Wing moult of Eastern Olivaceous Warblers 
*Hippolais pallida reiseri* at stopover sites at the 
southern fringe of the Sahara

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Recent research on the systematics of the genus *Hippolais* led to the proposal to split Olivaceous Warbler *Hippolais pallida* into Western Olivaceous Warbler *H. opaca* and Eastern Olivaceous Warbler *H. pallida* with the subspecies *pallida*, *elaeica*, *laeneni* and *reiseri*. Here, we present data on postnuptial primary moult in relation to age, for *H. p. reiseri* from five sites in southern and central Mauritania in late summer and autumn, 2003. Adult birds showed either interrupted primary moult or had not yet started to moult their primaries. First year birds were either not mouling in September or were actively mouling primaries in October. We suggest that some adult birds start primary moult on the breeding grounds and interrupt moult for migration. On the wintering grounds, adult birds either resume interrupted primary moult or moult their primaries completely. First year birds do not start primary moult on the breeding grounds but moult their primaries completely on stopover sites at the southern fringe of the Sahara prior to further southward migration. We discuss possible problems with this hypothesis and conclude that further research is needed to verify some of its assumptions.

**METHODS**

**Study sites**
The birds used in this analysis were mist-netted at various sites in central and southern Mauritania in late summer - autumn 2003. One adult bird (after first year
or EURING age code 4) was caught at Mohamed Lemna (18° 35'N 08° 38'W), a site in eastern sand desert where birds were mistnetted at the single tree present (Acacia tortilis) from 20 - 29 September. Nine first year birds (EURING age code 3) and one bird of unknown age were mist-netted at Gabou (18° 18'N 12° 23'W), which lies in Sahara-Sahelian transition zone, from 3 - 6 September and from 9 - 14 October. Sites were situated next to a lake in a strip of woodland of Acacia tortilis, Balanites aegyptiaca and Capparis decidua. Two adults were caught at Ouadâne (20° 54'N 11° 35'W), an oasis surrounded by stone desert to the north and sand desert to the south, from 22 August - 24 October between Acacia tortilis, Balanites aegyptiaca and Maerua crassifolia trees fringing a dry riverbed. Fourteen adult and six first year birds were caught at Tenlaba (20°59'N 11° 41'W), approximately 14 km northwest of Ouadâne. Mist nets were operated in a Date palm (Phoenix dactylifera) plantation from 29 August - 24 September, and in spring 2003 and 2004. Seven adult and one first year birds were trapped at Tichîtt (18° 28'N 09° 30'W), an oasis surrounded by stony and sand desert, with some higher vegetation consisting mainly of Date Palm plantations. Mist-netting took place between 13 August and 24 September in a Prosopis juliflora (introduced from America) forest planted at the eastern fringe of the oasis. From 26 September - 5 October birds were mist-netted between Acacia seyal in a depression about 12 km east of the oasis.

Biometrics and moult assessment

Birds were ringed and standard measurements were taken, including bill and tarsus lengths for all birds. The identity of the Olivaceous Warbler species (opaca versus pallida) was determined using the criteria described by Svensson (2001). The distribution of white on the outer tail feathers was also a good separation criterion. In general, pallida reiseri and opaca are quite distinct and, with some experience, easy to separate (Figs 1-2). All pallida were assigned to the subspecies reiseri mainly on the grounds of the distribution of white colouration on the outer tail feathers (Svensson 2001). The subspecies elaica may rarely also have broad white fringes on the outer tail feathers (Fig 3 in Svensson 2001). For distributional reasons this subspecies is, however, unlikely to occur in Mauritania; this is also the case for laeneni and pallida. The latter ones are difficult to separate from reiseri as characters of morphology and the wing formula widely overlap (Svensson 2001). Age of the birds was based on primary feather wear (Svensson 1992). Birds with all primaries fresh were assigned as first years whereas birds with at least some worn distal primaries were identified as adults. We assumed that no adult birds had moulted completely on the breeding grounds. Some birds were additionally aged according to skull pneumatisation.

All birds were checked for primary moult. When active or interrupted moult was detected, details were recorded on a moult card of the Swiss Ornithological Institute. Scoring of feathers followed Ginn & Melville (1983), where an old feather was given a score of zero and a new feather a score of five; growing feathers scored from one to four. Therefore, the sum for one wing (in this case the right wing) varied between zero (all feathers old) and 45 (all feathers new, outermost minute primary not considered).
Underhill & Zucchini (1988), Underhill et al (1990) and Rothery & Newton (2002) developed models to analyse moult scores with respect to timing and duration of primary moult. The application of those models requires linear data based on the assumption that progress in feather mass grown during primary moult is approximately linear with time. This assumption is violated in our data set because some birds showed interrupted moult. We were, therefore, not able to give any estimate for the beginning or duration of primary moult. We do, however, discuss a possible moult scenario for juvenile and adult Eastern Olivaceous Warbler of the subspecies reiseri based on our findings. Data from all sites were analysed together.

RESULTS

In total, 41 reiseri were trapped at the sites in September and October 2003. Thirty were first year birds, 10 were adults and one remained unaged. The birds could be separated in three groups according to primary moult status: a) birds not moulting, b) birds with interrupted moult (some inner primaries fresh, outer primaries worn), and c) birds in active primary moult (at least one primary growing). Assigning these three groups to age classes revealed that only adult birds showed interrupted primary moult and only first year birds showed active primary moult (Fig 3). For birds not in primary moult, the differentiation was not so clear, as both adult and first year birds were recorded without growing primaries. However, all first year birds trapped before 24 September had not yet started moulting their primaries, whereas all first year birds trapped in October showed active primary moult (no birds were trapped between 27 September and 9 October). Some of those birds had already almost finished moult by early October. No adult birds were caught after 26 September.

In first year birds, primary moult followed the regular descendant sequence starting with primary one (innermost; Jenni & Winkler 1994). Primary coverts moulted in about the same sequence as primaries. Secondaries started to moult with secondary one (outermost secondary) when approximately three or four primaries had been shed, and followed a regular ascending sequence (from outer to inner secondaries). Tertial moult started slightly after primary moult in most first year birds. In some cases it was not clear whether first year birds in the final stage of primary moult had retained old tertials, or had grown new tertials which were already slightly abraded. Adult birds with interrupted moult had not yet started secondary moult but some had renewed one or two tertials.

With respect to pre-nuptial moult, almost none of the 403 reiseri trapped between March and May in 2003 and 2004 showed any active or suspended primary moult. One bird in Tenlaba had secondaries four to six and tertials two and three old. Rectrices two to six were also old and showed juvenile growth bars (Marc Herremans, unpublished data).

DISCUSSION

Our study is the first to record primary moult of reiseri in the field, and our findings suggest that the previous descriptions of moult patterns for this taxon are incorrect (Cramp 1992, Baker 1997). It was previously thought that adult reiseri underwent a complete post-nuptial moult near their breeding grounds between July and September, although there was no information on post-juvenile moult (Cramp 1992, Baker 1997). Adult birds were caught only in September and none were actively moulting. Four birds had very worn feathers without having started moult whereas six others had new innermost one to four primaries. The latter case was never detected in first year birds because all feathers were either of one generation or they were in active moult.

The situation of moulting birds let us develop the following hypotheses about timing of moult in reiseri. Birds migrate through the area from more northern breeding grounds to more southern wintering areas. Many adult birds had already started to moult some of their innermost primaries on their breeding grounds, but interrupted moult for migration. The beginning of
primary moult near the breeding grounds might have led previous authors (Cramp 1992, Baker 1997) to assume a complete moult there. After arrival in the wintering grounds birds will either continue or begin moulting. First year birds leave the breeding grounds with juvenile primaries and start moulting at the southern fringe of the Sahara, possibly on stopover sites where they moult all primaries. They might do so very rapidly to continue migration to the final wintering areas further south. This hypothesis is based on a number of assumptions:
1) Birds migrate through the area and are not residents. According to Urban et al (1997) reiseri might breed in Mauritania but no further details with respect to locality are given. Assuming that the species is breeding in south Algeria and Morocco (Cramp 1992, Svensson 2001) it might also breed in the northern parts of Mauritania. However, the lack or scarcity of records in Lamarche (1988) and our own observations of the phenology of the species (unpublished data) lead us to believe that the species migrates through the study areas and does not breed, at least in the southern and central parts of the country.
2) The age of the birds was assigned correctly. Most birds were aged on plumage characteristics but in doubtful cases we also referred to skull ossification (Svensson 1992). We are therefore convinced that all birds were assigned to the right age class.
3) Interrupted moult in first year birds would have been detected. If first years start to moult some of their innermost primaries on the breeding grounds as adults do, this would have been difficult to detect because there should not be much difference in abrasion between the juvenile and the new primaries respectively. All birds were handled by experienced ringers who were looking closely for signs of moult. Therefore, we assume it to be unlikely that the occurrence of different feather generations would have gone undetected. Furthermore, we suspect that the statement that adult post-nuptial moult takes place near the breeding grounds (Baker 1997) is based on the fact that there are records of adults with moulting inner primaries. The fact that there is no information available for the moult of juveniles (Baker 1997), leads us to the assumption that there are no records of juveniles starting to moult near the breeding areas. We therefore believe that juveniles do not start primary moult on the breeding grounds.
4) The netting sites were not situated within the northern limits of the wintering grounds, but further south. For the sites Ouadâne, Tenlaba, Tichîtt and Mohamed Lemna we can safely confirm this. The sites are either not suitable for a longer stopover because of the lack of vegetation and therefore food (Mohamed Lemna, Tichîtt) or phenology data, for both autumn and spring, show that the species only migrates through the area (Tenlaba, Ouadâne, Swiss Ornithological Institute, unpublished data). Gabou lies only slightly south of the latitudes of Mohamed Lemna and Tichîtt but in an area where Sahel vegetation reaches far to the north with extended woodlands next to a large temporary lake. There are no phenological data available for reiseri from the region. We stayed at the site for only a few days but had the impression that the abundance of vegetation and insects could sustain a wintering population. There is no information in the literature about where the species spends the winter months and Lamarche (1988) mentions only two records for Mauritanian, both from Nouakchott. As the Swiss project did not record reiseri at the coast during three months of mist-netting at two sites in autumn 2003 (Swiss Ornithological Institute, unpublished data), the lack of inland records might be due to observer bias at coastal sites or along the Senegal valley. The situation is complicated by the fact that all first year birds in moult were recorded in Gabou at a time when the sites in Tenlaba and Tichîtt had ceased to operate. Fig 3 could therefore be misleading in that first year birds could have been in Gabou earlier but were not recorded. However, mist-netting in Gabou has also taken place between 3 - 6 September (although with a lower effort) with no reiseri captured. Therefore, we assume that birds arrived in Gabou in mid or late September. As birds are unlikely to start moult on migration, the most likely scenario is that first year birds started moult in a habitat which offered optimal conditions, at least in the wet autumn of 2003, and proceeded very quickly, as in Melodious Warbler Hippolais polyglotta (Aidley & Wilkinson 1987, Salewski et al 2004). Adult birds could also have started or continued their primary moult but no adults were caught in Gabou. The question remains whether adults were under-represented in the nets or whether they had moved further south to their normal wintering range, while first year birds stayed in the area to moult and continued migration afterwards. The answer remains speculative.

Our hypothesis is supported by records of interrupted moult of migrating H p elaeica (Cramp 1992, Baker 1997). In Kenya, 30% of all H p elaeica showed interrupted moult whereas 70% were in old plumage (Pearson, in Cramp 1992). At N’gulia, Kenya, 30 out of 64 birds showed interrupted moult with one to five new primaries, and four birds were in active primary moult with one to two innermost primaries growing between 8 and 19 November 1996 (L Jenni & R Winkler, unpublished data). With regard to our hypotheses, we are therefore convinced that at least some adult H p...
The hypothesis that first year birds moult rapidly on stopover sites whereas adults moult further south in the wintering areas remains to be verified. In this respect, it would be interesting to discover the final winter quarters of reiseri.

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REFERENCES


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