) left Al 4 unmoulted (one with and one without old PC). Unmoulted feathers often differed between the wings.

In some birds, the S differ slightly in their green tinge, but show the same degree of abrasion (Figure 99). It seems that the S renewed later during a moult may show a more brilliant green than the S moulted first.

Ageing criteria

Before and during moult

1cy: Compared to the European Green Woodpecker, the juvenile plumage of the Grey-headed Woodpecker is more similar to the adult plumage in colour, but the body feathers are fluffy, as is typical of juvenile feathers. The underparts are brownish-grey, the under-tail coverts and flanks mottled olive-brown (Figure 93), the black malar stripe is narrow and mottled (Figure 94), and GC and Al have distinct white spots (Figure 95). Juvenile P 10 is longer (42–49 mm, mean 45.2, n = 26, own data from museum skins) and broader and blunter than in adults. PC and S 1–8 are not renewed.

During moult, look for remaining juvenile body feathers. Body feathers are only renewed during the moult of the outer P (Glutz von Blotzheim & Bauer 1980).

Ad: The underparts are olive-grey (Figure 93), the upper parts uniformly olive-green, and the black malar stripe is distinct (Figure 94). Adult P 10 shorter than in juveniles: 31–37 mm (mean 34.3, n = 26, own data from museum skins). PC (all or some, together or not with the corresponding P) and S are moulted.

After the moult

1cy/2cy: All PC are juvenile (contrary to Demongin 2016, 2020; see True woodpeckers, Moults). They are paler than the renewed Al, GC and P and have distinct light spots, but the difference to adults is not always well marked and variable between individuals (Figures 96 & 98). The slightly duller-green juvenile S contrast with the renewed green GC. S 9–12 (S 12 often hidden and difficult to find) are barred to individually different degrees (often only on inner web) and sometimes only weakly, approaching those of adults. 10% of 1cy/2cy show a moult limit within S 9–12. Juvenile S 9–12 have marked light bars (Figure 98), renewed S 9–12 only faint bars. Because S 1–8 are all juvenile, and hence grown at the same time, their light spots are aligned across the tract (Figure 98).

Ad: PC have blurred spots which are less light (Figure 97–100). No distinct difference in colour between S and GC. No moult limit within S; S 9–12 without or with very faint bars. 58% of adults have some unmoulted PC (Figures 97 & 100), mostly in the central part. Unmoulted S (in only about 5% of adults) are not easily detected, as S of the same generation may vary in colour (see above).

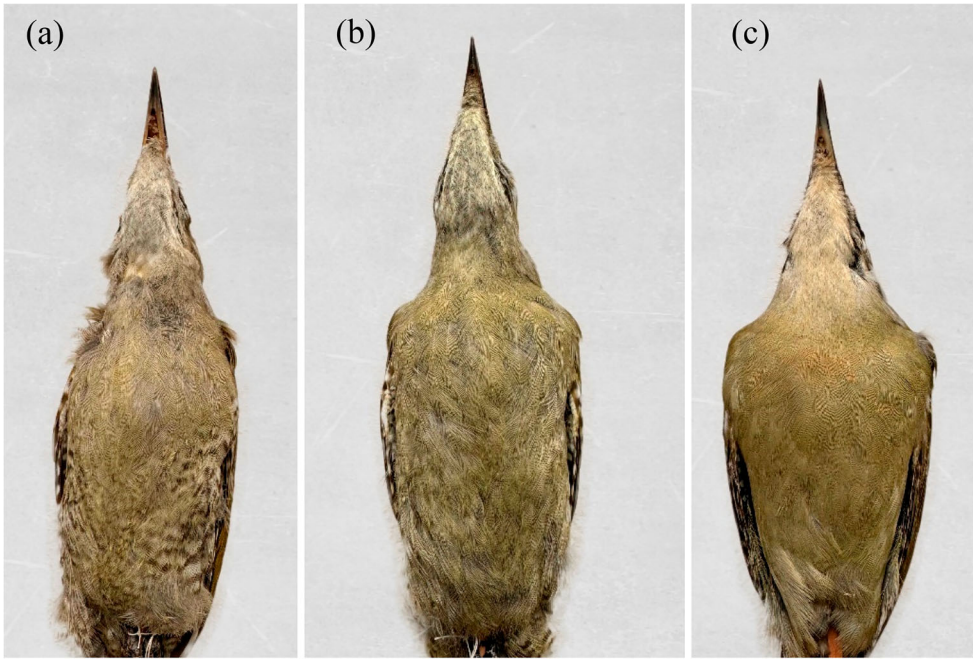


Figure 93. (a, b) Two Grey-headed Woodpeckers in juv plumage and (c) an ad. In juv plumage, the underparts are fluffy and brownish-grey, and the flanks mottled olive-brown to different degrees. Ad underparts are all olive-grey, not mottled. Specimens from the Natural History Museum of Basel (NMB 85-310, 5-175, 16779).

Adults with all PC renewed cannot be aged further (Figure 99). Adults with unmoulted PC may be further divided into those with retained juvenile PC (more worn, and spots clearer), hence Euring age code 5/7 (Figure 97), and those with retained PC from a former post-breeding moult (more like the moulted PC, and spots blurred), hence Euring age code 6/8 in spring (Figure 100). However, unclear cases must remain undetermined.

Iris colour in spring/summer varies from pale-pink to rusty and cannot be used for ageing (n = 37).

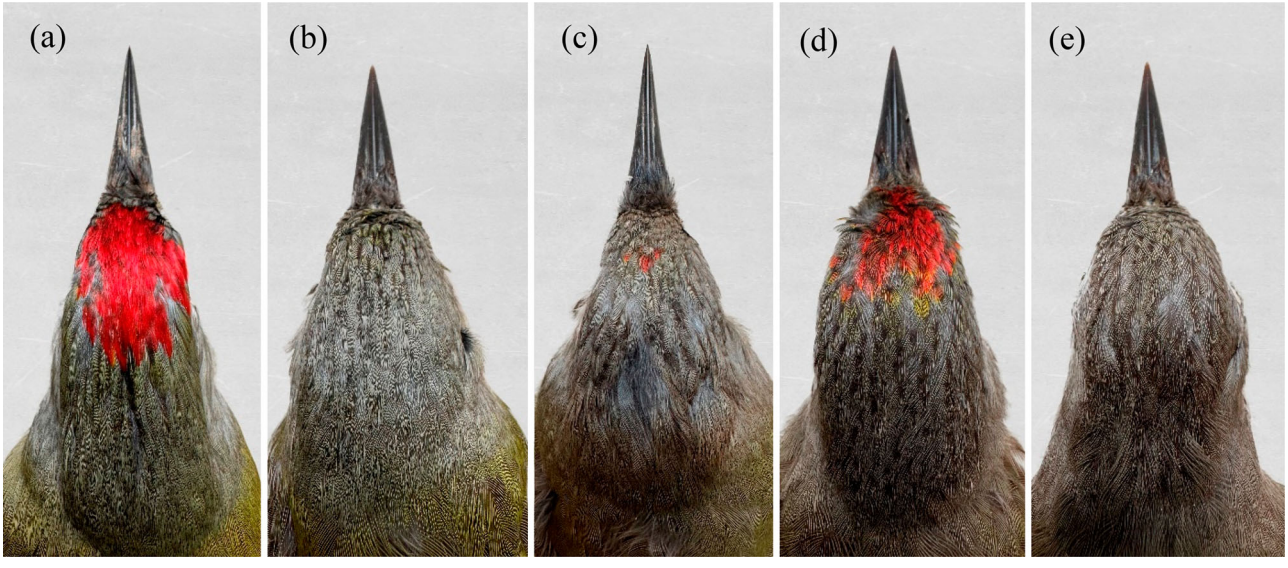


Figure 94. Head pattern of (a) male and (b, c) female after the post-juvenile moult, as well as of (d) juv male and (e) juv female Grey-headed Woodpeckers. Females may sometimes have a few red feathers (c). Specimens from the Natural History Museum of Basel (NMB 88-290, 15229, 14029, 83-142, 17377).

Sexing criteria

Male: Forehead and forecrown red (Figure 94a, d), in juveniles less extensive and less bright than in later plumages.

Female: Forehead and forecrown grey in juvenile and later plumages, rarely a few feathers at the front tipped red (Figure 94b, c, e).



Figure 95. 1cy male Grey-headed Woodpecker in juv plumage, 8 August. P 1–2 postjuv, 3–4 growing, 5–10 juv; rest of wing juv. The juv GC and AI have distinct white markings, which would not be present on postjuv feathers. Dots on S are aligned across the tract.



Figure 96. 1cy male Grey-headed Woodpecker after post-juvenile moult, 27 September. MaC, LeC, MeC, GC, AI and P postjuv; rest of wing juv. The juv PC are considerably paler than the renewed AI, GC and P. Ageing is straightforward. Juv PC have distinct, not blurred whitish spots.



Figure 97. Ad female Grey-headed Woodpecker after post-breeding moult, 4 April. Entire wing renewed, except PC 4–5. Typical ad with a moult limit within PC. Because the old PC are considerably worn, and pale with whitish spots, they are probably juv, and so this bird can be aged 3cy (Euring code 7). Photo by Lara Gross.



Figure 98. 1cy male Grey-headed Woodpecker after post-juvenile moult, 23 November. MaC, LeC, MeC, GC, Al and P postjuv; rest of wing juv. The juv PC are only slightly paler than the adjacent Al, GC and P. Ageing is difficult, but juv PC show well-marked spots, juv S 7–11 with barring and slightly brightened tips.



Figure 99. Ad male Grey-headed Woodpecker after post-breeding moult, spring. Entire wing postbr. PC of the same base colour as P, spots on PC blurred. S 7–11 without brightened tips and only very faintly barred. Dots on S not all aligned across the tract. Note that S 1 is slightly lighter than S 2–6 although being of the same generation. Because all PC have been moulted, this ad cannot be aged further.



Figure 100. Ad male Grey-headed Woodpecker after post-breeding moult, 28 October. Entire wing renewed, except PC 3–5. Typical ad with a moult limit within PC. Because the old PC are more similar to the renewed ones, and have blurred spots, typical of ad, they have probably been renewed during a previous post-breeding moult, and so this bird has undergone at least two post-breeding moults. It can thus be aged as 3cy or older (Euring code 8).

Other woodpecker species

The general ageing criteria for woodpeckers (see True woodpeckers) also hold for the European woodpecker species for which we do not have sufficient quantitative data on the variation in moult extent. Here we provide some photos and additional information on Eurasian Three-toed, Middle Spotted, Lesser Spotted and Black Woodpeckers.

Eurasian Three-toed Woodpecker Picoides tridactylus

Moult

For the reduced juvenile primaries, and the start and sequence of the post-juvenile moult in the nest, see Figures 60 and 61. Post-juvenile and post-breeding moult late June–late October. The post-juvenile moult is less extensive than in other woodpecker species: All or some GC and Al are retained, also some MaC, LeC and MeC may remain unmoulted (C.S. Roselaar in Cramp 1985, Miettinen *et al* 1986). Furthermore, S and PC are all retained (in accordance with Miettinen *et al* 1986, we doubt that some outermost PC may be moulted, as indicated by C.S. Roselaar in Cramp 1985). During the post-breeding moult, some PC may remain unmoulted (Miettinen *et al* 1986).

Ageing

In 1cy/2cy, the retained juvenile feathers are greyish-black and contrast with the more intensely black moulted feathers (Figure 103). A moult limit within PC is indicative of adults (Figure 102).

Iris of 1cy/2cy is brown or pale grey-brown, of adults pearl to bluish-white, this difference valid until March (Miettinen *et al* 1986). According to Miettinen (2002), probably all adults can be aged up to 4cy (criteria see Great Spotted Woodpecker).

Sexing

After the post-juvenile moult, males have a yellow crown, females a black crown with white spots (Figure 101). Most juveniles have a yellow crown, but

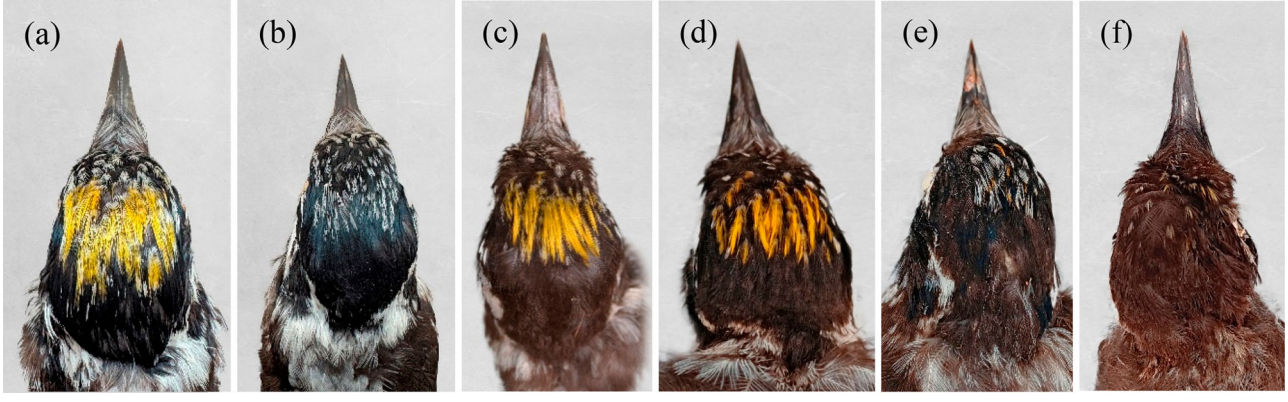


Figure 101. Crowns of Eurasian Three-toed Woodpeckers: (a) ad male, (b) ad female, (c–f) juvs. The yellow crown in the juv plumage varies greatly in extent, and sexing in juv plumage remains to be studied in more detail. In these examples, collectors considered to be reliable have sexed them anatomically as (c) male, (d) female, (e) female and (f) male. Specimens from the Natural History Museum of Basel (a, b, NMB 9764, 9765), the Natural History Museum at Tring (c, NHMUK 1898.3.10.1571) and the Natural History Museum of Berlin (d, e, f, ZMB 58/82, 58/81, 2000/65173).



Figure 102. Ad female Eurasian Three-toed Woodpecker of the subspecies *P. t. alpinus*, 29 August. P 1–6 new, 7 growing, 8–10 old. PC 1 new, 2–6 old, 7 new, 8–9 hidden. S 1 and 6–11 new, 2 growing, 3–5 old. Rest of wing new. Recognisable as ad by the growing and the renewed S as well as the moult limit within the PC. If the old PC and S are juv, the bird is a 2cy during its first post-breeding moult. Photo by Romain Béguelin.

some have a black crown (Lanz 1964, Ruge 1969). A small or absent yellow crown is probably indicative of juvenile females (as in American *Picoides*, Pyle 2022), but this needs further study.



Figure 103. 2cy male Eurasian Three-toed Woodpecker of the subspecies *P. t. alpinus* after post-juvenile moult, 4 June. P, MaC and LeC postjuv, MeC 1 postjuv, 2–5 juv, 6–10 postjuv. GC and rest of wing juv. Recognisable as 2cy by the moult limit within the MeC.

Middle Spotted Woodpecker Dendrocoptes medius

Moult

Timing and sequence of the moults is similar to Great Spotted Woodpecker (C.S. Roselaar in Cramp 1985, Pasinelli 2003; Figure 105), but post-juvenile and post-breeding moults on average are more extensive. Of 21 1cy/2cy from Switzerland and Vienna examined after the post-juvenile moult, 17 (81%) had all GC renewed, two birds had GC 1, and one bird each GC 1–3 and 1–4 unmoulted. This is in contrast to Demongin (2016, 2020) who indicated that no or only the innermost GC are moulted, as well as outermost PC.

Adults probably moult the entire plumage (including all PC) more frequently than adult Great Spotted Woodpeckers. All 10 adults examined in Vienna had all PC renewed (five of them could be examined for S and had them all renewed), but some may apparently retain some PC (Demongin 2016).

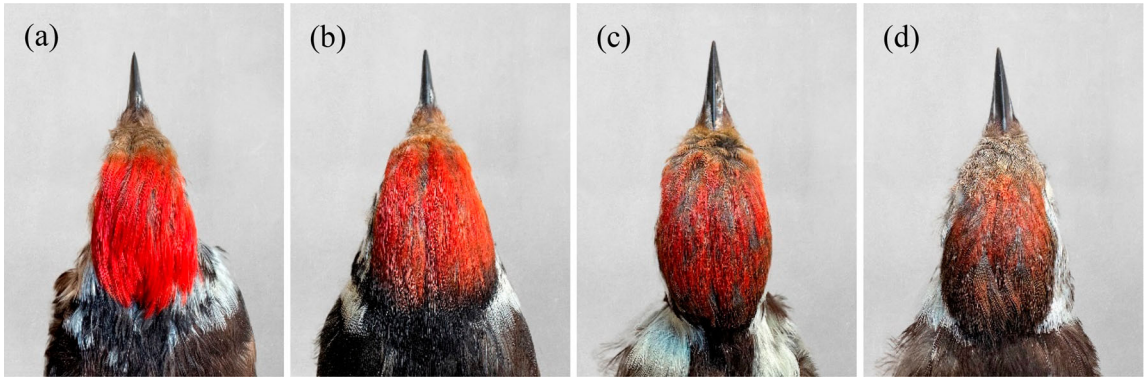


Figure 104. Crowns of Middle Spotted Woodpeckers: (a) ad male, (b) ad female, (c) juv male and (d) juv female. Anatomically sexed specimens from the Natural History Museum of Basel (NMB 85-117, 90-346, 19126, 5-160).

Ageing

There are only very few 1cy/2cy with a moult limit within the GC, and probably rarely adults with a moult limit within PC. Therefore, ageing can be very difficult and needs experience. Look for contrast between juvenile PC and surrounding moulted coverts (Figure 106), and for the alignment of the white spots across S, indicative of 1cy/2cy. In adults, there is no such contrast, and the alignment of white spots across S is often irregular.

Sexing

Males, females and juveniles have a red crown (Figure 104). The crown of males is larger and more intensely red than in females. In juvenile plumage the carmine-red crown in males is 24–25 mm long (mean 24.6, n = 6), in females 18–22 mm (mean 20.1 mm, n = 6) and brownish-red (Jenni 1980). After the post-juvenile moult, the red crown of males is 34–46 mm long (mean 37.0, n = 21), of females 29–38 mm (mean 32.8, n = 13) and less deep crimson-red, bordered pink-brown, yellow or golden-brown on the back edge (in males all crimson-red) (Pasinelli 2000, 2003). Females are smaller, with a shorter bill, but the overlap with males is considerable. However, when using both red-crown length and bill-to-skull length in the discriminant formula D = 33.95 - 0.85 * bill length - 0.29 * crown length, 94% of the individuals of a Swiss population could be sexed correctly, negative values of D indicating females, and positive ones males (Pasinelli 2000).



Figure 105. 1cy male Middle Spotted Woodpecker during post-juvenile moult, 22 June. P 1–2 postjuv, 3 growing, 4–10 juv; rest of wing juv. Slight contrast between juv PC and surrounding coverts. No growing S 8 (S 8 would be being moulted in an ad at this stage of moult).

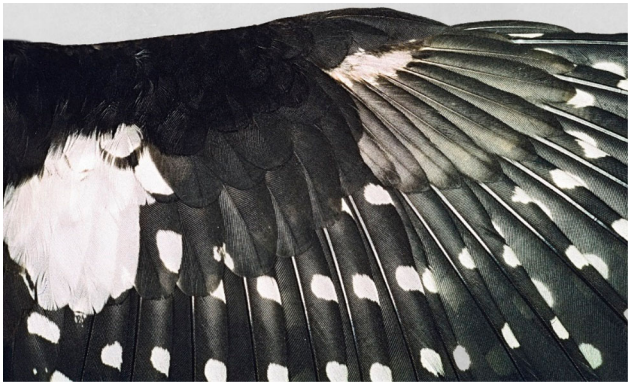


Figure 106. 1cy Middle Spotted Woodpecker after post-juvenile moult, 31 October. P, GC, MeC, LeC and MaC postjuv. Al 1–3 postjuv, 4 juv. PC and S juv. An example of a 1cy with all renewed GC black, contrasting with the greyish-black juv PC.

Ageing

Look for moult limits within GC, and contrast between juvenile PC and other coverts, indicative of 1cy/2cy (Figures 108 & 110). A moult limit within PC is indicative of adults, as well as absence of a contrast between moulted PC (all or part) and other coverts (Figures 111 & 112).

Iris dull-brown in juveniles, reddish-brown to reddish in adults, but it is unknown when this difference is no longer reliable for ageing.

Sexing

In juvenile plumage and after the post-juvenile moult, males have a crimson-red crown (in juvenile plumage of variable extent, often smaller and less intensively red), females lack red on crown, or with a few red feather tips (Figure 107).

Lesser Spotted Woodpecker Dryobates minor

Moult

Post-juvenile and post-breeding moults June–September (–early October). The extent of the post-juvenile moult is variable but similar to the Great Spotted Woodpecker: S and PC are retained, GC are moulted completely or partly (Figure 109). In northern populations, some MeC and LeC or all GC may be retained (Miettinen *et al* 1986).We doubt that some outermost PC may be moulted (C.S. Roselaar in Cramp 1985, Demongin 2016, 2020). During the post-breeding moult, some S and PC may be retained (Miettinen *et al* 1986, Demongin 2016).



Figure 108. 2cy female Lesser Spotted Woodpecker *D. m. hortorum* after post-juvenile moult, 13 February. P, MeC, LeC and MaC postjuv. GC 1 postjuv, 2 juv, 3–10 postjuv. Al, PC and S juv. Moult limit within the GC is indicative of 2cy.

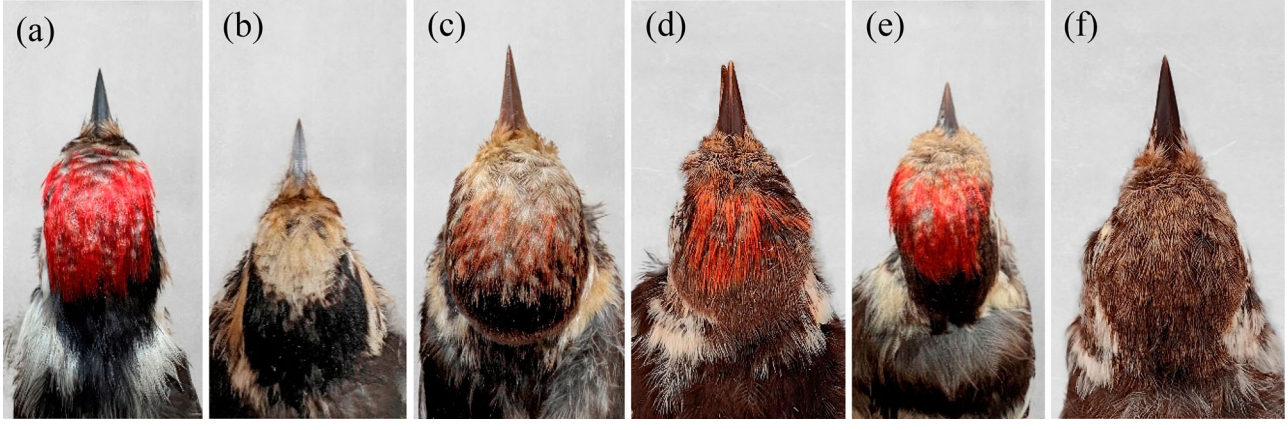


Figure 107. Crowns of Lesser Spotted Woodpeckers: (a) ad male, (b) ad female, (c–e) three juv males with varying amounts of red, (f) juv female. Anatomically sexed specimens from the Natural History Museum of Basel (a, b, c, e, NMB 96-098, 14947, 2722, 18698) and the Natural History Museum of Berlin (d, f, ZMB 21/599, 58/30).



Figure 109. 1cy female Lesser Spotted Woodpecker *D. m. minor* during post-juvenile moult, 19 July. P 1–3 postjuv, 4–5 growing, 6–10 and rest of wing juv. No growing inner S (at least S 8 would be growing or moulted in an ad at this stage of moult).



Figure 110. 2cy female Lesser Spotted Woodpecker *D. m. hortorum* after post-juvenile moult, 18 January. P postjuv. GC 1–6 juv, 7–10 postjuv. MeC, LeC and MaC postjuv. Al 1–2 postjuv, 3–4 juv. Rest of wing juv. Moult limit within GC is indicative of 2cy.



Figure 111. Ad male Lesser Spotted Woodpecker *D. m. hortorum* after post-breeding moult, 10 March. Entire wing postbr. No moult limits present; whole wing is fresh and of the same base colour.



Figure 112. Ad male Lesser Spotted Woodpecker *D. m. minor* during post-breeding moult, 12 July 1996. P 1 new, 2–4 growing, 5–10 old. PC 1–2 new, 3–4 old, 5–8 very old (probably juv), 9 old. S 1 growing, 2–4 very old, 5–7 old, 8–9 growing, 10–11 new (not visible). GC all growing. AI, MeC, Lec and Mac difficult to assign, probably still old. This bird, with three generations of S and very old, probably juv PC stands very likely in its third post-breeding moult, thus in its 4cy (hatched in 1993).

Black Woodpecker Dryocopus martius

Moult

Post-juvenile and post-breeding moults June–late October. The post-juvenile moult is the least extensive among European woodpeckers. In addition to PC and S, also all GC are usually retained (sometimes inner ones moulted), some LeC and MeC may also be retained, and Al are sometimes renewed (E. Sutter in Glutz von Blotzheim & Bauer 1980, Miettinen *et al* 1986). In accordance with Miettinen *et al* (1986), we cannot confirm that the post-juvenile moult includes the innermost and outermost PC (C.S. Roselaar in Cramp 1985, Demongin 2016). However, adults may retain some PC (Miettinen *et al* 1986).

Ageing

1cy/2cy: Retained juvenile coverts are brownish or duller black, while moulted coverts are jet-black (Figure 115, 116). A moult limit within PC is indicative of adults. According to Miettinen (2002), probably all adults can be aged up to their 4cy (see Great Spotted Woodpecker).

Iris is yellow-white in adults, pale blue-grey in juveniles after fledging, but juveniles attain adult colour in first weeks after fledging (C.S. Roselaar in Cramp 1985), hence not suitable for ageing. All ages have a black spot in front of the pupil (Figure 113).

Sexing

In juvenile plumage and after the post-juvenile moult, males have a red crown from bill to the back of the head; in juvenile plumage red is less extensive and hardly reaches forehead. Females have red on hind crown only, and forehead and crown centre are black (Figures 113 & 114).

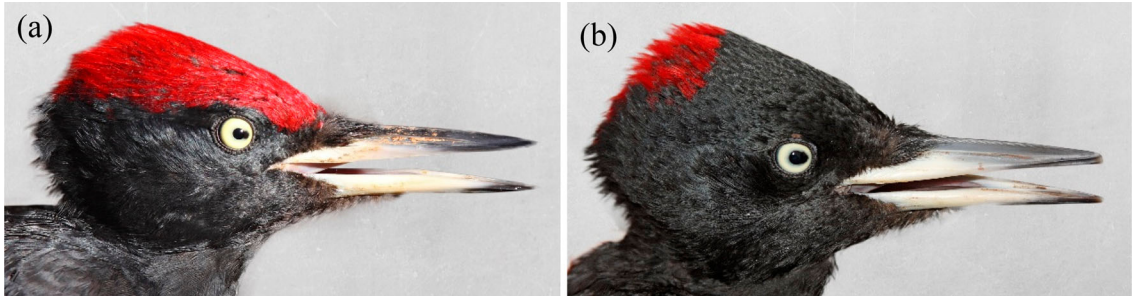


Figure 113. Heads of (a) male and (b) female Black Woodpeckers. Photos by Marco Thoma.

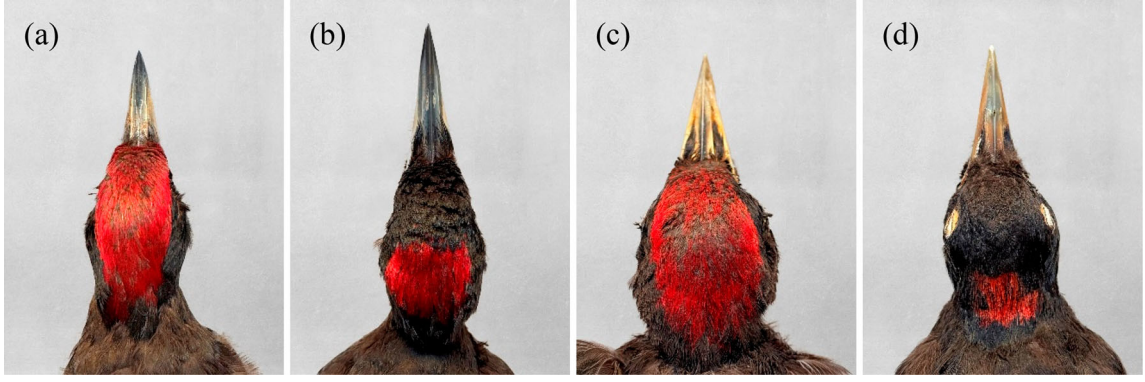


Figure 114. Crowns of Black Woodpeckers: (a) ad male, (b) ad female, (c) juv male and (d) juv female. Anatomically sexed specimens from the Natural History Museum of Basel (NMB 13525, 12-010, 11317, NMB 17759).



Figure 115. 1cy male Black Woodpecker during post-juvenile moult, 26 July. P 1–4 postjuv, 5–6 growing, 7–10 juv. MaC mostly new, some growing. LeC new and growing. MeC 1–2 juv, rest growing. GC juv (7 missing). Rest of wing juv. No moult limit within GC but between renewed jet-black MaC and LeC and juv dull-black GC. Note also the brown juv Al.



Figure 116. 1cy male Black Woodpecker during post-juvenile moult 2 September. P 1–7 postjuv (P 2 broken), 8 growing, 9–10 juv. S and PC juv. GC 1–8 juv, 9–11 postjuv. MaC, LeC and MeC postjuv. Moult limit between juv GC 1–8 and postjuv 9–11; the different exposure to light on this wing, photographed in the field, simulates a moult limit between GC 3 and 4. Colour difference between postjuv MaC, LeC and MeC and juv GC. Photo by Marco Thoma.

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