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The timing of moult in males and females of the monomorphic Pale-winged Starling *Onychognathus naboroupp*

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Pale-winged Starlings *Onychognathus naboroupp* inhabit the arid western interior of southern Africa and moult–breeding overlap may occur. We collected field data in two successive years on the moult of individual birds, whose sex was confirmed by genetic techniques. Small samples revealed a non-significant tendency for the moult of females in the early stages of wing moult to be more advanced than that of males in both years, but also clear evidence that the starting date of moult differed in the two years. In this species the moult schedule may thus be variable at both the individual and the population levels.

Keywords: moult, *Onychognathus*, sexual dimorphism, southern Africa, starling

As one of the major events in the annual cycle of all birds, the timing of the complete moult should be adjusted to the requirements of the individual bird, as well as being subject to selection at the species level (Stresemann and Stresemann 1966; Barta et al. 2006). Recent studies of South African passerine birds have shown that the timing of moult often varies regionally relative to the timing of rainfall in relation to the breeding season (Hulley et al. 2004; Craig et al. 2010). In addition, in some sexually dimorphic species the post-breeding moult starts earlier in males than in females (Bonnevie and Oschadleus 2010). This could be ascribed to reduced male involvement in the care of the young in such species (Verner and Willson 1969; Payne 1984; Oschadleus and Osborne 2005).

Of the 11 members of the genus *Onychognathus*, only two species are not sexually dimorphic in plumage. Male and female Pale-winged Starlings *O. naboroupp* are not distinguishable on plumage characters (Craig and Feare 2009), although they can be separated in the hand with some confidence by a combination of morphological measurements (LH et al. unpublished data). Earlier work has shown that moult and breeding in this arid-zone species can overlap at both the individual and the population level (Craig 2012). This raises the question as to whether males and females differ in the timing of their moult, which could reflect different investments in parental care. Therefore we investigated the stage of primary moult of wild Pale-winged Starlings, which were later sexed by genetic methods.

The study was carried out in Augrabies Falls National Park, Northern Cape, South Africa, (28°59' S, 20°33' E) over two consecutive years. From 25 to 28 October 2011, a sample of 58 adult birds was captured and 42 of these

individuals were subsequently sexed. From 1 to 7 November 2012 an additional 24 adult birds were captured, all of which were sexed, and two birds ringed and sexed in the previous year were recaptured. Birds were caught in baited clap traps, individually colour-ringed for behavioural observations, and released at the capture site. None had brood patches, and it appeared that nesting had not yet started in either year. Standard measurements (wing, tail, tarsus and culmen length in millimetres, body mass in grams) were taken, and primary wing-moult was scored according to the system whereby 0 = an old feather, 5 = a fully grown new feather, with 1–4 representing intermediate growth stages (Ginn and Melville 1983). These scores were converted to 'percentage feather mass grown' for analysis in the moult model of Underhill and Zucchini (1988) as written for R (Erni et al. 2013). Sex was ascertained by DNA sexing (Labofarm, France) from samples of 5–10 small feathers from each bird (Han et al. 2009).

One female bird had interrupted wing moult, with the two inner primaries new, the rest old, and no growing feathers, although there were some body feathers moulting. This is the first record of interrupted primary moult in this species (Craig 2012), and there is no apparent explanation for its occurrence in this bird. Although the sample sizes were relatively small, in both years the stage of moult as represented by the outermost growing primary remix showed a normal distribution, with wing moult in female birds rather more advanced than in males (Figure 1). The data were then examined statistically (using the Welch two-sample *t*-test), comparing mean percentage new feather mass grown in males and females in each year. In 2011 females were on average more advanced in their

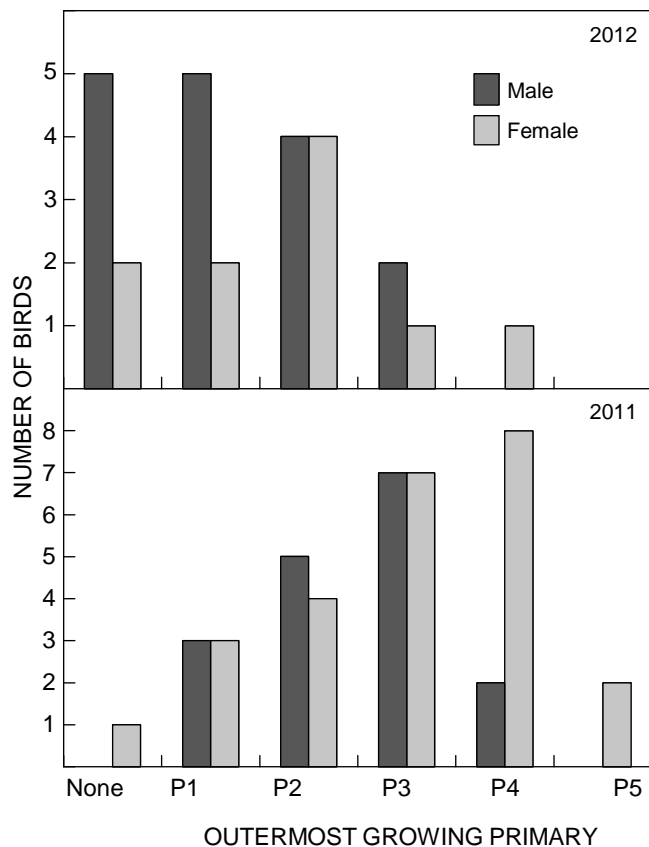


Figure 1: Stage of early primary moult of male and female Pale-winged Starlings handled at Augrabies Falls National Park, South Africa, from 25 to 28 October 2011 and 1 to 7 November 2012. Moult starts at P1 and proceeds outwards to P9; the x-axis shows the outermost growing primary in each case

moult, and the difference approached significance at the 5% level ($N = 17$ males, 25 females, $P = 0.064$). For 2011 there was also an indication that female moult was more advanced, but this was far from being statistically significant ($N = 16$ males, 10 females, $P = 0.503$).

However, for both males and females there was a significant difference between the years. In 2011 data were collected mostly during the last week of October, whereas in 2012 all birds were captured after 1 November. Yet moult was significantly more advanced in 2011 than in 2012 (Welch two-sample t -test, comparing mean percentage feather mass grown; for males, $P = 0.018$; for females $P = 0.009$).

Among the museum specimens examined previously (Craig 2012), there are 21 instances in which a male and a female Pale-winged Starling were collected on the same date at the same locality. Of these 'pairs', eight had wing moult: in four cases moult had reached the same primary in both birds (January [2], March [1], November [1]); one male had more advanced primary moult than the corresponding female (January), whereas three females had more advanced wing moult than their male counterparts (January [2], February [1]). This also hints at a tendency for moult in females to be more advanced than in male birds.

The Red-winged Starling *Onychognathus morio*, a sexually dimorphic species, favours more humid habitats, but is locally sympatric with the Pale-winged Starling in South Africa (Craig and Feare 2009). Moult–breeding overlap also occurs in this species, but there is no significant difference in the timing or duration of wing moult in male and female Red-winged Starlings in the winter rainfall region of the Western Cape (Bonnievie and Oschadleus 2010). On the arid island of Socotra, two *Onychognathus* species occur, the Somali Starling *O. blythii* and the Socotra Starling *O. frater*. During the same three-week period, Gedeon and Neumann (2004) handled three female Somali Starlings in very different stages of wing moult, whereas three males were not moulting. This may also imply less synchronous moult in harsh environments.

Although some field studies suggest survival costs to passerine birds that overlap moulting and breeding (Echeverry-Galvis and Hau 2013), others have found improved survival in such individuals (Morales et al. 2007; Buchmann et al. 2009). In understory passerines in central Amazonia, Johnson et al. (2012) found that species with slower feather growth rates and a longer moult duration were more likely to overlap moulting and breeding. Few studies have directly measured the metabolic costs of moult, but in the White-plumed Honeyeater *Lichenostomus penicillatus* Hoyer and Buttemer (2011) found that extending the moult period significantly reduced the energetic costs of feather replacement on a daily basis in this opportunistically breeding arid-zone bird.

For Pale-winged Starlings it appears that moult–breeding overlap is a regular phenomenon (Craig 2012), whereas the timing of breeding can vary markedly, probably dependent on local rainfall. As in other starlings of this African radiation only females incubate, but both sexes feed chicks in the nest (Craig and Feare 2009). However, the period of juvenile dependence on the adults has not been accurately determined; to date only females (colour-ringed birds, sexed from genetic samples) have been seen feeding fledglings out of the nest (February; MH pers. obs.). Our current data suggest that primary wing moult may start earlier and/or progress more rapidly in females than in males in this species. We cannot yet offer any biological explanation for this, but differences between the sexes in parental care, and in the subsequent timing of the annual moult, are known in both sexually dimorphic and monomorphic species (cf. Svensson and Nilsson 1997; Hemborg 1999). We also need more information from the entire moulting period, as it is possible that changes in the rate of feather replacement may occur at different stages of the moult cycle. The fact that differences in the timing of moult were observed in successive seasons confirms the flexibility of the breeding and moulting strategies in this arid-zone species.

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