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Moult strategies and morphometric precisions in the Lilford's woodpecker *Dendrocopos leucotos lilfordi*

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Aspect of the Plumage of the Lilford's woodpecker

Article

Summary: This article presents a study of the plumage of the Lilford's woodpecker *Dendrocopos leucotos lilfordi.* The species performs a partial post-juvenile moult for the first-year birds and a complete post-nuptial moult regularly arrested for adults. The criteria presented make it possible to differentiate the two age-classes of a bird in hand. Furthermore, a difference in wing shape via the wing formula appears between females and males, suggesting a different internuptial or post-juvenile dispersal behaviour depending on the sexes.

Key words: post juvenile moult, post nuptial moult, wing formula

INTRODUCTION

The White-backed Woodpecker *Dendrocopos leucotos* sensu lato is a polytypic species (11 to 12 taxa) with a wide Eurasian distribution whose nominal subspecies covers a wide strip of taiga from Norway to eastern Siberia. The other subspecies inhabit isolates, one, *lilfordi* in the mountains of southern Europe and Caucasus and the others in southeast Asia (Japan, Korea, China) (Cramp 1985; Winkler *et al.* 1997, 2002; Gorman 2004; Grangé 2022).

This complex has also been the subject of a recent revision based on a genetic analysis of 9 of the described subspecies (Pons *et al*. 2021). The conclusion of this work leads to a revision of this complex into 3 distinct clades: *Dendrocopos leucotos* sensu stricto, *D. insularis* and *D. leucotos lilfordi*.

Lilford's Woodpecker *Dendrocopos leucotos lilfordi* (4 population centers without contact between them) is isolated from *D. l. leucotos* in the mountains of southern Europe and the Western Caucasus in mature forests with presence of beech sp. *Fagus sp*., dead wood and high humidity (Grangé 2022). The habitat of the species in the Pyrenees is the old beech forest (*Fagus sylvatica*) pure or mixed with fir (*Abies alba*) constitutes its favorite habitat. This species is little studied, probably because of its mountainous habitat (Purroy 1972; Grangé and Vuilleumier 2009; Carcamo Bravo 2016; Grangé 2022).

In the literature, the only biometric data published for the Lilford Woodpecker concerns wing length, bill length, and mass. In Pyrenees, Danis (1937) and Purroy (1972) describe the moult and plumage respectively of 1 and 2 individuals. The moulting pattern has also recently been described in detail for 19 adults including 4 young and 15 adults (Villanúa *et al.* 2021). Furthermore, nestling chicks have never been described in detail before. The data pool is therefore quite small and deserves to be expanded. The interest of a precise description of the plumage at the different ages of the bird is therefore of great importance. A capture program of Lilford's Woodpecker obtained from the CRBPO (research center on the biology of bird populations, Paris museum) (2014 to 2020) allowed us to specify the main physical parameters of the bird: plumage, biometrics and moults (Grangé 2022). Many unpublished data appear here, including, for example, the fledgling plumage characteristics and the wing formula of this taxon. We also present a detailed study of age-dependent moulting strategies based on individuals captured in the French western Pyrenees compared with the results recently published by Villanúa *et al*. (2021) with birds of the southern Pyrenean slope.

MATERIAL AND METHOD

Captures were carried out in France, in the beech and beech-fir forests of the Béarn and Basque Pyrenees. Two periods have been selected, spring when the young are reared and autumn, at the end of October, with the upsurge of territorial demonstrations. These two periods allowed both to take advantage of the territorial behaviour and also to circumscribe the supposed period of moult.

Juveniles are birds whose age is between birth and the end of the post-juvenile moult, between May and September of the year of birth.

The young designation includes the age from the post-juvenile moult located during the summer of their year of birth until the first complete moult which occurs during the summer of their second year of life. It therefore includes first year individuals (until December 31 = 1yc) and second year individuals (from January 1 = 2yc).

We use the term adult for birds after their first complete molt which occurs during the summer of 2yc.

Captures of adults were made using mist nets rising 10 m high in the immediate vicinity of the breeding cavity. The use of playback (calls and drumming) and visual lures attracted the attention of the breeding birds and stimulated their territorial defense behaviour. Juveniles were removed from the breeding cavity 2 to 3 days before fledging with a snare. Captured birds were ringed and color marked. Sexes of juveniles, youngs and adults is determined by the tint of the crown (black for female and red for males). Measurements were taken to calculate the wing formula following Svensson (1975) and the CRBPO method (Demongin 2013). These measurements included the folded wing (LP), all primaries (P), their notches and indentations, the primary projection (PP). The length of the tail (RC) corresponds to the length of the rectrix 1 and is measured with the cleat method. We also measured the distances between each primary and the tip of the wing (WP, Wing Point). Precision was maintained at half a millimeter for feather measurements and to tenths of a millimeter for tarse length (LT) the length of head + bill, and bill alone (from skull to tip, nostrils to tip, thickness and width from bill to nostrils), mass, body length and wingspan.

We do not realize the wing formula of juveniles so as not to leave the nest empty for too long. For juveniles we measure only the P8 was thus measured. The measurement of the P8 of the juveniles was then compared to the average size of the P8 of post-juveniles of the same sex (a measured P8 of a female juvenile is compared to the average of the post-juvenile female P8, same for males). The distance to wing point of P1 and 2 was also measured.

Comparisons of means between males and females for the different measured values were tested in the R software using the Wilcoxon test, the sample size being reduced.

We named the internal primary P1 and the outermost P10, in accordance with Ginn and Melville (1983). The secondary 1 (S1) is the most external and the S11 the most internal (Figure 1). The tail feathers are numbered 1 to 6 from the central pair outwards.

During the manipulations, a moult card was also compiled to define the proportion of old and renewed feathers. Thus, the state of moult was recorded according to Ginn and Melville (1983) assigning the value 0 to the old feathers, 5 to the new feathers and 1–4 to the growing ones. Photographic archive was also carried out according to a strict and standardized protocol (a dorsal view, a ventral view, the bird in profile, the head in profile and from above, the sides wing open, the wing unfolded, the tail spread from above and below.). This picture archiving allows us to highlight the importance of apterias in juvenile plumage. In the case of recaptures between years, we considered only the first measurements.

RESULTS

Twenty-one Lilford's Woodpeckers were captured between 2014 and 2020: 3 youngs (2 males and 1 female), 7 adults (4 males, 3 females), 11 juveniles, pulli (9 females and 2 males), within a day or two before to fledge.

Characteristics of fledging plumage and biometrics

The texture of the contour feathers of the chick's back, uppertail coverts, belly and flanks is looser. The aptaria (featherless areas) are also more extensive. Thus the contour feathers are missing on the scapulars, sides of the lower mantle, flanks, belly and underwings and downy or bare areas appear. These characteristic apteries of juveniles disappear with post juvenile moult. Finally, the undertail coverts remain clear without a pinkish-red hue. This last criterion therefore appears only with the post-juvenile moult.

As in other Picidae, the external primary remige is wider and longer in the fledging, this criterion disappearing after the post-juvenile moult (see the section on the wing formula). The tips of the outer primary flight feathers are white on the two vanes with the shape of a brace or chevron. RC5 is very pointed in the juvenile. In some juvenile females, a small reddish iridescence may appear on the forehead and forecrown. The crown of males shows clearly red feathers, not just iridescence.

When fledged, the growth of juvenile flight feathers are yet not finished and waxy sheath remains at their bases. At this very moment, females (n=9) weigh on average 87g (65-99.5g). They have an LP of 112mm (98.5-119.5mm), a P8 of 75mm or 80.7% of a post-juvenile female P8, a head + bill of 53.1mm (52.9-54.2mm) and a bill of 27.7mm (27-30mm). When fledged, juvenile males (n=2) have an average mass of 86g (75-97.5g), an LP of 115.9mm (113.3-118.5mm), a P8 of 86.1mm or 78.3% of a P8 of post-juvenile male, a head + bill of 53.8mm (52.4-55.2) and a bill of 28.8mm (25-30mm). The distance between the tip of the P10 to the tip of the Primary Covers (CP) is on average 6.5mm +/- 1.95mm. Finally, R1 and 2 of fledging juveniles are atrophied: the P1 is just emerging from the sheath up to 1 mm (stade 2) and the P2 is half grown (stade 3) (Figures 2, 3, 4, 5 and 6).

Fledgling relative size compared adults of the same sex

11 juveniles (9 females and 2 males) have been measured. The relative size of the P8 length of juvenile females just before fledging is 80.7% of post juvenile female. In addition, the bill is 71% and the head + bill measurement is 81%. For the juvenile males, compared to post juvenile males, P8 grew in average 78.3%, the head + bill 81.2% and bill 78.9%. These feathers were still growing when they fledged (presence of protecting shaft).

Characteristics of Adult Plumage and biometrics

In addition to the descriptions of the plumage already described in literature, we present here two new characteristics. (Figure 7). The RC5 is clearly rounded in the adult and the tips of the outer primaries are white on the outer vane alone. Sometimes, on the internal P, the tip is white on the two webs, with a black indentation along the rachis drawing a white tip in the shape of a brace reminiscent of the chick pattern.

Biometrics and wing formula

Lilford's Woodpecker has 10 primaries, 11 secondaries and 12 rectrices. We measured 10 breeders divided into 6 males and 4 females. For the adult male, the average wing length is 149mm (145.5-152.5mm). The mass is 108g (101.3-108.5g), LT is 28.3 (26.3-30.2mm), the bill is 38.4mm (38-39mm), the head + bill is 68.6mm (68.2-69.5mm), RC is 90.5mm (87.5-95mm), P8 is 110.3mm (107-113.5mm), PP is 30mm (28.6-31.3mm). Total length is 264mm (262.5-266mm) and wingspan is 453mm (450-455mm). For the adult female, on average wing length is 147.2mm (145-149.5mm), mass is 101.3g (100.3-102.4g), LT is 25.3 (25.1-28.1mm), the bill is 37.4mm (37.2-39mm), the head + bill is 65.7mm (65.1-66.2mm), RC is 87mm (85-89mm), P8 is 109.8mm (109-110.5mm), PP is 26.5mm (24-29mm). Total length is 260mm (258-263mm) and wingspan is 434mm (429-441mm) (Tables 1, 2, 3 and 4). On average all sexes combined, the wingspan reaches 443.5mm, and the total body length is 262mm. The average mass all sexes combined at the end of the breeding period is 106g.

In adults, the average distance between the P10 and the tip of the primary coverts is short: 2 mm (-2; 4mm). In the pullus, at fledging, this is 6.5 mm (1.5; 10.5mm).

The wing tip (WP) corresponds to the P6 (80% of cases) or the P7 (20%). In general, P 5, 6 and 7 (sometimes 8) show an emargination (notch) and P 5, 6, 7, 8 (sometimes 4 and 9) show an indentation (Tables 1 and 2). The bill is always longer than the head.

The size dimorphism is not very pronounced in favor of the males on the main values, on average 4%. However, some measurements are clearly different such as the tarsus length (LT), on average 9% shorter in the female (Wilcox test=24; p-value=0.01306) or the width of the bill which is on average 14% lower in the female (Wilcox test=18; p-value=0.2263) and the thikness of the bill -16% for females (Wilcox test=24; p-value=0.01306) and the length of head + bill -7% for females (Wilcox test=44; p-value=0.01335) (tables 3 and 4).

The wings of the females seem more pointed, while having an end closer to the leading edge (P7). Males appear to have a more retracted wing tip (P6) and proportionately narrower wings (Tables 5 and Figure 12).

Moult

Juvenile moult

Juvenile Lilford's Woodpeckers undertake an extensive partial post-juvenile moult after fledging including all body feathers. Of the 11 chicks taken from the nest a couple of days before fledging, none had started the post-juvenile moult. Our work shows that this moult begins with certainty after flying from the nest. Large areas of apteria on flanks and underwing coverts will be covered in down and contour feathers. The pinkish-red hue on undertail coverts appears with the post-juvenile moult.

On the wing, the moult begins with the inner primary and continues towards the outer primaries. The lesser coverts are all renewed but in one 2yc, we observed 2 external PC retained. The median coverts (the outermost ones are sometimes retained) and the alula feathers (when they are) are also replaced. The largest alula is retained at 50% according to our sample. A moulting limit therefore appears there sometimes. Part of the greater coverts, the six inner ones, is renewed. In general, therefore, moulting limits appear, showing a contrast of discoloration of the dark parts. The RC are also changed. One to two primary covers are renewed but they are not necessarily contiguous (Figures 8 and 9). The S feathers are also retained.

2yc and adult moult

The start of moult begins at the end of May as shown by a bird captured on 06/02/2018. The P1 had a numerical score of 3 (in its second third of growth), P2 had a numerical score of 2 (in its first third of growth, 1 mm out of the pin). The corresponding CP were missing (Figure 11). Outer MC and PC were also missing. Outer RC 5 and 6 were surprisingly missing on the left side of the tail.

The adult moult is a complete post-nuptial moult regularly arrested on the S. In between 50% and 62.5% of cases, the central S4 and 5 are not renewed. The GC are all replaced, and the P moult from the inside to outwards. The S are renewed from two foci, one from the outer S, and the other centrifugal from the inner seven or eight S (Figure 12).

All birds captured at the end of October in the western Pyrenees had ended their annual moult. Moreover, the moult limits observed in the spring show no new feathers, but rather two generations of old feathers. Therefore, no prenuptial partial moult was detected.

DISCUSSION

Moult period

Our study is the only one that factually limits the moulting period between the end of May and the end of October. Unfortunately, the capturability of the Lilford's woodpeckers at times other than the rearing of the young or the pre-winter dispersal period in late October is very low and all attempts have ended in failure. However, the absence of new feathers in spring shows that only one moulting period occurs during the year.

We found that the moult of Lilford's Woodpecker follows the same modalities as those observed by other authors observations (Cramp 1985; Villanúa *et al*. 2021). Concernant *Dendrocopos l. leucotos*, Butev *et al*. (2005) places the post juvenile moult from mid June to late October for birds of the northern Russia. Cramp 1985 places the moult from mid may to late September for late September for Scandinavian birds. In the Pyrenees, we can certify that in the nest, the juveniles have not started their post-juvenile molt unlike Eurasian Wryneck *Jynx torquilla* or Tree-Toed Woodpecker *Picoides Tridactylus* (Sibley 1957; Sutter 1974; Winkler 2020).

The moult of young and adult Lilford woodpeckers begins in the Pyrenees at the end of May and is completed by the end of October. Thus, Danis (1937) described an individual who was in the process of moulting its P4 and for which RC4 and 5 were missing. In September, another individual finished moulting its primaries by P10, the tail moult being completed. Purroy (1972) in Iraty, specifies that two birds captured on October the 1st and the 2nd finished the moulting of their primaries by moulting P 9 and 10 respectively. Villanúa (2021) also specifies the dates of this unique annual moult. Our study confirms this period for juveniles, youngs and adults. Thus, we captured a bird which had started its moult in the very first days of June, placing the start of moult in the last days of May, and 2 others in mid October which had completed it.

Moult pattern and plumage characteristics according to age

Post juvenile moult

Our analyses on Lilford's Woodpecker are consistent with the literature and are very similar to those of Villanúa *et al.* (2021) on juvenile Lilford's Woodpecker. Juveniles replace P, RC and contour feathers, retaining S and some GC. Thus, five large coverts are concerned on the north and south side of the Pyrenees in 100% of cases. The only differences are that two additional greater coverts are moulted in only 25% of cases on the southern slope (Villanúa *et al*. 2021), and a few outer middle coverts are retained in 25% of cases on the northern slope. However, we had one case of a juvenile which had exceptionally moulted 2 CP. This point is discussed by different authors. Thus Baker (2013 and 2016) and Demongin (2013) specify that some CP can be replaced at random. This seems confirmed in the post juvenile moult of Lilford woodpecker. However, for the other woodpeckers, Pyle (1994) in north American woodpeckers (without *Dendrocopos* species) and also Winkler (2013) (including *Dendrocopos* species) assert that PC are never replaced. Our small sample does not allow us to establish a reliable percentage of the occurrence of this scenario. The statistical volume would need to be increased to clarify this point. Perhaps birds with more oceanic than continental climates have more extensive moults.

The difference in pattern between juvenile feathers (showing a white chevron on the tip of the primary) and post-juvenile flight feathers (without a chevron) is first described here for *lilfordi* (Figures 1, 2 and 7). This juvenile pattern is common with other species of the *Dendrocopos* and related genera, such as the White-backed Woodpecker *D. leucotos* (Cramp 1987), the Great-spotted Woodpecker *D. major*, the Middle-spotted Woodpecker *Leiopicus medius* and the Lesser-spotted Woodpecker *Dryobates minor* (Demongin 2013). This character therefore seems to be inherited from a common ancestor. It allows bird in hand to confirm the moult of all the primaries during the post-juvenile moult. In addition, the larger size of P10 compared to adults is also a character present in *lilfordi* and all woodpecker species. The tip difference of the C5, on the other hand, is described here for the first time.

Finally, it should be noted the total absence of pink feathers on the undertail, lower abdomen or lower flank in *lilfordi* juveniles. These pink-tinged feathers only appear after the post-juvenile moult.

Post nuptial moult

2yc and adults undertake a complete post-nuptial moult starting with R1 and 2, the corresponding CP, and the distal part of the MC and PC. The S moult from two foci which are S1 or 2, and S7 or 8. If we compare our results with those of Villanúa *et al.* (2021), we find that the moult seems to be more largely arrested on the northern Pyrenean slope with cooler temperatures: 100% of S5 and S6 are moulted on the southern slope against respectively 50% and 75 % on the northern slope. The absence of RC5 and 6 on the left side of the tail of the moulting bird that we captured on 06/02/2018 is not in agreement with the literature (Danis 1937; Villanúa *et al.* 2021). It should therefore be an accidental fall, especially since the absence of these feathers is not symmetrical, on the right side, RC5 and 6 were present.

Kiat *et al.* (2019) demonstrate the influence of temperature on moult extent using data from ten natural history collections. Regarding 4012 individuals from 19 species of passerine birds nesting in the western Palearctic, they show that the extent of post-juvenile moult has increased significantly over the past 212 years (1805-2016), a trend that is positively correlated with increasing environmental temperature. Thus, climatic conditions could also play a determining role in the extent of the post-juvenile or post-nuptial moult of Lilford's Woodpecker.

Measurements and wing formula

Comparison of folded wing and bill measurements between *lilfordi* from the French Pyrenees and elsewhere in Europe shows that it is in the Pyrenees that the birds are the largest. Similarly, Lilford's Woodpeckers of the northern Pyrenean slope are larger than the Scandinavian or Central European *D. leucotos*, yet further north, contrary to Bergmann's rule (Grangé 2022) (Table 5).

The a priori comparison between the adult wing shape of *leucotos* and *lilfordi* does not show any major difference but we observe that the values of P1 and P2 compared to WP in the literature for *leucotos* are in the average of males/females *lilfordi*. The pool of data in the literature therefore certainly includes both females and males. On the other hand, the tip of the wing of both sexes in *leucotos* is similar to that of *lilfordi* females alone (pointed on P7), an effect reinforced in *lilfordi* females by the distance between P10 and P9 which is clearly longer in *lilfordi* (Table 5 and Figure 13).

In *lilfordi*, the wing formula therefore differs between males and females. Females show a "pointier wings" phenotype and males show more squared wing tips. The selective phenomenon which gradually leads to this slight dimorphism is probably linked to differences in behaviour. The wing formula of *leucotos* (both sexes) closely resembles that of female *lilfordi* for the tip of the wing. But the propensity for movement is greater in *leucotos*. It is commonly accepted that migratory birds have more pointed wings than sedentary ones (Lockwood *et al*. 1998). It is therefore possible to think that females *lilfordi* move more than males and that this influences by natural selection more pointed wing shapes. Can there be a cause-and-effect relationship to the shape of the wing? Perhaps the inter-breeding behaviour of female *lilfordi* is more dispersive than male. In any case, we have only 1 inter-annual check of female on 4 ringed over 7 years of monitoring whereas we were able to check 4/6 males, over several years, who are then more sedentary and philopatric. A trend, to be verified due to the small sample, seems to be emerging.

Sexual dimorphism

The adult sexual dimorphism in *lilfordi* was not very pronounced (4%). However, this is not the case for the tarsus length (9%, Wilcox test=24; p-value=0.01306) and the bill thickness (16%, Wilcox test=24; p-value=0.01142), widths at nostril (14%, Wilcox test=18; p-value=0.2263) (Table 4), and the length of head + bill (7%, Wilcox test=44; p-value=0.01335). The male does most of the work of drilling the breeding cavity (Ivanchev 1997; Grangé 2022). These elements are associated with greater drumming activity in males (Verthein 1935, Schubert 1969). In addition, the female physiologically prepares the egg laying by spending a lot of time feeding (Grangé, 2022). This distribution of tasks necessary for better reproductive success seems to gradually accentuate sexual dimorphism in bill size (Grangé and Helfenstein 2023).

The slightly different mode of foraging between the sexes could be another phenomenon tending to accentuate the dimorphism of the bill. Males have a greater tendency than females to dig the lower and thicker parts of trees. They frequent the branches less than females, who mainly use gleaning and hammering of the bark, rather than the deep attack of the wood (Purroy 1972; Senosiain 1977; Grangé 1991a, 2022; Bernoni 1994). This morphometric difference of the bill is involved in a difference of ecological niche favorable to the two members of the pair.

Fledglings' plumage

Juveniles fledge when their flight feathers have reached 80.7% and northern slope Pyrenees. According to Stenberg (1998) in Norway, this happens at 70% to 75% of their total growth. Their bill is also grown at the rate of 70%. Independence flight and autonomous foraging is impossible. The dependence phase lasts a minimum of three weeks (Campión *et al*. 2020; Grangé 2022).

The plumage dimorphism of juvenile Lilford's Woodpeckers is evident. The females have a clearly black crown, rarely slightly iridescent with red at the tips of some feathers, while the males have an entirely red crown (Grangé 2022; present study). Female *lilfordi* therefore differs somewhat from descriptions known for juvenile *leucotos*. For this taxon, while the crown of juvenile males is also red, juvenile females show a varying number of localized red markings on the forehead (Stenberg 1998).

Juvenile P1 and 2 growth delayed.

We found in juvenile Lilford's woodpeckers a delayed growth of the two inner primaries (Figure 6). R1 being in its waxy sheath and R2 being half pushed, it cannot be a question of the beginning of moult in the cavity. Indeed, if the R had started to moult, R1 would have fallen first and would have started to grow before R2. R1 would therefore be greater than R2. All juveniles Lilford woodpeckers showed a short R1 and a half R2. Chapin (1921) reported that it appeared in 24 species out of the 29 he studied. Among these species is the Great Spotted Woodpecker *Dendrocopos major*. According to Chapin (1921), this feature limits the effects of lack of space in the nest by allowing a second chick to feed at the entrance hole by passing its head through the wings of the first chick already present at the entrance of the cavity. The food delivery would be more homogeneous and more youngs would thus manage to take flight in good conditions. However, in many species of medium-sized Woodpeckers, only one young at a time has access to the entrance of the chamber, making this explanation unlikely for small to medium-sized Woodpeckers (Grangé 2022). For Sibley (1957) and Koenig *et al*. (2006), the main advantage resulting from this was an opportunity for energy saving. In fact, juvenile Picidae are the only birds to undertake a complete moult of the primary flight feathers immediately after fledging. Sutter (1974) compared juvenile wing formula to adult wing formula for several species including *Dendrocopos major*. The juveniles that we captured shortly before fledging had R's still growing and therefore we did not measure each R independently. However, we observed R2's each time at half-growing and a vestigial R1 compared to neighboring R. Our results therefore agree with those of Sutter. According to him, for the great spotted woodpecker D. major, this has to do with the unusually early onset of the juvenile moult which starts with a nesting period of 22 days around day 20 and lasts 4 months.

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BIBLIOGRAPHY

Aulen G. (1988). Ecology and distibution of the White-backed Woodpicker Dendrocopos leucotos in Sweden. Swedish University of Agricultural Science. Uppsala.

Baker J. (2013 and 2016). Identification of European Non-Passerines, BTO books.

Becker M., Jegen H. (2008). Identification of central European woodpeckers on basis of flight-feathers. Dutch Birding, 30 (3): 145-154.

Bergmann C. (1847). Über die Verhältnisse der Wärmeökonomie der Thiere zu ihrer Grösse, Göttinger Studien, vol. 3, n° 1, 1847, p. 595–708.

Bernoni M. (1994). Il Picchio dorsobianco (Picoides leucotos lilfordi) nel Parco Nazionale d'Abruzzo. Rome, 69 p. + annexes.

Butev V.T., Zubkov N.I., Ivanchev V.P. (2007). Oiseaux de la Russie et des régions adjacentes: Owls, Caprimulgiformes, Apodiformes, Coraciiformes, Woodpeckers. Association revues scientifiques KMK, Moscou.

Campión D., Pardo I., Elosegui M. & Villanúa D. 2020. GPS telemetry and home range of the White backed Woodpecker *Dendrocopos leucotos*: Results of the first experience. Acta Ornithologica, 55: 77-87.

Carcamo-Bravo S. (2016). Distribution du Pic de Lilford Dendrocopos leucotos lilfordi à l 'ouest des Pyrénées espagnoles. Le Casseur d'Os, 16: 96-104.

Chapin J.P. (1921). The abbreviated inner primaries of nestling woodpeckers. Auk 38: 531–551.

Cramp S. (ed. 1987). Handbook of the birds of Europe, the Middle East and North Africa, vol. 4. Oxford University Press Oxford, England.

Csörgö T. and Takács N. (2008). Post-juvenil and post-nuptial moult in woodpeckers. Ornis Hungarica, 15-16: 79-80.

Danis V. (1937). Capture d'un spécimen mâle de Dryobates leucotos (Bechst.) dans les Basses Pyrénées. ORFO, 7 :110-111.

Dementiev. & Glatkov (1951). Ptitsy Sovietskjo Soyuza 1. Moscow.

Demongin L. (2013). Guide d'identification des oiseaux en main. Mortsel.

Ginn H.B., Melville D.S. (1983). Moult in birds. BTO Guide 19. BTO, Tring, UK.

Glutz Von Blotsheim U.N., Bauer K.M. (1980). Handbuch der Vögel Mitteleuropas, Band 9: Colombiformes-Picoformes. Wiesbaden.

Gorman G. (2004). Woodpeckers of Europe, a study of the european Picidae. Bruce Coleman Editions.

Gorman G. (2022). The Wryneck : biology, behaviour, conservation and symbolism of Jynx torquilla. Pelagic Publishing.

Grangé J.L. (1991a). Sur le dimorphisme sexuel dans la recherche de nourriture chez le Pic à dos blanc pyrénéen (Dendrocopos leucotos Lilfordi). Nos Oiseaux, 41 : 185-194.

Grangé J.L. & Vuilleumier F. (2009). Le Pic à dos blanc Dendrocopos leucotos : deux scénarios pour expliquer l'histoire de son peuplement dans le sud de l'Europe et analyse des rapports taxonomiques entre les sous-espèces lilfordi et leucotos. Nos Oiseaux, 56 : 195-222.

Grangé J.L. (2022). Les Pics à dos blanc et de Lilford. Une histoire naturelle du complexe Dendrocopos leucotos. Alauda, XC- 1, 152 pages.

Grangé J.L. and Helfenstein F. (2023). Des systems d'appariement chez les Picidés : une recension bibliographique. Nos oiseaux, 70/2- juin 2023-n°552.

Hogstad O. (1978). Sexual dimorphism in relation to winter foraging and territotial behavior of the three-toed Woodpicker Picoides tridactylus and three Dendrocopos species. Ibis, 120: 98-203.

Ivanhev V.P. (1997). Distribution, numbers and ecology of the White-backed Woodpecker Dendrocopos leucotos in European part of Russia. Russian Journal of Ornithology, 5 (3/4): 117-128.

Jenni L. and Winkler R. (2020). The biology of moult in birds. Helm.

Kendeigh S.C. Dol'Nik V.R. Gravilov V.M. (1977). Avian energetic pp 127-204 in Pinowski J. and Kendeigh S.C.. Graminivorous birds in ecosystems. Cambridge University Press, Cambridge.

Kiat Y. Vortman Y. & Sapir N. (2019). Feather moult and bird appearance are correlated with global warming over the last 200 years. Nature communication 1-7.

King J.R.(1974). Seasonal allocation of time and energy resources in birds. Pp4-85 in Paynter R.A., Avian energetic. Publication Nuttal Ornithological Club no. 15.

King J.R. (1980). Energetics of avian moult. Acta XVII Congressus Internationalis Ornitologici, Berlin 1978: 312-317.

Koenig W.D., Stanback M.T., Haydock J. (2006). Abbreviated inner primaries: a sex-linked dimorphism in the Acorn Woodpecker. Journal of Field Ornithology 77(2):157–162.

Kohl I. & Stollmann A. (1968). Die systematisch Lage des Weissrückenspechtes (Dendrocopos leucotos Bechstein) in der Karpaten. Aquila, 75: 207-2014.

Kovalev V. A. (2016). Results of the study of post juvenile moult in Picidae. Russian Journal of Ornithology, XXV : 1970-1971 (en Russe).

Lockwood R., Swaddle J.P., Rayner J.M.V. (1998). Avian wingtip shape reconsidered: wintip shape indices and morphomological adaptations to migration. Journal of Avian Biology. 29 : 273-292.

Myczko Ł., Mizerová Z, Kubicka A.M., Sparks T.H. and Hromada M. (2020). Bill morphology and biometrics of three sibling woodpecker species from sympatric populations. Bird Study, British Trust for Ornithology.

Murphy M.E. & King J.R. (1992). Energy and nutrient use during moult by White-crowned Sparrows Zonotrichia leucophrys gambelii. Ornis Scandinavica 23: 304-313.

Newton I. (1966). The moult of Bullfinch Pyrrhula pyrrulha. Ibis 108: 41-67.

Newton I. (2009). Moult and plumage. Ringing & Migration 24, 220-226.

Pons J.M., Campión D., Chiozzi G., Ettwein A., Grangé J.L., Kajtoch L., Mazgajski T.D., Rakovic M., Winkler H., Fuchs J. (2020). Phylogeography of a widespread Palaearctic forest bird species: The White-backed Woodpecker (Aves, Picidae). Zoologica Scripta. 2020: 1–18.

Purroy F. (1972). El Pico dorsiblanco (Dendrocopos leucotos) del Pirineo. Ardeola 16, 145-158.

Pyle P. & Howell S.N.G. (1994). Flight-feathers molt patterns and age in North-American Woodpeckers. Journal of Field Ornithology, 66 (4) : 564-581.

Senosiain A. (1977).– Observaciones de Pico dorsiblanco (Dendrocopos leucotos) en el Pirineo navarro y primera nidificacion comprobada en la peninsula Iberica. Ardeola, 24: 236-242

Short L.L. (1982). Woodpeckers of the World. Delaware Museum of Natural History Monogr. Series 4.

Schubert W. (1969). Anzeiger der Ornithologischen Gesellschaft, Bayern 8: 515-517.

Sibley C. G. (1957). The abbreviated inner primaries of nestling woodpeckers. Auk 74: 102–103

Stenberg I. (1998). Growth and development of White-backed Woodpecker Dendrocopos leucotos nestlings. Cinclus, 21: 93-107.

Svensson L. (1975). Identification Guide to European Passerines. (2nd. Rev. Ed.). Naturhistoriska Riksmuseet, Stockholm.

Tellería J.L. and Carbonell R. (1999). Morphometric variation of five Iberian Blackcap Sylvia atricapilla populations. Journal of Avian Biology 30: 63-71.

Verthein J. (1935). Ornis Monatsberg. 43 : 131-133.

Villanúa D., Campión D., Elosegi M. M. & Arizaga J. (2021). Wing-feather moult of the White-backed Woodpecker Dendrocopos leucotos Lilfordi. Ringing and Migration, 35 (1)

Voous K.H. (1947). On the history of the genus Dendrocops. Limosa, 20: 1-142.

Winkler R. (2013). Mue et détermination de l'âge des pics. Feuille d'information ornithologique. vogelwarte.ch.

Winkler H., Christie D.A. & Nurney D. (1997). Woodpeckers, a guide to the Woodpeckers, Piculets and Wrynecks of the world. Pica Press.

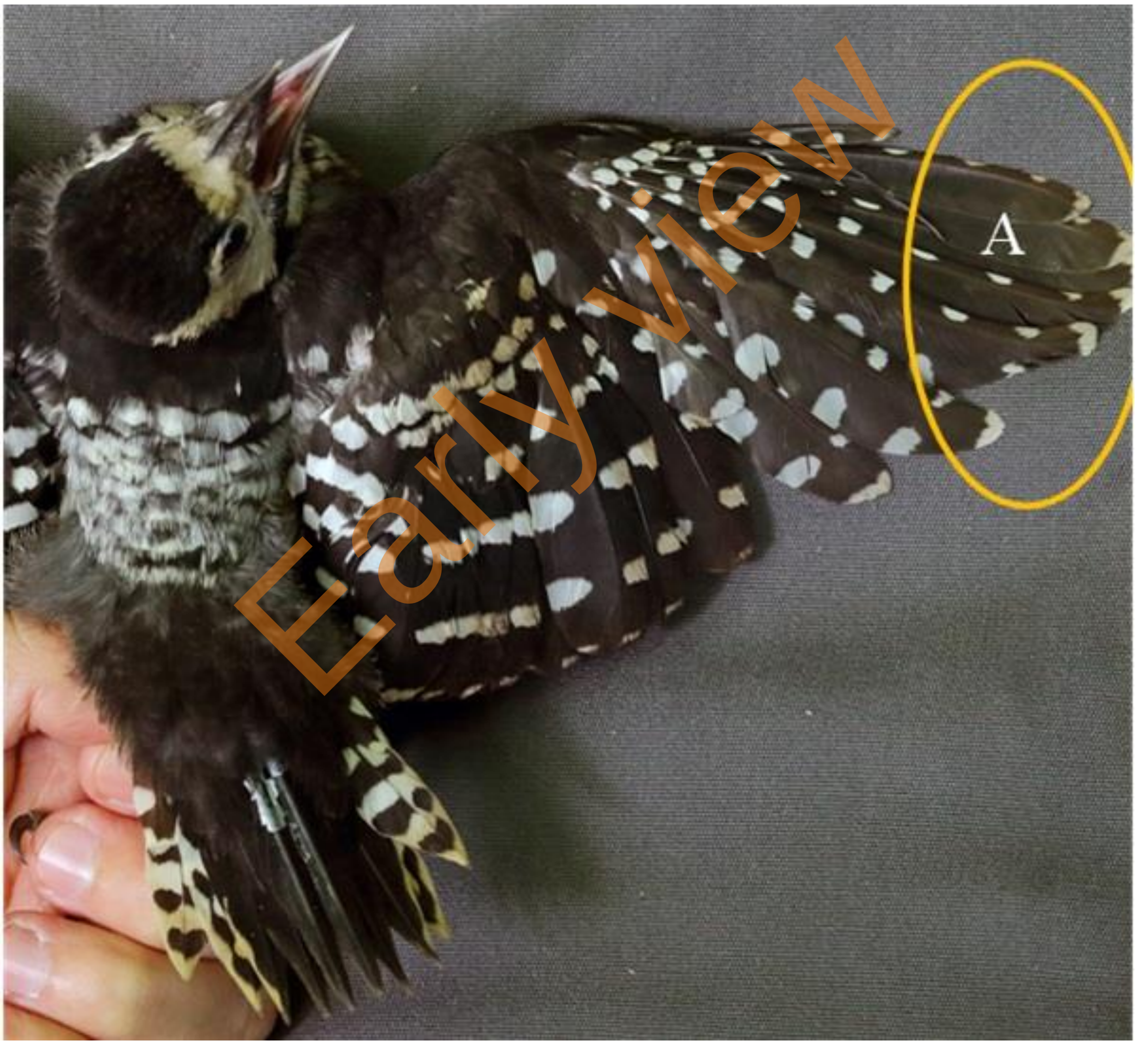
Winkler H. & Christie D.A. (2002). Family Picidae (Woodpeckers) pp. 296-555. In : Del Hoyo J., Eliott A. & Sargatal J. (ed.) Handbook of the Birds of the World, vol. 7 Jacamars to Woodpeckers. Lynx Edicions, Barcelona.

ILLUSTRATIONS

Figure 1: Topography of the wing of a male Lilford's woodpecker. P: primary flight feathers. S: secondary flight feathers. Al: alula. CP: primary covers. GC: Great covers. MC: medium covers. PC: small covers. CMa: Marginal covers. S9*: Rémige secondary 9 missing here because taken for the purposes of a genetic study. (Photography Pierre Navarre)

Figure 2: Lilford's woodpecker pullus female at fledging and characteristic pointed shape of the 5th juvenile rectrix.

All feathers are from the same generation. The P8 measures 80.7% of the P8 adult females average size. The P1 is still in the sheath state (calamus). The P 2 is grown about half the adult size. It can in no way be a question of an early moult of the P. Indeed: in this case, the P1 would be half-grown and the P2 would be in the sheath state. The pattern of P (A) is characteristic of juveniles with white chevron-shaped tips. This criterion is always absent from the post-juvenile external Ps although sometimes still present on the three to four internal Ps. The distance between the tip of the P10 (grown to 80%) to the tip of the Primary Covers (CP) is here 8.5cm. On average, this distance is 6.5mm +/- 1.95mm in the pullus. (Photography Pierre Navarre).



464 Figure 3: Upperparts aptery on scapulars and lower side of mantle characteristic of a juvenile
465 (Photography Candice Guyot)

Figure 4: Apteria of the flanks and underwings characteristic of a juvenile. (Photography Candice Guyot)

Figure 5: Apteria of the belly characteristic of a juvenile and the undertail coverts without pink tint. (Photography Candice Guyot)

Figure 6: R1 and R2 growth delayed

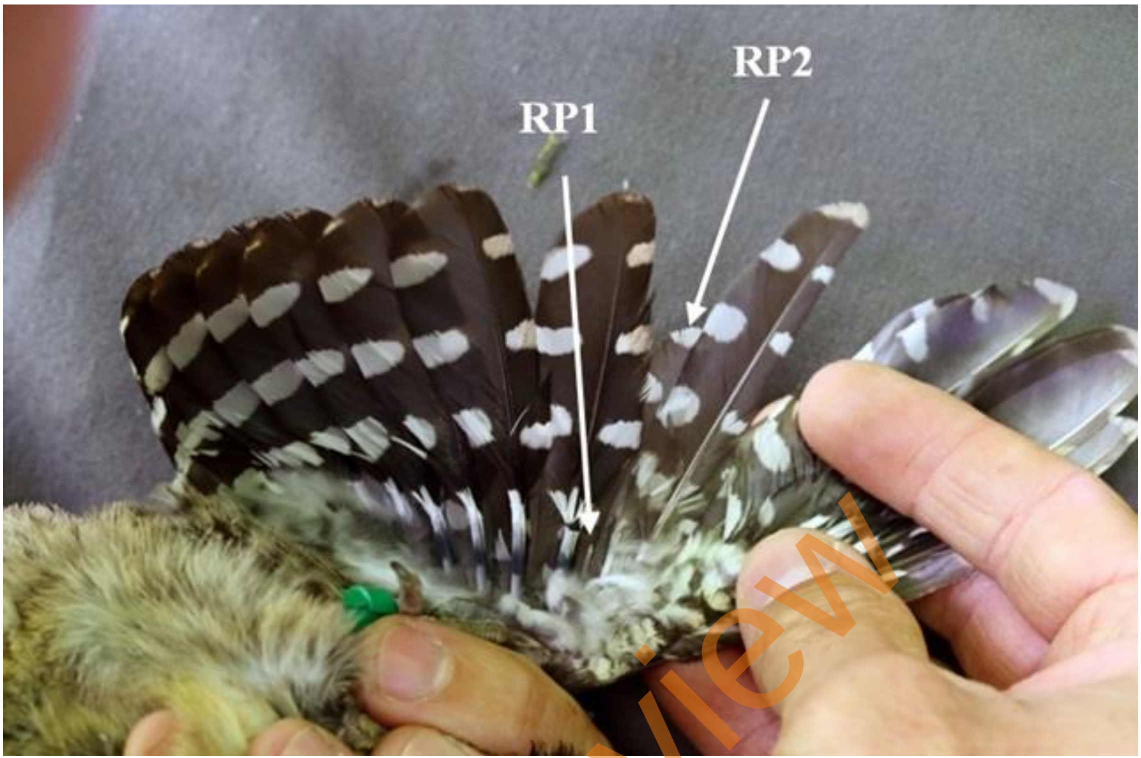


Figure 7: Lilford Woodpecker adult male: flight feathers of the wing dotted with 5 white spots on the two vanes of the secondary remige S and 7 on the outer vane of the primary remige P. Adult's fifth rectrice is clearly rounded. Note that the tips of the outer primary flight feathers are white on the external vane only. (Photography Stéphane Hommeau, ringer Laurent Joubert).

Figure 8: Diagram of post-juvenile partial moult of the Lilford woodpecker in the French Pyrenees (Urbina-Tobias and Grangé).

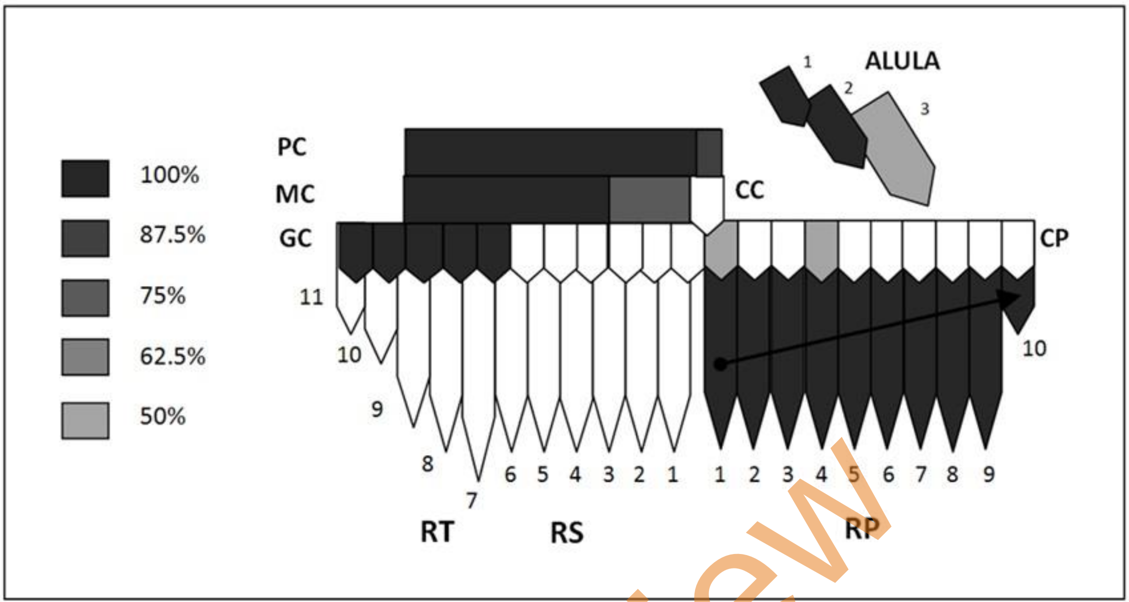


Figure 9: 2yc Lilford woodpecker with exceptionaly 2 CP renewed in the last post juvenile moult (Photography Stéphane Hommeau, ringer Laurent Joubert).

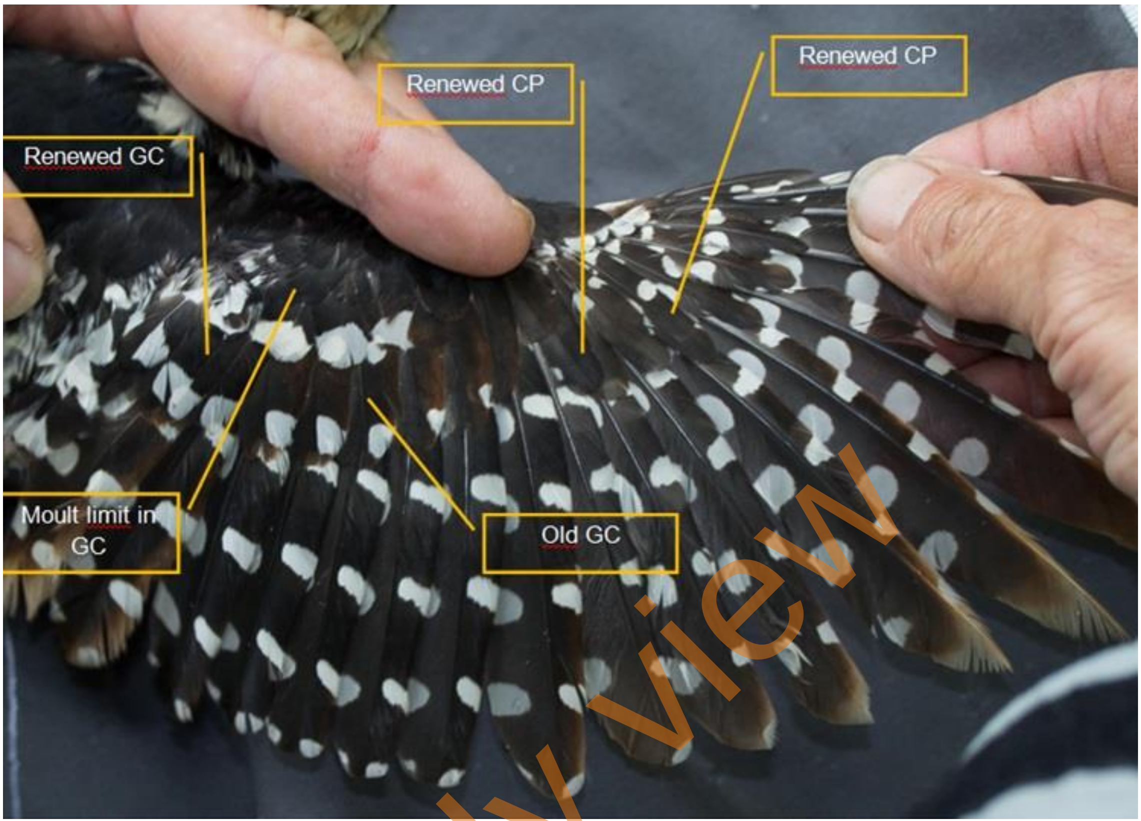
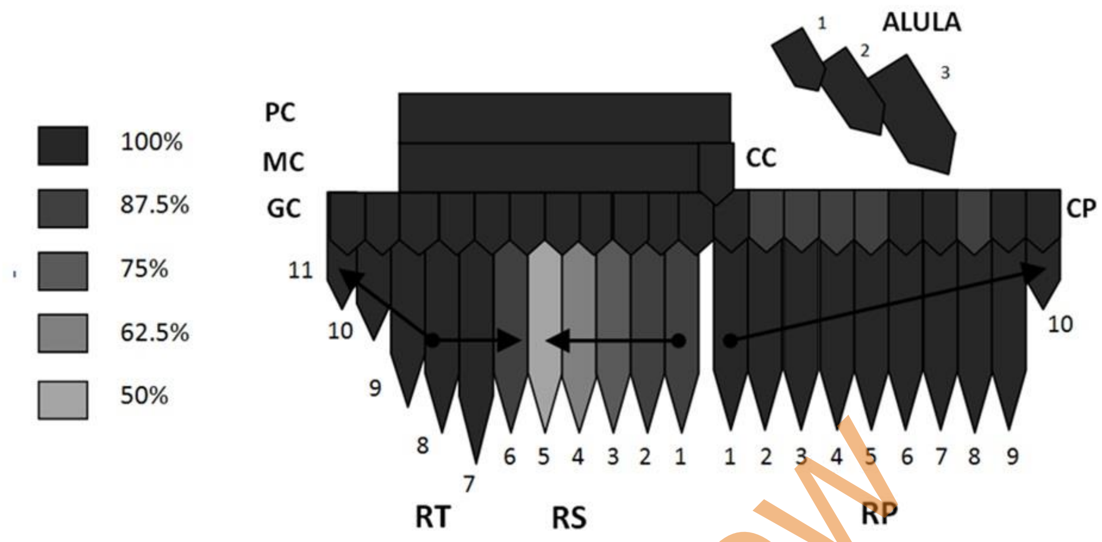


Figure 10 : Lilford woodpecker, 2yc. 06/02/2018. Beginning of the post nuptial moult, P1 and P2 in state 3 and 2. The corresponding CP are missing. Outer MC and PC are also missing. 6 outer GC are fledging feathers. 5 internal GC are post juvenile feathers. All S are juvenile feathers of the same generation (photography Pierre Navarre)

Figure 11: Pattern of the post-breeding complete adult moult, sometimes arrested in the French Pyrenees (Urbina-Tobias and Grangé).



509 Figure 12: Graphic representation of the wing formulas (distance to WP) of females and males of *lilfordi*
510 (this study) and *leucotos* (Cramp 1985 BWP).

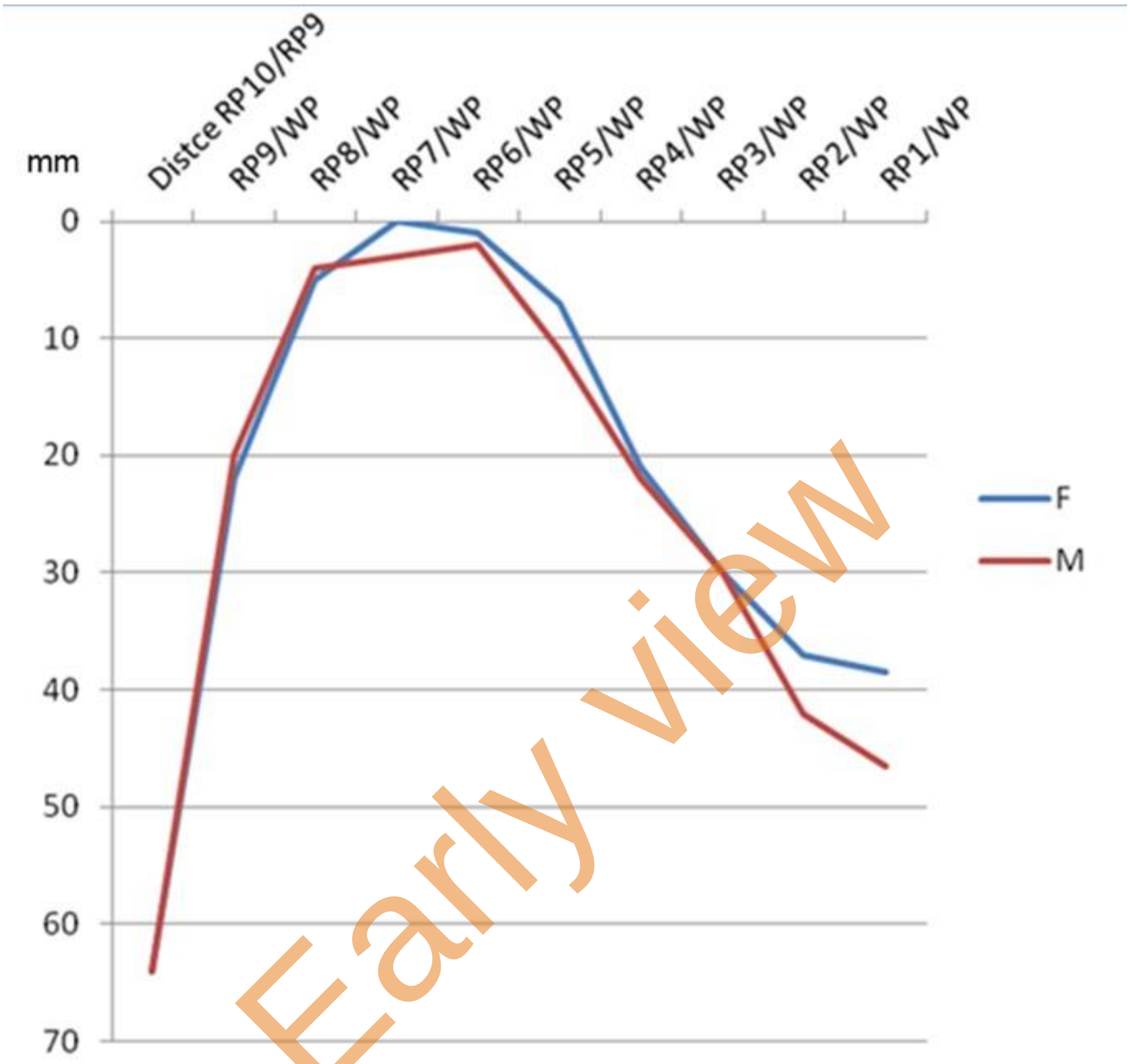


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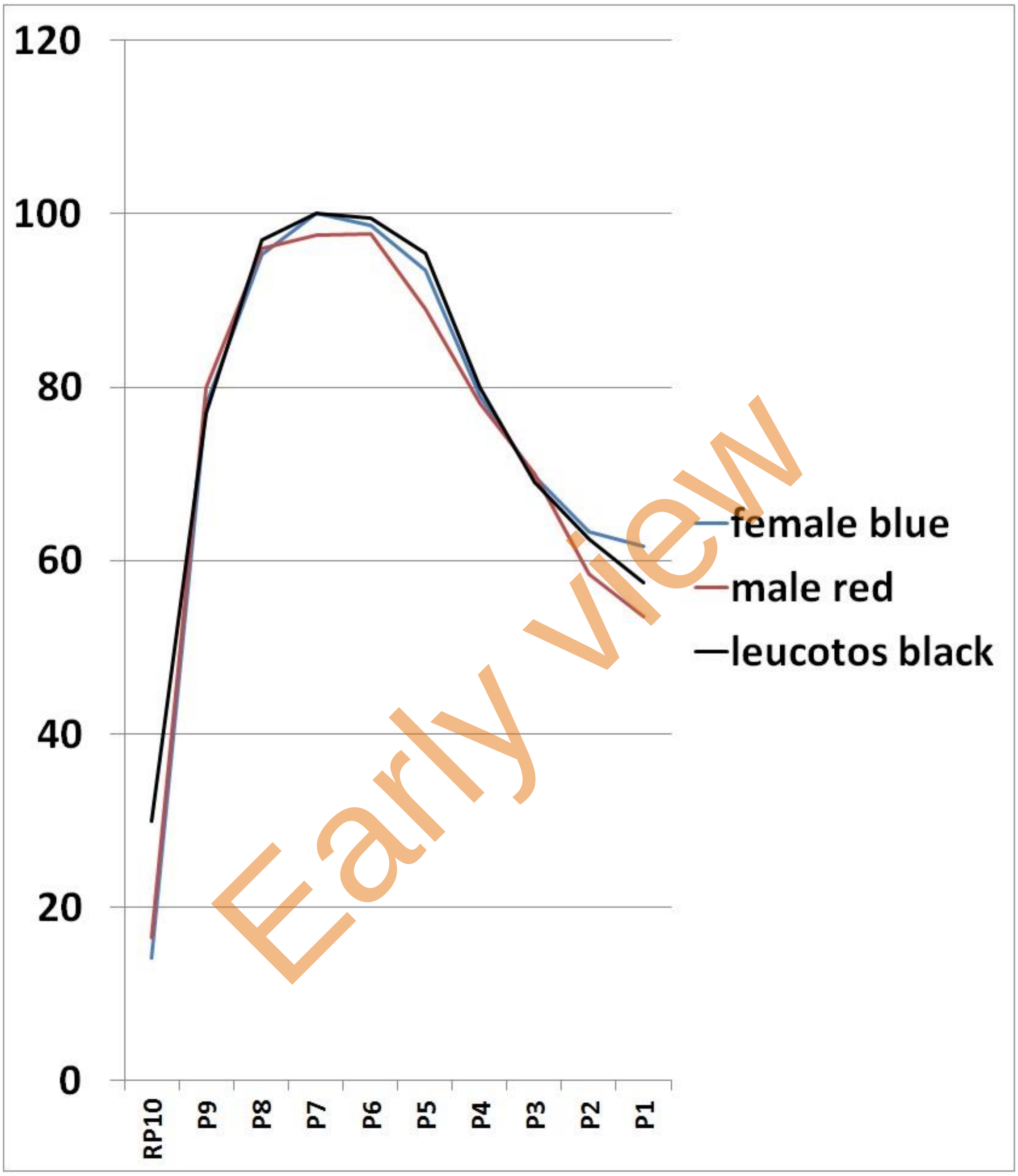
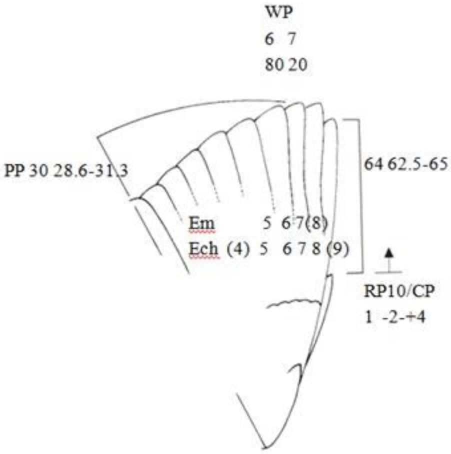
Figure 13 : Graphic representation of the R lengths of females and males of *lilfordi* (this study) and *leucotos* (Cramp 1985 BWP).



Tables

Table 1: Male Main body measurements, wing formula and flight feathers measurements.

	WP mm		
	Average	mini	maxi
P10	85	80	87
P9	20	18	22
P8	4	3	5
P7	3.5	0	5
P6	2.3	0	4.5
P5	11	4	18
P4	22	15	28.5
P3	30	24	36
P2	42	34	41.5
P1	47	35	46,5
	P mm		
P10			
P9	95	93	96.5
P8	110	107	113.5
P7	117	116	118
P6	118	115	121
P5	112	105	119
P4	105	104	106
P3	100	98	101
P2	96	92	96
P1	90	90	91

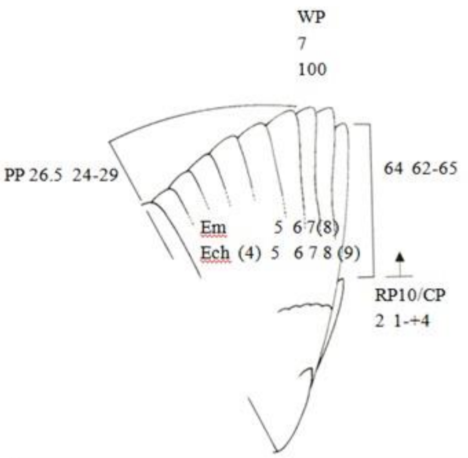


	Average mm	mini	maxi
Folded wing	148	145	153
tail	90.5	87.5	95
Tarsus	28.3	26.3	30.2
Head + bill	68.6	68.2	69,5
Bill	38.4	38	39
Bill nostril	30	28	32
Nostril bill width	10,1	8,6	13,8
thickness nostrial bill	10,8	9,6	12,3
Mass	108	101.3	108.5
Body length	264	262.5	266
Wing span	453	450	455

WP, RP forming the Wing point & percentage of occurrence / PP, Primary projection / Em & Ech, Notch and indentation: P concerned and (occasional) / P10/CP, Distance between the tip of the P10 and the tip of the Primary Coverts (negative if P10 shorter and positive if P10 longer) / P, Length of each Primary Flight.

Table 2: Female Main body measurements, wing formula and flight feathers measurements.

	WP mm		
	Average	mini	maxi
P10	85	80	90
P9	23	21	25
P8	4.3	3	5.5
P7	0	0	0
P6	1.3	1	1.5
P5	6	4.5	7.5
P4	20	18	22.5
P3	30	27	32
P2	36	34	38
P1	38	35	40
	P mm		
P10			
P9	92	88	95.5
P8	110	109	111
P7	113	113	114
P6	115	115	116
P5	114	112	116
P4	107	103	111
P3	98	95	100
P2	93	92	93
P1	91	90	91



	Average mm	mini	maxi
Folded wing	147.2	145	149.5
tail	87	85	89
Tarsus	25.4	25.1	28.1
Head + bill	65.7	65.1	66.2
Bill	37.4	37.2	39
Bill nostril	28.2	27.8	29.4
Nostril bill width	8.6	8,4	9
thickness nostrial bill	9.3	9,1	9.5
Mass	101.3	100	102.4
Body length	260	258	263
Wing span	434	429	441

WP, RP forming the Wing point & percentage of occurrence / PP, Primary projection / Em & Ech, Notch and indentation: P concerned and (occasional) / P10/CP, Distance between the tip of the RP10 and the tip of the Primary Coverts (negative if P10 shorter and positive if P10 longer) / P, Length of each Primary Flight.

Table 3: Main body measurements and flight feather measurements for each sex, all measurements in mm, Ma in g (LP: folded wing, Ma: mass, LT: Tarsus length, bill, TB head + bill, RC: rectrices length, PP: primary projection, L: length from bill to rectrices).

	n	LP	Ma	LT	Bill	TB	LR	P8	PP	L	Wingspan
Male	n=6	149	108	28,3	38,4	68,6	90,5	110,3	30	264	453
Female	n=4	147,2	101,3	25,3	37,4	65,7	87	109,8	26,5	260	434

Table 4: Main measurements taken and sexual dimorphism (LP: folded wing, Ma: mass, LT: Tarsus length, Bec: bill, TB head + bill, BN, bill from distal edge of the nostrils to the tip, LR: rectrices length, EB: bill width).

	LP	**Ma**	**LT**	**BILL**	**TB**	**P8**	**LR**	**EB**	**Bill thickness**
Average percentage substraction F-M (<0: female smaller)	-1,1%	-3%	**-9%**	-7%	-3,7%	0%	-2%	**-14%**	**-16%**
Wilcox.Test	14	18	**24**	11	44	14	20	**18**	**24**
p-value	0.7469	0.2366	0.01306	0.9133	0.013	0.7446	0.1066	0.2263	0.01142

Table 5: Comparison between the wing formulas of *lilfordi* and *leucotos* females and males in the literature (Cramp, BWP).

		Length P10-P9	P9 /WP	P8 /WP	P7 /WP	P6 /WP	P5 /WP	P4 /WP	P3 /WP	P2 /WP	P1 /WP
Leucotos Literature		50,5	23	3	0	0,5	4,5	20	31	37,5	42,5
Lilfordi Urbina-Tobias/Grangé	**F**	64	22	5	**0**	1	7	21	30	**37**	**38,5**
	M	64	20	4	3	**2**	11	22	30	**42**	**46,5**