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Burchell's Courser *Cursorius rufus*, Gould 1837, in Namibia: biometric and moult data, plumage and criteria for the determination of age

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ABSTRACT

This is the first comprehensive study on moult and plumage of Burchell's Courser (*Cursorius rufus*). Biometric measurements are few, the moult strategy is undocumented and detailed depiction is scarce. As bird ringers, we have the unique opportunity to observe these aspects closely while handling live birds, providing valuable insights. We add the measurements from our study to other available measurements and present moult observations of seven Burchell's Coursers from Namibia, of two age groups. Drawing on our own observations, existing literature, and public photographs, we aim to improve the understanding of plumage characteristics crucial for age determination during observation and ringing activities. We provide detailed descriptions of the plumage and moult variability across different age groups, highlighting similarities with the closely related Temminck's Courser (*Cursorius temminckii*) and the Cream-coloured Courser (*Cursorius cursor*). We illustrate non-described features of the juvenile and the post-juvenile plumage and discuss the challenging aspects, mainly of primary moult of adults and first-year birds, emphasising the need for further research in this area.

Keywords: bird ringing; Cream-coloured Courser (*Cursorius cursor*); determination of age; juvenile plumage; Namibia; plumage development; post-juvenile moult; post-juvenile plumage; primary moult; SAFRING; serial descendent moult; Temminck's Courser (*Cursorius temminckii*)

1. INTRODUCTION

Burchell's Coursers (*Cursorius rufus*) (Figure 1) are medium-sized birds of open, sparsely vegetated habitats of western southern Africa. As nomads and local migrants, their movements follow apparently the rainfall, but regular or long-distance movements have not been recorded. The distribution range is mainly in Namibia and South Africa, with records from southern Angola and Botswana. Over the last 200 years, its abundance and range have decreased rapidly and considerably in the southern range which is cause for conservation concerns. In Namibia, the habitat preferences are for the Namib desert and the Namibian escarpment. The protected and less disturbed areas seemed to provide stable numbers. (Maclean & Herremans 1997, p. 444; Maclean & Kirwan 2020; Urban *et al.* 1986).

Of nine courser species, seven occur in Africa. Burchell's Coursers remain understudied, with data lacking for areas like population size, longevity, breeding facts like mate fidelity, incubation period and breeding success, and especially moult, with

measurements of individuals in the low digits (Hockey 2005, p. 425). We conducted this very detailed research to clarify the unexplored moulting strategy and to accumulate data of measurements of Burchell's Coursers to fill these gaps of knowledge in the new edition of Roberts Birds of southern Africa (<https://www.robertsbirds.co.za/>).

Only limited data are available in the database of the South African Bird Ringing Scheme (SAFRING) and in the published literature. According to the SAFRING database, 38 Burchell's Coursers have ever been ringed (SAFRING 2024), and no individuals have been retrapped so far.

We searched the literature for data on moult and biometry and included unpublished SAFRING data. We illustrate with photographic evidence the development from hatchling to adult as well as the juvenile and undescribed post-juvenile features of the plumage. Furthermore, we discuss the observation that juveniles seem to grow a second set of body feathers which is unexplored, as is the occurrence of three feather generation in immature birds.

The information in this paper helps conservation efforts by improving how we monitor populations with more accurate age determination, and showing how environmental factors affect birds' life stages. In doing this, it provides clearer guidelines to citizen scientists to identify the different life stages, resulting in improved quality data. This may further improve collection methods and allow comparisons with other species, revealing bigger ecological trends. We describe our observations and recommendations for further research in the field and of museum specimens.

2. METHODS OF DATA COLLECTION

2.1 Timing and location

We caught the birds from our sample between December and February from 2009 to 2015 on the farm Sphinxblick, Erongo Region (around 22°29'S,



Figure 1: Adult Burchell's Courser. 15 June 2012. © Tom Heijne.

15°27'E). The habitat in the pre-Namib is arid savanna of sandy or gravelly plains with mostly sparse vegetation (Figure 2).

The photographs were taken by the authors unless specified otherwise. The number of and the link to their location in the publicly accessible Macaulay Library of the Cornell University are given, when accessible, in the caption of every photograph (e.g., ML619126968). For numbers and links without depiction the authors could not be reached.

2.2 Taxonomy, bird ringing, measurements and determination of age

The species is considered to be monotypic.

Birds were trapped in clap traps with mealworm bait or, occasionally, in mist-nets.

A ring with a unique number engraved was applied. Measurements of wing, tail, head, bill and mass were taken, as well as moult codes, in accordance with the guidelines of the SAFRING Bird Ringing Manual (de Beer et al. 2001, based on Svensson 1984). We determined the age primarily on plumage characteristics. Additional data for comparison were gathered from both published and unpublished sources, including the SAFRING database.

2.3 Moulting and moult codes

When recording moult, we considered the ten functional primaries and did not include the tiny eleventh primary. In the common code for recording moult, 5 stands for a new, fully grown, code 0 for an old primary, while 1 to 4 correspond with the growing size of each feather. Code 1 represents a feather in a still closed pin, code 2 a feather sprouting through the pin and up to 1/3 of the final length, code 3 stands for a growing feather of 1/3 to 2/3 of the final length and code 4 for 2/3 to final length, when still in the blood sheath.

This coding was applicable only in the case of the clearly descendent moult in first-year birds, since



Figure 2: Namibian habitat of our study of Burchell's Courser: sandy and gravelly plains in an arid open landscape. ML619126968.

the moult strategies of adults, namely the serial descending moult, proved to be too complex to be covered by the standard coding. The codes 0 to 5 do not reflect the age relation between the ten functional primaries, originating from up to three different growth waves. It is furthermore unclear if *Cursorius* species are subject to one single annual moult wave or if two or even three can start per year.

For moult strategies we referred to the publications on the Cream-coloured Coursers (*C. cursor*) since Burchell's Coursers 'have much in common' in size and structure with the East African races of this species (Cramp 1983, p. 97).

3. MEASUREMENTS

For Table 1, we gathered the measurements of five adults and two first-year Burchell's Coursers from our study and, to our knowledge, all the published measurements from the literature.

4. MOULT AND BREEDING

In Namibia, active nests have been recorded during all months with exception of November and December; peaks are from April and July, but the sample of 30 records is small (Figure 3; Brown et al. 2015). During our study between November and March, we did not record any breeding activity and did not observe brood patches in the birds ringed.

The only mention of moult in Burchell's Coursers in the literature is from Macdonald who observed in Namibia 'north-east of Kleinkaras a few birds, probably a family party'. Most of his five specimens, shot between 10 and 27 of January in southern Namibia, 'were in various stages of post-breeding moult' since it was 'clearly evident that the new feathers are darker and more richly coloured than the old' (1957, p. 67).

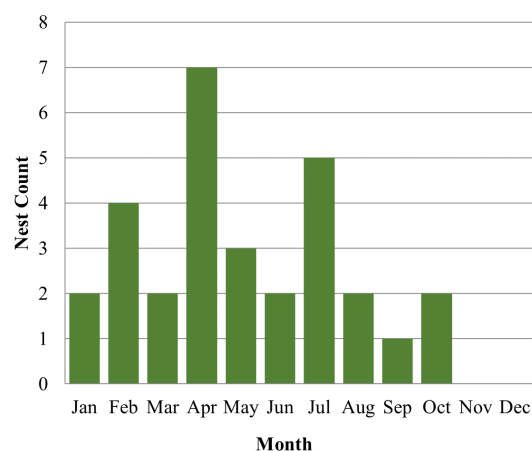


Figure 3: Nest count records of egg-laying months of Burchell's Coursers in Namibia (Brown et al. 2015).

Table 1: Measurement data for Burchell's Courser *Cursorius rufus*. Average measurements (including standard deviation, minimum and maximum measurements) of adult birds from our study and from Hoesch & Niethammer (1940, p. 126), Macdonald (1957, p. 67–68), Urban et al. (1986, p. 212), and Pearson & Ash (1996, p. 226) and Kok & Van Zyl (1996, p. 161), both in Hockey (2005, p. 425). Furthermore, we include unpublished data from SAFRING (2024).

Grouping	Parameter	Wing (mm)	Tail (mm)	Tarsus (mm)	Culmen* (mm)	Head (mm)	Mass (g)
Current study							
Adults	Mean ± SD	135 ± 3	51.8 ± 3.6	47.2 ± 1.7	28 ± 3.2	50.8 ± 1.1	75.5 ± 8.7
	Min–max	130–138	49–58	44.7–49.4	24.4–33	49–51.8	66.1–86.8
	<i>n</i>	5	5	5	5	5	5
Adults, sex unknown	Mean ± SD	135 ± 3.5	50.3 ± 1.3	47.9 ± 1.1	27.9 ± 3.7	50.6 ± 1.1	75.7 ± 10.1
	Min–max	130–138	49–52	46.7–49.4	24.4–33	49–51.6	66.1–86.8
	<i>n</i>	4	4	4	4	4	4
Adult female	Mean	135	58	44.7	28.7	51.8	75.1
	<i>n</i>	1	1	1	1	1	1
First-year	Mean ± SD	130.5 ± 3.5	52.5 ± 4.9	45.2	28.9 ± 0.1	53.4 ± 1.7	76.2 ± 8.3
	Min–max	128–133	49–56	45.2–45.2	28.8–29	52.2–54.6	70.3–82
	<i>n</i>	2	2	1	2	2	2
SAFRING Database 2024**							
Adults, sex unknown	Mean ± SD	136 ± 3.7	62.3 ± 17.9	49.5 ± 4	23.7 ± 4.6	52.4 ± 2.3	83 ± 2.5
	Min–max	129–143	51–89	45–52.4	17.9–28.4	50.6–55	78–85.4
	<i>n</i>	9	4	3	4	3	8
Macdonald 1957, pp. 67–68							
Adult females	Min–max	133–142	52–55		25–28		
	<i>n</i>	5	5		5		
Adult males	Min–max	133–140	50–57		27–29		
	<i>n</i>	3	3		3		
Urban et al. 1986, p. 212							
Adults, sex unknown	Mean ± SD	135	51.2	48	22.9		75 (Namibia)
	Min–max	132–138	48–53	46.5–51	21–25.5		
	<i>n</i>	13	13	13	13		unknown
Hockey 2005, p. 425							
with reference to		Pearson & Ash 1996, p. 226		Pearson & Ash 1996, p. 226	Pearson & Ash 1996, p. 226 to feathering		Kok & Van Zyl 1996, p. 161
Adult females	Mean ± SD	135.3		47	20.7		80.2 ± 2.9
	Min–max	131–138		44–48	20–21		61–90
	<i>n</i>	6		6	6		9
Adult males	Mean ± SD	139.2		47.6	20.6		94.3 ± 3.3
	Min–max	136–143		47–49	20–21		76–112
	<i>n</i>	5		5	5		11
Hoesch 1940, p. 126							
Adult female	Mean	135					82.5
	<i>n</i>	1					1

* The measurements of the culmen were taken to the skull, i.e. to the indentation on the front of the skull (Demongin 2016, p. IX). In two individuals, additionally the culmen was measured to the feathering (Demongin 2016, p. IX). It amounted to 20.7 mm (adult) and 21.4 mm (first-year).

** Of the 38 data sets in the SAFRING database, seven are from our studies, 15 are from small chicks, and of nine adults with measurements of wing and mass, only four have the remaining measurements of tail, tarsus, culmen and head recorded.

5. PLUMAGE AND AGE

In our research area in the arid savanna of the pre-Namib, small flocks of three to seven Burchell's Coursers would arrive overnight, and in the mornings, we would find groups of first-year birds in transition to adult plumage, obviously well able to fly, and adults. Due to the sporadic and erratic appearance of the birds, we could not observe a continuous development of moult.

The lifespan of Burchell's Coursers is unknown. One captive Cream-coloured Courser was at least seven years old (Glutz von Blutzheim 1986, p. 844). The age of Burchell's Coursers can roughly be determined by different plumage expressions described in the literature and documented by photographs: those of freshly hatched young, downy young, juveniles, immatures and adults. Here we give a short general overview and discuss details of the wing, its flight feathers and the primary moult in greater depth below.

The determination of age by plumage features must be considered a rough estimation. In contrast to migratory wader species, no clear seasonal allocations seem possible, frequently feathers are retained, even for longer periods, and breeding and the subsequent age development can occur throughout the year. Approximate fixed points are given when adults and non-adults show active primary moult at the same time.

5.1 Adults

Small and medium-sized birds are generally considered adults when they have completed one year of ageing. In Burchell's Courser, adults can be recognised by a plumage without markings: plain upperparts, a rufous crown with a grey hind-crown ending in a black triangle and a black stripe behind the eye, located below a bright white band. Also, the underparts are plain, brown on the chest and separated from the white belly and vent by a black band, darkening towards the belly (Figure 4).

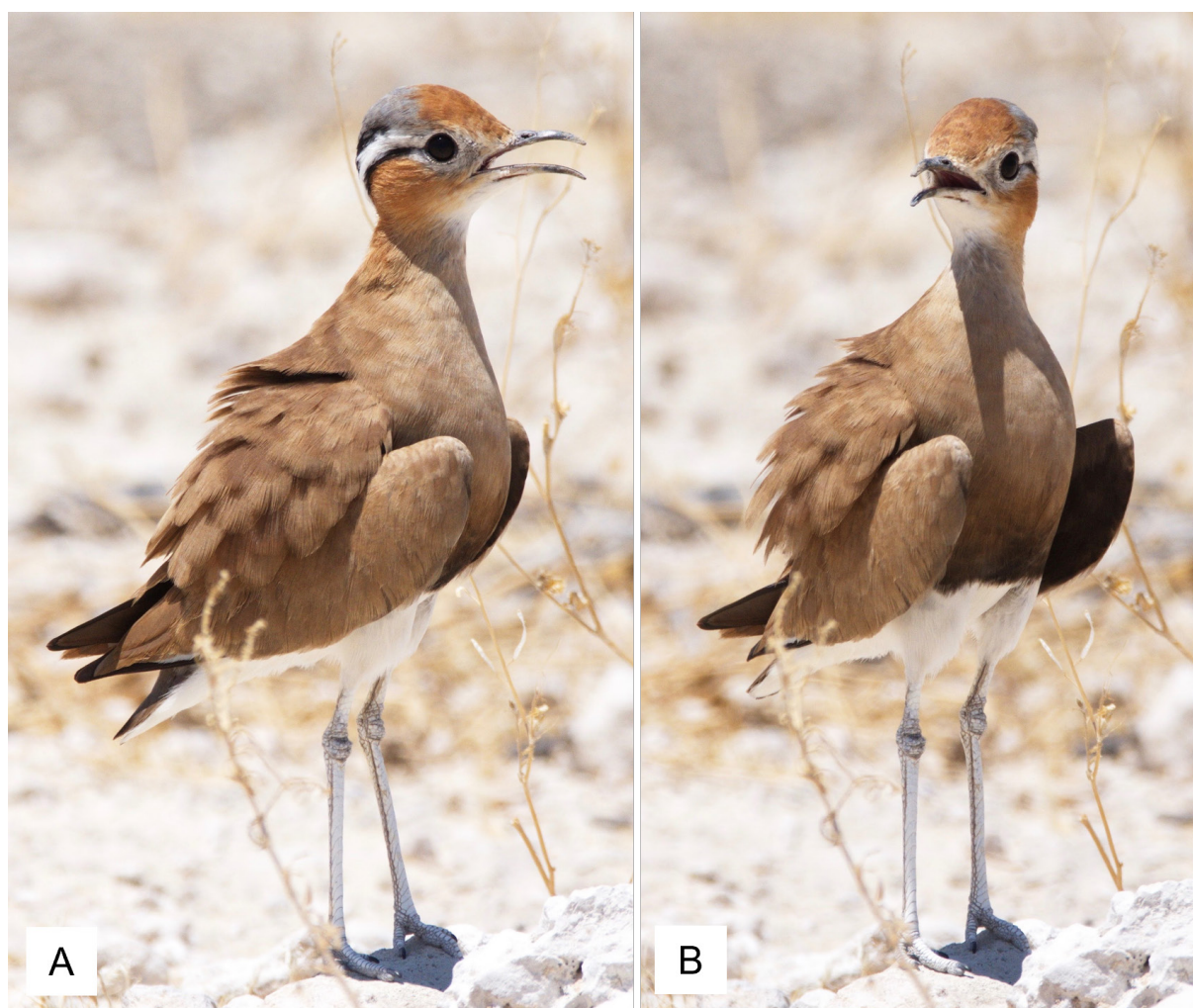


Figure 4: Burchell's Courser in adult plain plumage showing: (A) the distinct head markings of the adult and (B) the brown chest divided from the white underbelly by a dark line. Omusati, Namibia, 2 November 2018. © Dominic Standing. ML217492281 and ML217492271.

However, this seems to occur earliest in the second year.

We found broad, round rectrices, a shape commonly associated with the adult age, which had non-adult markings (see 5.5.2; Figure 13C), and several visible moult waves of primaries concurrent with retained coverts of a former plumage (Figure 19). It is unexplored if these features are related to a slow progress over more than one year to reach full adult plumage or if they are moulted off in the next 'complete' moult. It has also not been confirmed if the primary moult waves are started once a year or more frequently.

Presumably, there are no seasonal variations in the plumage of Burchell's Coursers and no significant sex differences, equal to the Cream-coloured Courser (Cramp 1983, p. 91 and p. 97 respectively).

5.2 Development of first-year to adult plumage

After egg-laying which can take place in almost any month (see Figure 3; Brown *et al.* 2015), the juvenile and post-juvenile, immature plumage consequently can be found throughout the year. Juveniles seem to grow a second set of body feathers which is unexplored - as is the occurrence of three feather generations in immature birds.

Full body size is reached after a few months, possibly only two (see 5.2.1), while the post-juvenile moult stretches over many months. We defined first-year birds as such by the abundance of markings of the plumage, mainly on the head, belly, rump and tail while taking into consideration that full adults possibly show residual feathers from an earlier plumage. For the determination of young age we also considered:

- the lack of the black line behind the eye,
- the lack of the black triangle on the neck,
- the leg colour changing from dark grey to whitish,
- the pointed shape of primaries and outer secondaries,
- the occurrence of only one moult wave of the primaries (or none in early young),
- the colouration of the axillaries (dark in younger and light in adults)
- and the combination of these features.

5.2.1 Freshly hatched and downy young

The freshly hatched young (Figure 5A) is described with down of a 'creamy stone colour, with a fair number of black markings on the crown and a few black markings on the back' (Bromley 1952, p. 61).

The only picture of a downy young we found was in Dixon (1975, p. 64) and shows light and dark markings all over the upperparts (Figure 5B). The growth of the young and with it the feather development progresses quite quickly. Lane (1933, pp. 73) observed two chicks in Potchefstroom, South Africa, following an adult in mid-September and resighted them 'a month later when they were almost fully grown'.

5.2.2 Juvenile plumage

Juveniles change their appearance in a few weeks from pale and faintly patterned (Figure 6A and 6B) to distinctly marked and rich in contrast (Figure 6C).

This points towards an additional set of body feathers, similar to that of most passerine species (described by Bub 1981, p. 119; Jenni & Winkler 2020b, pp. 61-62).

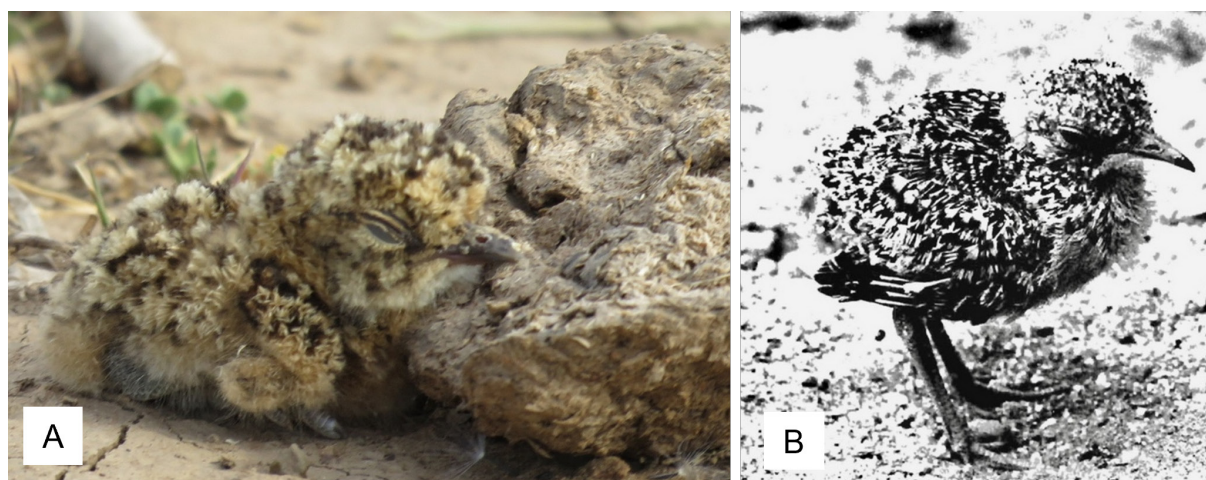


Figure 5: (A) Hatchling resting on dry animal droppings. Northern Cape. 21 October 2020. © Riëtte Griesel. (B) Downy young of the Burchell's Courser. The blood sheaths show the growing primaries. Namib Desert Park. Photo in Dixon (1975, p. 64).

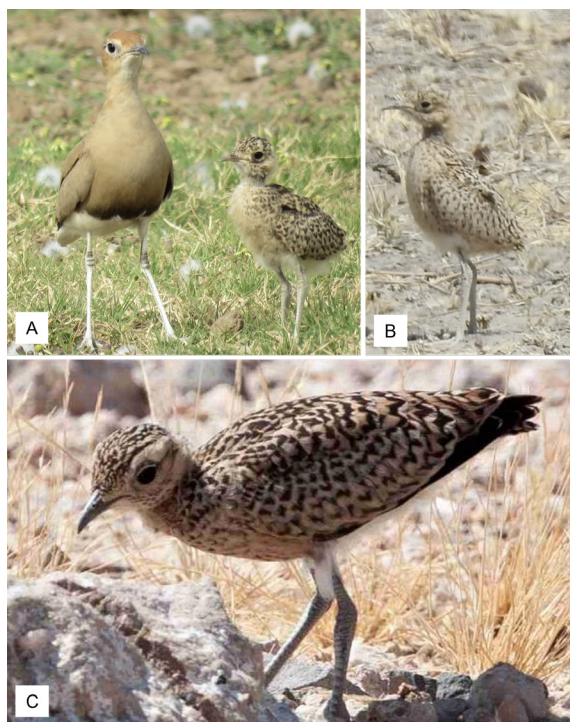


Figure 6: Juvenile plumage in progress. (A) Chick with adult for comparison of size. Northern Cape, 21 October 2020. © Riëtte Griesel. (B) Young chick with lesser marked plumage, but older than (A), determined by comparison with (non-depicted) parent. Etosha NP, Namibia, 1 September 2019. © Marti Ikehara. ML223744091. (C) 'Half-grown chick', so-called by the photographer, in juvenile plumage with distinct markings. Spitzkoppe, Erongo, Namibia, 2 September 2008. © Dorothee Suter. ML368614011.

Furthermore, despite both being from September, one (Figure 6C) is further developed in size and plumage than the other (Figure 6B), pointing towards an early hatching. Generally darker legs are also observable in juveniles compared to the pale white of the adult.



Figure 7: Immature Burchell's Courser in transition to adult plumage. 4. February 2012. SAFRING 4H46518. ML619128077.

5.2.3 Post-juvenile plumage

During the post-juvenile moult, the adult-looking plumage is acquired progressively and marked feathers of the first year are frequently retained into the second year (Figure 7). For a detailed discussion see Section 7.

5.3 Head markings

Two features stood out as far as the head markings are concerned. Firstly, the black triangle in the neck develops fully with age during several years (Figure 8).

Secondly, in some individuals, the grey area starts behind the eye (Figure 8A), in others between the eyes (Figure 8B; see also ML596222591). It is unknown if the size of the brown frontal patch is a sign of sex. It is not a sign of age as we can confirm after reviewing all the photographs available in the Macaulay Library (<https://birdsoftheworld.org/>).

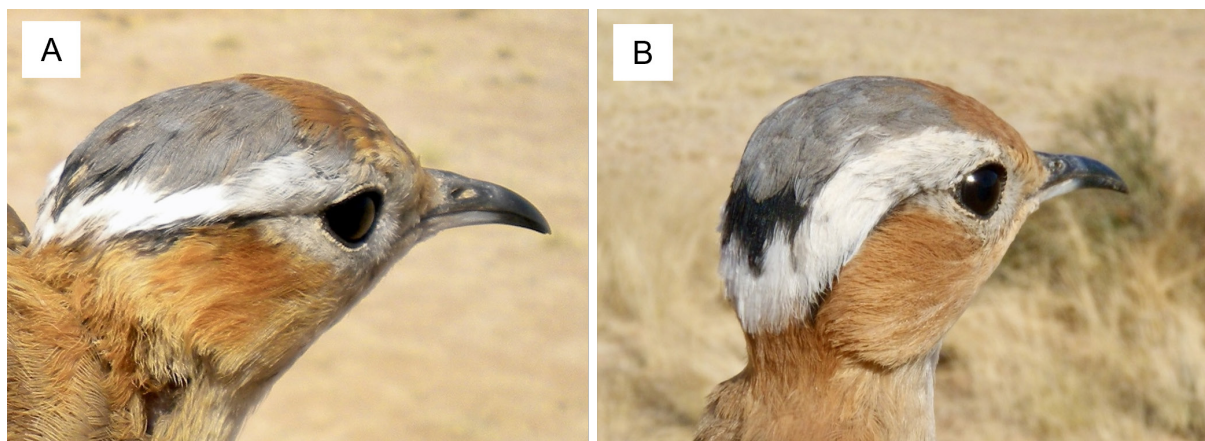


Figure 8: Comparison of the head markings of first-year (A) and adult (B) Burchell's Courser. (A) 27 December 2009. SAFRING 497781, ML619127150; (B) 4 February 2012. SAFRING 4H46516, ML619127571.

5.4 Colouration of chest and belly

In our research area, we found that the colouration of the upper- as well as the underparts is variable, as is the colour and the width of the dividing line

between the brown chest and the white belly. Birds at the end of their first year still might retain a central area of vermiculated juvenile feathers (Figures 9A and 10A).

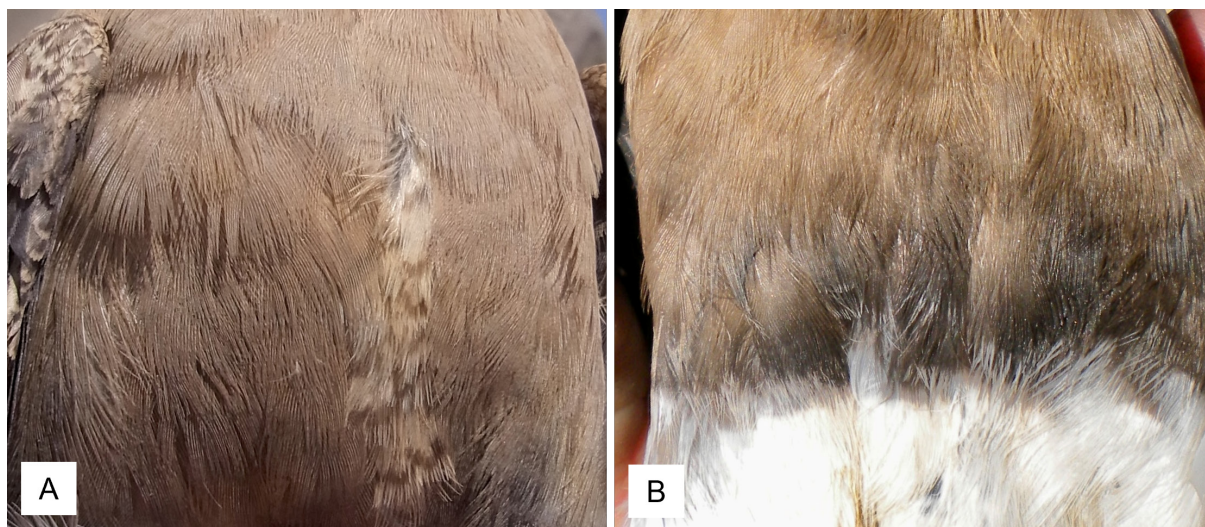


Figure 9: Comparison of the underparts of a first-year (A) and an adult (B) Burchell's Courser. (A) The markings on the belly and the wing are from the juvenile plumage. 4 February 2012, SAFRING 4H46517, ML619128812. (B) Unmarked underparts of an adult with a washed blackish dividing line between chest and belly. 27 December 2009, SAFRING 497782, ML619128435



Figure 10: Comparison of the colouration of the dark dividing line between chest and belly. (A) Blackish tinge in a first-year bird. 27 December 2009, 497781, ML619127145. (B) Brown tinge in an adult. 28 February 2015, SAFRING CC79107, ML619128272

The dividing line may be of a pale blackish or dark-brown colouration (Figures 9B and 10B). The black tinge can already show in first-year birds (Figure 10A). It is thus not a sign of age but may differ between the sexes or be a population or an individual feature.

Furthermore, this dividing line can be almost absent (ML220679131), a few millimetres wide (ML596222571) or well over a centimetre wide (ML611229139). More research is needed to clarify if these differences relate to progressing age and maturity, sex or seasonal changes in plumage.

5.5 Tail

The tail consists of 12 rectrices. The moult strategy of the tails is unexplored and not fully understood. The description of the appearance of the rectrices of adults as well as of young birds is multiform and even contradictory. This is possibly due to variability of the plumages based on age, wear and individual variation, and also to imprecise age labelling, especially the use of the term ‘juvenile’ for any young bird. In addition, coursers are known to retain their feathers for up to two years (and perhaps more) and a full adult plumage might take even

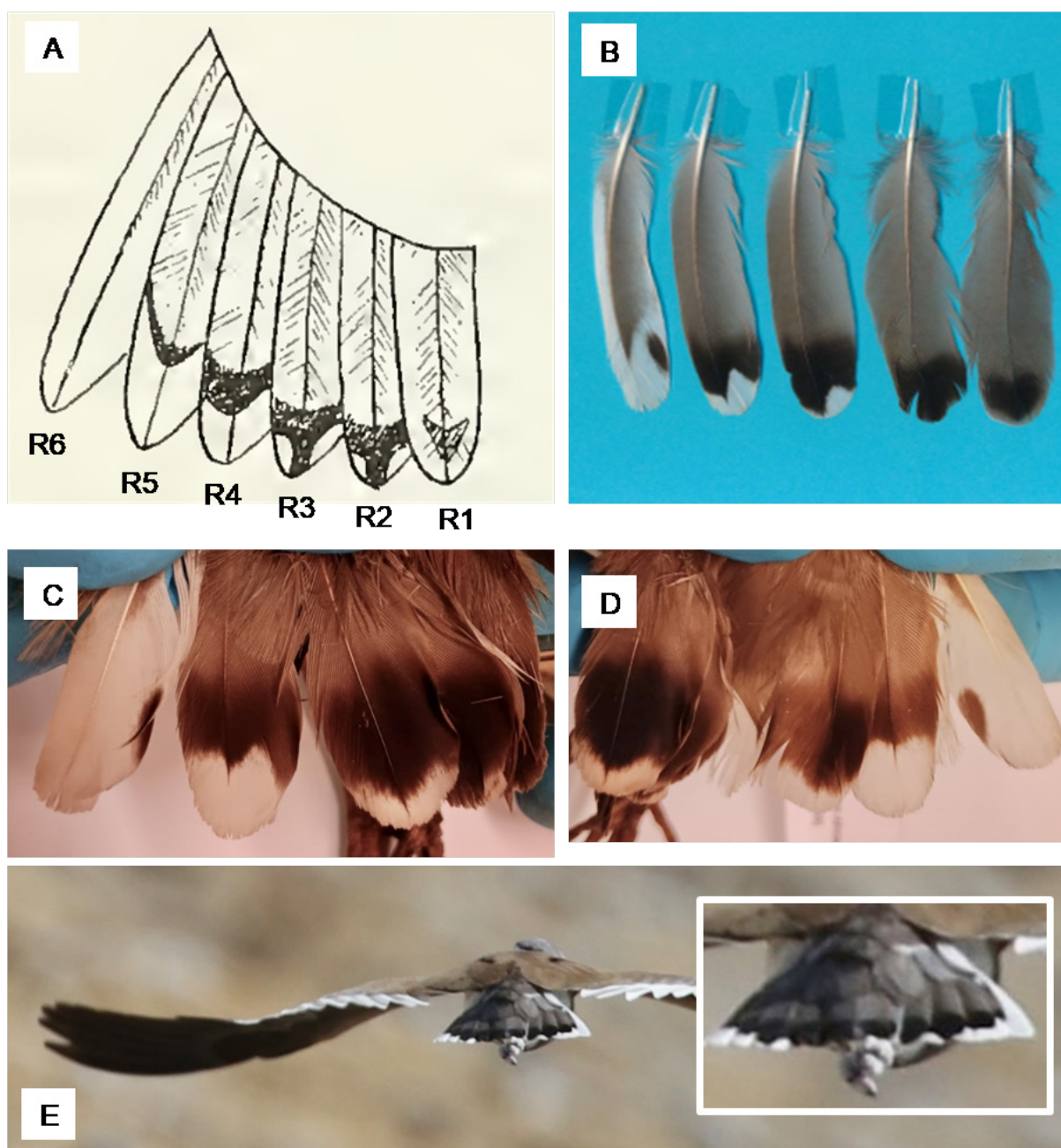


Figure 11: Variation of the patterns on the upper tail of adults: (A) drawing from Pearson & Ash (1996, p. 228). (B) Skin with one missing rectrix (R3?). February 1967, Namibia. Private scientific collection. © Pascal Eckhoff. (C) Left and (D) right tail of a mount. Museum of Natural History, Berlin, Inv. Nr. ZMB 12932. Collected between 1820 - 1839. © Anna Kowalczevska. (E) Etosha NP, Namibia, 1 November 2020. © Steve James. ML276365951.

longer to reach completion. Photographs providing detailed information of age are scarce. Beyond our own pictures (of poor quality), of adults we found only one depiction from a collection, one of a museum specimen and one drawing, and two drawings of a then called ‘juvenile’.

5.5.1 Tail of adults

None of the descriptions of the pattern of the rectrices found in the literature fully matches the drawing or the photographs from Figure 11 (Mackworth-Praed & Grant 1962, p. 330; Maclean & Urban 1986, p. 211; Pearson & Ash 1996, p. 227; Stark & Sclater 1906, p. 324).

All mostly have the ‘outer tail feathers increasingly tipped white with subterminal dusky bar’ in common (Hockey 2005, p. 424). The (sub-)terminal bar, the amount and pattern of white at the tip, the

colour and markings on the outer rectrix R6 and the colour of tail and bar are all variable. The different descriptions are not only due to individual emergence in the plumage. We hypothesise that they might describe age- and possibly sex-related differences, like tail patterns in Lesser Grey Shrikes (*Lanius minor*) (Krištín *et al.* 2007). However, more material is needed for clarification.

The depictions of Figure 11 show tail feathers of different individuals. Noteworthy is the variation of the outer tail feather R6, either plain white (A), white with a small dark sub-terminal patch on the inner vane (C and D) or grey with white outer vane and tip and dark patch (B); the variation of the extent and the contour of the white tips; and of the width of the dark (sub-)terminal band. See also Figures 21B and 22B with two tails from December in different wear.

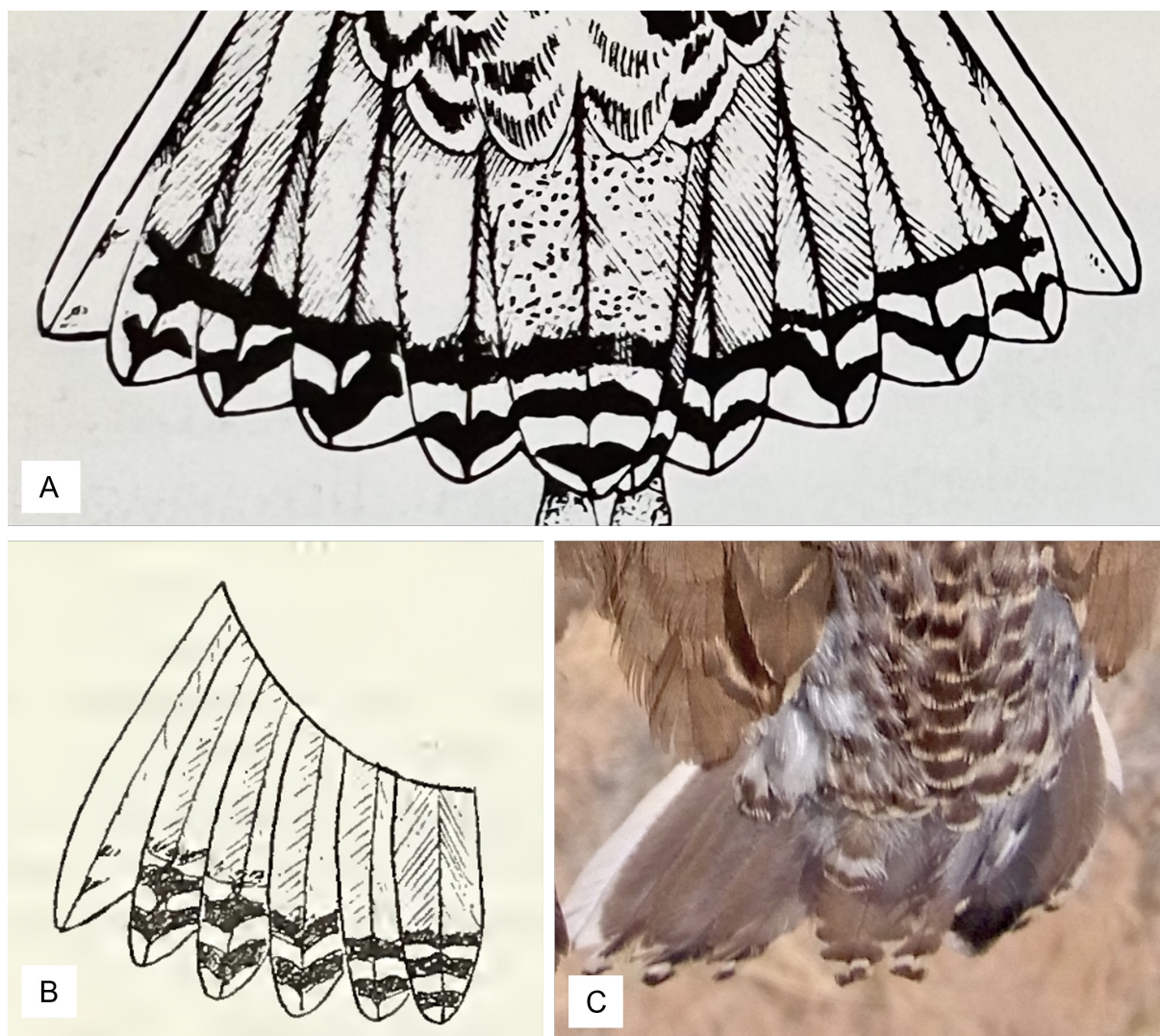


Figure 12: Upper tail of young birds: (A) Juvenile from South Africa (from Hayman *et al.* 1987, p. 250); (B) Determined as ‘juvenile’ by Pearson & Ash (1996, p. 228). The rectrices will be replaced only in the second year of life, and the very same feathers will thus also be found in immatures. (C) Immature (same individual is in Figure 17). 4 February 2012. SAFRING 4H46518, ML619128073.

5.5.2 Tail of first-year birds

There is no precise and consistent description of the tail feathers of the juvenile, nor of the immature Burchell's Coursers. First-year, thus non-adult birds include juveniles (until their post-juvenile moult) and immatures. Stark & Sclater (1906, p. 324) described for 'young birds: the tail is ashy, the tips of the feathers black with sandy spots along both webs'. Since the term 'juvenile' is used randomly in the literature for both ages, the value of the data is lost. Maclean & Urban (1986, p. 212) found immatures with 'tail mottled with tawny' (sic) which in the literature turns into juveniles with 'upper tail mottled tawny, with 2-3 subterminal dark bars and white tip on all except outer rectrices, which only have subterminal bars on inner web, otherwise predominantly white' (Hockey 2005, p. 424).

Apart from Figure 12, there are no images for either this age or the transition in the first year available. The tail markings on Figures 12A and 12B are quite

well resemblant, although the shape of the tips is more pointed in B, as generally common in first-year birds. Figure 12C shows abraded tips in an immature from early February of about one year of age.

Figure 13A shows an immature from December where the tail (Figure 13B) still wears markings also on the central feathers. In contrast, Figure 12C depicts the tail of an adult (from the same flock as Figure 12C) with broad round rectrices and with two non-adult feathers of the same shape (presumably R4 and R5 with white R6 missing). All rectrices are subject to the same modest abrasion, which points towards simultaneous growth.

The latter feature led us to the hypothesis that possibly some individuals replace some of their rectrices during the post-juvenile moult with round but marked new feathers or produce feathers with non-adult markings moulting into the adult plumage or grow them as adults.

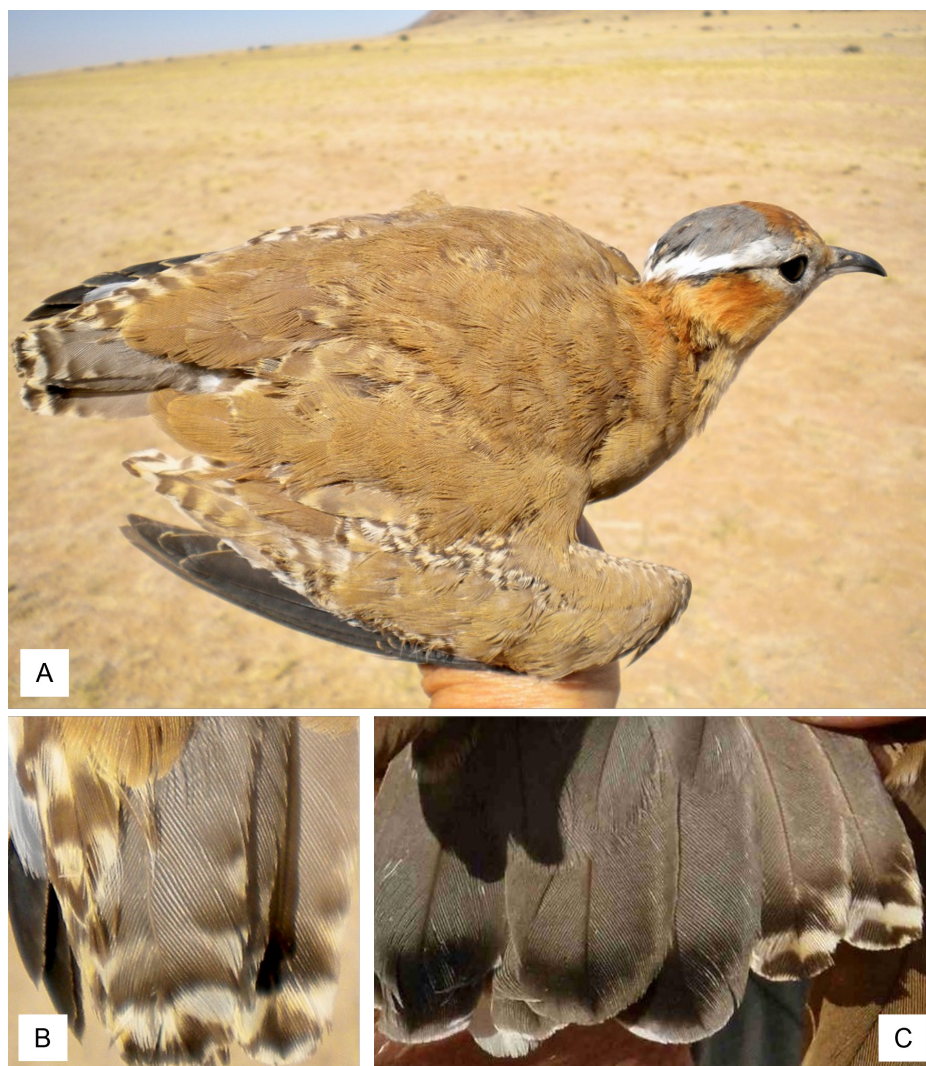


Figure 13: (A) Immature in transition to adult plumage and (B) corresponding tail. 27 December 2009. SAFRING 497781. (C) Tail of an adult (individual from Figure 20) with two retained, marked rectrices. Compare the round shape of the tips with 12A, 12B and especially 12C. 4 February 2012. SAFRING 4H46516, ML619127568.

5.6 Secondaries, tertials, axillaries and underwing coverts

The shape of several feather groups is generally different between the first and the following plumages which gives an additional tool for determining the age of a feather and with this, of the bird (Baker 1993, p. 16). In our sample, this also concerns the secondaries with apparent differences on the tips and of the width. In first-year Burchell's Coursers, we found pointed outer secondaries, while in adults the outer secondaries have rounded tips.

It is unrecorded at what stage of moult and in which age the inner secondaries are replaced by round ones. We observed one individual in adult plumage with sharply pointed, possibly abraded secondaries (Section 9.3, Figure 21A). See also Section 7.3.

The tertials of a first-year plumage bear markings and correspond with the length of the secondaries (Figure 14A and 14B), those of adults are much longer and reach the end of the tail (Figures 20 and 22B). Furthermore, for more precise age determination you can draw on the colouration of the proximal part of the axillaries which are dark in younger birds (Figure 14A) and light grey in adults (Figure 14C).

6. MOULT

Beyond the most common strategy of simple descendent moult, various other general and frequent strategies have been described linked to the orders, but also to the size of the species and corresponding with their biological necessities. These include the frequent arrested moult with interrupted and suspended growth, a serial descendent moult (Jenni & Winkler 2020b) and



Figure 14: (A) Immature with brown, marked feathers on tail, rump and tertials, dark proximal axillaries and underwing coverts and white fringes on the primaries. The inner secondaries are pointed, the parting line between chest and belly is indistinct. Sesriem, Namibia, August 2022. © Jacques de Spéville. (B) Marked tertials and belly of an immature. 4 February 2012, SAFRING 4H46517, ML619128810. (C) Adult with light grey-brown proximal axillaries and ashy brown underwing coverts. The black line behind the eye turns more distinct. Central Namibia. © Paul Donald.

other types like ‘slow continuous moults’ (Rogers 1990, p. 144). For *Cursorius* species, a ‘seemingly serial descendent moult’ (Cramp 1983, p. 97) has been described (discussed in Section 8.4).

6.1 Annual Mould

It is generally agreed that in the annual cycle of adult small- and medium-sized birds, a complete moult usually occurs after the breeding season; variations occur (Jenni & Winkler 2020b, p. 220). Differences in timing may arise depending on the bird family or order. In small and medium-sized first-year birds, the timing of the first complete moult, which includes remiges and rectrices, is generally established at the time of the moult of adults throughout the families (Jenni & Winkler 2020b, pp. 231 and Figure 148 on p. 232), while Hayman *et al.* (1987, p. 20) allocate the moult of adult waders as ‘usually later than that of first-year birds’.

We found in our sample that both age groups moulted the primaries at the very same time. Out of a flock of seven birds, we ringed one adult (Figure 20) and two non-adults (Figures 13 and 17). All three had progressed approximately evenly in their primary moult.

6.2 General moult strategies of Burchell’s Coursers

Neither for the post-juvenile moult nor for the primary moult of the first and subsequent years in southern African *Cursorius* species, data about the exact duration are available. We observed that the process is extended and that it might take several years for the wing, especially for the primaries, to be completely renewed (Figures 21 and 22).

7. MOULT IN FIRST-YEAR BIRDS

Shorebirds, which coursers are allocated to, start their post-juvenile moult with a few weeks, until, exceptionally late, with up to three months, and at large, the phenotype of the adult plumage in courser family of *Glareolidae* is acquired at the age of several months to just over one year (Cramp 1983, p. 84). Like other *Cursorius* species and waders in general, juvenile feathers are usually retained (Hayman *et al.* 1986, p. 20) into the second-year plumage and possibly even longer.

Glutz von Blotzheim (1986, p. 839) remarks that the closely related Cream-coloured Coursers replace the innermost primaries and rectrices during the post-juvenile moult. In our study we could not confirm this for the tail of Burchell’s Coursers but found a possible realisation in the wing of a first-year bird. See also Section 7.3.

The comparison with the moult strategy of the Cream-coloured Coursers, which is helpful as a starting point for the moult description in Burchell’s

Coursers, comes to its limits when studying that of the first year. Cream-coloured Coursers begin their post-juvenile moult within a few weeks of fledging. As a partly migratory species they adjust to the necessities of being able to migrate and this moult is partial or complete, dependent on the time of fledging (Cramp 1983, p. 97).

For Burchell’s Coursers, no long-distance movements are recorded (Maclean & Kirwan 2020; also Sclater 1906, p. 22) and hence the strategy of a complete post-juvenile moult lacks a functional basis. We observed the beginning of the first primary moult in February, when the moult of body and median coverts was almost completed (if not for residual feathers).

In our sample of two immatures, the rectrices and remiges were not included in the post-juvenile moult. Their first moult process occurred at the beginning of the second year of life when adults undergo their annual post-breeding moult (Figures 17 and 18).

In most, if not all, (non-passerine) species, juvenile feathers, mostly detectable in outer primaries, secondaries, tertials and greater-coverts, are narrower and the tips are more angled and wear more rapidly to a pointed shape (Baker 1993, p. 16; Hayman *et al.* 1987, p. 20). We found this in the outer primaries and in the secondaries, which confirm the young age of the feathers and thus of the birds (Figure 18 vs. adults in Figures 21 and 22).

7.1 Unexplored features of the post-juvenile plumage

In the first-year plumage, we found unaccounted differences in colour, and markings of the post-juvenile plumage that cannot be explained by retained feathers (Figures 15A and B). Both immatures are from the end of the calendar year: Figure 15A from 2 November from northern Namibia and Figure 15B from 28 December from the northern Cape in South Africa. They show a varying degree of the zigzag pattern: thin and pale in Figure 15A, well distinct, broad and warm brown in Figure 15B.

The intensity of the plumage colouration may be faded by the sun, and other factors may play a role: clinal variations or regional differences, although subspecies are not recognised. More material is needed to test our hypotheses that either the immature grows a specific set of coverts and body feathers, or that there is a unlikely specific post-juvenile plumage. This is possibly a general feature of coursers. In the Temminck’s Coursers, we found likewise two different generations of coverts (Figure 16). See also Bryson and Pajmans (2024, in press).

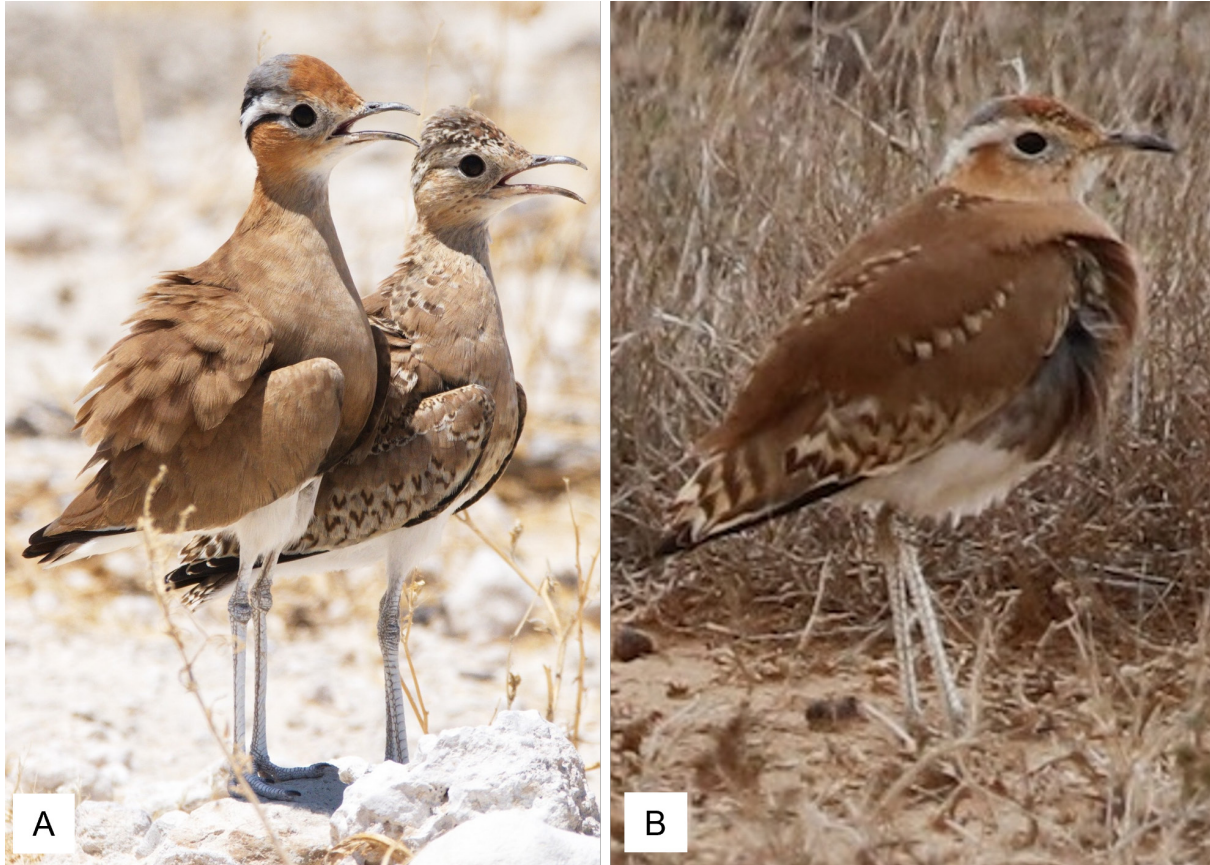


Figure 15: (A) Adult Burchell's Courser and young during its post-juvenile moult. Omusati, Namibia, 2 November 2018. © Dominic Standing. (B) Immature completing its first adult plumage. Only a low number of coverts remain from the juvenile plumage. The head shows the adult supercilium, the rufous cheek and the grey hind crown, while the black stripe behind the eye still is in development. Northern Cape, South Africa, 28 December 2023. © Jason Fidorra. ML614135534.



Figure 16: Residual coverts of two non-adult feather generations in Temminck's Courser. Okavango, Botswana, December 2019. © Luboš Mráz



Figure 17: Burchell's Courser in transition: The difference between marked juvenile and plain adult plumage is quite obvious. While most of the head, mantle and of the median coverts is moulted, the rump and the lesser and greater coverts are still in process. In the left tail one fresh, grey rectrix has grown. 4 February 2012. SAFRING 4H46518, ML619128076.

7.2 First complete moult

The primaries of first-year birds generally look uniform since they have grown at about the same time. Their replacement starts during the first complete moult. In the Cream-coloured Courser, advanced first-year birds look ‘like adults, but all primaries [are] equally new, rather than showing suspended moult as in many adults; occasionally, a few juvenile wing-coverts or scapulars are retained’ (Cramp 1983, p. 97).

7.3 The moult of two different first-year birds

In the same small flock, we observed two first-year birds in similar transitional plumage (Figure 17).

Both birds were at the beginning of their second year of life, determined by the beginning primary moult with approximately the same moult sequence 3000000000 (Figure 18A) and 4100000000 (Figure 18B; but see Glutz von Blotzheim 1986, p. 839, on the replacement of the innermost primary during the otherwise partial post-juvenile moult).

When comparing the two wings, they seem homologous at first glance. At closer inspection, the differences of colour, shape and markings of primaries, secondaries and the different groups of coverts are so pronounced that they even appear to represent two different age groups. Figure 18A

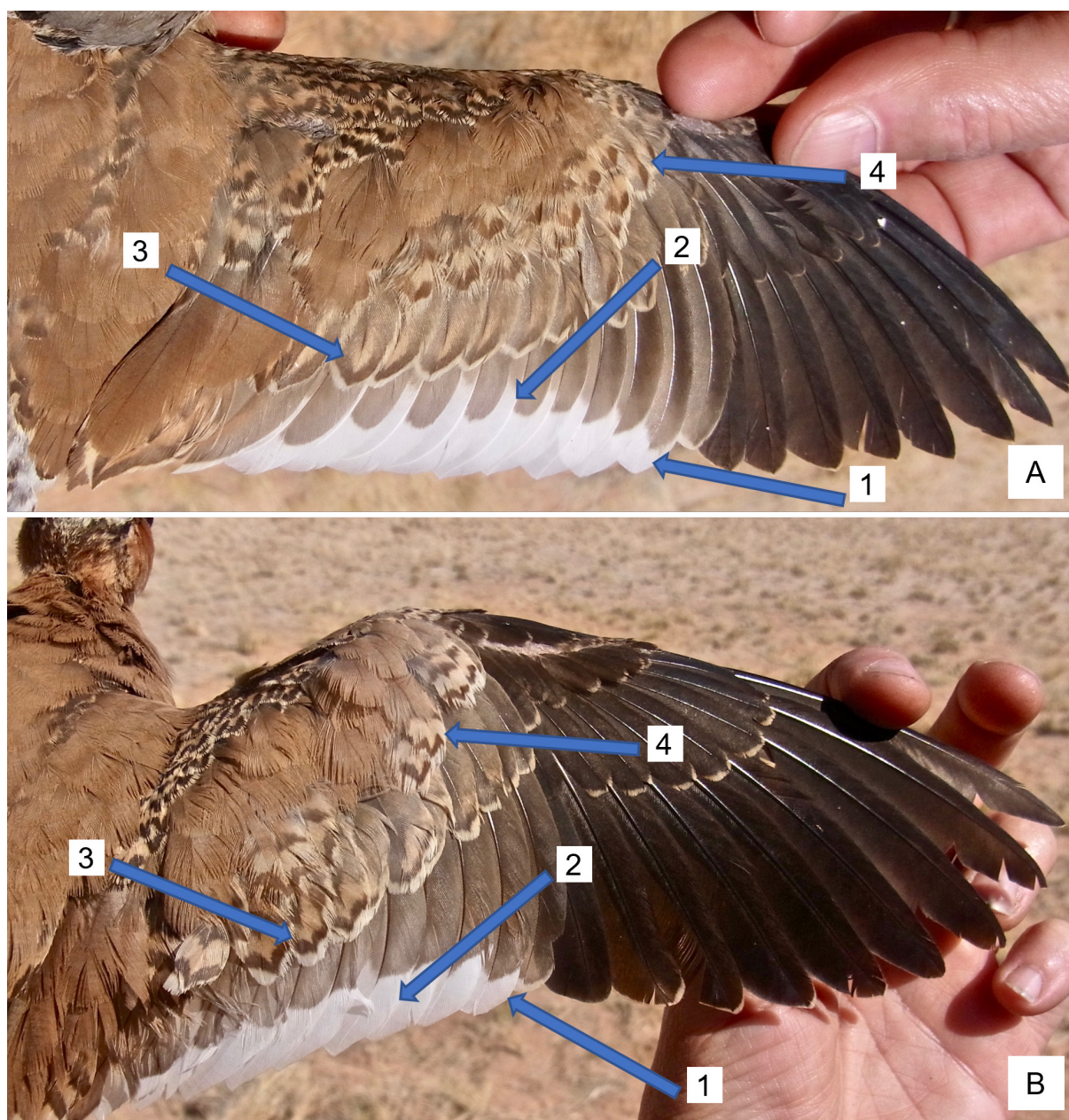


Figure 18: The wings of two first-year birds of one group from 4 February 2012. On the first view the two wings look similar but on closer inspection they seem to represent two different age groups. Note the differences in colour, shape and markings of primaries, secondaries (1 and 2) and coverts (3 and 4). (A) SAFRING 4H46518, ML619128078. Moult sequence 3000000000. (B) SAFRING 4H46517, ML619128809. Moult sequence 4100000000.

shows features of a younger age. The overall wing is paler. The inner primaries in Figure 18A have a juvenile pointed tip, those in Figure 18B round ones with small buff fringes. The outer secondaries (1) are pointed in Figure 18A vs. round in Figure 18B. The white edge (2) stretches far up the outer vane in Figure 18A, but not in Figure 18B. It is possibly an individual and not an age-related feature. The greater coverts (3) in Figure 18A are pointed vs. rounded in Figure 18B, have a straight subterminal bar along the white edges vs. a darker vermiculation, and dark shafts, often a sign of early feathers, whereas Figure 18B does not show them. The median coverts (4) in Figure 18A are almost transparent of poor quality with thin fringes, and show paler, undefined markings vs. distinct, vermiculated markings in Figure 18B.

Unfortunately, we were not able to find detailed photographic material or descriptions that could explain these differences. Hypotheses to be tested are a distinct immature generation of plumage of higher feather quality and more distinct markings. We can only speculate about the underlying patterns and hope that with this observation and description other researchers will help us out with more data and explanations.

8. MOULT IN ADULTS

8.1 Primary moult of Burchell's Coursers

The primary moult in the *Cursorius* family is highly complex with numerous variations and is not fully understood (Cramp 1983, p. 97). The primary moult, as in all *Charadriidae*, is descendent (Stresemann & Stresemann 1966, p. 217) as also documented in Temminck's Coursers (Bryson & Paijmans 2024, in press, and as in ML616708191). In Cream-coloured Coursers, the primaries take about six months to be replaced (Cramp 1983, p. 97). For the southern African species, the duration of the primary moult is unknown. In some individuals, we found a white tip on the inner primary (Figures 20 and 21).

8.2 Determination of age

We could not find any information in the literature on whether (Burchell's) Coursers start one or more primary moult waves during one calendar year or during a moulting season. The *Sternidae*, the sub-family of terns, of the same order of *Charadriiformes* as the *Glareolidae*, which the coursers are allocated to, can undergo three or even four moult waves per year (Demongin 2016, pp. 151). This concerns the inner primaries that are moulted twice or even three times a year, a process which is then called *repeated moult* (Jenni & Winkler 2020b, p. 211) and is different from the moult strategy of the coursers. For the Burchell's Courser, the extent of the wear and abrasion makes one yearly moult wave more likely (Figure 19), although solid data are lacking.

If Burchell's Coursers are subject to one single wave or moult series per year, the number of waves in a wing will indicate the minimum age of this individual. The following discussion is based on the assumption of one wave per year.

8.3 Serial descendent moult

The moult strategy of the Burchell's Coursers is basically a serial descendent moult, although not all requirements are fully met. 'In a serial descendent moult, a moult wave starts at P1 and is suspended whenever the moult period ends, even though only some of the primaries have been moulted. At the next moult period, the suspended moult wave is resumed at the point of interruption and carried on for a few more primaries or until it is completed' (Jenni & Winkler 2020b, p. 222).

Every year (or in large birds every second or third year), 'a new wave starts at the innermost primary concurrently with the resumption of previously suspended moult waves.

Depending on the number of primaries moulted per year and the frequency of starting a new moult wave, the number of concurrent moult waves varies, and so the number of *concurrently* [highlighted by UB] growing feathers too. ... This results in a very complex mixture of primaries of three or four generations' (ibid.).

Young (Burchell's) Coursers can be recognised as such by the occurrence of one single moult wave which is their first and until then only primary moult event.

8.4 Seemingly serial descendent moult in *Cursorius*

Jenni and Winkler determine as a serial moult strategy when moult starts in 'a new wave before the previous one has ended', and thus one or several feathers are in active growth (2020b, p. 228). The adult Burchell's Coursers in our sample had only one active centre of moult, conforming with Cramp's description of the Cream-coloured Coursers: 'Apparently, two moult series [are] never active at the same time'. He thus called the strategy 'seemingly (but actually not) serially descendent.' He also ascertained that the innermost primary 'perhaps does not start before the outer one has finished' its growth or that the outer series temporarily stops when the innermost starts. Some primaries are probably replaced only every second year (1983, p. 97).

9. DISCUSSING THE MOULT OF FOUR DIFFERENT ADULTS

Below we discuss the moult phenology of four different adult Burchell's Coursers ringed in December, February and March and one wing from

February. We were not able to establish a general pattern in the primary moulting process in this species during our studies. We describe and comment in detail some features to summarise the actual knowledge of the moult strategies. It is unexplored to what extent the findings can be transferred to the moult of other *Cursorius* species like the Temminck's Courser. (But see the scarce records of moult of the Double-banded Courser *Rhinoptilus africanus* in Bryson & Engelbrecht 2023, and compare with the common, regular progression in passerines Bryson & Engelbrecht 2024; Bryson & Pajmans 2022, 2023; Bryson *et al.* 2023).

9.1 Adult 1 from 1 March 2015

'A ... new series [of moult] may start with [the] innermost [primary], but this does not always happen: apparently, two moult series are never active at the same time, and the innermost primary perhaps does not start before the outer ones are finished, or the outer series temporarily stops when the innermost starts' (Cramp 1983, p. 97 on the moult of the Cream-coloured Courser).

In Figure 19 the different generations of primaries in an individual from March are well distinct. By that, the age of the individual can be determined

approximately. If it was known if single residual feathers can remain unmoulted for more than two seasons, the determination of age could be even more precise.

On the upperparts, three generations of feathers are recognisable. The upperparts are plain, if not for one single marked, thus juvenile feather (from 2013, blue arrow on the right in Figure 19B) and a plain but pale feather from a post-juvenile plumage, older than the surrounding feathers (left arrow).

The inner primaries P1 to P4 have moulted in a first wave of a complete moult (2014), now the inner three primaries belong to a second moult wave (2015), while P5 is resuming the first wave from 2014. The primary coverts are simultaneously moulted with the primaries.

The pointed, very abraded outer primaries P6 to P10 are older than P4, thus from 2013. The outer secondaries have rounded tips which is a sign for at least the second plumage. Compare the pointed secondaries of first-year birds in Figures 18A and 18B.

Based on these criteria, we preliminarily concluded that this individual is in its third year, during its second complete moult although the temporal relation between the growth of P3 and P5 is unclear. Do they belong to the growth of the same season or to two consecutive ones? In the latter case, the primaries would belong to four generations.

The tail includes at least two generations of feathers: two pale rectrices with white tips (presumably R4 and R5, following the white, here missing R6), a growing, grey one with blackish terminal spot, and darker inner rectrices with undefined brown terminal patches, probably the central pair which differs in colour. Compare with the full adult tail in Figures 11 and 21B.

This leads us to the hypothesis that it can possibly take up to four years for a Burchell's Courser to acquire an entirely adult plumage without residual body feathers from the first year.

9.2 Adult 2 from 4 February 2012

Primary 'moult starts with the inner primaries ... shortly after the eggs hatch ... but the primary moult is suspended.... A few individuals moult some more primaries after that, occasionally reaching completion, but the outer primaries usually are retained until next year and some primaries are probably replaced only every two years' (see Figure 19) (Cramp 1983, p. 97 on the moult of the Cream-coloured Courser).

On the wing of this adult (Figure 20) from February, two moult waves and three generations of primaries

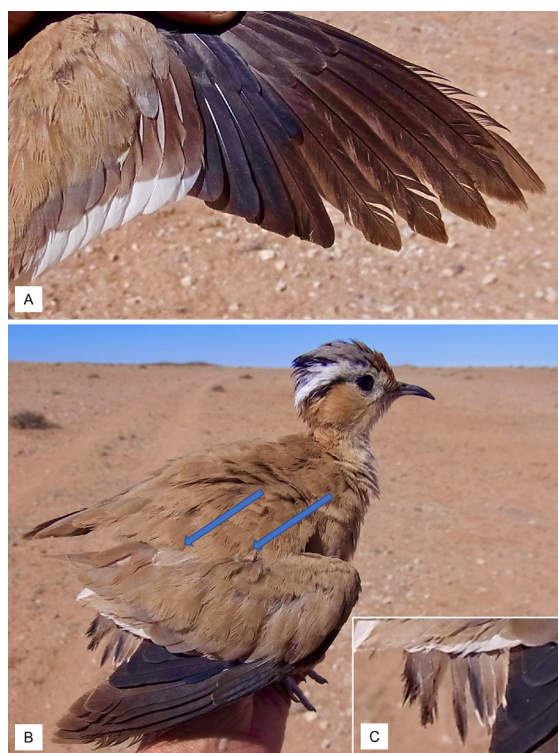


Figure 19: Adult in its third year during primary moult. (A) Wing with three or possibly four different generations of primaries. ML619128271. (B) The blue arrows indicate residual feathers: right from the juvenile, left from a post-juvenile plumage. The remaining upperparts have undergone (at least) one complete moult. ML619128270. (C) Tail feathers of different age groups. 1 March 2015. SAFRING CC79107.



Figure 20: Adult in at least third year. Primary moult with P1 and P2 growing, P3 to P5 from a former generation and P6 to P10 oldest. A white tip shows on the innermost primary. Long tertials indicate adult plumage. 4 February 2012. SAFRING 4H46516, ML619127414.

are visible, with P2 as the only active moulting one. The first wave stopped with P5, now the next wave comprises growing P1 and P2, and P6 to P10 are older but in good condition: dark, dense and hardly abraded (compared to Figure 19A) which makes it



Figure 21: Adult. (A) The wing shows different moulting waves (P1 to P3 with not visible P4 moulting), P5 to P7, and P8 to P10. The innermost primary has a small white tip. The three outer secondaries have round, i.e. adult, tips, the remaining secondaries are sharply pointed. ML619128436. (B) The tail shows an adult, fully black sub-terminal band, white tips. 27 December 2009. SAFRING 497782, ML619128438.

likely that they already have been moulted after the juvenile plumage.

The adult age is also evident by the rather long tertials that reach the end of the tail, rounded, not pointed outer secondaries and the lack of residual juvenile feathers on the upperparts. On the other hand, for a younger adult speak the rudimentary black triangle at the neck (compare to Figure 8); the shape of the outer primaries which are narrower and more pointed than in the older adult with uniform grey tail with white tips from Figure 21B in December; the outer coverts with pale tips and the tail with barred tips of a juvenile plumage (Figure 13C).

9.3 Adult 3 from 27 December 2009

The birds from Figures 21 and 22 are both from December which allows a comparison in moult progress. The individual from Figure 21 is a fully grown adult from December with at least four years of age. The wing shows three moulting waves, the outer one being from an adult. Brown P1 is from a former wave with the actual continuation of darkest P2 and P3, and P4 as a growing pin; fully grown P5 to P7 as

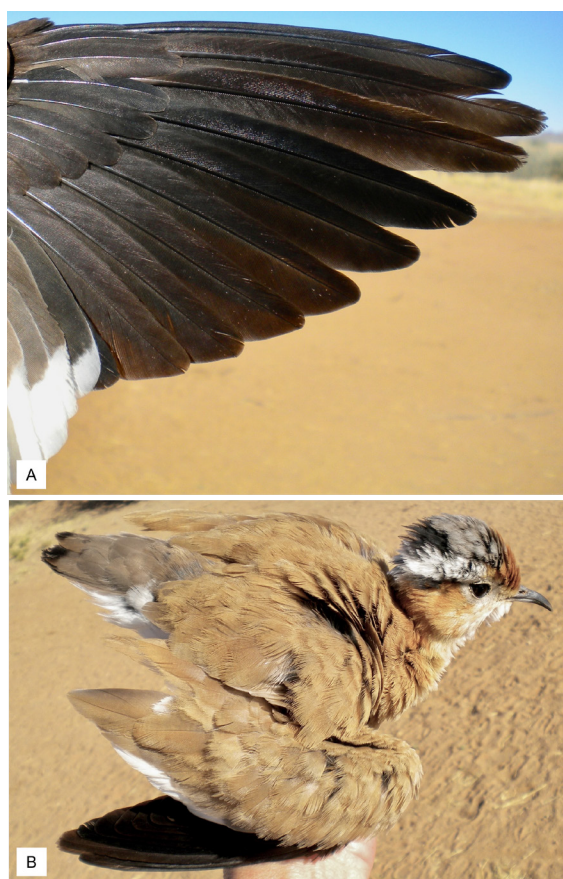


Figure 22: Adult. (A) Wing in primary moult; no white tip on inner primary. Three dark new feathers stand out: fully grown P1 and P7 and growing P10. ML619129152. (B) Uniformly coloured wing, back, rump and tail, the latter having the tips abraded. 12 December 2009. SAFRING 4H35568, ML619129150.

the last feathers from a former wave, seemingly older than P1, but possibly from the same season; and fully grown P8 to P10 as a continuation and completion of this wave.

A white tip shows on the innermost primary (as the individual in Figure 20). Also, the secondaries are moulting. The three outer secondaries are darker, and have round, i.e. adult, tips. The remaining secondaries are sharply pointed, whereby it is not clear if this is a normal adult shape, since these tips are not described.

It is undetermined if the description of Jenni and Winkler (2020b, p. 222) about the serial descendent moult of large raptors and storks can be applied here, too. The ‘time taken for one wave to reach its end at P10 increases with age... With age, the serial moults develop irregularities, such as asymmetries between left and right wing, longer or shorter intervals between the shedding of adjacent feathers’.

9.4 Adult 4 from 12 December 2009

The adult from Figure 22 is a fully grown adult. The wing shows three moult waves ending with P1, P7 and P10, the latter being the only actively growing primary in the wing. It is, though, obviously resuming the outer wave from an earlier year, taking it to completion. P7 is fully grown, the corresponding primary covert is completing its growth, as is the outermost secondary. With three moult waves and P8 and P9 with rounded tips, we hypothesise that the age of this bird is at least four years.

Cramp describes this strategy as a ‘seemingly (but actually not) serially descendent’ moult (1983, p. 97), since at the end of the three waves not all but only one, P10, is in active moult. No white of the tips of the rectrices is visible, in contrast to the other adult from December (Figure 21).

9.5 Adult 5, wing

This said and concluding our research and the photographic evidence of the ‘seemingly serial descendent moult’ of Burchell’s Coursers, we discovered in a private collection a wing from February of a fully grown adult with a de facto serial descending, bi-focal moult with primaries and one corresponding covert growing in both moult centres (Figure 23). This strategy is an addition to the strategy described by Cramp (1983) and our observations.

This variability reminded us of the statement by Jenni and Winkler in their book about the passerine moult: ‘Although most species cluster into distinct moult categories ..., moult strategies can be highly variable within species ... and also between years and within individuals ..., and are apparently

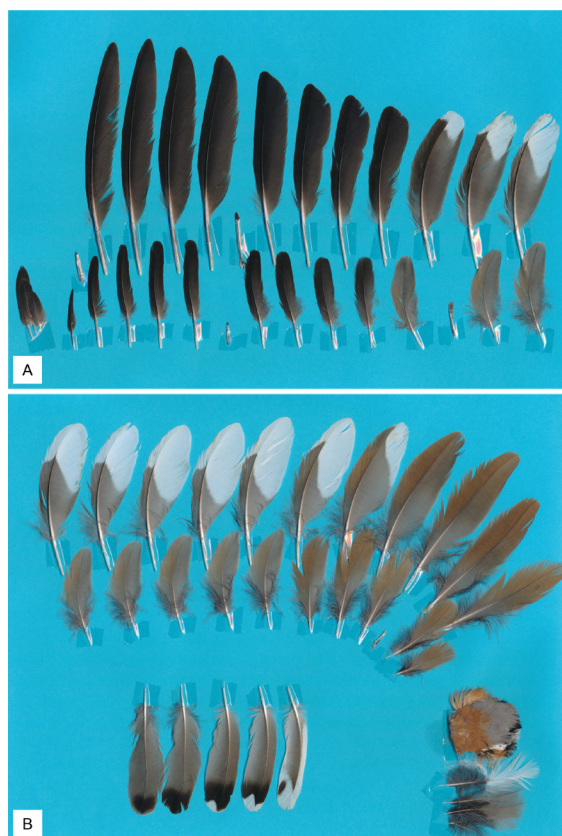


Figure 23: A wing of an adult Burchell’s Courser. (A) Primaries with two active moult centres and three secondaries with corresponding coverts and alula. The outer primaries seem slightly paler and browner, although hardly more abraded than the inner ones. This difference would not justify a whole year of wear. (B) Continuation of the secondaries, tertials, tail, head and body feathers. One tertial and one rectrix (R5?) are missing. February 1967, Namibia. Private scientific collection. © Pascal Eckhoff.

adapted to the ecological conditions specific to the population or individual’ (2020a, p. 47).

9.6 Further moult data

Beyond our own data captured, only two sets of moult data are recorded by SAFRING (2024, unpublished data), both from adults ringed in the Northern Cape in South Africa; one ringed on 23 March 2024 with arrested moult (moult sequence 5555555000) and one from 6 September 2023 displaying ten new primaries (moult sequence 5555555555). Neither of these two individuals had a broodpatch. Considering the complexity of the moult strategy and the similarity in colouration of feathers from different generations (for example in Figures 13 and 15), it seems appropriate to reconsider at least the moult sequence from the March individual. Possibly the moult waves were not recognised as such, as happened to us at the beginning of our studies.

10. FURTHER RESEARCH

Overall, the basic documentation of detailed plumage features, the age development and the physical moult process of the Burchell's Courser shows many gaps or is non-existent.

Following subjects need further exploration and precise description.

Plumage

A detailed description and photographic documentation of the plumage and the changes throughout all ages is needed, including features of a plumage in the second and third year and older, like residual feathers on body, tail and wing. Also, the question of seasonal changes is not yet explored.

Body

Variations in the colouration and the size of the dividing line on the belly should be examined, based on age, sex, season and geography, as well as the overall colouration and progressive darkening of the feathers during the first year.

Head

The size of the brown and the grey area on the crown and the relation to sex should be addressed.

Tail

A detailed description of the variations in tail shape and pattern throughout the first-year and ageing adulthood.

A detailed description of the variations in shape and tail pattern over time and the moulting process should be explored, including a description and comparison of the colouration of the different rectrices.

Wing and moult

Special attention should be directed to the moult progress, including:

- the sequence of the overall moult progress on body and wing,
- the moult strategy during the post-juvenile and adult moult,
- the process of primary moult, including symmetry of both wings, also with progressing age,
- the frequency of primary moult waves, also depending on the age of the birds,
- the duration of the individual moult waves and
- and the duration of the complete replacement from P1 to P10.

Of interest is also how long individual feathers can be retained, especially of coverts and tail, and if the post-juvenile moult process advances slowly and continuously, or if all residual feathers are moulted during the second complete moult.

The understanding of the moult processes allows conclusions about the annual life cycle of the species and the family group. It is a tool for scientific researchers and citizen scientists alike to determine more precisely of age during field observation, as well as in captured individuals and museum skins. Discerning age groups gives insight into the ecology of population. Observing and predicting trends of population dynamics are crucial for the conservation, especially in little known species in decline.

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