













Molt patterns and age and sex determination criteria for selected landbirds in an urban area of the Peruvian Central Coast

Patrones de muda y criterios de determinación de edad y sexo para aves terrestres seleccionadas en un área urbana de la Costa Central del Perú

Alexis Díaz ^{1,2,3*}, Pamela Ayala ³, Elizabeth Valdiviezo ³, Jorge Mendoza ³, Kathia Silva ³, Rolf Rivas ³, Dayanne Cornelio ³, Fabiola Guardia ³, Yaquelin Tenorio ^{2,3}, Rocío Calsina ³, Lorena Alvarino ³, José Iannacone ^{3,4}.

- Received: 21/Jan/2020
- Accepted: 12/Feb/2021
- Online Publishing: 17/Feb/2021

Citation: Díaz A, Ayala P, Valdiviezo E, Mendoza J, Silva K, Rivas R, Cornelio D, Guardia F, Tenorio Y, Calsina R, Alvarino L, Iannacone J. 2022. Molt patterns and age and sex determination criteria for selected landbirds in an urban area of the Peruvian Central Coast. *Caldasia* 44(1):165-177. doi: <https://doi.org/10.15446/caldasia.v44n1.84650>

ABSTRACT

Despite molting is an important and expensive activity in the life cycle of birds, this process is poorly known for neotropical species and even less so for species inhabiting urban zones. We studied molt patterns, aging and sexing criteria, and morphometrics for seven common resident species in an urban area of Lima city, Peru. All species evidenced complete prebasic molts. Partial to eccentric incomplete preformative molts were evidenced for six species (*Camptostoma obsoletum*, *Pyrocephalus rubinus*, *Catamenia analis*, *Poospiza hispaniolensis*, *Coereba flaveola*, and *Thraupis episcopus*); whereas *Columbina cruziana* exhibited a complete molt. All thraupid species exhibited partial prealternate molts. Preformative and prebasic molts were recorded mostly during the dry season, and the few records of prealternate molts might suggest its occurrence soon after the wet season. Our species also exhibited low molt synchrony, with some of them (*C. cruziana*, *P. rubinus*, and *C. flaveola*) exhibiting extensive molt periods likely explained by its potential to reproduce throughout the year and/or the existence of suspended/ protracted molts. Morphometric analysis evidenced significant differences according to sex for *C. cruziana*, *P. rubinus*, and *C. analis*, with the wing chord being the most common characteristic for distinguishing between sexes. Our study covers an important gap in the knowledge of the natural history of urban birds and provides information to test hypotheses of molt pattern variation on species with widespread distribution throughout the Americas.

Keywords. Age determination, molt, morphometrics, sex determination, urban birds.

¹ Department of Biology, University of Miami, Coral Gables, FL 33146, USA.

² Centro de Ornitología y Biodiversidad, Calle Santa Rita No 105, Dpto. 202, Urb. Huertos de San Antonio, Surco, Lima, Perú. alexis.diaz@corbidi.org, ytenorio@corbidi.org

³ Laboratorio de Ecología y Biodiversidad Animal, Facultad de Ciencias Naturales y Matemática, Universidad Nacional Federico Villarreal, Av. Río Chepén s/n, El Agustino, Lima, Perú. pamela.ayalanagao@gmail.com, lizziedc.vz@gmail.com, jorgeluismendozasilva@gmail.com, kathya09@gmail.com, rolf.rivas@gmail.com, 2daia12@gmail.com, fasell.gc.777@gmail.com, rociocq.1710@gmail.com, lorenaalvarino@gmail.com, joseiannacone@gmail.com.

⁴ Laboratorio de Ingeniería Ambiental, Facultad de Ciencias Ambientales, Universidad Científica del Sur, Av. Antigua Carretera Panamericana Sur km 19, Villa El Salvador, Lima, Perú.

* Corresponding Author



RESUMEN

A pesar de que la muda constituye una actividad importante y costosa en el ciclo de vida de aves, este proceso es poco conocido en especies neotropicales y lo es aún menos para especies que habitan ambientes urbanos. Estudiamos los patrones de muda, criterios de determinación de edad y sexo y datos morfométricos correspondientes a siete especies de aves residentes comunes en un área urbana de la ciudad de Lima, Perú. Todas las especies evidenciaron muda prebásica completa. Mudadas preformativa parcial e incompleta excéntrica fueron evidenciadas para *Camptostoma obsoletum*, *Pyrocephalus rubinus*, *Catamenia analis*, *Poospiza hispaniolensis*, *Coereba flaveola* y *Thraupis episcopus*; mientras que *Columbina cruziana* evidenció una muda completa. Todos los traúpidos exhibieron mudas prealterna parcial. Las mudas preformativa y prebásica fueron registradas principalmente durante la temporada seca, y los pocos registros de muda prealterna sugieren su ocurrencia poco después de la temporada húmeda. Nuestras especies también exhibieron una baja sincronía de muda, y algunas de ellas (*C. cruziana*, *P. rubinus* y *C. flaveola*) exhibieron períodos extensos de muda probablemente explicados por su potencial para reproducirse durante el año o la existencia de mudas suspendida / prolongada. El análisis morfométrico evidenció diferencias significativas según sexo para *C. cruziana*, *P. rubinus* y *C. analis*, siendo la cuerda alar la característica más común para distinguir sexos. Nuestro estudio cubre un vacío importante en conocimiento de la historia natural de aves urbanas y proporciona información para probar hipótesis sobre la variación de patrones de muda en especies con amplia distribución en las Américas.

Palabras clave. Aves urbanas, determinación de edad, determinación de sexo, morfometría, muda.

INTRODUCTION

Molt is the regular process of feather growth (Howell *et al.* 2003) and constitutes an important and energetically expensive activity in the life cycle of birds (Foster 1975). Description of the extent and timing of molt patterns of birds is crucial to understand the trends and changes in their demography in reference to space and time (Hernández 2012), as well as the ecological, evolutionary, physiological, and phylogenetic factors that affect molt (Guallar *et al.* 2016). Research about molt and/or aging and sexing criteria in Neotropical landbirds is a growing research area (Rueda-Hernández *et al.* 2018), but further effort is needed in order to comprehend these aspects for most of them (Kennedy *et al.* 2018). Such studies have been conducted in remote places (such as Amazonian and Atlantic rainforests, montane forests, and volcanic islands), while only a few of them have been published on urban landscapes (González 1998, Bugoni *et al.* 2002, Cueva 2018).

Urbanization can affect the life history of birds, either directly by altering the ecological processes, physiology, behavior and morphology (Isaksson 2018), or indirectly by changing their predators, competitors and pathogens (Chace and Walsh 2006). Birds in urban areas are additionally affected by increased levels of human activity, leading to altered food type and food availability (Lancaster and Rees 1979, Ditchkoff *et al.* 2006) and resulting in many species being negatively impacted while others will benefit over time (Fokidis *et al.* 2008). Therefore, bird monitoring using bird banding techniques constitutes a mechanism to explore the potential effect of urban development on bird communities, their long-term survival, as well as to establish proper management policies in urban spaces (González 2004). The aim of this work was to study the molt patterns, as well as age and sex determination criteria of selected landbirds in an urban area of the central coast of Peru, in order to investigate the potential effects of urbanization on molt strategies, extent, and timing along the annual cycle of Neotropical birds.

MATERIALS AND METHODS

The study was carried out in the lower slopes of the “El Agustino” Hill (12°02’35.14” South, 76°59’30.82” West, 226 m), adjacent to the campus of Universidad Nacional Federico Villarreal (UNFV), El Agustino district, department of Lima, Peru. This urban area was settled on a desiccated-Subtropical desert (dd-S) (Holdridge 1962), whose water regime was characterized by an annual precipitation of 437 mm concentrated from June to August, and with an annual average temperature of 17° to 19 °C (SENA-MHI 2010). From March 2014 to February 2020, seven

standard mist nets (12 m in length with 36 mm mesh) were used to capture birds around fruit crops and ornamental shrubs cultivated in introduced agricultural soil. Even though this area was restricted to general public, it was settled at a distance of 50 m away from faculty buildings. The nets were opened between 06:30 h and 12:30 h (GMT-5) during one day per month, ensuring a monthly effort of 36 net-hours. Mist-netting operations were performed on Sundays due to the low concurrence of people on campus. All birds were marked with a uniquely numbered aluminum leg band, processed and released following international standards (NABC 2001). Sex of birds was assessed

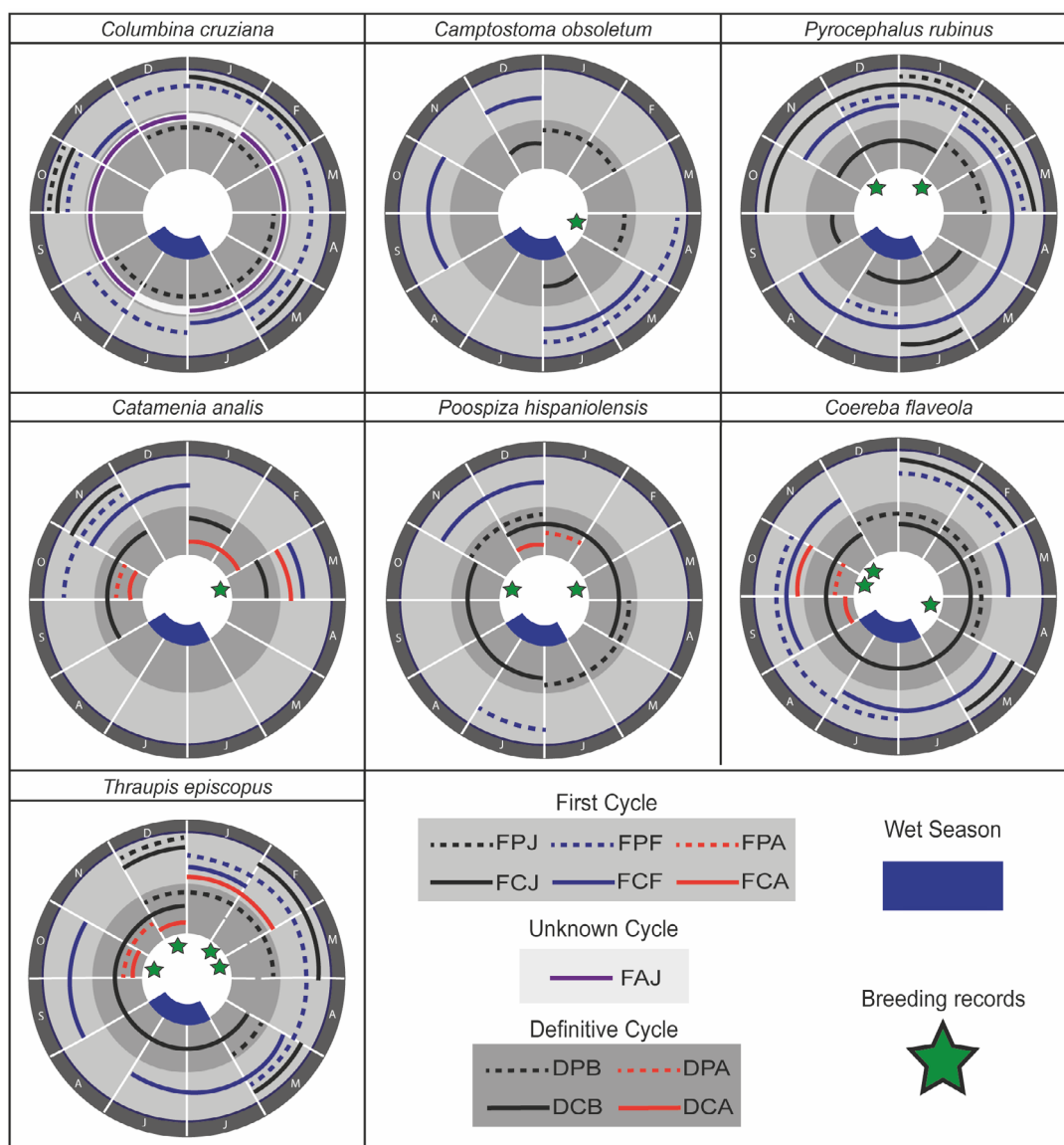


Figure 1. Annual molt cycle and breeding records for seven resident landbirds commonly found in urban areas from the coast of Lima, Peru; according to the representation format of Díaz et al. (2020). Age classes correspond to those from the W-R-P system (cycle code’s definition in Table 1) and are grouped as those present in the first molt cycle and those present in the definitive cycles of the bird. Dashed and solid lines represent the distinct molt and plumage categories, respectively.

by plumage coloration and the presence of breeding characters such as the brood patch (BP) and the cloacal protuberance (CP) following Pyle (1997b). Only vascularized and wrinkled BPs, as well as medium-sized and enlarged CPs, were considered in our analysis. Age was assessed, when possible, through identification of molt limits, plumage criteria, and extent of skull ossification (Pyle 1997a). Age was categorized according to the molt cycle-based aging system proposed by Wolfe *et al.* (2010), refined by Johnson *et al.* (2011) and based on the molt terminology of Howell *et al.* (2003) (Table 1). Feather-tract, molt extent terminology and color descriptions followed Pyle (1997b). Rectrices (rects), primaries (pp), secondaries (ss), and their coverts (covs) are considered as “inner” and “outer” depending on their position in relation to the body of the bird. Photographs of the body and open wings were taken to corroborate information collected in the field. Five standard measurements were taken (i.e. wing chord, tail length, bill length from nares to tip, tarsus length, and body mass) following Pyle (1997b); values presented are means \pm standard errors (SE). Independent Student's *t*-tests were performed to assess differences in the means between sexes using the JMP Pro version 13.1 (Sall *et al.* 2017). All tests were two-tailed, and *p*-values < 0.05 were considered significant (Zar 1999). Only species with ≥ 5 individuals represented by each sex were considered in the sex-specific morphometric analysis (Kennedy *et al.* 2018).

RESULTS

Molt patterns, molt cycle-based age categories, and annual molt cycle for seven common resident species at an urban area of the central coast of Peru are summarized below (Tables 2-3, Fig. 1). Six out of the seven species exhibited a partial or eccentric incomplete preformative molts, and thus the presence of molt limits within wing covs or some flight feathers facilitated the recognition of formative- and definitive-plumaged individuals. Most species underwent complete prebasic molts, with two species suspending the definitive prebasic molt in a small portion (< 3.2 %) of the sample. Three species exhibited partial prealternate molts (Table 3). For three out of the seven species, selected measurements (Table 4) were found to be useful in distinguishing between sexes, with wing chord being the most common criteria to separate females from males (Table 5).

Croaking Ground Dove (*Columbina cruziana*; *n*=93). FPJ: complete. FCJs appeared superficially like older birds

but were duller and scaled with pale-buffy tips along the upperparts, including upperwing covs. They also lacked the chestnut bar on lesser secondary covs characteristic of older birds, and their primary covs were tinged buffy along the rachis and tips when fresh (Appendix S1a of the supplementary material). Juveniles were also characterized by their pale iris and bill, and narrower rects compared to older birds (Appendix S1b, c of the supplementary material). FPF: complete. FPFs resembled FCJs when molt had just started or resembled FCFs when molt was nearly complete (Appendix S1d of the supplementary material). DPB: complete. After following complete molts, FCFs and DCBs were not distinguishable and were aged as FAJ (Appendix S1e of the supplementary material). FAJs were characterized by the absence of molt limits in flight feathers or covs, black wing feathers, white iris, and a bright yellow bill with black tip (Appendix S1b of the supplementary material). However, some FCFs were identified by the presence of retained juvenile feathers, including 1-2 outermost primary covs, outer pp (p8-10), or inner ss (s2-5) (Appendix S1d of the supplementary material). Individuals of unknown age included categories UPU, UCU, and UUU. It was difficult to sex FCJs and FPFs, except for very few (21 %) of the latter when the preformative molt was about to finish. Among the rest of the post-juvenile birds, males (58.6 %) appeared to have more extensive gray color in the head and with pinkish brown underparts, whereas females were browner throughout (27.6 %). **Breeding characters:** CP and BP were poorly developed and thus unreliable for sexing. **Southern Beardless-Tyrannulet** (*Camptostoma obsoletum*; *n*=28). FPF: partial. Includes most body feathers, none to some inner (0-4) median covs, none to all greater covs, but no lesser covs. None to all tert, some ss (s5-9), but no rects were replaced as a consequence of this molt (Fig. 2). FCFs had molt limits among greater coverts, between greater coverts / primary coverts, and among ss. Replaced (formative) secondary covs were distinctively darker, wider and buff-edged compared to the retained ones (juvenile) (Appendix S2a of the supplementary material). Moreover, retained (juvenile) rects were narrow and relatively abraded in this age category (Appendix S2b of the supplementary material). DPB: complete. DCBs had no molt limits and exhibited gray head, pale yellowish underparts, olive gray back, yellowish green rump, dark remiges with olive edging, and rounded rects with yellowish white edges and tips (Appendix S2b, c of the supplementary material). Individuals of unknown age included categories UPU, UCU, and UUU. Sexes were similar in all plumages.

Breeding characters: One individual with a vascularized BP was recorded in April.

Vermilion Flycatcher (*Pyrocephalus rubinus*; n =77). FPJ: complete. FCJs had overall dull brown plumage with buffy tips along upperparts and upperwing covs (Appendix S2d of the supplementary material). They also had whitish underparts with dull brown streaks along the breast and sides. Dark morph FCJs had dark brown plumage with faint buffy color tips, especially along the back and upperwing covs (Appendix S2e of the supplementary material). FPF: partial to eccentric incomplete. It included most body feathers, all secondary covs, some ss (s6-9), and all rects as consequence of partial molts. Some pp (p2-10), ss (s1-9), all rects, but no primary covs can be replaced as consequence of eccentric incomplete molts (Fig. 2). FCJs and FPFs could not be sexed in early stages in the cycle; however, FPFs that were about to finish their molt were reliable sexed on individuals of color morph. FCFs were identified by the presence of molt limits, which occurred between greater covs and primary covs, and even between pp and ss as a consequence of an eccentric replacement (Appendix S2f of the supplementary material). DPB: complete. DCBs had no molt limits and exhibited broader

wing feathers and rects compared to younger birds (Appendix S2g of the supplementary material). DCB males exhibited black upperparts, and bright red head and underparts; whereas DCB females exhibited grayish brown upperparts, whitish breast, and streaked underparts with variable amount of red tones along the belly and flanks. DCBs of dark color morph occurred in both sexes and were difficult to sex in the hand. Individuals of unknown age included categories UCU, and FPU. **Breeding character:** Two individuals with medium-sized CP were recorded in November and February. One individual with a vascularized BP in November.

Band-tailed Seedeater (*Catamenia analis*; n=31). One FCJ looked like a female but was duller with dusky streaks along the head, underparts, and upperparts. FPF: partial. It included most body feathers, some (6 inners) to all lesser and median covs, and none to all greater covs. None to all terts and rects were replaced as consequence of this molt (Fig. 2). FCFs had molt limits among secondary covs (including lesser, median or greater covs), ss, and rects. FCF females exhibited a variable mixture of pale brown (juvenile) and buffy brown (formative) feathers with dusky streaks along upperparts, and underparts except on central abdomen. Moreover, formative females showed blackish secondary covs with distinct buffy edging, contrasting in wear and color with other retained covs. FCF males exhibited pale gray feathers (formative) that mix with the retained pale brown (juvenile) feathers along the head and upperparts, and grayish white underparts tinged buff with faint streaks along the breast and sides. Formative males also had distinct secondary covs, being black with a greyish edging and white tips. Moreover, the greater covs had a buffy-gray and whitish coloration at the leading edge of each feather (Appendix S3a of the supplementary material). No FPAs were recorded. One FCA had three generation of feathers and two molt limits as a consequence of the preformative and first prealternate molt. It replaced some of the body feathers including the head, lores, breast, back, scapulars, all lesser covs, and two inners median covs as consequence of the prealternate molt (Appendix S3b of the supplementary material). No rectrices were replaced. No DPBs were recorded. DCBs had no molt limits (Appendix S3c of the supplementary material). DCB females showed a buffy brown coloration with faint dusky streaks along the underparts; while, DCB males exhibited blackish lores, gray (or gray tinged with buffy) upperparts, and chestnut undertail coverts. Both

Table 1. Definitions of the molt-based age-classification system codes (WRP) (Wolfe *et al.* 2010) used in the present study.

WRP Code	Definition
FPJ	First molt cycle, undergoing a first prebasic (prejuvinal) molt
FCJ	First molt cycle, basic (juvenale) plumage
FPF	First molt cycle, undergoing a preformative molt
FCF	First molt cycle, formative plumage
FPA	First molt cycle, undergoing a prealternate molt
FCA	First molt cycle, alternate plumage
FPU	First molt cycle, unknown molt status
DPB	Definitive molt cycle, undergoing definitive prebasic molt
DCB	Definitive molt cycle, alternate plumage
DPA	Definitive molt cycle, undergoing definitive prealternate molt
DCA	Definitive molt cycle, alternate plumage
FAJ	Unknown molt cycle, unknown plumage after juvenal
UPU	Unknown molt cycle, unknown if preformative or prebasic molt
UCU	Unknown molt cycle, unknown plumage
UUU	Unknown molt cycle, unknown molt status

Table 2. Molt patterns and sample sizes for seven species of resident landbirds commonly found in urban areas from the coast of Lima, Peru. CBS = Complex basic strategy; CAS = Complex alternate strategy.

Species	N	Preformative molt	Definitive prebasic molt	Prealternate molt	Molt strategy
<i>Columbina cruziana</i> (Prévost, 1842)	93	complete	complete	absent	CBS
<i>Campostoma obsoletum</i> (Temminck, 1824)	28	partial	complete	absent	CBS
<i>Pyrocephalus rubinus</i> (Boddaert, 1783)	77	partial-eccentric incomplete	complete	absent	CBS
<i>Catamenia analis</i> (d'Orbigny y Lafresnaye, 1837)	31	partial	complete	partial	CAS
<i>Poospiza hispaniolensis</i> (Bonaparte, 1851)	54	partial	complete	partial-eccentric incomplete?	CAS
<i>Coereba flaveola</i> (Linnaeus, 1758)	107	partial-eccentric incomplete	complete	partial	CAS
<i>Thraupis episcopus</i> (Linnaeus, 1766)	94	partial	complete	partial	CAS

sexes exhibited rects with a large white patch of variable extent on the middle of the inner webs. DPA: partial. It followed a similar replacement pattern as evidenced in FCA, but also included none to all median and greater covs ([Appendix S3d of the supplementary material](#)). DCAs showed molt limits among secondary covs (median and greater covs), ss, and rects. In both sexes, alternate feathers had a similar color pattern but glossier than the basic ones. Individuals of unknown age included categories UCU, and UUU. **Breeding characters:** One bird with large-sized CP was recorded in March.

Collared Warbling-Finch (*Poospiza hispaniolensis*; n=54). FPF: partial. It included most body feathers, all secondary covs, none to all tert, and some (two inners, two outers) to all rects [Fig. 2](#). FCFs had molt limits between greater covs / primary covs, and among ss. FCF females resembled older birds but were duller, and with a variable amount of dusky streaks along underparts. They also showed distinct secondary covs with a buffy edging, and buffish white tips. One FCF male also resembled older birds but was duller and with pale brown tones along its face, crown, and upperparts. It also exhibited distinct secondary covs, being black with a greyish edging and flat white tips. Additionally, greater covs showed a buffy and white coloration at the leading edge of each feather. DPBs: complete. DCBs were had no molt limits and exhibited uniform wing covs and remiges that do not differ in wear or quality ([Appendix S3e of the supplementary material](#)). DCB males exhibited a well-defined white supercilium and throat, black auriculars and lores, gray (or gray tinged with buffy) upperparts, and a black band across the

breast bordered by a gray color gradient along their sides until the belly level. DCB females showed similar plumage pattern, but the gray and black were replaced by brown feathers. Moreover, DCB females lacked the breast band and showed none to very few streaks along their underparts. One male individual displayed a suspended/arrested prebasic molt. Such bird retained some inner secondaries (s4-6), and the outermost primary (p9) with its respective primary cov. DPA: partial. Although we captured one DPA male following a partial molt ([Appendix S3f of the supplementary material](#)), one DCA male exhibited molt limits between median and greater covs, and among pp and ss as consequence of an eccentric incomplete molt. It replaced some body feathers including the head, breast, back, scapulars, all lesser and median covs, but no greater covs. Moreover, the two visible outermost pp covs, some pp (4-9), all tert, but no rects were replaced as consequence of this molt. Individuals of unknown age included categories UCU, and UUU. **Breeding characters:** Two individuals with medium-sized CP were recorded in October and March.

Bananaquit (*Coereba flaveola*; n =107). FCJs resembled older birds but were duller and with more gray tones in face and crown, and with olive tones in the back and the upper secondary covs. FPF: partial - eccentric incomplete. It included most body feathers, none to all lesser and median covs, and at least one to all greater covs as consequence of partial molts. Moreover, some pp (p4-9) and ss (s4-9), none to all rects, but no primary covs were replaced as consequence of eccentric incomplete molts ([Fig. 2](#)). FCFs had molt limits between secondary covs / primary covs,

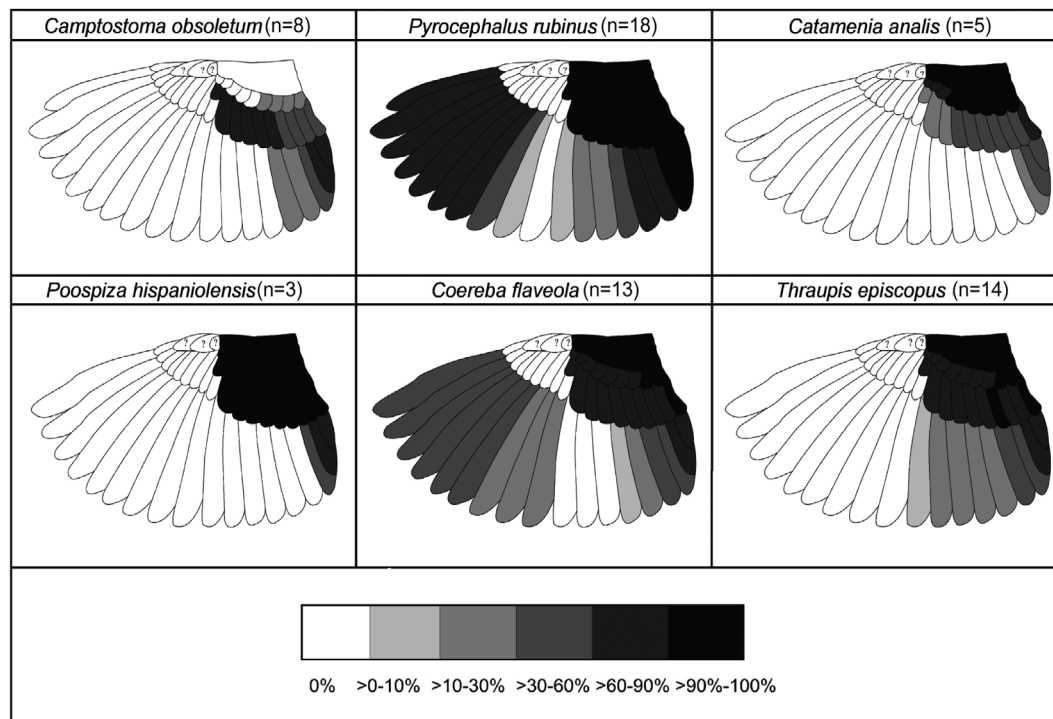


Figure 2. Representation of the frequency of feather replacement as consequence of partial or eccentric incomplete preformative molts for six resident landbirds commonly found in urban areas from the coast of Lima, Peru. The grayscale indicates the percentage of individuals (with available photographic information) that have replaced such feathers. Alula tracts were not included in the analysis.

or even sometimes among pp and ss in case of an eccentric pattern. Formative secondary covs contrasted in size and appearance with the retained ones that were worn, tapered, and washed brown with faint olive-edging (Appendix S4a of the supplementary material). FPA: partial. One FCA had three generation of feathers and two molt limits as a consequence of the preformative and first prealternate molt. It replaced some body feathers, including the head, breast, back, scapulars, all lesser covs, some median covs, and three inners greater covs as consequence of the first prealternate molt (Appendix S4b of the supplementary material). No rectrices were replaced. DPB: complete. DCBs had no molt limits and exhibited well-defined white supercilium, bright yellow underparts, and dusky gray upperparts. DCBs also exhibited uniform gray covs and remiges that do not contrasted in wear or color between both type of feathers (Appendix S4c of the supplementary material). Two individuals displayed suspended/arrested prebasic molts. One individual retained all terters and three inner primary covs whereas the other individual retained some inner secondaries (s3-6), and the three outermost primary covs. DPA: partial. One DCA had a molt limit among greater covs. It replaced some body feathers including the head, breast, back, all lesser and median covs, and

the innermost greater cov. Moreover, some inner recters on left side (r3-5), and no terters were replaced (Appendix S4d of the supplementary material). Individuals of unknown age included categories FPU, DPU, UPU, and UUU. Sexes were similar in all plumages. **Breeding characters:** Three individuals with medium-sized CP were recorded in October and April, whereas three individuals with large-sized CP were recorded in September and January. Five individuals with vascularized BP were recorded in October, November and April, whereas one individual with wrinkled BP was recorded in October.

Blue-gray Tanager (*Thraupis episcopus*; n =94). We captured at least two introduced races in our study site, the race *quaesita* from norwestern Peru and another race probably from western or central Amazonia (subspecies *caerulea*, *major*, *urubambae*, or *coelestis*). Individuals of these groups were differentiated by the amounts of blue and grey shading in plumage, and color of the upper wing covs. Besides such differences, both races exhibited similar molt patterns that are described below. FPJ: complete. FCJs in both races resembled older birds but were duller, lacked contrast between head and back, and had washed blue (*quaesita*) or light blue (Amazonian race)

coloration on lesser covs. FPF: partial. It included most body feathers, all lesser covs, none to all median covs, and at least one to all greater covs. Moreover, some ss (s1-9), and none to some rects (1-3 inners, one outermost), but no primary covs or pp were replaced as consequence of this molt (Fig. 2). FCFs had molt limits among secondary covs (including median or greater covs), and ss. Formative secondary covs contrasted in size and appearance with the retained ones that were worn and duller. Lesser covs exhibited a blue (*quaesita*) (Appendix S5a of the supplementary material) or whitish coloration (Amazonian race), while median and greater covs were dark bluish (*quaesita*) or bluish-green (Amazonian race). No FPAs were recorded. FCAs had three generation of feathers and two molt limits as a consequence of the preformative and first prealternate molt. It replaced some body feathers including the head, breast, back, scapulars, all lesser covs, but no median or greater covs as consequence of the prealternate molt (Appendix S5b of the supplementary material). DPB: complete. DCBs had no molt limits and exhibited uniform pale gray (*quaesita*) (Appendix S5c of the supplementary material). or bluish grey (Amazonian race) head and underparts, and darker bluish gray upperparts. DPA: partial. It followed a similar replacement pattern as evidenced in FCA. DCAs had molt limits between lesser and median covs, or among median covs. First and definitive alternate feathers had a similar color pattern but glossier than the formative and basic ones (Appendix S5d of the supplementary material). Individuals of unknown age included categories UPU, UCU, and UUU. Sexes were similar in all plumages. *Breeding characters*: Three individuals with medium-sized CP were recorded in October, February and March, whereas one individual with large-sized CP were recorded in February. One individual with vascularized BP were recorded in February.

DISCUSSION

Molt patterns for our target species were similar to those reported for related Nearctic and other Neotropical taxa studied so far (Rueda-Hernández *et al.* 2018). For example, *C. cruziana* exhibited complete preformative and prebasic molts as shown by other columbids (Pyle 1997b, Johnson and Wolfe 2017, Bosque *et al.* 2018), whereas *C. obsoletum*, *P. rubinus*, *C. analis*, *P. hispaniolensis*, *C. flaveola* and *T. episcopus* exhibited partial or eccentric incomplete preformative molts and complete prebasic molts as reported in other tyrannids, thraupids and Nearctic taxa previously included among thraupids (e.g. the genus *Piranga*) (Pyle 1997a, b, Guallar *et al.* 2009, Gómez *et al.* 2012, Pyle *et al.* 2015, Díaz and Hernández 2018). These might suggest the phylogenetic conservation of molt patterns across temperate and tropical taxa (Ryder and Wolfe 2009); however, despite taxonomic affinities, there are environmental variables (i.e. abrasive habitats, solar exposure, ambient temperature) that may strongly influence molt patterns among Neotropical species (Willoughby 1991, Greenberg and Marra 2005, Kiat *et al.* 2019). For example, even though the presence of prealternate molts in temperate zone species of North America appear to be more common in Nearctic-Neotropical migrants than in residents, the presence of prealternate molts in resident thraupids has been suggested to be due to prolonged exposure to sunlight, especially for birds inhabiting open or scrubby habitats (Moreno-Palacios *et al.* 2017, Díaz *et al.* 2020). All thraupids studied here did also exhibit partial to eccentric incomplete prealternate molts. However, our results for *C. flaveola* and *T. episcopus* contrasted with previous studies that have suggested the existence of complete preformative molts (Johnson and Wolfe 2017) and even the absence of prealternate molts (Gómez *et al.* 2012)

Table 3. Sample sizes of molt cycle-based age categories for sizes for seven species of resident landbirds commonly found in urban areas from the coast of Lima, Peru.

WRP Code	F PJ	F C J	F P F	F C F	F P A	F C A	F P U	D P B	D C B	D P A	D C A	D P U	F A J	U P U	U C U	U U U
<i>C. cruziana</i>	1	6	38	4	0	0	0	12	0	0	0	0	13	15	1	3
<i>C. obsoletum</i>	0	0	7	8	0	0	0	6	2	0	0	0	0	1	2	1
<i>P. rubinus</i>	1	24	13	18	0	0	1	5	13	0	0	0	0	0	2	0
<i>C. analis</i>	0	1	3	6	0	1	0	0	11	1	4	0	0	0	1	3
<i>P. hispaniolensis</i>	0	0	1	4	0	0	0	19	24	1	1	0	0	0	1	3
<i>C. flaveola</i>	0	4	25	13	0	1	1	19	31	2	1	2	0	3	0	5
<i>T. episcopus</i>	2	5	14	18	0	3	0	18	25	2	2	0	0	1	2	2

Table 4. Mean morphological measurements \pm standard error for seven resident landbirds commonly found in urban areas from the coast of Lima, Peru. Length measurements are in millimeters; body mass in grams; sample size is indicated in parentheses.

Species	Wing chord	Tail	Bill from nares to tip	Tarsus length	Mass
<i>C. cruziana</i>	86.35 \pm 0.62 (17)	67.9 \pm 0.75 (14)	9.83 \pm 0.15 (16)	19.02 \pm 0.20 (16)	46.48 \pm 0.75 (17)
<i>C. obsoletum</i>	47.70 \pm 0.36 (10)	38.88 \pm 0.56 (9)	6.20 \pm 0.08 (10)	15.91 \pm 0.40 (8)	7.77 \pm 0.37 (9)
<i>P. rubinus</i>	76.73 \pm 0.67 (15)	60.50 \pm 0.74 (14)	11.21 \pm 0.12 (14)	17.37 \pm 0.13 (15)	14.71 \pm 0.18 (15)
<i>C. analis</i>	64.43 \pm 0.57 (23)	50.81 \pm 0.67 (21)	6.12 \pm 0.08 (22)	18.50 \pm 0.17 (21)	12.52 \pm 0.20 (18)
<i>P. hispaniolensis</i>	61.92 \pm 0.63 (24)	48.43 \pm 0.38 (23)	8.35 \pm 0.11 (20)	20.35 \pm 0.23 (23)	15.22 \pm 0.23 (21)
<i>C. flaveola</i>	53.13 \pm 0.36 (49)	31.65 \pm 0.53 (41)	8.35 \pm 0.09 (42)	16.75 \pm 0.09 (43)	9.00 \pm 0.12 (40)
<i>T. episcopus</i>	90.81 \pm 0.49 (48)	67.02 \pm 0.50 (46)	9.47 \pm 0.08 (51)	21.83 \pm 0.22 (46)	35.64 \pm 0.44 (50)

for conspecific populations in other neotropical regions. These two species are considered exotic species introduced in Lima for illegal trade possibly from Amazonia or northern Peru (Guillen and Barrio 1995). The high relative abundance of these species in various green areas of the city would suggest that these species have already found their ecological niche in the urbanity of Lima (González 1998, Nolazco 2012). Such a niche shift would not only have modified its interspecific interactions but also might have influenced variation on some of its life-history traits, including the molt patterns. Unfortunately, variation in molt patterns between urban and non-urban populations of these and other invasive species yet requires further investigation.

Timing of molt for our target species was similar to other Neotropical related taxa so far studied. In the case of *C. cruziana*, the absence of discrete preformative molt periods might suggest that some individuals follow their own molt cycle likely determined by fledging time, as reported for *C. passerina* Linnaeus, 1758 in an arid coast of Venezuela (Bosque *et al.* 2018). However, the tendency for individuals to molt in the dry season have been also proposed for another three ground-dove species inhabiting seasonal savannas of central Venezuela (Bosque *et al.* 2004). In the case of *C. obsoletum*, *P. rubinus*, *P. hispaniolensis*, *C. flaveola* and *T. episcopus*, these species evidenced discrete preformative/prebasic molt periods mostly during the dry season as documented for other resident tyrannids and trauipids inhabiting semiarid scrubs of coastal Chile (Pyle *et al.* 2015). However, these species showed low molt synchrony likely influenced by the urban nature of the habitat. Despite the similarity in seasonality, *P. rubinus* and *C. flaveola* evidenced extensive molt periods compared to what have been reported in other neotropical trauipids from previous studies (Pyle *et al.* 2015, Moreno-

Palacios *et al.* 2017). These extended periods can be explained by the fact that both species can reproduce throughout most of the year, based on breeding records in other urban areas of the city of Lima (González 1998, 2004, iNaturalist 2020). In the case of *C. analis*, more evidence is needed in order to infer molt periods for this species. Previous studies for a closely related species (i.e. *Pipraeidea bonariensis* Bonaparte, 1838) in a montane desert scrub at the highlands of the same region showed preformative/prebasic molt also occurring mainly during the dry season (early April to late November) (Díaz *et al.* 2018). Lastly, the few instances of prealternate molts among the trauipids studied here point to periods soon after the wet season and within 2-3 months before prebasic molt; however, more information is needed to establish a proper timing of prealternate molts.

We did not have enough recaptures to estimate molt duration, but we could still infer relevant information from recapture data for some of the species under study. With respect to the preformative molt, the evidence of a captured individual of *C. cruziana* that was still undergoing its preformative molt after 112 days of being captured for the first time (molting rate of 1.9 feathers per month, assuming no interruptions of the primary molt) opens the possibility of the existence of protracted complete molts for this species. In fact, it has been estimated that adult primary molt in other ground-dove species might take as long as 150-200 days to be completed, with a mean rate ranging from 1.5 to 2 feathers per month (Bowman 2002, Bosque *et al.* 2004). We also recaptured an individual of *P. rubinus* still undergoing its preformative molt after 141 days of being captured for the first time, a considerably longer period compared to what has been previously reported for other populations of this species in North America (Butler 2013). Given the molt extent and the timing in which in-

dividuals of this species were recorded undergoing preformative molts, our most parsimonious explanation is species is suspending molt probably to escape from the driest peak of the season (January to April), and then activating it again some weeks or months after this event. Such hypothesis could also be the case for *C. flaveola* that also exhibited long-terms of individuals undergoing the preformative molt. However, we cannot rule out the possibility that these species are exhibiting protracted preformative molts as suggested for other neotropical landbirds (Pyle et al. 2015, Moreno-Palacios et al. 2017). With respect to the prebasic molt, we recaptured individuals of *P. hispaniolensis* and *C. flaveola* still undergoing their prebasic molts after 35 days, and from 50 to 57 days of being capture for first time, respectively. It is known so far that the duration of prebasic molts in Neotropical resident passerines can range approximately from 59 days (e.g. *Volatinia jacarina* Linnaeus, 1766) to 310 days (e.g. *Pithys albifrons* Linnaeus, 1766) (Johnson et al. 2011, Silveira and Marini 2012, Moreno-Palacios et al. 2018), while in temperate regions the molt of resident species ranges from 42 to 105 days (Newton 1966, Lind 2001, De la Hera et al. 2009,

Butler 2013). Finally, and with respect to the duration of the complete molt cycle, we captured two formative-plumaged individuals of *P. rubinus* after 303 and 360 days of being initially captured in their juvenile plumage. We also captured an individual of *C. flaveola* undergoing its definitive prebasic molt after 362 days of being captured undergoing its definitive prebasic molt from a previous molt cycle. These events corroborate that the molt cycle of Neotropical birds typically match to an annual cycle, as have also been proposed for temperate birds (North America and Europe) (Howell et al. 2003, Johnson and Wolfe 2017). Further study is needed in order to estimate average durations of the different molt stages of Neotropical birds in urban and non-urban landscapes.

The sex-specific morphometric analysis showed that females of *C. cruziana*, *P. rubinus*, *C. analis*, and *P. hispaniolensis* were smaller than males. Selected measurements showed significant differences between sexes (except for *C. analis*), being the wing chord the most common criteria to distinguish female from males (Table 1). Previous studies among Neotropical passerines have evidenced that significant di-

Table 5. Select mean morphological measurements \pm standard error useful for classifying sex for four resident landbirds commonly found in urban areas from the coast of Lima, Peru. Length measurements are in millimeters; body mass is in grams; sample size is indicated in parentheses. df = degrees of freedom. P = p-value ($\alpha = 0.05$).

Species	Measurement	Females		Males		df	P
		Mean \pm SE (n)	Range	Mean \pm SE (n)	Range		
<i>Columbina cruziana</i>	Wing chord	86.20 \pm 1.35 (5)	81 - 88	89.25 \pm 0.50 (12)	86 - 92	15	0.02
	Mass	43.76 \pm 1.06 (5)	41.7 - 47.9	47.60 \pm 0.75 (12)	44.7 - 52.9	17	0.01
<i>Pyrocephalus rubinus</i>	Wing chord	75.14 \pm 0.96 (7)	71 - 78	78.12 \pm 0.61 (8)	75 - 80	13	0.02
	Tail	60.0 \pm 1.59 (6)	55 - 66	60.87 \pm 0.61 (8)	58 - 63	12	0.50
<i>Catamenia analis</i>	Mass	14.71 \pm 0.30 (7)	13.9 - 16.1	14.71 \pm 0.22 (9)	13.9 - 15.7	13	0.99
	Wing chord	63.37 \pm 1.01 (8)	59 - 68	65.00 \pm 0.65 (15)	59 - 70	21	0.18
<i>Poospiza hispaniolensis</i>	Tail	49.71 \pm 1.44 (7)	44 - 55	51.35 \pm 0.70 (14)	47 - 55	19	0.26
	Mass	12.44 \pm 0.48 (5)	10.7 - 13.7	12.54 \pm 0.39 (13)	10.5 - 15.7	16	0.88
<i>Poospiza hispaniolensis</i>	Wing chord	59.40 \pm 1.01 (13)	51 - 62	63.71 \pm 0.32 (22)	61 - 65	22	0.01
	Tail	47.50 \pm 0.48 (10)	45 - 50	49.15 \pm 0.48 (13)	45 - 51	21	0.03
<i>Poospiza hispaniolensis</i>	Mass	14.94 \pm 0.37 (9)	13.6 - 16.5	15.24 \pm 0.28 (12)	15.4 - 16.7	19	0.32

ferences in morphometric measurements (e.g. wing chord, tail length, or mass) between sexes can vary across species, but being in general males larger than females (Montalti *et al.* 2004); although exceptions such as the reversed sexual dimorphism in size can occur (Pyle *et al.* 2015). Differences in sexual dimorphism in size can be attributed to ecological polymorphism and sexual differences in niche utilization (Selander 1966, Montalti *et al.* 2004). Our species without sexual dichromatism, *C. obsoletum*, *C. flaveola*, and *T. episcopus* could only be sexed by the presence of breeding characters. Thus, sex-specific analysis for such species was not feasible due the limited number of breeding individuals (< 7 %). This added to the relatively small number of captured juveniles, might suggest that our urban study area does not constitute a main breeding site for these species, or there have been occurred misidentifications of non-breeding individuals among breeding individuals. Similar proportions of captured breeding individuals for some commonly studied species have been reported in another banding station at a nearby urban location (8 km SE from our study site) (Salvador pers. comm.), which makes less likely the possibility of having committed misidentification of non-breeding individuals. It is also important to note that the proportion of captured breeding individuals might be subjected to several other factors, such as the sample effort, habitat size and structure, and niche utilization, to cite some examples (Dunn and Ralph 2004).

In conclusion, except for *C. flaveola* and *T. episcopus*, our study of urban birds did not show variation in molt strategy and extent compared to what has been reported for the analyzed species from previous publications. Molts occurred mostly during the dry season, but with low synchrony among species likely influenced by the urban nature of the habitat. Additionally, some species exhibited extensive molt periods potentially explained by the fact that these species can breed throughout the year and/or the existence of suspended or protracted molts. We emphasize the importance of increasing our knowledge about molt patterns and morphometrics for a better understanding of the ecology and evolution of urban birds. We also recommend making studies evaluating the effect of urbanization upon other bird life-history traits such as abundance, body condition, longevity, and survival rate of these species.

ACKNOWLEDGEMENTS

We thank the many volunteers from the banding station operating at the Universidad Nacional Federico Villarreal, who assisted with data collection; special mention to José Ortega, Frank Rodriguez, Leonardo Ospina, Alissa Anaya, Gianella Pajares, Mahyron Montoya, Lewis Hein, Danae Tataje and Jose Quispe. To the Vice-chancellor on Research of the Universidad Nacional Federico Villarreal for the provided funds. This research was conducted under the permit RD N°213-2013-MINAGRI-DGFFS/DGEFFS, Ministerio de Agricultura y Riego, Dirección general Forestal y de Fauna Silvestre. Our thanks to Programa de Anillamiento CORBIDI (PAC), led by Eveling Tavera, for providing bands and banding tools for the project. This manuscript was greatly improved by comments provided by Flor Hernández, Mauricio Ugarte and two anonymous reviewers.

AUTHOR'S CONTRIBUTION

All authors contributed to the study conception, data collection, and study design. Analyses were performed by P.A. and A.D. The first draft of the manuscript was written by A.D, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declares that there is no conflict of interest.

LITERATURE CITED

- Bosque C, García-Amado MA, Pacheco MA. 2018. Breeding and molt patterns of the Common Ground-Dove (*Columbina passerina*) in xeric, unpredictable environments of Venezuela. *Ornitol. Neotrop.* 29(2): 37-42.
- Bosque C, Pacheco MA, García-Amado MA. 2004. The annual cycle of *Columbina* ground-doves in seasonal savannas of Venezuela. *J. Field Ornithol.* 75(1):1-17. doi: <https://doi.org/10.1648/0273-8570-75.1.1>
- Bowman R. 2002. Common Ground-Dove (*Columbina passerina*). En: Poole A, Gill F, editores. *The Birds of North America* N°645. Filadelfia: The birds of North America, Inc.

- Bugoni L, Mohr LV, Scherer A, Efe MA, Sherer SB. 2002. Biometry, molt and brood patch parameters of birds in southern Brazil. *Ararajuba*. 10(1): 85-94.
- Butler LK. 2013. The grass is always greener: Do monsoon rains matter for molt of the Vermilion Flycatcher (*Pyrocephalus rubinus*)? *Auk*. 130(2): 297-307. <https://doi.org/10.1525/auk.2013.12216>
- Chace JF, Walsh JJ. 2006. Urban effects on native avifauna: a review. *Landsc. Urban Plan.* 74(1): 46-69. doi: <https://doi.org/10.1016/j.landurbplan.2004.08.007>
- Cueva D. 2018. Molt strategy and aging of Rufous-collared Sparrow. *Caldasia* 40(1): 18-26. doi: <https://dx.doi.org/10.15446/caldasia.v40n1.63337>
- De la Hera I, Pérez-Tris J, Tellería JL. 2009. Migratory behaviour affects the tradeoff between feather growth rate and feather quality in a passerine bird. *Biol. J. Linn. Soc.* 97(1): 98-105. doi: <https://doi.org/10.1111/j.1095-8312.2008.01189.x>
- Díaz A, Hernández F, Salinas L. 2020. Unraveling a complex alternate molt strategy: More evidence for prealternate molts and alternate plumages in the Blue-and-yellow Tanager (*Pipraeidea bonariensis darwini*). *Ornitol. Res.* 28: S61-S68. doi: <https://dx.doi.org/10.1007/s43388-020-00004-3>
- Díaz A, Hernández F, Alza L, Chumpitaz K, Salvador J, Berrocal E, Tenorio Y, Poma T, Santos C, Iannacone J. 2018. Age determination based on molt patterns and skull ossification in the Blue-and- Yellow Tanager (*Pipraeidea bonariensis*). *Ornitol. Neotrop.* 29 (Special issue): S51-S61.
- Díaz A, Hernández F. 2018. Muda preformativa excéntrica en un espécimen de colección de la Tangara Azul y Amarilla (*Pipraeidea bonariensis darwini* Bonaparte, 1983) (Aves: Thraupidae). *Biologist (Lima)*. 16(2):273-279. doi: <http://dx.doi.org/10.24039/rtb2018162248> eBird. c2020. *Pyrocephalus rubinus* [Last accessed: 06 Oct 2020]. <http://www.ebird.org>
- Ditchkoff SS, Saalfeld ST, Gibson CJ. 2006. Animal behavior in urban ecosystems: modifications due to human-induced stress. *Urban Ecosyst.* 9: 5-12. doi: <https://doi.org/10.1007/s11252-006-3262-3>
- Dunn EH, Ralph CJ. 2004. Use of mist nets as a tool for bird population monitoring. *Stud. Avian Biol.* 29: 1-6.
- Fokidis HB, Greiner EC, Deviche P. 2008. Interspecific variation in avian blood parasites and haematology in a desert habitat. *J. Avian Biol.* 39(3): 300-310. doi: <https://doi.org/10.1111/j.0908-8857.2008.04248.x>
- Foster MS. 1975. The overlap of molting and breeding in some tropical birds. *Condor*. 77(3): 304-314. doi: <https://doi.org/10.2307/1366226>
- Gómez C, Botero-D E, Bayly N, Moreno M, Páez C. 2012. Documentando estrategias de muda en aves neotropicales: ejemplos de la Sierra Nevada de Santa Marta, Colombia. *Ornitol. Neotrop.* 23: 129-138.
- González O. 1998. Coereba flaveola, un ave nueva en el ecosistema de los parques de la ciudad de Lima. *Ecología*. 1(1): 79-83.
- González O. 2004. *Ecología de Aves Urbanas en un Parque de la ciudad de Lima*. [Tesis]. [Lima]: Universidad Nacional Mayor de San Mayor.
- Greenberg R, Marra PP. 2005. *Birds of two worlds: the ecology and evolution of Migration*. California: Johns Hopkins University Press.
- Gullar SX, Ruiz-SánchezA, Rueda-Hernández R, Pyle P. 2016. Molt strategies of ten neotropical forest passerine species. *Wilson J. Ornithol.* 128(3): 543-555. doi: <https://doi.org/10.1676/1559-4491-128.3.543>
- Gullar S, Santana E, Contreras S, Verdugo H, Gallés A. 2009. Paseriformes del occidente de México: morfometría, datación y sexado. *Monografías del Museu de Ciències Naturals n°5*. Barcelona: Instituto de Cultura de Barcelona.
- Guillen C, Barrio J. 1995. Los Pantanos de Villa y sus aves. *Boletín de Lima* 16: 53-58
- Hernández A. 2012. Molt patterns and sex and age criteria for selected landbirds of southwest Colombia. *Ornitol. Neotrop.* 23: 215-223.
- Holdridge LR. 1962. The determination of atmospheric water movements. *Ecology*. 43(1):1-9. doi: <https://doi.org/10.2307/1932033>
- Howell SNG, Corben C, Pyle P, Rogers DI. 2003. The first basic problem: A review of molt and plumage homologies. *Condor*. 105(4): 635-653. doi: <https://doi.org/10.1093/condor/105.4.635>
- iNaturalist. c2020. *Pyrocephalus rubinus* [Last accessed: 06 Oct 2020]. <http://www.inaturalist.org>
- Isaksson C. 2018. *Impact of Urbanization on Birds*. Cham: Springer.
- Johnson EI, Wolfe JD. 2017. *Molt in Neotropical birds: Life history and aging criteria*. Florida: CRC Press.
- Johnson EI, Wolfe JD, Ryder TB, Pyle P. 2011. Modifications to a molt-based ageing system proposed by Wolfe et al. (2010). *J. Field Ornithol.* 82(4): 422-424. doi: <https://doi.org/10.1111/j.1557-9263.2011.00345.x>
- Kiat Y, Vortman Y, Sapir N. 2019. Feather moult and bird appearance are correlated with global warming over the last 200 years. *Nat. Commun.* 10(1): 1-7. <https://doi.org/10.1038/s41467-019-10452-1>
- Kennedy J, Heavyside J, Jankowski J, Scholer M. 2018. Molt patterns and sexing and aging criteria for ten species of high elevation landbirds from Southeastern Perú. *Ornitol. Neotrop.* 29(2): 63-73.
- Lancaster K, Rees WE. 1979. Bird communities and the structure of urban habitats. *Can. J. Zool.* 57: 2358-2368. doi: <https://doi.org/10.1139/z79-307>

- Lind J. 2001. Escape flight in moulting tree sparrows (*Passer montanus*). *Funct. Ecol.* 15(1): 29-35. doi: <https://doi.org/10.1046/j.1365-2435.2001.00497.x>
- Montalti D, Kopij G, Maragliano R. 2004. Morphometrics and sexual dimorphism of some Neotropical passerines. *Ornitol. Neotrop.* 15: 271-278.
- Moreno Palacios M, Losada-P S, Echeverry-G MÁ. 2017. Secuencia de mudas y plumajes de *Volatinia jacarina* y *Sporophila intermedia* en el valle del Magdalena. *Ornitol. Colomb.* 16: eA02.
- Moreno-Palacios M, Losada-Prado S, Echeverry-Gálvis MÁ. 2018. Duration and intensity of primary molt in two neotropical grasslands Passerines. *Caldasia.* 40(1): 27-40. doi: <http://dx.doi.org/10.15446/caldasia.v40n1.68817>
- NABC] North American Banding Council. 2001. The North American banders' study guide. California: North American Banding Council.
- Newton I. 1966. The moult of the Bullfinch *Pyrrhula pyrrhula*. *Ibis.* 108(1): 47-67. doi: <https://doi.org/10.1111/j.1474-919X.1966.tb07251.x>
- Nolazco S. 2012. Diversidad de aves silvestres y correlaciones con la cobertura vegetal en parques y jardines de la ciudad de Lima. *Bol. Inf. UNOP.* 7(1): 4-16.
- Pyle P. 1997a. Molt limits in North American passerines. *North American Bird Bander.* 22(2): 49-89.
- Pyle P. 1997b. Identification guide to North American birds, Part I. Bolinas. California: Slate Creek Press.
- Pyle P, Engilis A, Kelt D. 2015. Manual para estimar edad y sexo en aves del Parque Nacional Bosque Fray Jorge y Chile Central, con notas sobre rangos de distribución y estación reproductiva. Special Publication of the Occasional Papers of the Museum of Natural Science. Louisiana: LSU Museum of Natural Science.
- Rueda-Hernández R, Guallar S, Ruíz-Sánchez A, Pyle P. 2018. The molt issue: where do we go from now? *Ornitol. Neotrop.* 29(Special Issue): S1-S2.
- Ryder T, Wolfe J. 2009. The current state of knowledge on molt and plumage sequences in selected Neotropical bird families: a review. *Ornitol. Neotrop.* 20: 1-18.
- Sall J, Stephens ML, Lehman A, Loring S. 2017. JMP start statistics: a guide to statistics and data analysis using JMP, Sixth Edition. North Carolina: SAS Institute Inc.
- Selander RK. 1966. Sexual dimorphism and differential niche utilization in birds. *Condor.* 68(2): 113-151. doi: <https://doi.org/10.2307/1365712>
- [SENAMHI] Servicio Nacional de Meteorología e Hidrología del Perú. c2010. [Revisada en: 10 Ago 2010]. <http://www.senamhi.gob.pe/>
- Silveira MB, Marini MA. 2012. Timing, Duration, and Intensity of Molt in Birds of a Neotropical Savanna in Brazil: Tiempo, Duración e Intensidad de la Muda en Aves de una Sabana Neotropical en Brasil. *Condor.* 114(3): 435-448. doi: <https://doi.org/10.1525/cond.2012.110022>
- Wolfe JD, Ryder TB, Pyle P. 2010. Using molt cycles to categorize the age of tropical birds: an integrative new system. *J. Field Ornithol.* 81(2): 186-194. doi: <https://doi.org/10.1111/j.1557-9263.2010.00276.x>
- Willoughby EJ. 1991. Molt of the genus *Spizella* (Passeriformes, Emberizidae) in relation to ecological factors affecting plumage wear. *Proc. West. Found. Vertebr. Zool.* 4: 247-286.
- Zar J. 1999. *Biostatistical Analysis*. 4ta ed. Upper Saddle River. New Jersey: Prentice Hall.