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Avian Behavior, Ecology, and Evolution

Molt and body measurements for Gray Hawks in the Lower Rio Grande Valley of Texas

Muda y medidas corporales del Busardo Gris Norteño en el Bajo Valle del Río Grande, Texas

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ABSTRACT. We captured 235 Gray Hawks (*Buteo plagiatus*) in the Lower Rio Grande Valley (Hidalgo, Willacy, and Cameron counties) of Texas from 6 February 2003 to 8 April 2023. We identified birds in five molt cycles: 115 birds in their first cycle, 16 in their second cycle, 73 in at least their second cycle, 19 in at least their third cycle, and 12 in at least their fourth cycle. Of these, we documented 15 instances of preformative molt, six instances where birds had an incomplete second prebasic molt, resulting in one to three retained juvenile rump feathers and/or wing coverts, and 18 instances where incomplete prebasic molts resulted in birds with multiple generations of flight feathers. We also present morphometric data from 144 Gray Hawks (nestlings and first-cycle birds captured prior to 1 October excluded). These results from the Lower Rio Grande Valley, on both molting strategies and measurements, differed in some respects from other sources based on the entire Gray Hawk population, most notably that birds from this northern and non-migratory population may show lower incidence of Stafflemauser molting patterns, and that they are heavier, which supports Bergmann's rule.

RESUMEN. Se capturaron 235 Busardos grises norteños (*Buteo plagiatus*) en el Bajo Valle del Río Grande (condados de Hidalgo, Willacy y Cameron) en Texas entre el 6 de febrero de 2003 y el 8 de abril de 2023. Se identificaron cinco ciclos de muda en los individuos: 115 en su primer ciclo, 16 en su segundo ciclo, 73 en al menos su segundo ciclo, 19 en al menos su tercer ciclo, y 12 en al menos su cuarto ciclo. De estos, se documentaron 15 casos de muda preformativa, seis casos en los que las aves presentaban una segunda muda prebásica incompleta, con entre una y tres plumas retenidas en la rabadilla y/o en las cobertoras alares, y 18 casos en los que la muda prebásica resultó en individuos con plumas de vuelo de múltiples generaciones. Se presentan además datos morfométricos de 11 Busardos grises norteños (los pichones y los individuos capturados durante el primer ciclo antes del 1 de octubre fueron excluidos). Estos resultados del Bajo Valle del río Grande, tanto sobre estrategias de muda como de medidas morfométricas, difirieron en algunos aspectos de otras fuentes de información basadas en la población completa de la especie, principalmente debido a que los individuos de esta población no-migratoria ubicada en el norte de la distribución de la especie podrían mostrar una menor incidencia de los patrones de muda de Stafflemauser, y a que estos individuos son de mayor peso, lo que acuerda con la regla de Bergmann.

Key Words: *Buteo plagiatus; Gray Hawk; molt pattern; molt timing; morphometrics; Staffelmauser*

INTRODUCTION

Molt is an energetically demanding, essential part of a bird's annual cycle (Newton 2009). Despite this, timing and extent of molt are often poorly understood compared with other aspects of a bird's natural history. Understanding timing and extent of a species' molts and morphological variation, especially across its entire range, is crucial to obtaining a full picture of its ecology. This knowledge will help us better understand variation within populations, among years, or by regions. It will also help us gauge how these relate to other events within a bird's annual cycle, and how these are responding to our changing climate (Newton 2009, Zuberogoitia et al. 2018).

Gray Hawk (*Buteo plagiatus*) total length ranges from 37–46 cm with females noticeably larger than males (Bibles et al. 2020); they are similar in size to the Red-shouldered Hawk (*Buteo lineatus*). Their range extends from the southwestern USA south to northern Costa Rica. In the USA, its range includes the Lower Rio Grande Valley of Texas where they are largely non-migratory (Sutton 1953, Brush 2005, Alderfer 2014, Stewart et al. 2023); throughout the remainder of its USA range and in northern Mexico, they are migratory (Bibles et al. 2020). Gray Hawk was split from the Gray-lined Hawk (*Buteo nitidus*) of South America in 2012 (Millsap et al. 2011).

Gray Hawks typically hunt from perches, and their diet consists almost entirely of vertebrates, especially reptiles (Bibles et al. 2020). Commencement of breeding and timing of molt is similar to other raptors that breed in the USA. Egg laying commences in mid-April, and young typically fledge from the nest by mid-August (Bibles et al. 2020). Most individuals begin to molt primaries and body feathers in April, completing their prebasic molt in August (Bibles et al. 2020).

Many large, flighted birds exhibit Staffelmauser (i.e., stepwise) molt (Stresemann and Stresemann 1966, Pyle 2006), and this includes many accipitrid raptors (Clark 2004, Pyle 2005*b*). During this process, molt among primaries and secondaries commences where previous incomplete molts were arrested in sequence, while at the same time beginning new series, which results in up to several waves of active molt through the remiges. Roughly 70% of Gray

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Hawks in basic plumage are reported to show evidence of Staffelmauser among the remiges (Pyle 2008). In addition, diurnal raptors have recently been recognized to have limited preformative molts within the first molt cycle (Pyle 2005*a*), and Gray Hawks are reported to molt up to 10% of body feathers in most individuals (Pyle 2008). However, these values were based on a cursory review of specimens collected throughout the species' range (at the time a subspecies) and need to be confirmed and evaluated for birds that occur in the USA. Here, we summarize findings on Gray Hawk molt and morphometrics based on 235 captures in the Lower Rio Grande Valley of Texas.

We hypothesize that Gray Hawks in our study, which winter in south Texas, will be physically larger as indicated by body mass compared with measurements from other sources obtained from birds that winter in the tropics, which would support Bergmann's rule. Bergmann's rule (Bergmann 1847) is a general pattern that originally stated larger species of endothermic vertebrates within a genus tend to be found in cooler environments. The rule has been expanded to account for intraspecific variation and suggests that within a species, body size is larger in response to temperature (Mayr 1956, James 1970, Freckleton et al. 2003).

METHODS

We captured Gray Hawks in the Lower Rio Grande Valley (LRGV), specifically in Hidalgo, Willacy, and Cameron counties. Native vegetation types include mid-delta thorn forest with thick stands of trees such as brasil (*Condalia hookeri*), anacua (*Ehretia anacua*), and Texas ebony (*Ebenopsis ebano*), plus mid-valley riparian woodland consisting of large trees like cedar elm (*Ulmus crassifolia*), Rio Grande ash (*Fraxinus berlandieriana*), and Texas palm (*Sabal mexicana*; Texas State Historical Association n.d.). However, agriculture and urbanization have resulted in destruction of 95% of native vegetation, including 99% of riparian areas (Jahrsdoerfer and Leslie 1988).

We primarily used bal-chatri traps with 8–10 cm nooses made from 13.6 kg test monofilament fishing line to capture free-flying Gray Hawks (Bub 1991). We also used phai traps, bow net, and mist nets with a mounted Great Horned Owl (*Bubo virginianus*) lure near nest sites (Bloom et al. 2007). We fit Gray Hawks with individually numbered U.S. Geological Survey (USGS) aluminum bands, and birds banded after November 2019 also received an aluminum color band (Acraft Sign and Nameplate Co. Ltd., Edmonton, Alberta, Canada and Anillas Talismán S. L., Madrid, Spain). We recorded hallux claw length, tail length, mass, wing chord, and exposed culmen length for each bird (Hull and Bloom 2001, Pyle 2008). Measurements were obtained using digital scales and calipers, clear plastic rulers, and metal wing rules with a 90-degree stop following the techniques outlined in Pyle (2008). We did not measure tarsus length because this was too difficult to standardize among multiple banders. Measurements on 196 birds were performed by WSC or MTS, with ten banders performing measurements on the remaining 39 birds under their direct supervision.

We banded nestlings when they were 28–35 days old (Bibles and Mannan 2004) to ensure they were at least half of adult body mass (Hull and Bloom 2001). Nestlings were banded prior to noon to ensure they were not exposed to excessive heat (Fyfe and Olendorff 1976), and we lowered them to the ground for increased safety when attaching bands (Hull and Bloom 2001). Females are approximately 10% larger than males with no overlap in adult mass (Bibles et al. 2020) and this size difference was used to determine sex of nestlings (Olendorff 1972). Nestlings were weighed to allow for sexing; we did not perform additional measurements because the purpose was color banding individuals to aid in studying their movements.

We initially categorized birds as in their first year (juvenile or formative plumage) or as adults (basic plumage) based on the criteria of Pyle (2008). We also categorized birds as actively molting flight feathers or not molting. First-year birds were examined for preformative molt, i.e., newer gray formative body feathers contrasting with juvenile feathers. Preformative molt occurs prior to the onset of the second prebasic molt, as documented and discussed for Gray Hawk and other raptors in Pyle (2005*a*). Adults were examined for retained, worn, brown juvenile or moderately worn, gray, basic flight feathers. We ensured that our findings were based on molt by examining replacement patterns on both wings, and not adventitious replacement, which is not symmetrical between wings.

We categorized molt and plumage cycles using Humphrey-Parkes-Howell terminology, and age classes according to molt cycle (Howell et al. 2003, Clark and Pyle 2015, Pyle et al. 2021). We separated age classes into local (nestlings, unable to fly), first cycle (between fledging and dropping the first primary during the second prebasic molt, or HY/SY in calendar-based terms), second cycle (between this and dropping the first primary during the third prebasic molt, or SY/TY), minimum second cycle (AHY/ASY), minimum third cycle (ASY/ATY) , and minimum fourth cycle (ATY/A4Y). When examining flight feathers, we looked for "sets" of sequentially replaced feathers between distally oriented waves of molt (Pyle 2006, 2008). Sets are defined by an older, more worn primary distal to an adjacent newer primary, each set showing a cline in freshness from older inner to newer outer feathers, although a cline may not be even due to differing generations or molt suspensions; the number of these sets was used to determine minimum age for birds beyond third cycle (Pyle 2006, 2008). Open-wing images showing front and back of an extended wing were taken for archival purposes and to study molting patterns.

We excluded nestlings (n = 37) and juveniles captured prior to 1 October (n = 45) from measurement means, ranges, and analyses. The 1 Oct cutoff was used to exclude fledglings prior to beginning their dispersal movements and was based on dispersal dates reported by Stewart et al. (2023). Prior to dispersal, many fledglings captured were still actively molting remiges and were under normal adult body weight. We further excluded nine individuals for whom one or more measurements were not recorded. We used a Welch two sample t-test to account for unequal variance between groups, and performed analyses using R version 4.3.0 (R Core Team 2023).

Our project was conducted in compliance with the "Guidelines to the Use of Wild Birds in Research" (Fair et al. 2010). Gray Hawk banding and auxiliary marking were conducted under Federal Bird Banding Permits 09289 and 24234, and Texas Scientific Permits SPR-0702-226 and SPR-0422-060. Possession

Table 1. Breakdown of newly banded and recaptured Gray Hawks (*Buteo plagiatus*) by plumage category, molt status, and sex of birds captured in the Lower Rio Grande Valley of Texas from 6 February 2003 to 8 April 2023.

Sex	Capture type	Juvenile	Formative	Second prebasic	Second basic	Minimum second prebasic	Minimum second basic	Minimum third prebasic	Minimum third basic	Minimum fourth prebasic	Minimum fourth basic
Male	New	39	4	1	3	1	42	1	4	1	8
	Recapture	11	0	0	0	0	2	0	2	0	0
Female	New	43	8	5	3	2	27	1	2	0	6
	Recapture	10	0	1	3	0	2	0	3	0	0
Totals per plumage category		103	12	7	9	3	73	2	11	1	14

of a taxidermy mounted Great Horned Owl was authorized under Federal Scientific Collecting Permit MB81980D-0. Use of these trapping methods and audio playback were authorized on our banding permits, and playbacks were used sparingly when trapping.

RESULTS

From 6 February 2003 to 8 April 2023, we captured 235 Gray Hawks, 201 newly banded birds and 34 recaptures of previously banded birds (Table 1); recaptures of known-age birds allowed us to age some birds more specifically when retained juvenile or basic feathers were not present. Molt of each recapture was initially examined independent of the banding data to test the accuracy of our molt-based aging. We recorded hallux claw length, tail length, mass, wing chord, and exposed culmen length for 144 Gray Hawks. As first-year Gray Hawks have longer rectrices than adults, we present first-year (Fig. 1) and adult (Fig. 2) measurements separately. We found overlap between sexes for ranges of all measurements except mass, but interquartile ranges did not overlap for any of our five measurements. We found significant differences between sexes for each of the five measurements ($P < 0.001$) for first-year (Table 2) and adult (Table 3) Gray Hawks.

Of these captures, 115 were of birds in their first cycle, captured 30 May-8 April, and 110 were of adults captured in every month of the year. Sixteen birds captured between 2 February–11 August were actively molting remiges. We observed 15 of 78 first-cycle birds (19%), excluding nestlings, with evidence of preformative molt, from 23 December to 1 April (Fig. 3). We did not observe preformative molt in 47 first-cycle birds captured from July–October. Twelve of 26 birds captured in November–February (46.1%), and three of six in March–June (50%) had formative feathers. The remaining first-cycle birds had retained all juvenile feathers, including birds captured as late as 28 June.

We aged six birds as second cycle by retained juvenile body feathers among basic feathers. In five instances this included one to two juvenile feathers on the rump, and a sixth had one retained juvenile feather on its rump and two retained feathers in the secondary coverts of its right wing. No birds were observed with retained juvenile primaries or secondaries, as frequently occurs in second-cycle birds of larger raptors.

Of the 98 remaining non-molting adults, 81 had uniformly basic primaries and secondaries (of one generation) and were aged as minimum second cycle or AHY/ASY. We documented 18 instances of Staffelmauser molt in 17 individuals (Table 4). Of these, 10 showed two sets of primaries and were aged as minimum third cycle (ASY/ATY) and eight showed three sets of primaries and were aged as minimum fourth cycle (ATY/A4Y). Of birds in minimum second basic plumage or older (e.g., showing basic remiges), ten of 61 males (16%) and eight of 44 females (18%) exhibited Staffelmauser, with the proportion of birds showing three sets also being greater in females (14%) than in males (6%). One female (band no. 1947-45497) was captured twice, approximately 2.3 yrs

Fig. 1. Boxplots of hallux claw length, tail length, mass, wing chord, and exposed culmen length separated by sex for 40 first-year Gray Hawks (*Buteo plagiatus*) (nestlings and first-cycle birds captured prior to 1 October excluded) captured in the Lower Rio Grande Valley of Texas from 6 February 2003 to 8 April 2023.

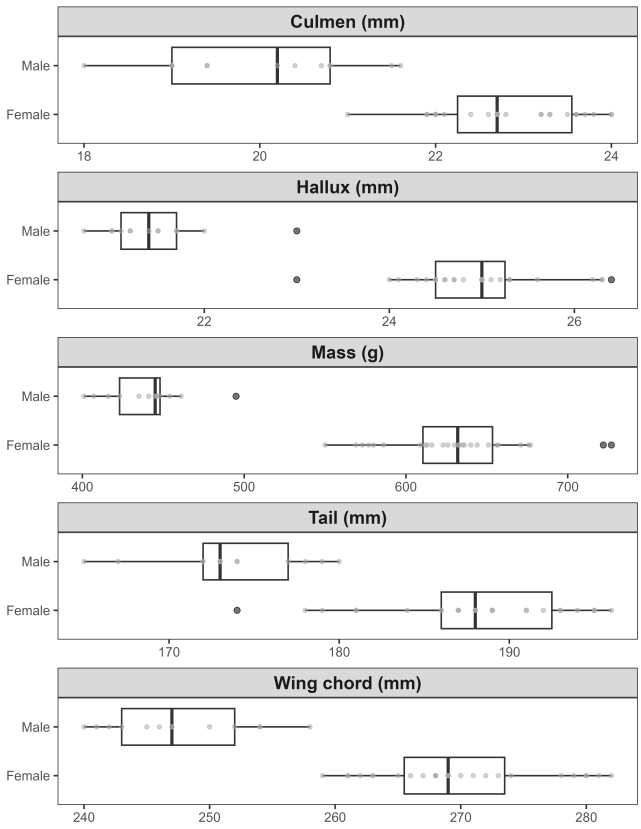
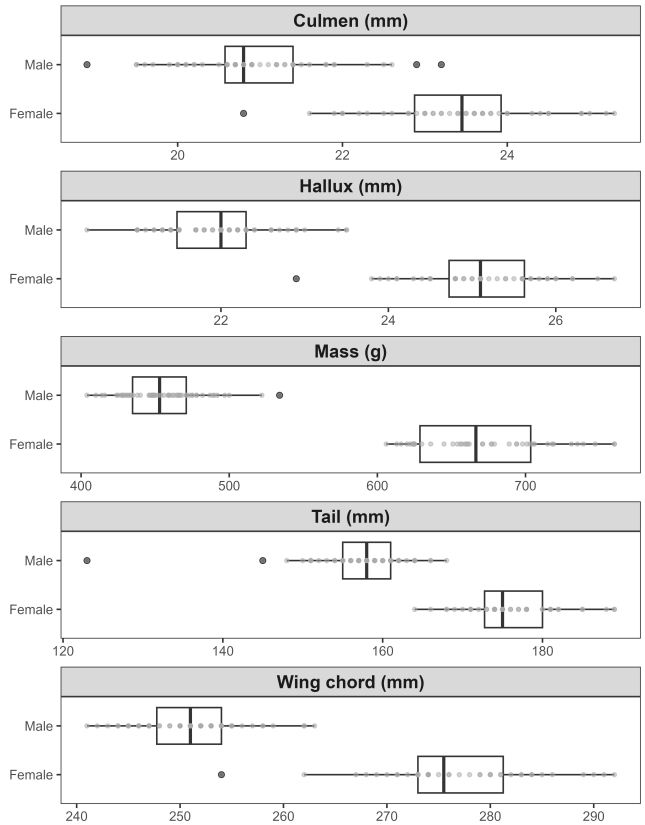


Fig. 2. Boxplots of hallux claw length, tail length, mass, wing chord, and exposed culmen length separated by sex for 104 adult Gray Hawks (*Buteo plagiatus*) captured in the Lower Rio Grande Valley of Texas from 6 February 2003 to 8 April 2023.



between captures, and she exhibited Staffelmauser on both occasions. Three individuals (i.e., band nos. 1266-03756, 1266-08051, and 2187-08511) may have exhibited four sets of primaries and would be at minimum in their fifth cycle (A4Y/A5Y), but we lacked confidence to assume this unprovisionally (Fig. 4).

Of molting birds (Table 1), examination of retained juvenile or basic feathers and of sets among unmolted feathers resulted in seven being classified as undergoing their second prebasic molt (SY), five as undergoing their minimum third prebasic molt (ASY), and four as undergoing their minimum fourth prebasic molt (A4Y; cf. Fig. 4f).

DISCUSSION

Our study enhances the current understanding of Gray Hawk molt and morphological variation at the northern range periphery, offering valuable ecological insights. Given that Gray Hawks are year-round residents in the LRGV (Stewart et al. 2023), it is unsurprising that certain measurements, notably mass, exceeded those recorded for the species overall. The ten heaviest birds in each sex significantly surpassed the species account's listed maxima (male: 489–554; female: 718–760). This aligns with our hypothesis that the LRGV population, wintering farther

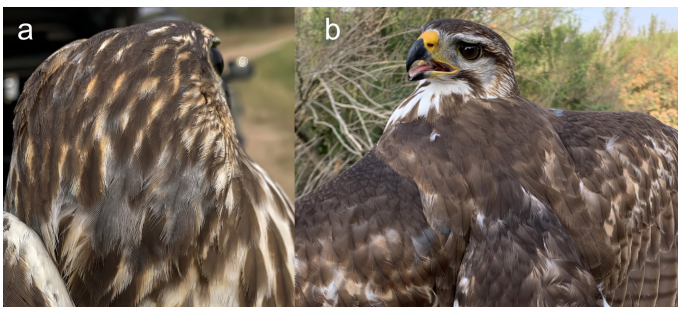
Table 2. Mean values and ranges of hallux claw length, tail length, mass, wing chord, and exposed culmen length for 40 first-year Gray Hawks (*Buteo plagiatus*) (nestlings and first-cycle birds captured prior to 1 October) captured in the Lower Rio Grande Valley of Texas from 6 February 2003 to 8 April 2023, along with Welch t-test results comparing mean values between males and females.

	Male mean (n = 13)	Male range (n = 13)	Female mean (n = 27)	Female range (n = 27)	P	95% CI
Hallux (mm)	21.5	20.7 - 23.0	24.9	23.0 - 26.4	< 0.001	[3.03, 3.92]
Tail (mm)	174	165 - 180	188	174 - 196	< 0.001	[11.07, 17.70]
Mass (g)	438	401 - 495	630	550 - 727	< 0.001	[168.79, 212.33]
Wing chord (mm)	247	240 - 258	270	259 - 282	< 0.001	[18.10, 26.37]
Culmen (mm)	20.0	18.0 - 21.6	22.9	21.0 - 24.0	< 0.001	[2.15, 3.58]

Table 3. Mean values and ranges of hallux claw length, tail length, mass, wing chord, and exposed culmen length for 104 adult Gray Hawks (*Buteo plagiatus*) captured in the Lower Rio Grande Valley of Texas from 6 February 2003 to 8 April 2023, along with Welch t-test results comparing mean values between males and females.

	Female mean (n = 71)	Female range (n = 71)	Male mean (n= 73)	Male range (n = 73)	P	95% CI
Hallux (mm)	25.1	22.9 - 26.7	21.9	20.4 - 23.5	< 0.001	[2.94, 3.42]
Tail (mm)	181	164 - 196	160	123 - 180	< 0.001	[17.47, 23.03]
Mass (g)	656	550 - 760	453	401 - 534	< 0.001	[190.81, 216.31]
Wing chord (mm)	274	254 - 292	251	240 - 263	< 0.001	[21.37, 25.78]
Culmen (mm)	23.2	20.8 - 25.3	20.7	18.0 - 23.2	< 0.001	[2.14, 2.77]

Fig. 3. First-cycle (SY) Gray Hawks (*Buteo plagiatus*) captured in the Lower Rio Grande Valley on 19 January 2020 (a) and 17 March 2020 (b) showing gray formative feathers among otherwise brown juvenile plumage. We found formative feathers in three of six birds captured between March and June.



north than other populations within the species' range, tends to exhibit larger sizes, consistent with Bergmann's rule (Meiri 2011). Although we do not propose a specific mechanism for this pattern, acknowledging the challenge with at least six hypotheses suggested (Blackburn et al. 1999, Pincheira-Donoso 2010), our study

Table 4. Feather sets for 18 adult Gray Hawks (*Buteo plagiatus*) with Staffelmauser that were captured in the Lower Rio Grande Valley of Texas from 12 January 2018 to 15 January 2023.

USGS band number	Date	Sex	Molt cycle	Calendar-based age class	Feather sets
1266-03749	28 Jan 2020	Male	Minimum third cycle	ATY	2 sets: p1-p8, p9-p10
1266-03755	8 Mar 2020	Male	Minimum third cycle	ATY	2 sets: p1-p9, also s3, s9 retained basic
1266-08051	30 Mar 2020	Male	Minimum fourth cyle	A4Y	3 sets: p1-p7, p8-p9, p10
1266-08052	6 Apr 2020	Male	Minimum third cyle	ATY	2 sets: p1-p8, p9-p10 (Left s3 and s7 old basic?)
1266-08060	7 Jun 2020	Male	Minimum third cyle	ASY	2 sets: p1-p8, p9-p10
1156-12750	27 Feb 2021	Male	Minimum fourth cyle	A4Y	3 sets: p1-p5, p6-p8, p9-p10
1156-12751	27 Feb 2021	Male	Minimum third cyle	ATY	1 set and ss
1266-08070	1 Mar 2021	Male	Minimum fourth cyle	A4Y	3 sets. RW: p1-p6, p7-p9, p10; LW: p1-p6, p7-p8, p9-p10
1266-14103	2 Jun 2022	Male	Minimum third cyle	ASY	At least 2 sets, otherwise not precisely documented
1266-11171	10 Jan 2023	Male	Minimum third cyle	ATY	2 sets: p1-p8, p9-p10
1947-38645	12 Jan 2018	Female	Minimum fourth cyle	A4Y	3 sets: p1, p2-p8, p9-p10
1947-45497	25 Feb 2020	Female	Minimum fourth cyle	A4Y	3 sets: p1-p7, p8-p9, p10
2187-08511	28 Feb 2020	Female	Minimum fourth cyle	A4Y	3 sets: p1-p6, p7-p9, p10 (p10 older than p9)
1947-50305	12 Mar 2020	Female	Minimum third cyle	ATY	2 sets: p1-p8, p9-p10
1947-50372	2 Nov 2020	Female	Minimum fourth cyle	ATY	3 sets: p1-p5, p6-p7, p8-p10
1947-50399	7 Jan 2021	Female	Minimum third cyle	ATY	2 sets. LW: p1-p7, p8-p10; RW: p1-p8, p9-p10
1947-45497	9 Jun 2022	Female	Minimum third cyle	ASY	At least 2 sets, otherwise not precisely documented
1947-56276	15 Jan 2023	Female	Minimum fourth cyle	A4Y	LW 2 sets: p1-p6, p7-p10; RW 3 sets: p1-p6, p7-p9, p10

establishes the existence of this size variation between Gray Hawks wintering in south Texas and those wintering in the tropics.

Ranges for tail length, wing chord, and exposed culmen length were similar for both sexes to those in Pyle (2008) for birds throughout the species' range. Compared with the species account (Bibles et al. 2020), we recorded shorter exposed culmen length for males, longer lengths for females. Range for wing length was similar for both sexes, although, unlike ours, measurements in the species account were flat wing lengths (Millsap 1986). This difference is typically about 5–8 mm in birds of this size (P. Pyle, *unpublished data*).

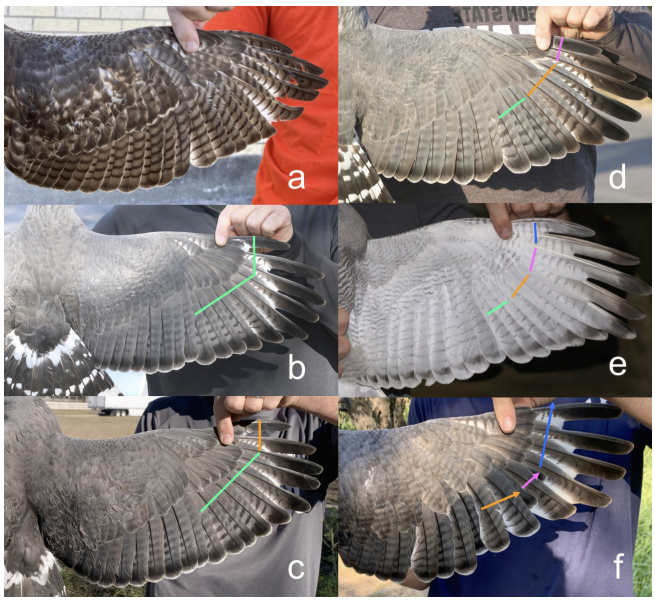
Extent of preformative molt documented was approximately 1% of body feathers, considerably less than many other species of North American *Buteo* hawks (Pyle 2008). Of 66 birds captured in November–June, 22% exhibited preformative molt, a figure that may represent the incidence of this molt. This and the fact that some birds were captured as late as 28 June without evidence of preformative molt indicate that it is absent in most birds, as suspected by Pyle (2008). Among other diurnal raptors, for comparison, 11–100% of birds within species were suspected of lacking preformative molts, including 14–100% of birds within *Buteo* species (Pyle 2005*a*).

Sixteen birds were captured when actively molting remiges, from 2 February–11 August, most within expected timeframes, including two birds undergoing their second prebasic molt in mid-April. In many large birds, including buteonines, the second prebasic molt occurs earlier than later prebasic molts due to a lack of breeding constraints (Pyle 2008; see also below). Of note was one bird aged as minimum third cycle that was molting on 2 February; the next earliest bird recorded in molt was 13 April. The early molting bird may indicate that molt of primaries can continue at low levels throughout winter, which was observed for Golden Eagles (*Aquila chrysaetos*; Bloom and Clark 2001).

We did not observe any second-cycle birds with retained juvenile primaries, secondaries, or rectrices, which Pyle (2008) observed on occasion in specimens. Perhaps this occurs more regularly in birds that reside south of the USA. In the LGRV, first-year birds were observed with adults, in some cases defending a territory together. In one instance, a pair was observed copulating and bringing lining material to a nest the first-year female occasionally occupied. However, we have not observed any first-year birds successfully breeding. Breeding birds have less time to molt so lack of breeding by 1-year-old birds in the LRGV may explain the lack of retained juvenile remiges in this population. Non-breeding first-year birds can start their second prebasic molt as early as April (see above) and usually undergo an uninterrupted complete molt by fall; thus, many individuals we aged as minimum second basic with one generation of basic feathers may have been in second basic plumage.

Eighteen instances out of 104 captured birds, excluding known-age recaptures, with potential to exhibit Staffelmauser (aged as in at least their second cycle, ASY/ATY) is 17%, much lower than the 70% documented by Pyle (2008). This may be because south Texas birds do not migrate, and thus have more time for molt. It may be possible more Gray Hawks residing outside the LGRV exhibit Staffelmauser or that we missed more than one generation of basic feathers in some birds recorded as minimum second cycle. Staffelmauser often occurs in older birds that are more successful in breeding and thus have less time to undergo the following molt before onset of winter (Pyle 2008). We found that Staffelmauser occurs in a greater proportion of female than male Gray Hawks, perhaps because females are both larger and take a more expansive role in breeding activities, resulting in less time and energy to replace a greater amount of feather mass than males (Pyle 2005*b*). Suspension of molt for breeding also may occur in Gray Hawks, as recorded for other large raptors (Pyle 2005*b*, 2008), but documenting this in individuals that exhibit Staffelmauser is difficult. We documented individuals with up to

Fig. 4. Gray Hawks (*Buteo plagiatus*) captured in the Lower Rio Grande Valley showing different molt patterns. (a) A first-cycle individual (SY), captured 16 January 2023 in formative plumage, showing uniformly juvenile flight feathers but some grayer formative wing coverts. We recorded 15 birds in this plumage showing formative body feathers or wing coverts between 23 December and 1 April. (b) An individual (ASY) captured 2 February 2020 showing a single set of basic remiges. Birds in their second cycle (SY/TY) may more often show only one generation of flight feathers due to lack of breeding constraints. (c–e) Individuals showing Staffelmauser, with two sets (c: 7 January 2021; minimum third cycle or ATY), three sets (d: 2 November 2020; minimum fourth cycle or ATY), and possibly four sets (e: 30 March 2020; minimum fifth cycle or A5Y) of feathers, a set being defined as a more worn feather distal to a newer feather (see text). Sets are marked with bars of different colors (green, orange, pink, and blue from inner to outer). (f) An individual captured 17 August 2020 undergoing a definitive prebasic molt. The three waves of active molt (p3, p5, and p10 growing) indicate minimum fourth cycle (A4Y) for this individual.



three sets of primaries, leading to age classification of minimum fourth basic plumage (ATY/A4Y), as also found by Pyle (2008). It may be possible that occasional Gray Hawks can be confirmed with four sets of primaries and be aged as minimum fifth basic plumage (A4Y/A5Y), as can occur in other large raptors like Golden Eagle, but this would appear to be rare at best in Gray Hawks of the Lower Rio Grande Valley.

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Data Availability:

The data/code and pictures are available upon request from the corresponding author.

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