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Moulting in the wrong season? A House Sparrow replacing a significant part of its plumage in winter

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Extra moult episodes in wild passerines have rarely if ever been documented. Here, we report a case of a possible extra moult episode in a House Sparrow *Passer domesticus*, a species with just one moult per annual cycle. This bird was captured in active and intense plumage growth in Barcelona on 15 February 2021, c. five months after it had been ringed whilst undergoing its post-juvenile moult. This possible extra moult episode involved all body tracts except the crural, all tail tracts, and most wing tracts except the underwing coverts, primaries, primary coverts and alula. We found no evidence that this plumage replacement was the final phase of an interrupted post-juvenile moult. Hypotheses that could explain this extraordinary plumage growth include a mutation affecting the endogenous rhythm of the bird, severe stress, endocrine disruption or a predation event. Although the replacement of the wing feathers was highly asymmetric, we interpret this case as an extra moult episode of unknown cause rather than plumage regrowth after accidental loss (e.g. by predation), given that this plumage growth was compatible with three characteristics of moult not expected during the replacement of accidentally lost plumage: (i) it affected the whole of the bird's plumage, (ii) involved feathers such as the axillaries that are rarely exposed, and (iii) showed sequential rather than simultaneous feather growth.

Key words: House Sparrow, extra moult episode, moult anomaly, moult phenology, Iberian Peninsula, Barcelona.

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Passerines organize their lifetime in terms of annual cycles (Barta *et al.* 2006, 2008) consisting of at least three life-history stages every year: breeding, moulting, and wintering. Although some trans-Saharan migratory species delay their complete moult until after departing from their breeding territories, all non-migratory species in the Palearctic region moult immediately after their breeding season, usually between late summer and early autumn (Newton 1989, Shirihai & Svensson 2018). A well-known case is the House Sparrow *Passer domesticus*, which undergoes one complete moult a year, which includes its post-juvenile moult (Svensson 1992).

As with any other physiological process, moulting requires mechanisms to control its correct timing and progression (Berthold 1978, Gwinner 2003) since any regulatory failure could negatively affect survival and reproduction (Edwards 2008). Despite this, certain moult anomalies are often observed. For example, fault bars and odd final moult phenotypes have been documented and discussed (Illa 2016, Jovani & Rohwer 2017, Norman 2021). Conversely, anomalies in moult timing are rarely observed in wild birds, as they are usually associated with late hatched birds in northern latitudes that delay their post-juvenile moult until after migration (e.g. Alström & Mild 2003). Although protracted and adventitious feather growth has been described in many species outside the Palearctic region (Willoughby 1991, Guallar *et al.* 2009, Lantz & Karubian 2016), as far as we know there are no reports of extra moult episo-

des in individuals of passerine species such as the House Sparrow that have a single annual moult event.

Here, we document an episode of extensive and intense feather replacement in a House Sparrow recaptured in the 2021 winter season. We describe four elements of its plumage replacement (intensity, sequence, extent, and symmetry) and discuss several hypotheses that could explain this anomaly.

Material and Methods

The House Sparrow is one of the species targeted by the PASSERCAT project. The study site is

Figure 1. Wings, tail, and underparts of House Sparrow T55187 recaptured in Parc de la Ciutadella, Barcelona, on 15 February 2021. Note the untidy body plumage caused by pin feather growth.
Ales, cua i parts inferiors del pardal comú T55187 recuperat al Parc de la Ciutadella de Barcelona el 15 de febrer de 2021. El desordre del plomatge corporal és causat per les plomes en canó.

in Parc de la Ciutadella, an urban park in the centre of Barcelona (41º23'21"N, 2º11'6"E). Twelve funnel traps containing peanut feeders are set up in an area of 17.5 ha that allow free access and *ad libitum* feeding. From 15 January to 15 March and from 15 August to 15 October traps are deployed one morning a week (approximately from 08:00 until 14:00 h); birds can enter traps but are unable to leave. Traps are periodically revised and individual captures are ringed and processed according to the project's protocols (Covas *et al.* 2017). Three biometric measures (mass, wing chord, and tarsus length), fat and muscle reserves (ICO 2020), and sex and age are recorded. During the summer-autumn period, the progress of the active moult is also logged. The presence of winter moult was also recorded from the year 2018 onwards.

We assessed two typical elements of the moult process, intensity and sequence, and two elements of the moult pattern, extent and symmetry. Since we did not keep House Sparrow metal ring Aranzadi (ESA) T55187 in captivity, we were unable to quantify the extent of replaced plumage after our observation (i.e. we could not infer the total area of plumage replaced). This could have affected the final degree of symmetry, an element of plumage quality frequently used to define accidental plumage replacement.

Results

House Sparrow T55187 was ringed on 25 August 2020 as a juvenile male starting its post-juvenile moult (inner primaries and accompanying primary coverts were growing, along with a few dorsal feathers) corresponding to the complete sequence that is typical in this species (Table 1; Zeidler 1966, Alonso 1984). On 15 February 2021, it was recaptured, again exhibiting active plumage growth. Approximately 20% of its body feathers were growing on most body tracts: capital, ventral, pectoral, femoral, dorsal, axillar, scapular, alar (lesser, median, and greater coverts) and caudal (under- and upper-tail coverts). As well, six rectrices, four remiges and five wing coverts were growing (Table 1). Plumage growth was not simultaneous and feathers were in different growth phases. Although this

Table 1. Moult cards of House Sparrow T55187 when ringed on 25 August 2020 and recaptured on 15 February 2021. On the latter date, all feathers were post-juvenile; those not scored could not be assigned either to summer-autumn or winter moult. Growth is indicated either as the estimated percentage of the total feather length or the estimated percentage of the number of body feathers (0 indicates juvenile feathers, while 100 indicates recently finished growth). Secondaries and greater coverts are numbered from outside to inside, the rest of tracts from inside to outside.
Fitxes de muda del pardal comú T55187 quan va ser anellat el 25 d'agost de 2020 i recuperat el 15 de febrer de 2021. En aquesta última data, totes les plomes eren postjuvenils; les no puntuades no es van poder assignar ni a la muda d'estiu-tardor ni d'hivern. El creixement s'indica com el percentatge estimat de la longitud total de les plomes o el percentatge estimat del nombre de plomes corporals (0 indica plomes juvenils, mentre que 100 indica creixement acabat recentment). Les secundàries i les grans cobertores es numeren cap a l'interior, la resta de tractes cap a l'exterior.

Primaries [primary covs]	Secondaries	Tertials	Greater covs	Median covs	Rectrices
Moult card 25 August 2020 (symmetric)					
P1=90 [90] P2=60 [30] P3=2 [pin] P4=shed [0] PP5-9=0 [0]	0	0	0	0	0
Moult card 15 February 2021: right side					
Older [older]	S4=80 SS5-6=100			MC3-4=pin	R1=50 R3=40 R5=80
Moult card 15 February 2021: left side					
Older [older]		T3=75	GC4=90 GC5=80 GC6= 70 GC10=60		R1=shed R5=70 R6=shed

was visible on the body feathers, it was most apparent on the wing feathers. Thus, while some median coverts were just pins, some secondaries and tertials were already nearly fully grown (Fig. 1, Table 1). Alula feathers, primary coverts, and primaries were post-juvenile, although tenuous fading indicated that they were slightly older than the growing feathers. We did not observe any juvenile feathers (Fig. 1). Although we were unable to estimate the final extent of the plumage replaced, we noted that most body and tail areas were affected, as well as four wing-feather tracts. For the same reason, we were unable to assess the final degree of asymmetry, although this was high on the wings and low on the tail.

The biometry of this bird was that of an average adult male belonging to this wintering population: mass, tarsus length, and wing chord were within one standard deviation of their means for this adult male population (Table 2).

The observed body condition was apparently good. It had moderate fat reserves (score = 3) and strong pectoral muscles (score = 3) *sensu* Kaiser (1993). There were mild signs of dry pox around the eyes and bill (van Riper & Forrester 2007), a frequent infection in the House Sparrow population in Barcelona in winter (S. Guallar, pers. obs).

In the previous three winters (2018–2020), we had captured eight House Sparrows (n = 140) with up to 10 pins growing on their bibs and heads. Only one of these was a female, therefore the presence of growing feathers was significantly higher than expected in males (Chi-square test with continuity correction: $\chi^2 = 4.5$, $p = 0.03$).

Discussion

Here, we document the observation of a House Sparrow in active, intense, non-simultaneous (i.e. feathers in different plumage areas were in different growth stages) and asymmetric plumage growth in winter, generally a period of moult stasis for this species (Svensson 1992). This is remarkable, since House Sparrows in the northeast Iberian Peninsula only moult once per annual cycle, between summer and early autumn (ICO 2021).

An initial explanation of the plumage growth in T55187 is that it was in the final phase of its post-juvenile moult. House Sparrows have been reported to interrupt their moults in temperate areas (Casto 1974, Harper 1984), so the present case could represent the continuation of this birds' post-juvenile moult (suspended moult, *sensu* Harper 1984). Indeed, suspended moult is a strategy documented in House Sparrows that engage in late-breeding events (autumn) in subtropical areas (Mathew & Naik 1986). However, we found no evidence of moult interruption: i) the moult sequence in the remex tracts and among these and other tracts did not correspond to the sequence described for this species (Zeidler 1966; Table 2); and ii) this bird showed two post-juvenile feather generations with no signs of juvenile feathers being replaced in February.

The specific but still hypothetical causes of this plumage growth can be classified as either congenital or exogenous. Congenital causes could arise from a mutation affecting this bird's endogenous rhythm, which would be responsive to a second Zeitgeber in winter (Gwinner 2003). The genetic basis of moult regulation remains obscure, although its contribution is believed to be significant. Passerine moult has a significant heritability component (Berthold & Querner 1982, Helm & Gwinner 1999) and has a polygenic regulation (Helm & Gwinner 1999, Saino *et al.* 2013, Bazzi *et al.* 2017). Thus, if a mutation affecting the endogenous rhythm is the cause of the unusual plumage replacement documented here, future winter recaptures of this bird will prove this hypothesis. On the other hand, and since moult is frequently associated with gonadal increase, the observed plumage growth could be the consequence of a rare reproduction event. Urban populations of a related species, Italian Sparrow *Passer italiae*, are known to undergo a pre-nuptial moult affecting head and body feathers linked to anomalous winter breeding activity (Fulgione *et al.* 1998). However, we detected no winter breeding activity in 2011-2021 in the study area (Quesada pers. obs.) and none has been reported anywhere else in the Iberian Peninsula (Murgui 2016, ICO 2021).

Congenital causes can be assimilated to moult and, for this reason, if the plumage growth in T55187 was of congenital origin, it should have had characteristics compatible to what we regard as a true moult, i.e. the distribution of growing feathers, moult extent, moult sequence, and the symmetry of replacement. Alternatively,

Table 2. Mass (g), tarsus length (mm), and wing chord (mm) of House Sparrow T55187 recaptured on 15 February 2021, and the mean of the adult male population resident in Parc de la Ciutadella, Barcelona (based only on mean values of single winter captures in 2011–2017; *n* = 348).
Massa (g), longitud del tars (mm) i corda alar (mm) del pardal comú T55187 recuperat el 15 de febrer de 2021 i valors mitjans de la població de mascles adults residents al Parc de la Ciutadella, Barcelona (basada només en els valors mitjans d'individus únics capturats a l'hivern del 2011 al 2017; n = 348).

	Mass (Mean ± SD)	Tarsus length (Mean ±SD)	Wing chord (Mean ± SD)
T55187	27.91	18.40	79.00
Population	26.56 ± 2.77	18.69 ± 1.52	78.92 ± 6.06

any replacement of accidentally lost plumage would deviate from these characteristics.

Two groups of exogenous causes could explain the winter plumage growth in this sparrow: accidental and physiological. Birds can renew accidentally lost feathers due to collisions, aggression by conspecifics, or predator attacks. The fact that the observed winter moult involved nearly all its body surface, with similar intensity throughout and independent of feather exposure, rules out a collision or any other mechanical traumatism, which would not affect the whole body (Willoughby *et al.* 2002). Our results for the previous three winters indicate that winter is a period of frequent replacement of feathers lost after aggressive interaction with conspecifics, although the extent of this type of adventitious moult is generally much smaller (i.e. it affects a very limited area of the plumage). Neither can a failed predation event explain such generalized plumage growth, and the set of replaced feathers and the extent of plumage involved was likewise inconsistent with a fright moult (*sensu* Møller *et al.* 2006). There are four potential predators present in the area: Brown Rat *Rattus norvegicus*, Eurasian Magpie *Pica pica*, Yellow-legged Gull *Larus michahellis*, and Feral Cat *Felis catus*. Of these predators, only cats manipulate live prey for long enough to have caused a substantial loss of feathers. However, cats do not pluck feathers from the birds they capture, much less from all over the bird's body. In addition, this bird had no wounds or scars.

Physiological causes of exogenous origin can also drive plumage replacement. Thus, the intake of an unknown endocrine disruptor could have induced this bird's winter plumage growth. A widespread practice in the poultry industry consists of forcing moult in hens to increase their egg production. Several methods are used for this purpose, including hormonal treatments, the feed or water deprivation, and an imbalance in a particular nutrient such as sodium, calcium, iodine, or zinc along with other dietary constraints (Khan *et al.* 2011, Patwardhan & King 2011). Additional lighting to simulate the photoperiod is necessary to correctly induce moult in poultry (Kuenzel *et al.* 2005).

Finally, the origin of the winter plumage growth could have originated from a combination of accidental and physiological causes. Analogously to the hair loss in mammals as a reaction to trauma (Choi *et al.* 2021), T55187 could have experienced a traumatic event or severe stress (e.g. predation or accident) that triggered its moult response.

Given the above, we believe that the observed plumage growth in winter 2021 was an extra moult episode independent of its post-juvenile moult that could have been physiologically induced or congenital. Accidental, traumatic, and adventitious plumage growth would only affect part of the body, most probably the most exposed feathers. However, it was replacing feathers on nearly all its body and wing tracts, including axillaries and one innermost greater covert, which are feathers that are rarely with a very low exposure. Since the replacement of accidentally lost feathers occurs simultaneously, only a highly improbable succession of accidents could have caused such non-simultaneous replacement. The sequence of replacement in this bird was evident within and between feather wing tracts (Table 1).

Moult intensity, extent and sequential replacement were compatible with passerine moult. However, T55187 deviated from the replacement symmetry associated with moulting. Although a lack of symmetry is an aspect often invoked to detect accidentally growing wing feathers, it is in fact very frequent in partial passerine moults. For example, Minias & Iciek

(2013) reported that 49% of captured European Greenfinches *Chloris chloris* showed asymmetries. The degree of asymmetry is larger in eccentric moults and spring moults undergone by trans-Saharian species including Melodious Warbler *Hippolais polyglotta* (Pinilla 2001, Guallar *et al.* 2009). Indeed, the asymmetric replacement of wing feathers suggests anomalous plumage replacement and, although rare, extreme anomalies have been documented. For example, an adult European Nuthatch *Sitta europaea* captured in 2002 in northern England had undergone a highly anomalous, incomplete, and asymmetric post-breeding moult but then underwent a 'correct' and complete post-breeding moult in 2003 (Norman 2021).

Although our observations do not allow us to completely exclude accidental replacement, the examination of the process and pattern of the plumage growth in T55187 is compatible with those of a plumage moult. The documentation of anecdotal data such as this case is important as i) a record of infrequent or new phenomena that would otherwise remain undetected and/or underestimated, and as ii) scientific knowledge that does not fit current theories (Chinn & Brewer 1993). Although moult abnormalities are known to be relatively frequent in captive birds (Rubinstein & Lightfoot 2012, Golembeski *et al.* 2020), to our knowledge this is the first case reported in the scientific literature of a wild House Sparrow undergoing an extra moult episode.

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Resum

Mudant en l'època equivocada? Un pardal comú reemplaçant una part significativa del plomatge a l'hivern

Els episodis addicionals de muda en ocells passeriformes en llibertat han estat rarament documentats. Aquí comuniquem un possible episodi de muda addicional en un pardal comú *Passer domesticus*, una espècie amb només una muda durant el seu cicle anual. Aquest ocell va ser capturat en un intens creixement del plomatge a la ciutat de Barcelona el 15 de febrer de 2021, aproximadament cinc mesos després d'haver estat anellat en plena muda postjuvenil. Va afectar tots els tractes corporals excepte el crural, tots els tractes de la cua, així com la majoria de tractes alars excepte infracobertores alars, primàries, cobertores primàries i àlula. No vam trobar indicis que aquest reemplaçament del plomatge fos la fase final de la muda postjuvenil interrompuda. Les hipòtesis per explicar aquest creixement extraordinari del plomatge inclouen una mutació que afecta el ritme endogen de l'ocell, l'estrès sever, l'alteració endocrina i un esdeveniment de depredació. Tot i que la substitució de les plomes de les ales va ser molt asimètrica, vam interpretar aquest cas com un episodi de muda addicional de causa desconeguda en comptes d'un recanvi del plomatge després d'una pèrdua accidental (per depredació, per exemple) perquè era compatible amb tres característiques de la muda que no s'esperen trobar durant la substitució del plomatge perdut accidentalment: va afectar el plomatge en general, incloïa plomes amb molt baixa exposició com ara les axil·lars, i va mostrar un creixement no simultani de les plomes.

Resumen

¿Mudando en la época equivocada? Un gorrión común reemplazando una parte significativa del plumaje en invierno

Los episodios adicionales de muda en aves paseriformes en libertad han sido raramente documentados. Aquí, comunicamos un posible episodio de muda adicional en un gorrión común *Passer domesticus*, una especie con sólo una muda durante su ciclo anual. Este pájaro fue capturado con un intenso crecimiento del plumaje en la ciudad de Barcelona el 15 de febrero de 2021, aproximadamente cinco meses después de haber sido anillado en plena muda posjuvenil. Esta afectó todos los tractos corporales excepto el crural, todos los tractos de la cola, así como la mayoría de tractos alares excepto infracoberteras alares, primarias, coberteras primarias y álula. No encontramos evidencias de que fuera la fase final de una muda anterior interrumpida. Las hipótesis para explicar este crecimiento extraordinario del plumaje incluyen una mutación que afecta al ritmo endógeno del pájaro, el estrés severo, la alteración endocrina y un evento de depredación. Aunque la sustitución de las plumas de las alas fue muy asimétrica, interpretamos este caso como un episodio de muda adicional de causa desconocida en vez de un recambio del plumaje tras haberse perdido accidentalmente (por depredación, por ejemplo) por

ser compatible con tres características de la muda que no se esperan encontrar durante una sustitución del plumaje perdido accidentalmente: afectó al plumaje en general, incluía plumas con muy baja exposición como las axilares, mostrando un crecimiento no simultáneo de las plumas.

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