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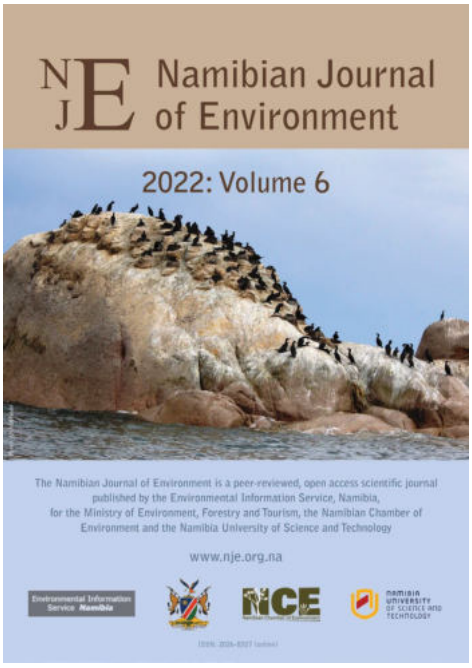

SECTION D: MEMOIRS

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White-crowned Shrike (*Eurocephalus anguitimens*) A. Smith, 1836: comparative biometrics, moult data and criteria for the determination of age

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CONTENTS

ABSTRACT

We present measurement and moult data on the nominate subspecies of the White-crowned Shrike *E. a. anguitimens* from Namibia and South Africa and discuss plumage development through the different age groups. We compare our Namibian observations of the moult process and our records of active brood patches with breeding records (Brown *et al*. 2015) to gain a better understanding of the year's cycle of the species. For South Africa, we show the progress of moult over the months, and note an overlap of moult and breeding in both Namibia and South Africa. We found three distinct plumages in the Southern White-crowned Shrike. Based on photographic evidence, we describe in detail the plumage development through the discernible age groups, from nestling to juvenile and immature to adult and describe criteria to determine a more exact age. We discuss variation in colouration and present observations on site fidelity, longevity and other aspects. This monograph is intended to supplement published data and encourage further discussion and research on plumage, moult and breeding, social structure and site fidelity.

Keywords: age; biometrics; brood patch; white-crowned shrike; *Eurocephalus anguitimens*; moult; plumage; sex

1. INTRODUCTION

Species and subspecies of Namibian birds are underrepresented in research and literature of southern African birds. To help address this shortcoming, we present our observations and our measurements and moult data on White-crowned Shrike (*Eurocephalus anguitimens*; Figure 1), supplementing the information available for this data deficient species and its nominate subspecies. Additionally, we compare our Namibian moult records with breeding data in Brown *et al.* (2015) to place the moult process into the annual life cycle of the species.

We have included data collected by selected colleague ringers, who generously gave us access to their records and with whom we share the same precise method of measurement. In this article we present measurement and moult data from 55 Southern White-crowned Shrikes of the nominate subspecies *E. a. anguitimens*, 22 of them being from Namibia and 30 from South Africa. The research was conducted under a ringing permit issued by the Namibian Ministry of Environment, Forestry and Tourism, and the South African Bird Ringing Unit (SAFRING) permit number 1240, respectively.

2. SITES AND METHODS

Our data on the Southern White-crowned Shrike in Namibia were collected mainly south of the Waterberg (Farm Hamakari), in the Erongo Mountains and the Kunene region (Figure 2). The data on the South African birds were collected in the Northern Province, close to the Botswana border.

2.1 Distribution and sites

Southern White-crowned Shrikes were ringed in **Namibia** near Otavi (19°37'S, 17°11'E), in the Erongo mountains (21°29'S, 15°52'E), near Omaruru (21°20'S, 16°04'E), at the Farm Hamakari (20°36'S, 17°20'E), along the Kunene River, and in **South Africa** at various locations in the Northern Province, mainly in D´Nyala Nature Reserve (23°44'S, 27°45'E) and Platjan (22°29'S, 28°50'E)

Figure 1*: Adult Southern White-crowned Shrike. July 2003, D´Nyala Nature Reserve, South Africa.*

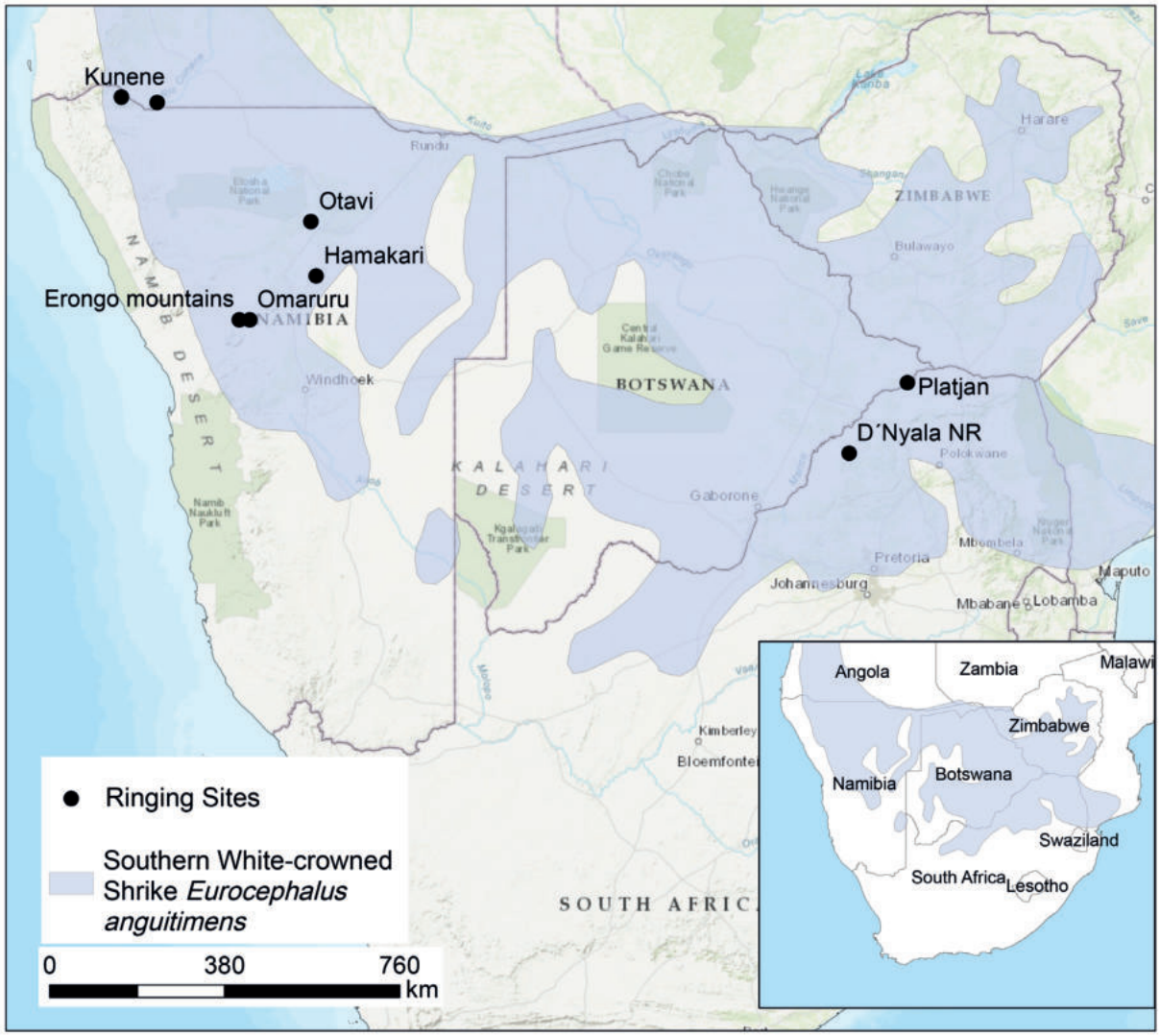

Figure 2*: Distribution of the Southern White-crowned Shrike in southern Africa, downloaded from www.iucnredlist.org on 18 May 2019. Black dots designate sites where data were gathered.*

(Figure 2). Site descriptions and photos are provided in Appendix 1.

2.2 Bird ringing and measurements

Birds were ringed and measured and moult scores were taken in accordance with the guidelines of the South African Bird Ringing Unit's (SAFRING) Bird Ringing Manual (de Beer *et al.* 2001, based on Svensson 1984). The birds' sex was determined, if possible, by the shape and position of the pelvic bones, by cloaca and the brood patch, while being aware of brood patches being found in helpers and smaller patches also in males.

3. CHALLENGES FACED

In Afrotropical species literature, we find considerable gaps in descriptions of plumage by age categories and a lack of more supportive criteria and precise terminology for the ageing of Namibian shrikes. Thus, we oriented ourselves on the Palaearctic literature, concerning ageing and age development.

3.1 Terminology

In general, the terminology to describe the age of birds is far from consistent or clearly defined. Several core terms are used arbitrarily in both a general and a restricted sense. It is hence not standardised and differs across Africa and widely between the continents (Schulze-Hagen 2019). We tried to be consistent in the terms used and as clear as possible, primarily following Harris & Franklin (2000), Jenni & Winkler (2012, 2020) and Shirihai & Svensson (2018).

3.2 Age categories in the Palaearctic and in the Afrotropical Region

The description of the age of Palaearctic birds falls into categories that follow the major seasonal changes. All Palaearctic passerines breed in the northern summer and start moulting thereafter.

Through clear distinction of summer and winter, a clear distinction of the age differences of plumage can be made and named. Young birds can be categorised after calendar years, and at any stage clearly distinguished from adults based on plumage differences.

These categories cannot be simply transferred to the Afrotropical region, since breeding times are variable in many passerine species dependent on a variety of factors, mostly precipitation and the subsequent abundance of food. We use the terms juvenile, immature and sub-adult for birds in their first year of life, and the term "second year of life" for birds with features that allow, as we assume, this specification (see 7. Moult and determination of age).

3.3 Age description

For defining the exact and often approximate age of a bird, the plumages of different developmental stages of Namibian birds, and African birds in general, are not yet adequately researched and described. As first described by Stresemann & Stresemann (1966, p. 10), some species grow, before adulthood, a second set of juvenile feathers, some even a third, which changes into immature plumage during the post-juvenile moult. In some species, the post-juvenile moult sets in before the growth of the juvenile plumage is completed (Dorsch 1993). When handling Afrotropical birds, one can observe how in some species the different plumages can be well distinguished, while in others the moult progress looks more like a continuous process (pers. obs.) (as described for Palaearctic species by Roselaar, pers. com. 2021). These details of juvenile feather growth and moult have not yet been addressed in the African literature.

3.4 Age distinction

The literature on Afrotropical birds generally does not differentiate between the two quite distinctive plumages of juvenile and immature birds, if two different plumages are described at all. For the Southern White-crowned Shrike we could identify two distinct plumages during the first year of life after the nestling age: a juvenile and, after the post-juvenile moult, an immature plumage, which we describe in this article.

A glossary of the terms used for ageing can be found in Appendix 2.

4. SPECIES DETAILS

4.1 Taxonomy

Of two southern African subspecies, only the Southern White-crowned Shrike of the subspecies *E. a. anguitimens* is found in Namibia (N and NE). It also occurs in SW and S Angola and eastwards to Botswana (except SW), in extreme S Zambia, on the central plateau of Zimbabwe, and in N South Africa (W Limpopo and N North West Provinces) (Yosef & International Shrike Working Group 2019, del Hoyo *et al.* 2016).

4.2 Measurements

Table 1 presents the measurements of our samples of the Southern White-crowned Shrike of the subspecies *E. a. anguitimens* taken in Namibia and in South Africa.

Table 1: *Average measurement data (including standard deviation [SD], minimum and maximum) of adult Southern White-crowned Shrikes (*E. a. anguitimens*). Measurements are grouped by sex and location of adult (SAFRING Code Age 4) birds.*

Grouping	Parameter	Wing (mm)	Tail (mm)	Tarsus (mm)	Culmen (mm)	Head (mm)	Mass (g)
Adults SAFRING Code Age 4	Mean ± SD	136.4 ± 3.7	105.0 ± 3.7	25.9 ± 1.2	22.5 ± 2.9	47.5 ± 1.1	64.5 ± 5.4
	Min-max	129-152	97-114	24.4-30.7	17.9-27.6	43-49.7	48.2-76.8
	n	52	51	46	46	49	51
Adults Unknown Sex	Mean ± SD	136.3 ± 4.0	104.4 ± 3.4	26 ± 1.3	21.6 ± 2.7	47.5 ± 1.3	64.3 ± 5.9
	Min-max	129-152	97-114	24.4-30.7	17.9-27.6	43-49.7	48.2-76.8
	n	41	40	35	35	38	40
Adult Males	Mean ± SD	136 ± 1.4	108.5 ± 6.4	26 ± 0.6	25.8 ± 0.6	47.3 ± 0.6	62.6 ± 1.8
	Min-max	135-137	104-113	25.5-26.4	25.3-26.2	46.8-47.7	61.3-63.8
	n	2	2	2	2	2	2
Adult Females	Mean ± SD	137.1 ± 2.8	106.6 ± 4.2	25.6 ± 0.7	25.1 ± 1.6	47.5 ± 0.3	65.7 ± 3.2
	Min-max	133-142	101-112	24.5-26.6	21-26.3	46.9-48	61-72
	n	9	9	9	9	9	9
Adults in Namibia	Mean ± SD	135.6 ± 2.8	105.4 ± 3.8	25.9 ± 0.8	23.9 ± 2.7	47.1 ± 1.2	62 ± 5.2
	Min-max	130-140	100-113	24.5-27.8	17.9-27.6	43-48.6	48.2-68
	n	22	22	19	19	22	22
Adults in South Africa	Mean ± SD	137 ± 4.3	104.7 ± 3.7	26 ± 1.4	21.5 ± 2.6	47.8 ± 1	66.4 ± 4.7
	Min-max	129-152	97-114	24.4-30.7	18.1-26.8	45.9-49.7	58.3-76.8
	n	30	29	27	27	27	29

Table 2: *Extent of primary feather moult of adult Southern White-crowned Shrikes from Namibia. Values are average moult scores of each primary for n number of birds per month sampled. The colour gradient is shown on the side. The tail (t), head (h), body (b) and brood patch (bp) are expressed as a percentage of birds assessed showing signs of moult. Nest count values of the Southern White-crowned Shrike for Namibia are taken from Brown* et al. *(2015). No moult records were collected during the months marked in grey.*

Month	n	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	t	h	b	bp	Nests	Moult Score
Jul	0															0	
Aug	3	0	0	0	0	0	0	0	0	0	0					0	0
Sep	1	0	0	0	0	0	0	0	0	0	0					0	
Oct	0															2	1
Nov	0															5	
Dec	0															6	2
Jan	1	5	4	2	0	0	0	0	0	0	0				100%	7	
Feb	4	5	5	5	4	3	0	0	0	0	0		0%	0%	50%	5	3
Mar	8	5	5	5	5	4	4	2	0	0	0	13%	0%	0%	100%	4	
Apr	0															4	4
May	0															0	
Jun	4	5	5	5	5	5	5	5	5	3	3					0	5

5. MOULT AND BREEDING

Breeding is usually followed by a complete moult, as replacing the plumage is costly. The limited energy resources are invested sequentially in the establishment of territory, mating, egg-laying, breeding and feeding the young. Moult should occur when no other activity has priority (Jenni & Winkler 2020, p. 178). Thus, moult is strongly related to breeding, and mostly indicates the actual status of the bird in its annual cycle. Similar to all sedentary shrikes, the White-crowned Shrike generally should undergo a single complete post-breeding moult (Yosef 2008). The sequence follows the normal passerine descending pattern (Tables 2 and 3).

Young Southern White-crowned Shrikes fledge about 38 days after egg-laying, following 18-20 days of incubation (20 days considered being too long by Tarboton 2014) and 19-20 days for the nestling period (Harris & Franklin 2000, Tarboton 2014).

Figure 3: *Southern White-crowned Shrike on its nest in the Etosha National Park in August, which is a breeding event out of the recorded season for Namibia. August 2017. Photo courtesy of Billi A. Krochuk.*

6.TIMING OF BREEDING AND OVERLAP WITH MOULT

Moult onset varied between the Southern White-crowned Shrike populations in Namibia, Botswana and South Africa. The samples were small, and many variables may play a role, particularly occurrence and beginning of precipitation in different regions and years, and individual differences in the annual reproduction cycle.

6.1 Namibia

6.1.1. Nesting dates

In Namibia, egg laying has been recorded between October and April (Brown *et al.* 2015; Table 2). In the data base of Jarvis *et al.* (1999), eggs were recorded from November to early May, while the majority of records, 49 of 57, were from January to May.

We found one photographic record of an adult breeding in August in the Etosha National Park which is an exceptional early timing for the species (Figure 3).

The females in our study had fully active brood patches from the end of January until mid-March (Table 2) which corresponds with the nesting data of Brown *et al*. (2015). We did not collect data for this species in April.

6.1.2. Overlap of nesting dates and moult

At the same time we observed that the process of moult in our sample, as depicted in Table 2,

overlapped with the egg laying data of Brown *et al.* (2015).

6.1.3. Overlap of brood patches and moult
This corresponds with our findings from the months January to March when we examined ten females and males for brood patches, all of which were in moult. Of 21 adults, the moult of the first primary feather was completed in January. Five of these were displaying full brood patches, while the other five showed receding ones.

6.1.4. Post-breeding moult and brood patches in family/helper groups with young
In Namibia, we recorded family/helper groups, with one or two begging young, from the beginning of February to mid-March.

On 3 February 2010, one young bird was observed together with five adults. Three adults were ringed and showed primary moult: two with a moult score of 25 (5555410000) and one with a moult score of 20 (5554100000) (mean score 23), while the young, in partial juvenile moult, showed no primary moult. This group was not checked for brood patches.

On 13 March 2019 one begging young was seen with four adults. Two of the adults were ringed and showed a moult score of 31 (5555542000) and 29 (5555540000) (mean score 30) and still a brood patch, which we considered on our scale as "fully" active by colour, swelling and skin quality. By recording the moult, it became clear that one of them was a full, older adult, while the second must have been a younger adult, maybe a helper. (See the discussion and figures below in 9.5. Wing feathers and wing moult in young and adults: shape, length, colour and density).

This second bird showed the same quality of brood patch as the older adult, the possible dominant female. From these parallels in brood patches we formed the hypothesis that, during the breeding and fledgling period, the hormonal status in helpers corresponds with those of the egg laying and breeding birds. Active brood patches can be seen in individuals which are not the main breeders, such as males in several species (Thiede 1985, p. 118-122, pers. obs.), and in parasitising cuckoos that do not brood at all (pers. obs.).

On 4 March 2020, from a group of eight adults and three young, six adults and two young, were ringed. All adults were moulting the wing, five with decreasing, one with still fully expressed brood patch. Two individuals had four new primaries, four individuals six, and one seven primaries fully replaced (moult scores from 26 to 39, mean score 32).

6.2. Botswana
For northern **Botswana**, Traylor (1965, p. 369) reported that "breeding appeared [to be] over in mid-January" and that wing and tail moult was half completed. This is when the nesting records for the Namibian birds start to peak, and when the birds in our sample had completed the moult of their first primary feather (Table 2).

Skinner (1995 in Dean 2005) collected eight breeding records from October to January, and again one for April. This sequence of timing can be understood with rainfall starting later the further west and south, and thus the length of time it takes from the start of the rainy season to achieve a certain cumulative amount of rain. In higher rainfall areas the amount of rain effective enough to trigger breeding is achieved more quickly - often in the first month. In more arid areas it may take two or three months of cumulative rain to reach the "effective" tipping point - which compounds the delay in breeding (Chris Brown, pers. com. 2021).

6.3. South Africa
In the NE of South Africa, where both southern African subspecies occur (*E. a. anguitimens* in the west and *E. a. niveus* in the east), Tarboton *et al.* (1987, p. 237) recorded egg-laying only in October, November and December. More recently Tarboton (2014) notes that the laying dates are mainly October to December with extension from September to April, earlier than in Namibia. We noted in our study that the primary moult in **South African** birds also started earlier than in Namibian birds (compare Table 2 and Table 3). Here too, our moult data show an overlap of moult with the breeding data of Tarboton (2014), like in our Namibian sample.

Our sample of moulting Southern White-crowned Shrikes in South Africa is small and prone to reduced statistical significance when one individual shows irregular moult. The overall pattern matches the findings from Namibia, with breeding in the southern summer months and the usual post breeding moult starting during the breeding activity. No moult has been observed during the southern winter months (August/September and July/ August). These samples of breeding and moult are very small and more research is needed.

7. MOULT AND DETERMINATION OF AGE

The plumage and moult features particularly, give clues about the age of a bird.

First year phases and corresponding plumages in typical shrikes (Laniinae) are: nestling, juvenile, post-juvenile moult (Cramp & Perrins 1993, p. 443) and post-juvenile plumage, which we call immature

Table 3: *Extent of primary feather moult of adult Southern White-crowned Shrikes of the subspecies* E. a. anguitimens *from South Africa. Values are average moult scores of each primary for n number of birds per month sampled. The colour gradient is shown on the side. No moult records were collected during the months marked in grey.*

Month	n	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	t	h	b	bp	Nests	Moult Score
Jul	17	0	0	0	0	0	0	0	0	0	0						0
Aug	1	0	0	0	0	0	0	0	0	0	0						
Sep	0																1
Oct	0																
Nov	2	3	4	3	1	0	0	0	0	0	0						2
Dec	0																
Jan	2	5	5	5	5	4	1	0	0	0	0						3
Feb	3	5	5	5	5	5	4	2	1	1	0						
Mar	0																4
Apr	0																
May	0																5
Jun	0																

plumage following Harris & Franklin (2000, p.50). Passerines reach adulthood and maturity when entering their second year of life (Bub & Dorsch 1988, p. 7).

In their first year, young Southern White-crowned Shrikes are clearly distinguishable as non-adults by the colouration of bill and gape flange, plumage features (colour, quality, density, existing abrasion and wing moult limits or lacking thereof, shape of wing and tail feathers) and other features like leg colour and quality of the skin, softness of the skeleton, behaviour and wear of the bill.

With a complete moult of birds of all ages after the breeding period of the adults, generally young passerines tune into the moult cycle of adults, although with much variation.

Occasionally, residual feathers of the juvenile plumage can be found in a freshly moulted adult bird. These indicate the age, the second year, of this individual. From the third year on, it appears that the features of the plumage can no longer be used to identify the exact age of Southern White-crowned Shrikes.

8. DEVELOPMENT FROM JUVENILE TO ADULT

All the photographs below if not otherwise credited were taken by the authors and show Southern White-crowned Shrikes (*E. a. anguitimens*).

8.1. First year

First year development is only occasionally described for passerine species in southern Africa. This includes the time frames in which young Southern White-crowned Shrikes pass through the different phases and plumages over the first year, and how the plumage develops through the months. The sequence in which the different areas of plumage are moulted during ageing has yet to be examined, and whether there is a determined sequence at all.

Harris & Franklin (2000, p. 140) describe juvenile and immature plumage of the White-crowned Shrike, both descriptions being merged in Dean (2005). It appears that in the White-crowned Shrike the transition from juvenile to adult plumage is a continuous one (pers. obs.). This concurs with Palaearctic Laniinae as stated by Cramp & Perrins (1993, p. 443) and Kees Roselaar (pers. com. 2021) who describe the post-juvenile moult of Palaearctic Laniinae as "very gradual", starting "shortly after fledging", while later growing feathers are "progressively resembling adult breeding plumage more closely." See more details on this transition in Jenni & Winkler (2020, pp. 43-45).

During this development from juvenile and immature, the age of the Southern White-crowned Shrike is recognisable by such features as the beak colour, the colouration and extent of the gape flange, the extension of the black ear coverts, and the colour and growth of the bristles above the beak. Additionally, the crown of the head and underbelly change colour.

8.1.1. Juvenile age

The juvenile plumage is described in Harris & Franklin (2000, p.140) as brown with pale ash-brown head and back and cream coloured nape and underparts. The brownish-black face mask is still much reduced and lacks the dark ear coverts, while the bill is pale. We observed that the nestling shows a light-yellow bill and a light brown chest well divided from a white belly (Figure 4). It seems that these differences belong to different stages in the development of the juvenile. Of interest might be studies about the possible second and third set of

juvenile feathers (Gwinner 1969, Berthold *et al.* 1970, p. 311, Dorsch 1993), and the result in the phenomenology of the birds.

When out of the nest, the juvenile bird acquires continuously more and more adult features: a darker bill, bristles on the forehead, which are still dark, first markings of the black mask and of a white chest. We estimate, by gape flange, beak colouration, plumage features and behaviour, that the birds shown in Figures 5 and 6 were only a few weeks old. The sequence of the body areas undergoing moult and the exact allocation of plumage to determine the age will be possible only through continuous observation.

Figure 4: *The nestling, about two weeks old and still in the nest, shows a dark mask, grey cap, buff chest and belly, white underbelly, dark brown wings, orange-yellow beak and protruding bright orange gape flange. Etosha National Park, November 2016. Photo courtesy of John Drummond.*

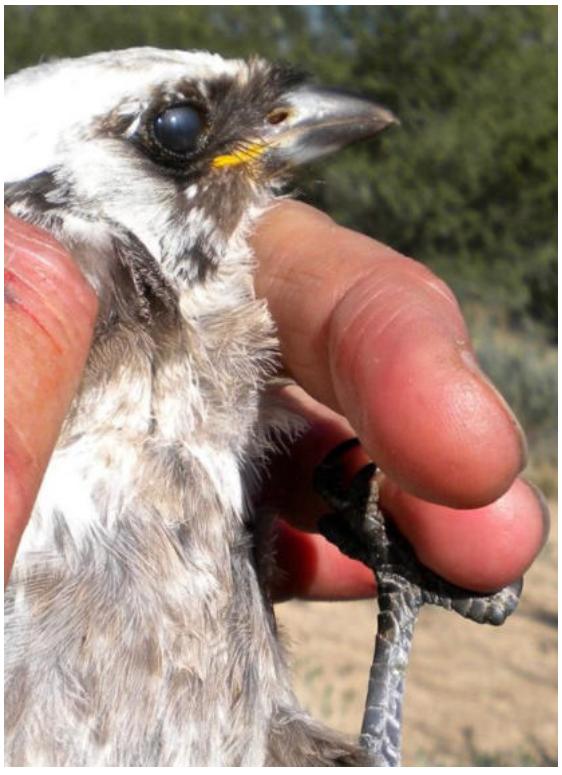

Figure 5: *A juvenile in transition to immature plumage during its post-juvenile moult. The cap is mainly moulted from grey to white, the first black ear coverts are appearing, throat and chest show the immature, and later adult, white feathers, while the belly is still mainly juvenile ash brown. February 2010.*

8.1.2. Post-juvenile moult and immature age

Immature birds have passed their post-juvenile moult, but still show features of young birds in the first year of life (Figure 7).

With growing age, the gape flange recedes, and the bill gains a uniform blackish colour. Main plumage features which distinguish this age group from juveniles are the black ear coverts and the white bristles above the beak. The white chest and brownish underbelly show a distinct contrast, and the median coverts start moulting (Figure 8).

8.2. Adult

Passerines older than one year, with predominantly final plumage, are called adult birds (Bub & Dorsch 1988, p. 7). Adult White-crowned Shrikes display a brown, white and blackish plumage (Figure 9) although variations occur. During proceeding age, certain features become more expressed (for example the black frontal bow of the wing in male Cape Sparrows *Passer melanurus* pers. obs.), while

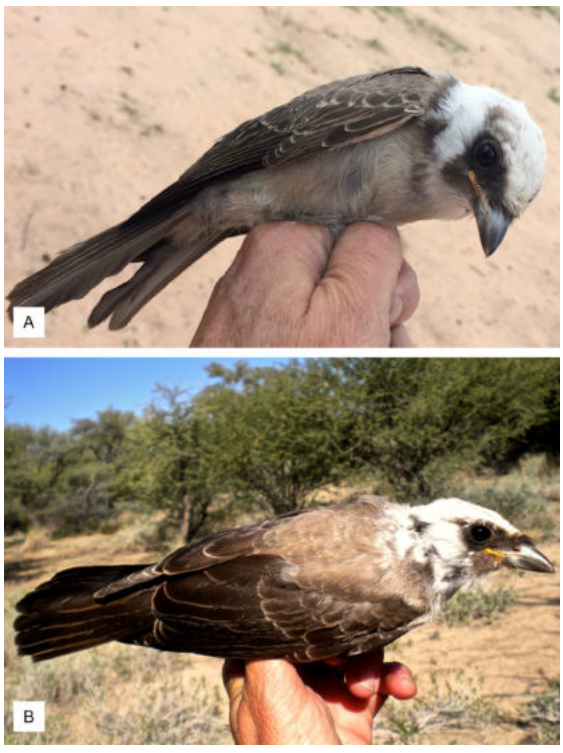

Figure 6: (A) *Under- and* ***(B)*** *upperparts of two juvenile White-crowned Shrikes with brown plumage, buffy edged tail feathers, wing with buff fringes on primaries, secondaries, primary coverts and mantle feathers; still lacking dark ear coverts; yellow gape, beak dark horn with lighter base. March 2020 and February 2010.*

other features fade away due to the hormonal processes in advanced age (for example the red colouration of the breeding male of the Southern Red Bishop (*Euplectes orix*).

At this point of knowledge and research, we can only hypothesise that the differences in adult plumage are related to the age of the bird, in our understanding between second year and older birds. Other hypotheses extend to the dominance in the group, which again, could be related to age, rank and the breeding experience of the individuals.

Figure 7: *First year bird in transition to adult with receding gape flange and white bristles on the forehead. The uniformly coloured bill is still horn, not black as in immatures and adults, the dark neck band is developing. A distinction of white upper and light brownish underbelly is visible. Botswana, February 2006. Photo courtesy of Grant Reed.*

Figure 8: *First year bird after its post-juvenile moult: the two dark and only thinly fringed new inner median coverts contrast clearly in colour and abrasion from the neighbouring coverts. The crown is now all white and well formed, as are the fresh black ear coverts with a few tiny whitish residual juvenile feathers in between. The front bristles are almost all white, but still short, the bill is still not black. Waterberg, Namibia, May 2019. Photo courtesy of Augusto Faustino.*

9. FURTHER CRITERIA FOR DETERMINING THE AGE

For the White-crowned Shrike we document with photographic evidence the development of the front bristles and of the colouration of the bill. The subsequent features, too, were identified during our field observations and for further discussion and research: the feather ring around the eye, the colouration of the underparts, the variation of grey and brown colouration, shape, length, colour and density of wing feathers and residual feathers from a former plumage.

9.1. Development of the front bristles and of the colouration of the bill

With the birds in the hand, we could feel the feather structure above the bill towards the crown. Adult Southern White-crowned Shrikes as well as adult Magpie Shrikes (*Urolestes melanoleucus*) have stiff bristles. In juveniles, these bristles are dark and softer, in adults white and hard, possibly increasing in length with age (Figures 10A and 10B).

In fledglings, the bill is orange yellow (Figure 4), while in juveniles it turns horn coloured, often with darker tip (Figure 10A). In adults, the bill is fully black (Figure 10B).

9.2. Feather ring around the eye

The white ring of tiny feathers around the eye (orbital feather ring), is absent in juveniles. First, the upper half grows, then the feathers behind and below the eye. It is never a complete circle. We counted in full adults mostly seven or eight white feathers in the back of the lower half, which might create a quarter of a circle, while presumably younger adults throughout showed only a few of these feathers (Figure 11). It is unclear at what age the growth is completed (Figure 12).

Figure 9: *Adult White-crowned Shrikes in early February in post-breeding moult in plain, light and dark brown and white plumage with black bill and face mask, white, long front bristles and plain wing. The median coverts and the alula are already moulted, as are some primaries. Primary moult score 22 (5554300000). Otavi, Namibia, February 2005.*

In the process of moulting, the orbital feathers are replaced and thus cannot serve as an additional criterion for ageing during this time (Figure 13).

9.3. Colouration of the underparts of juvenile, immature and adults

We observed that the underparts are changing in colouration throughout the first year from a light brown chest with white belly in the nestling (Figure 4) through a uniform grey-brown underbelly in juvenile (Figure 6A) to a white chest, creating a clear contrast to the ash-brown underbelly in immatures (Figures 14A and 14B), which appears to darken with age (Figure 15).

Adults do not show strongly contrasting edges of the wing feathers, but mostly a plain wing and a continuous band from the mask over the neck to the mantle (compare the immature from Figure 14B with the adults from Figure 15). We hypothesise that the intensity of the underbelly might be a sign of age, thus 15A being a second year bird with pale and 15B being an older adult with clearly brown underbelly. See also the discussion below in 9.4. Variation of grey and brown and 9.5. Wing feathers and wing moult in young and adults.

Figure 10: *Comparison of* ***(A)*** *a juvenile in transition to immature and* ***(B)*** *an adult Southern White-crowned Shrike. The juvenile is in post-juvenile moult with bright yellow gape flange and horn coloured bill; head white with remaining brown juvenile feathers and very first feathers of immature black ear coverts and mask; front bristles dark. The adult has a black bill, a white crown, black lores and ear coverts, a brown neck, a white throat, and white front bristles. Compare also the smooth, shiny surface of the bill in the juvenile with the battered one of the adult, and the shape difference of head and bill. February 2005.*

9.4. Variation of grey or brown colouration

Adults show almost plain lighter backs and plain darker wings with thin light edges on the feathers, best visible from close by. The mask is blackish, the crown white, the bill jet black.

We observed a colour variation between brownish and greyish individuals (as in Figures 16A and 16B). More research is needed to define if this variation is due to age, season and wear and moult, genetics, group or individual differences, sun bleaching or other causes.

During further studies, at the same location, during the same ringing session and in the same group, we found substantial colour variations in two adults (Figure 17). This raised the question of this being the possible expression of two different age groups. The moult progress was almost identical (with primary moult score of 29 and 31 (Figure 17). See also the discussion in 9.5. Wing feathers and wing moult in young and adults.

It would be interesting to follow these individuals through longer time periods to see if the colour is a constant feature or if is subject to change.

Figure 11: *Comparing the orbital feather ring:* ***(A)*** *Juvenile, still without orbital white feathers. March 2020.* ***(B)*** *Adult with three growing orbital feathers in the lower half. This is presumably a second year bird, since one residual median covert from the first year is still present after a complete moult. Both Waterberg area, Namibia, March 2019.*

9.5. Wing feathers and wing moult in young and adults: shape, length, colour and density

The overall view of the wing and the features of its feathers hold information for determining the age of a bird. These features are signs of moult, like moult limits or lacking thereof; contrast of colour between feather groups or individual feathers; bleaching, abrasion and general wear; the quality, mainly the density, of the individual feathers and the shape of the wing and the tail feathers.

In juvenile and immature Southern White-crowned Shrikes, the fringes and tips of all coverts and the tips of the remiges are distinctly contrasting, while in adults the fringes are expressed only slightly.

During the nestling and juvenile development, the whole wing grows quickly.

Consequently, the feathers are similar in colour, shape, size and state of abrasion. The feathers on the brownish rump are fringed buff (Figure 18). Additionally, the wing shape seems to change with age: Before adulthood, the outer primaries are considerably longer than the inner primaries (compare Figures 18 and 19 for juvenile vs. adult wing).

In adults, we did observe noticeably different moult features during the same month.

From a family/helper group in mid-March 2019, with one young still being fed, two fully grown birds were caught. Although the primary moult scores were close, 29 and 31, the wings showed major differences, which made us hypothesise about two different age groups (Figures 20A and 20B). Considering its plumage features, we presume that 20A is a second year bird, while 20B appears to be an older adult.

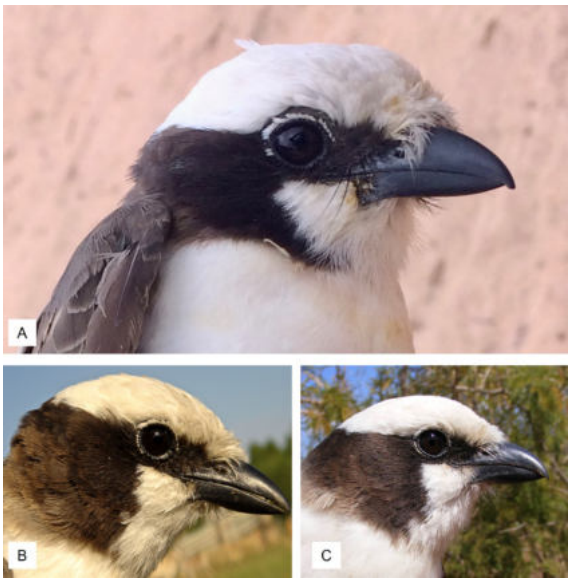

***Figure 12**: **(A)** Compare the presumably young adult (from Figure 10A) showing two tiny white orbital feathers in the lower half with two fully grown adults, with more complete orbital feathering. Waterberg area, Namibia, March 2020. **(B)** Otavi, Namibia, February 2005. **(C)** Hoedspruit, South Africa, July 2010. Photo courtesy of Kobie Raijmakers.*

***Figure 13:** We ringed this adult during its complete moult in mid-February. The alula is moulting (2-0-1), as is the wing with primary moult score 25 (5555410000). Some coverts, now dark, have been replaced. Of the lower orbital feathers just one was fully grown, while the one further up was in pin. Erongo, Namibia, February 2010.*

***Figure 14:** Comparison of the colouration of the underparts of two first year birds: **(A)** Underparts of a still begging juvenile with soft, loose feathers: pale brown from the white throat to the tail coverts. March 2020, Waterberg area, Namibia. **(B)** Underparts of an independent, self-feeding immature, age determined by the prominent fringes on the ends of the coverts, the completely white chest and clearly separate pale grey-brown underbelly; bill all blackish, still with thick, by now darkening, gape flange. Etosha, Namibia, July 2004. Photo courtesy of Augusto Faustino.*

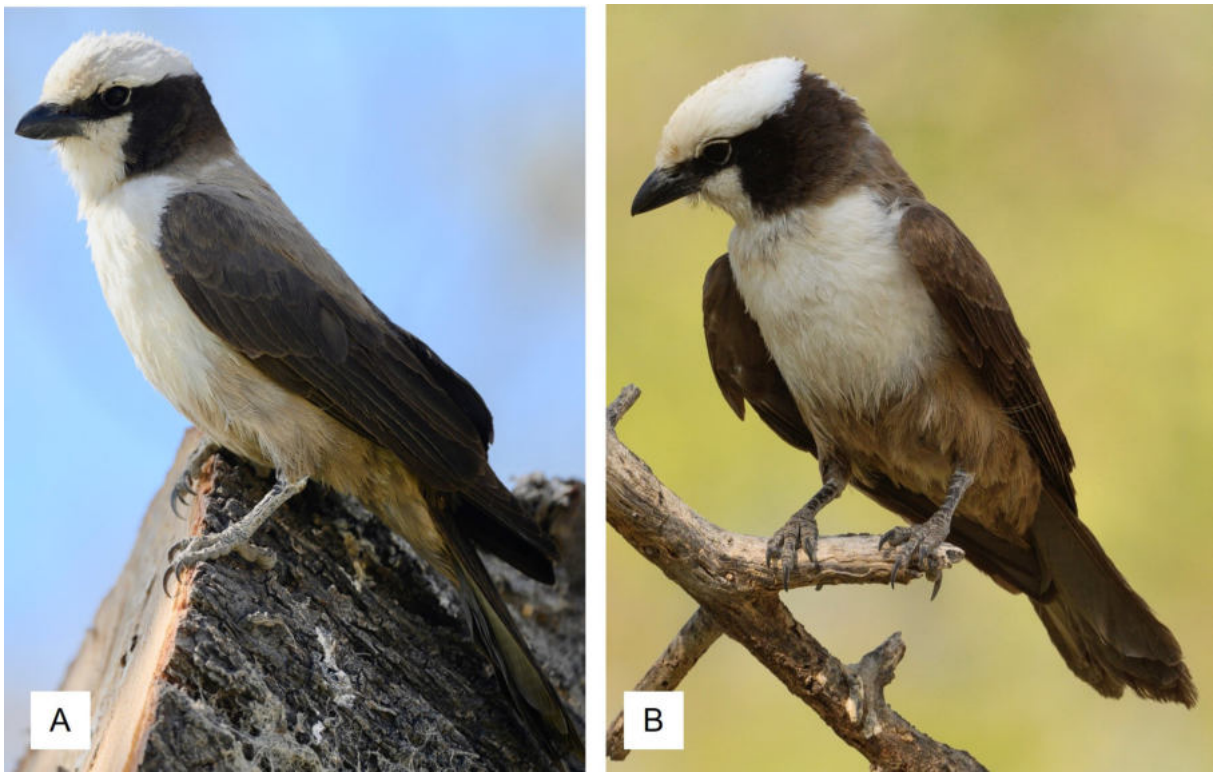

Figure 15: *Comparing the underparts of two adults from end of August:* ***(A)*** *with pale and* ***(B)*** *with darker, well contrasting brown underbelly. Etosha National Park and Oshikoto, Namibia, August 2019. Both photos courtesy of Peter Hawrylyshyn.*

Figure 16: *Comparison between two adult Southern White-crowned Shrikes:* ***(A)*** *Adult with brown plumage and a distinctive brown underbelly vs. white chest in post-breeding moult. March 2020, Botswana. Photo courtesy of Grant Reed.* ***(B)*** *Presumably younger individual with grey plumage. Mokuti Lodge, Oshikoto, Namibia, August 2017. Photo courtesy of Billi A. Krochuk.*

In the open wing one can see the differences of shape and colour of the primaries and secondaries, including the tertials: Compared to 19B, the bird of Figure 19A shows paler unmoulted primaries (P7 to P10) while the already moulted primaries (P1 to P6) are more pointed and slimmer. Especially the secondaries, including the tertials, show

Figure 17: *Two adults from the same family/helper group:* ***(A)*** *with brown and* ***(B)*** *with greyish overall plumage. Both Waterberg area, Namibia, March 2019.*

considerable difference in shape, becoming broader and rounder with age. Also, the moulted remiges of 20A are still more transparent and don't yet have not yet the dark colouration of the second bird. It is known that the typical juvenile wing shows in most passerines "slim and pointed" versus "broad and round" remiges in adults, while a great variation of these expressions is possible (Pascal Eckhoff, pers. comm. 2021).

9.6. Residual feathers from a former plumage

In migratory Laniinae, we quite often find residual feathers in the freshly moulted plumage, which help to determine the birds first two years of life. From the third year on, plumage differences seem to have abated, so that a precise ageing is no longer possible.

Although not as common as in the migratory Laniinae, which are subject to a stricter time regime due to the migratory windows, we found old feathers in a fresh plumage, mainly in the lesser coverts.

10. SITE FIDELITY, LONGEVITY, RECAPTURES AND GROUP COHESION

All our data refer to small samples and thus give only a first view into this quite unexplored field of the White-crowned Shrike.

10.1. Site fidelity

Southern White-crowned Shrikes are sedentary (Lefranc & Worfolk 1997). This reflects in the records of recaptured birds in the SAFRING database: Out of 460 individuals ringed prior to 2020, 19 were retrapped. All but three were found at the very same location as the first ringing. One had moved an astonishing 392 km in 141 days, one 5.5 km in 980 days, and one was recovered 253 km from the ringing site after 849 days.

10.2. Longevity

Three birds were refound in the first seven days, five in the first year, four in the second and third year, one in the fourth, two in the fifth year and finally one after six years and 2 months (2,248 days).

10.3. Recaptures

Four of the 19 were recaptured twice, all at the original site. The bird with the SAFRING ring number 594922 after 352 and 2,248 days, number 4A17216 after 371 and 1,140 days, number 4H47937 after 1,773 and 1,774 days, and number D93836 after 713 and 857 days.

10.4. Group cohesion

Two individuals ringed together on 17 January 2002, Safring ring number D49154 and D49155, were both retrapped at the same location seven months later, on 31 August 2002.

Figure 18: *Wing of a juvenile, the same individual as in Figure 6B, with uniformly coloured, only slightly abraded primaries, secondaries and coverts with contrasting fringes and tips and pointed, fringed tertials. The feathers on the rump still show lighter coloured fringes. February 2010.*

Figure 19: *Compare the wings of these two individuals which were ringed on the same day in mid-March and belonged to the same group.* ***(A)*** *This wing of a possibly second year bird shows a moult score 29 (5555540000), secondary moult (410455) and tertial moult (5-1-1).* ***(B)*** *This wing shows a presumably older adult of unknown age with primary moult score 31 (5555542000), secondary moult (540005) and completed tertial moult (5-5-5). The moulted primaries and secondaries, including the tertials, are visibly broader and rounder than in (A). Also, the feathers are darker and less transparent, which hints to a higher feather density, a sign of an older bird. Both Waterberg, Namibia, March 2019.*

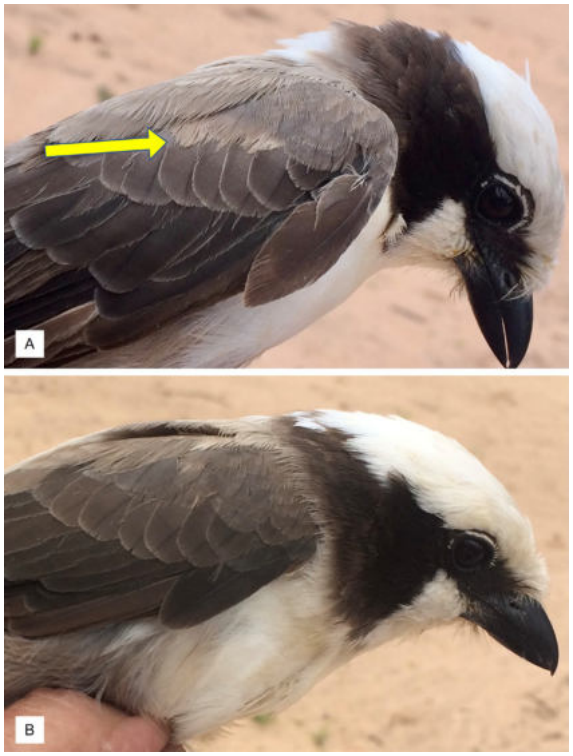

Figure 20: *Comparing the coverts of two birds out of the same family/helper group, ringed at the same day.* ***(A)*** *Example of pale and worn residual feathers in the lesser coverts from the former first year plumage. This fact indicates that this individual is in its second year, as does the low number of orbital feathers.* ***(B)*** *Uniform coverts of a presumably also second year bird. Both Waterberg area, Namibia, March 2020.*

11. FURTHER RESEARCH

Much is still unknown about this species and for a fuller understanding further research is needed on issues like the occurrence of moult over the course of a calendar year; the overlap of moult and breeding; residual feathers from a former plumage; the feather ring around the eye; the development of wing feathers to full adulthood; the colouration of the underparts and factors for differences in the overall tone of the plumage colouration; the plumage and the feather quality of second year birds; the development of well distinguished plumages vs. a continuous moult progress, the sequence of the body areas undergoing moult. Furthermore, questions about the social structure of this species need research concerning hierarchy in the family groups, the age of the helpers (second year birds or older adults), breeding pair fidelity, duration of group cohesion, site fidelity and longevity.

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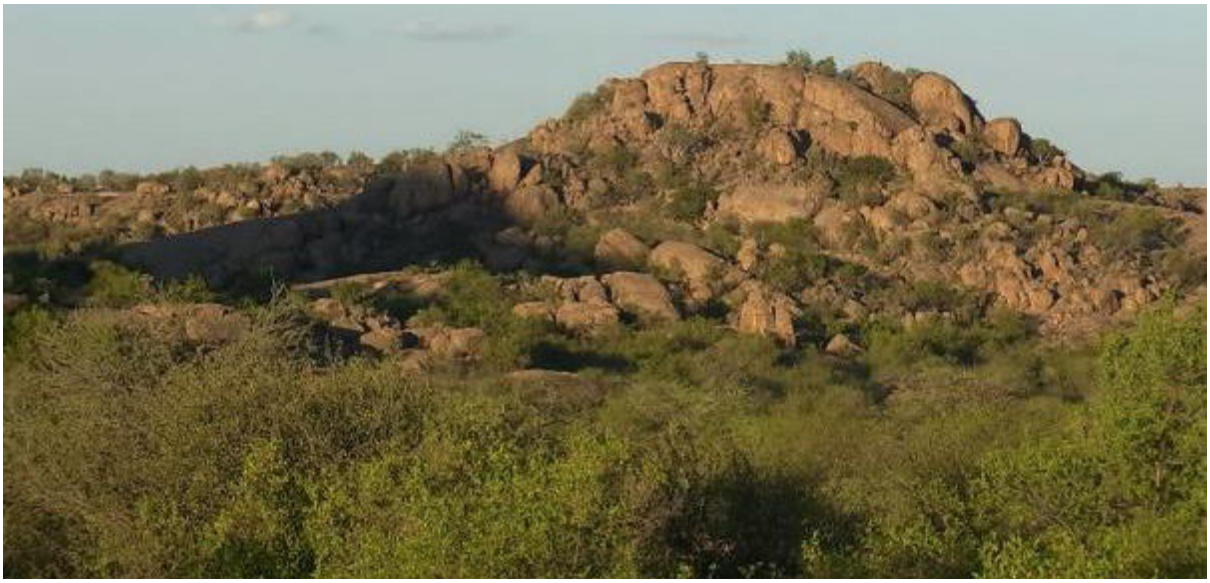
APPENDIX 1: SITE DESCRIPTIONS

The locations are sorted by country, then in alphabetical order. Site descriptions and dates are noted below each photograph.

1.1. NAMIBIA

1.1.1. Erongo Mountains (21°29'S, 15°52'E)

Landscape 1: *Arid savanna with dry riverbeds after good rains. March 2017.*



Landscape 2: *Mountain valley in the Erongo Mountains. January 2016.*

1.1.2. Farm Hamakari, south of the Waterberg (20°36'S, 17°20'E)

Landscape 3: *Savanna and mixed woodland. February 2019.*

Landscape 4: *Riverine growth. February 2019.*

1.1.3. Kunene region

Otjitafel (17°11'S, 13°35'E)
Hippo Pools (17°24'S, 14°13'E)
Ehomba (17°30'S, 13°49'E)

1.1.4. Otavi, Farm Dabib (19°37'S, 17°11'E)

Landscape 5: *Savanna, brushland-woodland mixture and grassland. June 2007.*

1.2. SOUTH AFRICA

1.2.1. D´Nyala Nature Reserve (23°44'S, 27°44'E)

Savanna and mixed woodland.

APPENDIX 2: METHODS

For more detailed descriptions see Svensson (1984) and de Beer *et al*. (2001).

2.1. MEASUREMENTS

The following biometric measurements were taken:

Wing: Stop rule used to measure longest extent of the flattened wing (mm).
Tail: Rule used to measure from the tip of the rectrices to the root of the central pair (mm).
Head: Callipers were used to measure from the back of the head to the tip of the beak (mm).
Culmen: Callipers were used to measure from the skull to the tip of the beak (mm).
Tarsus: Callipers were used to measure from the notch of the intertarsal joint to the end of the tarsometatarsal bone, bending the foot downwards to approximately 90 degrees to the tarsus (mm).
Mass: An electronic gem scale was used (to the nearest 0.1 g).

For biometric measurements, recaptures were not reported.

2.2 MOULT

The following moult scores were recorded whenever possible:

Active moult of the 10 primary feathers, given by a score of 0 to 5.
Active moult of head, tail and body, based on absence or presence of moult (yes/no).

2.3 SEX

Sex was determined by distance and shape of the pelvic bones, existence and size of a brood patch, and, if possible, by the cloacal shape. When the **brood patch** was scored, it was determined as absent, or during its development, as starting, full and post-breeding. For the determination of sex, we used only the data of a fully developed, active brood patch.

The brood patch is likely to develop shortly before incubation starts, in females always, but also in males to an extent that, often but not always, corresponds with their active participation in breeding. The brood patch lies between the two ventral feather tracts (*pterylae*) and is not feathered or only irregularly with downs (*apteria*) (Duquet & Reeber 2020, p. 20, Thiede 1985, p. 112). The skin of the area, on which the bird has contact with the eggs, falls naked and looks swollen, as it thickens and non-inflammatory oedema develop, and, as the blood vessels increase in size and number, the skin turns dark red. When the young have hatched, the area starts returning to normal conditions. The naked patch shrinks, the skin becomes paler and finely wrinkled; then dry scales appear. Shortly after fledging of the young, the skin has returned to normal, while the new feathering on the belly will occur only during the next complete, post-breeding moult, which might start soon after breeding (Svensson 1984, p. 38-39, and pers. observations).

From the quality of a brood patch the timing of breeding can be estimated and calculated (Brown & Franke-Bryson 2016).

For more information on the position, timing, functions and other details see Thiede (1985).

2.4 AGE

2.4.1 General determination of age

Age was determined by plumage features (colour and pattern of feathers; moult features, abrasion, feather quality, shape of remiges and rectrices, colour and development of frontal bristles); beak colouration, shape and wear; gape flange colour, extent and quality; leg skin colouration and its softness/dryness, and mainly by a combination of the above features.

Feather quality

The first plumage, in its first and second feather generation, is often still of lower quality. This shows in more transparency of the flight feathers and shafts less stiff than those of adult birds. The body plumage is less dense

and smooth, but softer and more uneven. The barbs of the individual feathers are looser. On the head , chest, flanks and rump the feathers are fluffy ("hairy"), and thinner and shorter in the neck.

Even in second year birds, the plumage quality seems still lower than in older adult birds. We deduct this from the observed density of feathers and the more intense wear and bleach of our presumably second year birds compared to full adults. It would need specific research to confirm or reject this hypothesis.

2.4.2 Glossary for ageing and moult

The glossary is a summary, among others, of Stresemann & Stresemann (1966), Bub (1981), Kasparek (1981), Shirihai & Svensson (2018). See there for more details, or also Jenni & Winkler (2012).

"Adult" describes a mature bird with clearly defined plumage. This term corresponds to the SAFRING ageing code of 4.

"Juvenile" refers to an individual with its first feathered plumage after down plumage, or as Pittaway (2000) puts it: "Juvenile has a precise meaning: It is the first immature plumage."

In the process of acquiring their final plumage, birds can grow a **second generation of juvenile plumage** (Bub 1981, p. 119, Jenni & Winkler 2012, p. 29). In a more general sense, as often found in the literature, the term "juvenile" is also used to distinguish young from adult plumage.

"Partial moult" refers to the moult of only parts of the plumage, mostly of the body or contour feathers, without the greater feathers of tail and wing.

"Complete moult" means that the whole plumage is being replaced, including the remiges and rectrices.

"Post-juvenile moult" refers to the first moult of a bird, when the plumage, grown during nestling and juvenile period, is moulted. This moult may start even before the juvenile plumage is fully grown. It can be partial or complete, though seems to be consistently partial in the Laniinae. The following plumage is generally the immature one which is similar to the adult plumage but still shows features of a younger bird like lighter fringes and tips or generally fainter colouration.

"Immature" describes a young bird of unspecified age, but still not adult. This term is used to describe a variety of plumage stages following juvenile plumage *sensu stricto*. It can include the juvenile stage if the precise age is not known (Harris & Franklin (2000, p. 50).

We used the term strictly for a distinct plumage after the juvenile plumage with its possible two or three growth phases.

"Sub-adult" describes the last stage of the immature plumage before reaching full adulthood.

2.5 SAFRING CODES

Age 0 = Age unknown
Age 1 = Pullus
Age 2 = Juvenile
Age 3 = Immature
Age 4 = Adult
Age 5 = 0 to 1/2 year
Age 6 = 1/2 to 1 year
Age 7 = 1 to 2 years
Age 8 = 2 to 3 years
Age 9 = > 3 years