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Moult of Oriental Honey-buzzards

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Flight feather moult of larger birds like raptors is difficult to study in skin collections, because the wings are normally closed when the skins are prepared, and the sample sizes tend to remain quite small. The best material would be birds caught alive, but in this case the problem of small sample sizes is even greater. It is easier to collect larger samples from photographs, although there are some problems, discussed later. This is a study of the moult of Oriental Honey-buzzard *Pernis ptilorhynchus* based on photographs. It is a part of the background work for the Raptors of Eurasia application. Most of the used photographs were found on the internet - most of them in eBird (eBird 2019).

In newer texts (e.g. Orta *et al* 2018), the most commonly accepted subspecies of Oriental Honey-buzzard *Pernis ptilorhynchus* are *orientalis*, *ruficollis*, *torquatus* (these three breed in mainland Asia, the last also in the Greater Sundas), nominate *ptilorhynchus* (Java), *palawanensis* (W Philippines) and *philippensis* (N & E Philippines). I will not discuss the three wholly insular taxa any further here.

Orientalis is the northern taxon, breeding from Altai to Japan and wintering in South-east Asia, mostly in Indonesia, Borneo and the Philippines, and to some extent west to Arabia. *Ruficollis* is the breeding taxon in the Indian Subcontinent, and also in parts of South-east Asia. *Torquatus* is the resident taxon in the Thai-Malay peninsula, Sumatra and Borneo. More about the taxonomy, distribution and identification of these taxa will be published in a separate article.

Moult score

The material of this article consists of photos. The primary moult was scored using the method described in Ginn & Melville (1983), and in many other sources: 0 = old feather, 1 = old feather missing or new feather completely in pin, 2 = a new feather just emerging from the sheath, up to one third grown, 3 = a new feather between one and two thirds grown, 4 = a new feather more than two thirds grown, but with a waxy sheath still at its base, 5 = a fully grown new feather with no trace of a sheath at its base. However, because the original scoring was developed for studying birds in the hand, some modifications were needed:

- scores 1 and 2 are not always separable in photographs (versus in the hand). Therefore if there were two adjacent primaries seemingly lacking, the innermost of these were assigned score 2 and the outermost score 1. If there is only one primary seemingly lacking, it was assigned score 1. (The rationale is that this type of scoring will afford the closest results to scoring in the hand).
- The waxy sheath is not normally visible in the photos. Therefore we modify the score 4 and 5 in this way:

4 = a new feather more than two thirds grown, but not fully grown (as can be seen in a photo).
5 = a new feather fully grown

The total primary moult score is the total of the scores of the individual feathers, with the possible values in Oriental Honey-buzzard being 0 (moult still not commenced) to 50 (moult completed). In addition, the raggedness score can be calculated - it is the sum of 50 minus the total score of the individual feathers, where the individual score of 0 is replaced by 5. It describes the intensity of the moult. The raggedness score of incomplete moult can be 0, when all the new feathers are fully grown, but no primaries are missing - *i.e.* suspended moult. In some bird species a moult can stop while being suspended - that is called arrested moult, but this does not happen in Oriental Honey-buzzard, based on that on spring migration, suspension patterns do not occur.

The main problem when assessing moult in photos is that it is not possible in all cases - some photographs are not good enough. This may lead

to bias in the sampling. Some photos may be good enough for the active moult-score to be assessed, but for example, suspension of moult might not be visible. For the purposes of this study, only good photographs were selected - those where suspension patterns were estimated to have been visible, had there been any.

Also the moult of secondaries and tail is often possible to judge from in-flight photos. In this study, no regular scoring was done for these feather tracts. Their moult is typically quite synchronised with the primary moult, starting when the primary moult has reached the middle primaries and finishing just before the outermost primaries are fully grown. The last remaining secondaries and tail feathers are important when ageing the bird - the difference between juvenile and adult feathers is easier to see there than in the outermost primaries.

The length of the primaries is variable so that the outermost are generally longer than the innermost. Feathers grow at about the same rate and therefore it takes longer for the outermost primaries to grow than the innermost, and the moult score is not linear with respect to time. There is no data of Oriental Honey-buzzard about this phenomenon, but we suppose the same applies in this case. In some analysis, instead of moult score, the proportion of renewed feather mass was used. This was counted from single feather scores by taking into account the relative lengths of the feathers. No information about Oriental Honey-buzzard feather lengths was found, and instead, relative lengths of primaries of European Honey-buzzard *Pernis apivorus* were used. These were calculated from the table of Cieślak & Dul (2006) and the values were from innermost to outermost primary: 0.08, 0.09, 0.09, 0.09, 0.1, 0.11, 0.12, 0.12, 0.11 and 0.09.

Subspecies *orientalis*

The northern subspecies *orientalis* is a summer breeder and long-distance migrant. Adult birds start wing-feather moult on the breeding grounds and suspend or slow it down for the migration, completing it in the wintering areas before the spring migration. This strategy resembles that of European Honey-buzzard (Stresemann & Stresemann 1966), which similarly is a long-distance migrant.

The primary moult, and the annual moult in general, starts in June. Of the June birds in the material (n=12), six had started the primary moult, with the most advanced bird (from Taiwan) having seven old primaries left.

Lindholm & Forsten (2016) scored migrating birds in Liaoning, China in late September. At that time all adult birds had started the primary moult but none had finished it. Moult gaps were generally rather small, indicating a slowly advancing moult. About one fourth of the adults had a full wing, so they had suspended the moult. The individual variation was very broad, with from nine to two old primaries remaining. Females were significantly more advanced, on average, but the difference was less than one feather. The mean moult index of males was 19.4 (n=45) and of females 23 (n=38). Also in European Honey-buzzard the females are more advanced on autumn migration than the males (Forsman 1984).

In October, in the Chumphon province in Thailand, the passing Oriental Honey-buzzards are still moulting. The average moult score in the material was 25 (n=32), so somewhat higher than in Liaoning (where it is 21, sexes combined), as expected. However, 44% of the birds had suspended the moult (26% in Liaoning). The average raggedness score of the Liaoning birds was 2, so they only needed to complete the growing feathers to almost reach the moult state of the Chumphon birds. It should be noted that birds in Chumphon may include some *ruficollis* and even *torquatus*, that will be discussed further in a separate article.

The moult is completed after the birds have reached their winter quarters. Three birds from Taiwan in November were still moulting, with one to no old primaries left, but five birds from December and four birds from January had all completed the moult. Sulawesi and Bali, Lombok and other parts of Nusa Tenggara, Indonesia are part of the main wintering area, where no resident subspecies occur, so all Oriental Honey-buzzards there should be *orientalis*. In that area, in January

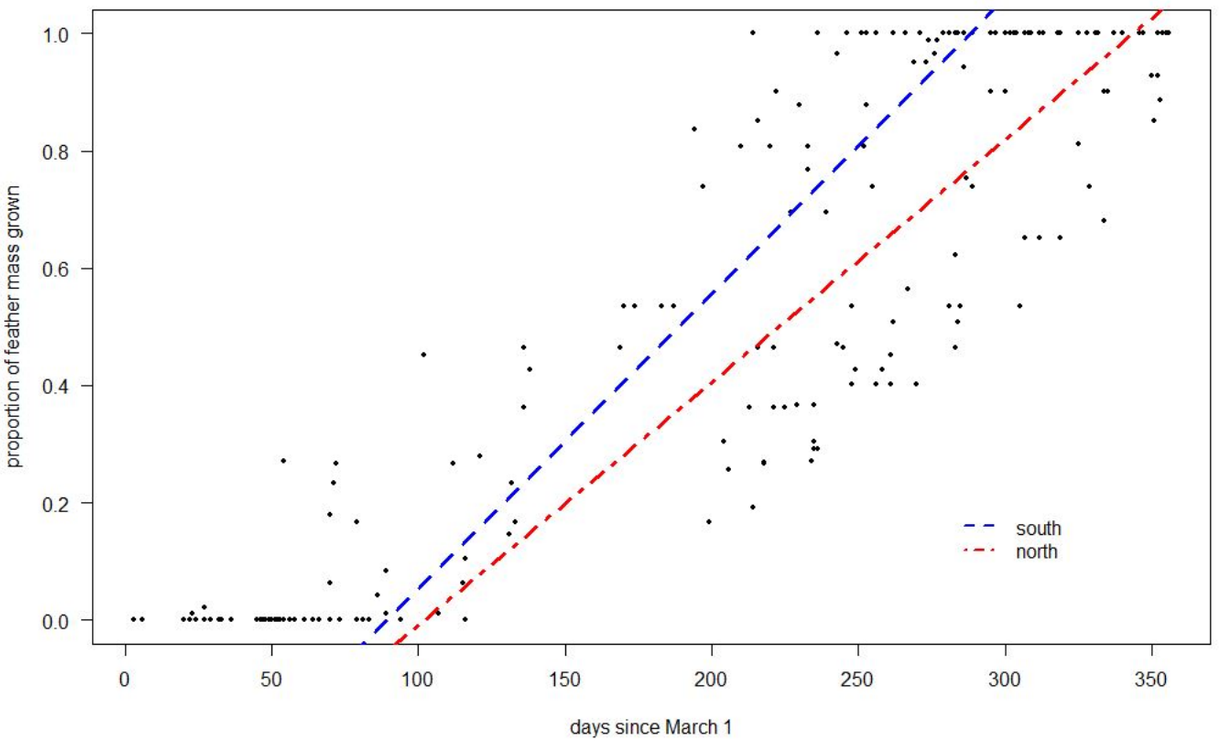

Table 1. Moult scores of Oriental Honey-Buzzards from peninsular India. Regression lines of northern and southern birds shown.

/ February, two birds had finished the moult, while four were still moulting in the final stages. It seems probable that Taiwan winter birds complete earlier and that their shorter migration route may enable that.

On spring migration, in March, April and May, on the Thai-Malay Peninsula, and in China, the Oriental Honey-buzzards, almost without exception, show a complete set of primaries of a single generation.

First-year birds do not moult during the autumn. In Nusa Tenggara, Indonesia, February, two 2cy birds still had not commenced. In the Chumphon province, Thailand, March, five still had intact juvenile primaries, while four had dropped the innermost primary.

I have not seen much material of 2cy birds on autumn migration. Some still have a part of the juvenile wing feathers left and are readily identifiable. Some may have moulted completely by that time, and are therefore indistinguishable from adults.

Subspecies *ruficollis*

The subspecies *ruficollis* was studied only in India, because it was too difficult to get a sizable confidently identified sample of South-east Asian birds. All the material is from peninsular India, therefore everything from West Bengal and further east is excluded, as are the areas adjacent to the Himalaya. It is possible that these results are not applicable to the South-east Asian part of the range. O*rientalis* also occurs in the Indian peninsula, but in small numbers, and more likely in the excluded areas. If a bird showed *orientalis* characters it was excluded from the material - this did not happen frequently, and *orientalis* seems to be rare in India except in the northeast.

A total of 225 photographed individuals were

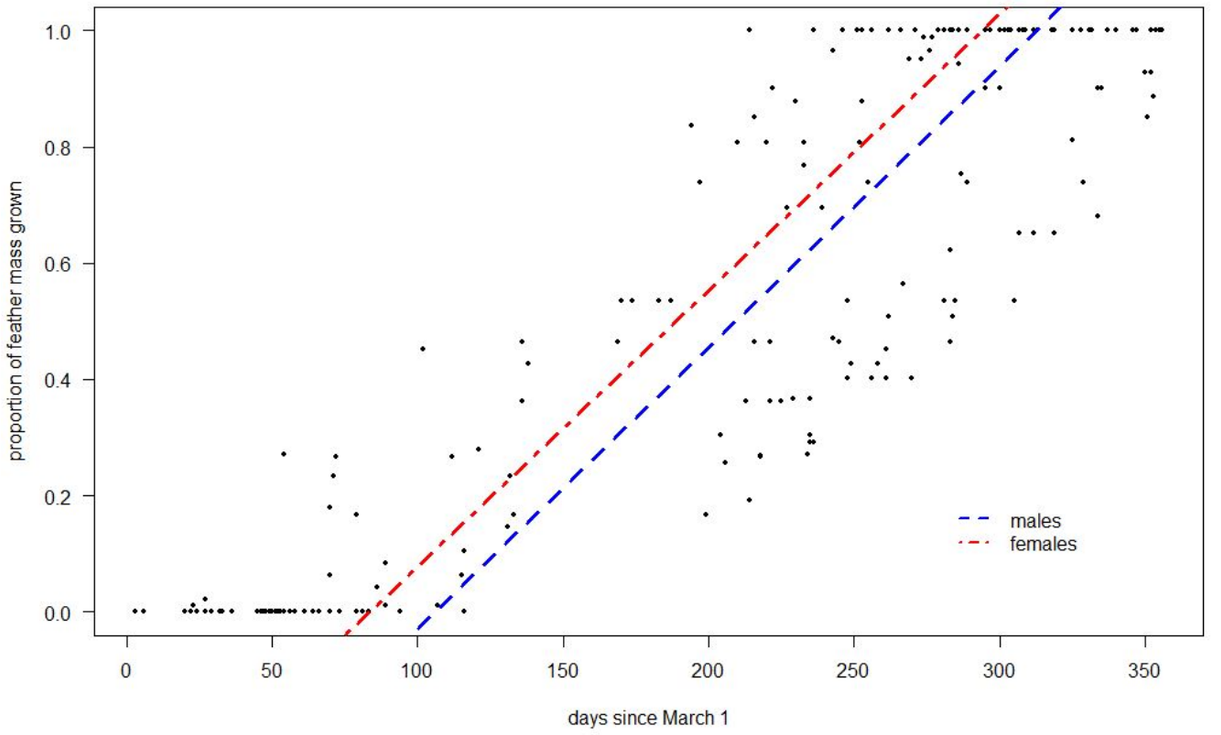

Table 2. Moult scores of Oriental Honey-Buzzards from peninsular India. Regression lines of males and females birds shown.

scored to collect the material. There is data from every month, but less from the summer months, and least from August, with only four individuals scored. A total of 84 were from northern India (Maharashtra, Madhya Pradesh and further north) and the rest from the south.

To analyse the moult, R package moult was used (Erni *et al* 2013, R Core Team 2017). That package implements Underhill and Zucchini models for estimating duration, mean start date, and variation in start date of moult in a population of birds. See that article, and also Underhill & Zucchini (1988) for details, especially about reasons why standard linear regression methods are not appropriate when analysing moult scores.

In India *ruficollis* lays eggs from February in the south, to April in the north, and the young fledge around May in the south, and in late August to early September in the north (Baker 1928, Ali & Ripley 1983). There is some variation, but generally adults moult from the northern summer onwards, with the earliest starting in May, and all are in moult by July. Therefore the moult overlaps with the breeding quite broadly. The earliest birds have completed the primary moult by late October. In the material there was one completed bird from Kerala, a male from 30 September, but it may have been a 2cy bird, which generally cannot be separated after the moult is complete. Roughly half of the birds are still moulting during November and some still in January and even February. Generally, the moult is slowish, but not suspended at any time. Only one suspended bird was found in the material, a male from Maharashtra, from 11 July, which had the two innermost primaries fully grown and of a newer generation than the rest. See Table 1 and 2.

See figures 1 and 2 for regression lines of moult, separated by sex and the area of the bird. The moult function was called as moult(formula =

Mindex ~ Day | Area | Area, data = Perpti, type = 2) and moult(formula = Mindex ~ Day | Sex | Sex, data = Perpti, type = 2). There seems to be no difference between the duration of moult between the sexes, but females start earlier, the estimate of difference is 22 days, with the standard error 15,46. Southern birds start perhaps somewhat earlier, but the standard error is quite high compared to the estimate (estimate 12,48, error 15,97) and proceed faster (estimate of duration 43,3 days shorter, standard error 23,63).

The material of 2cy birds was too small for a similar analysis. The first 2cy birds with a moulted inner primary were from February and April, one from Gujarat on 23 April had not yet commenced moulting, while one southern Indian bird was already at stage 23 (thus about half way) in early May. In May and June all (n=5) were actively moulting, northern birds in the early stages, while southern birds were much more advanced. After that, lack of material prevents conclusions, but one bird from Gujarat, in late December, had no juvenile primaries left, and the outermost post-juvenile ones growing, with some juvenile secondaries and rectrices still intact, enabling ageing. It can be summarised that young birds moult somewhat earlier in the year than adults, and distinctly earlier in the south.

Subspecies torquatus

The timing of the breeding of the resident *torquatus* of the inner tropics is inadequately known. For example, Wells (1999) did not know of any nests or fledglings reported from the Thai-Malay peninsula, just some display seen from late February to late May. There may be some geographic variation in timing, because the climate is variable across the breeding areas. From what is known, the breeding starts during the northern spring (e.g. chicks about 20 days old in Sarawak on 1st May). The moult seems similar to that of *ruficollis*. A June bird from Sarawak was already at stage 16, and all the birds from June - early November (from different parts of the distribution area) were actively moulting (n=9). None of the at least six different adults from Krung Ching, Surat Thani, Thailand from mid November were in active moult and two of the five February birds from around the distribution area were in early stages of moult. So the moult mostly occurs from spring to November and probably is not suspended at any stage. No material of the moult of young birds was available.

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