Strong sexual size dimorphism in the Dark-eared Myza *Myza celebensis,* a Sulawesi-endemic honeyeater, with notes on its wing markings and moult

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Summary: We present morphometric and moult data for the Sulawesi-endemic Dark-eared Myza, based on 35 individuals captured at Lore Lindu National Park, Central Sulawesi, during March–April and July 2011. Four individuals banded in March were recaptured at the study site in July, suggesting that the population is probably sedentary. Like most meliphagids, although this species is not sexually dimorphic in plumage, measurements show that males are significantly heavier and have longer wings, tail and head–bill than females. Seven of the 16 adults in March–April and five of the 19 in July were moulting their primary feathers. Assuming that primary moult follows breeding, estimated laying dates for adults in the final stages of moult suggest breeding in December and early April, the latter corroborated by the presence of brood patches on two females in late March. A brood patch on a female in July further suggests that the breeding season is protracted. All birds photographed also showed distinct buff tips to most, if not all, secondary coverts and buff fringes to median coverts, a feature that appears to have gone unnoticed in the literature.

Ringkasan: Kami sajikan data morfometrik dan gugur bulu burung endemic Cikarak Sulawesi, berdasarkan hasil dari 35 individu burung yang ditangkap di Taman Nasional Lore Lindu, Sulawesi Tengah selama bulan Maret-April dan Juli 2011. Empat individu yang dicincin di bulan Maret berhasil ditangkap kembali di lokasi studi pada bulan Juli sehingga mengindikasikan bahwa mereka merupakan jenis penetap. Seperti kebanyakan meliphagids, secara seksual jenis ini tidak dimorfik dalam hal warna tubuhnya, hasil pengukuran secara signifikan menunjukkan bahwa bobot jantan lebih berat dan memiliki sayap, ekor dan kepala-paruh yang lebih panjang dibanding betinanya. Di bulan Maret tujuh dari 16 burung dewasa, dan di bulan Juli lima dari 19 burung dewasa mengalami gugur bulu primer. Dengan asumsi gugurnya bulu primer berlanjut dengan masa berbiak serta perkiraan tanggal-tanggal telur mulai ditaruh oleh Burung dewasa pada fase finalnya, menunjukkan bahwa masa berbiak terjadi pada bulan Desember dan awal April, ditandai dengan adanya bulu-bulu burung muda pada tubuh dua individu betina pada akhir bulan Maret. Bulu-bulu burung muda pada tubuh betina di bulan Juli lebih jauh menunjukkan bahwa musim berbiak berlangsung lebih lama. Semua burung yang difoto juga menunjukkan warna coklat-kuning pucat yang nyata pada ujung-ujung bulu penutup sayap sekundernya, ciri yang nampaknya sudah tidak banyak diperhatikan dalam literatur.

Introduction

The honeyeaters (Meliphagidae) are a predominantly Australasian family, with only one species occurring west of Wallace's Line. Yet 26 species occur in Wallacea, of which 18 are endemic (Coates & Bishop 1997) and poorly known in terms of their morphometrics and annual cycle. Sexual dimorphism in size is the norm among honeyeaters, males being larger than females in nearly all species, although data are lacking for many species, especially those from New Guinea, Wallacea and the Pacific Islands (Higgins *et al*. 2008). Annual cycles and moult strategies of honeyeaters are fairly simple, with adults of all except a few species undergoing a single complete post-breeding, or pre-basic, moult annually (Ford 1980; Higgins *et al.* 2008).

As part of the Training of the Trainers (ToT) programme, jointly organised and funded by the Australian Bird & Bat Banding Schemes (Canberra, ACT, Australia) and recently founded Indonesian Bird Banding Scheme (Noske *et al.* 2011), the authors, except JBCH, conducted bird banding over six days during March 2011 in and around Lore Lindu National Park, Central Sulawesi. As these trips were essentially training exercises, individual species were not targeted. Rather, several different habitats were sampled to provide sufficient numbers of birds for training purposes. JBCH visited the National Park during July 2011, mainly to look for undescribed taxa. Morphometric and moult data were collected on all birds captured to enable analyses of morphological variation and assessments of annual cycles.

In this paper we present such data for the Dark-eared Myza (or Lesser Streaked Honeyeater) *Myza celebensis*, a Sulawesi endemic. Although this species is considered a common inhabitant of lower montane rainforest (Coates & Bishop 1997; Prawiradilaga 2006), nothing is known of its breeding biology or moult. Indeed the breeding seasons of the majority of Wallacean endemic birds, except for some species in Flores and Timor (Verheijen 1964; Noske 2003) remain unknown. It has long been known that the male is larger than the female in this species (Meyer & Wiglesworth 1898; Riley 1924; Stresemann 1940). Indeed, measurements taken on internally sexed specimens collected in the late 19th and early 20th centuries indicate that males have longer wings, tails and, possibly, tarsi (Table 1). In this paper we examine the nature and extent of variation in two of these characters, and two others, in a population of Dark-eared Myzas inhabiting Lore Lindu National Park, Central Sulawesi. Unless otherwise specified, this paper concerns the nominate subspecies (*M. c. celebensis*), found throughout the island except South Sulawesi, where it is replaced by the slightly smaller subspecies *meridionalis* (Coates & Bishop 1997; Higgins *et al.* 2008).

Table 1: Morphometrics of male and female Dark-eared Myza from the literature and museum specimens. All lengths given in millimetres. Altitude given in metres above sea level.

Parameter	Sex	Meyer & Wiglesworth (1898)	Riley (1924)	Stresemann (1940)	AMNH[1]
		Individuals	**Mean (n)**	**Range[2]**	**Mean ±SD (n)**
Wing-length	Male	86	85.7 (8)	82–89	81.5 ± 2.5 (10)
	Female	77, 74	75.0 (3)	75–76	74.2 ± 1.2 (10)
Tail-length	Male	70	73.4 (8)	–	–
	Female	66, 63	66.2 (3)	–	–
Tarsal length	Male	20.5	–	–	–
	Female	19.5, 18.0	–	–	–
Altitude		1100–1500		1800–2000	1700–2300
Collector(s)		P. & F. Sarasin	H. C. Raven	P. & F. Sarasin	G. Heinrich

[1] AMNH, American Museum of Natural History; specimens collected from January to November 1930 from Ile-Ile (n=5) and Mt Latimodjong (n=15) in North and Central Sulawesi, respectively.

[2] No sample size given; may have included some specimens of race *meridionalis*.

Study site and methods

Mist-netting and banding of birds were carried out in Lore Lindu National Park, Central Sulawesi, by: (1) ToT personnel from 27 March to 2 April 2011; and (2) JBCH and his colleagues from 10 to 19 July 2011. Dark-eared Myzas were captured at three sites, all within 3 km radius. Site 1, adjacent to Lake Tambing (01°19.41′S, 120°18.86′E; 1,674 m above sea level), was sampled on 29 and 31 March, and from 10 to 15 July; Site 2, along the Anaso Trail (01° 19.04′S, 120° 18.37′E; 1,858 m asl) was sampled on 30 March and 1 April 2012; and Site 3, Puncak Dingin (01°16.07′S, 120°19.02′E; 2,300 m asl) from 17 to 20 July.

The National Park covers 2,180 km^2 of rugged mountains, with a wide altitudinal range from 200 m to the 2,610 m-high Mount Rorekatimbu but *c.* 64% of the reserve lies above 1,200 m (Waltert *et al.* 2005). The bulk of the vegetation in the park is lower montane rainforest, characterised by the dominance of oaks *Lithocarpus* spp. and chestnuts *Castanopsis* spp., with dense stands (at least formerly) of the Kauri Pine *Agathis dammara* on some of the larger ridges. Southern conifers of the genera *Podocarpus* and *Phyllocladus* are well represented while other widespread trees include species of *Elaeocarpus*, *Adinandra*, *Lasianthus*, *Cinnamomum*, *Litsea* and *Callophyllum*. The understorey is generally dense at lower altitudes, but is sparser on the ridges and consists mainly of ferns, orchids and various rubiaceous and urticaceous species (Watling 1983; Whitten *et al.* 2002).

Mist-nets (mesh-size, 31 mm; length 9–18 m, mostly 12 m) were erected along the trails leading to Lake Tambing and Mount Rorekatimbu, and up to 50 m inside the adjacent forest. The number of nets used ranged from 12 to 29, depending on the number of teams present. Nets were erected in the morning and taken down in the late afternoon, and checked at intervals of *c.* 1 h. The mist-netting effort during March–April ranged from 7 to 9 h per sampling day over four days, with a total effort of 503 net-h. During the July trip mist-netting effort ranged from 7 to 10 h over ten days, with a total effort of 1,820 net-h.

After careful extraction from nets, birds were bagged for a short period, then banded using bands supplied by the Indonesian Bird Banding Scheme, after measuring the width of the tarsus to check the appropriate band size. Birds were then weighed to the nearest 0.5 g or 0.1 g using 50g Pesola spring balances and an electronic balance, respectively, and measurements (all in mm) were taken of flattened wing-length and tail-length using a butt-ended and normal rule, respectively, and head–bill length (from tip of bill to rear of skull) to the nearest 0.1 mm using both Vernier or dial callipers. The abdomen was checked for indications of a brood patch by blowing on the feathers to expose the bare skin. If the primaries were in moult, each of the ten feathers on one wing was scored according to the following scheme: 0, old; 1, missing feather or small pin; 2, up to one-third of total length; 3, one- to two-thirds grown; 4, more than two-thirds grown; 5, fully grown. These scores were added to provide a total primary score (maximum, 50). Most individuals captured were also photographed for subsequent reference.

In March–April, measurements were taken by AL, RN and at least one other trainer and two trainees in the ToT group, those of the last checked by trainers. In July, measurements were taken by JBCH and DD. Principal Components Analysis (PCA) was used to evaluate the level of morphological variation, with individual birds as replicates and the four metrics as dimensions. PCA was performed using the standard princomp function in R 2.15.1 (R Development Core Team 2012). Morphometric data collected by the ToT group and JBCH were compared using unequal variance *t*-tests. As these tests showed that the two sets of measurements were not significantly different ($P>0.4$), they were combined for further analyses.

Results

During the March–April sampling period, 104 individuals of 24 species were captured and banded, of which the Dark-eared Myza (Plate 1) was the most frequently caught species (18%). Of the 19 individual Myzas banded, 16 were caught at Lake Tambing and three at Site 2; seven were recaptured at the banding site on the same or subsequent days. All were adults except three that were identified as first-year birds on the basis of pointed tips to the tail-feathers and parallel pattern of growth bars across these feathers, sparseness of underwing coverts and generally soft, loose contour feathers (Svensson 1970; Rogers *et al.* 1986). During the July sampling period, 98 birds of 18 species were netted at Lake Tambing, including 15 Myzas (15%), four of which were recaptures from the March–April sample, suggesting these birds were sedentary, at least over the 3.5 months between sampling. None of these birds was identified as an immature, although the age of three birds was not recorded. At Puncak Dingin, 45 birds of 14 species were netted, of which five (11%) were adult Dark-eared Myzas. One bird was euthanased to retain as a specimen for the Museum Zoologicum Bogoriense, Bogor, Indonesia.

During the course of processing these birds we noticed that many, and possibly all, birds had distinct pale-buff tips on the outer vanes of most, if not all, of the greater coverts as well as broad pale-buff fringes to the tips of the median coverts of the upperwing (Plate 2). Initially we considered this to be a juvenile characteristic, but eventually realised that adults also possessed these markings. These buff tips are not shown on the illustrations of the species in Coates and Bishop (1997), which shows narrow pale (olive) fringes to both median coverts and secondary coverts, or in Higgins *et al.* (2008), which shows inconspicuous olive fringes to secondary coverts only.

Plate 1: Dark-eared Myza *Myza c. celebensis*, Lake Tambing, Lore Lindu National Park, Central Sulawesi. Note buff tips to greater and median coverts.

Plate 2: Close-up of spread wing of Dark-eared Myza (band number 03Y-006111), showing buff tips to outer vanes of greater (secondary) coverts, and buff fringes to tips of median coverts.

Due to substantial variation among individuals in size, larger birds were banded with larger bands (03Y) than smaller birds (02Y). As males and females of this species are apparently identical in plumage we could not determine the sex of birds that we captured, except for five individuals that showed evidence of breeding. Three birds (band numbers 03Y-006103, 03Y-006226 and 02A-007290) had brood patches (Plate 3), suggesting that they were brooding females, since only females incubate in the vast majority of honeyeaters (Higgins *et al.* 2008). The other two sexed birds had either small deflating seminiferous tubules (03Y-006225) or an obvious cloacal protuberance (03Y-005028), indicating they were males. In addition the euthanised bird was internally sexed as a male, having a small left testis (8 × 4 mm).

Plate 3: Active brood patch of adult female Dark-eared Myza (band number 03Y-006103).

The first component of the PCA explained 89.8% of the variance. Components other than Component 1 were weak in their explanatory power, and could represent measurement error attributable to differences between measurers, or variation among individual birds in the relative proportions of the measurements, including time-of-day and time-of-year effects on weight. The extremely high value of Component 1 indicates that the four morphometrics were very strongly correlated with one another, and that the relevant ordination consisted of one dimension. The vector values of each of the four morphometrics were very similar, as indicated by the length of the lines away from the centroid on the 2-dimensional plot (Fig. 1). This plot also shows very strong separation of individual birds into two clusters. Thus there is a clear size distinction between the clusters that is consistent across all measured morphometrics. Further, the three known females are all in the right-hand cluster (smaller measurements) and the two known males are both in the left cluster (larger measurements), indicating that the two clusters represent the two sexes. The same clusters were evident when the metrics were graphed against wing-length (Fig. 2a-c). Basic statistics for inferred males and females are presented in Table 1.

Active primary moult was evident on seven birds (44% of adults) captured in March–April, scores ranging from 16 to 47 (maximum 50), with a median score of 26.5. In July, five individuals (26% of adults) were moulting their primaries, with moult scores of 7–47 but a median score of 45. Three of these birds had been banded in March, *c.* 3.5 months earlier. Two of these recaptured individuals showed no sign of primary moult in March (02A-007128 and 03Y-006217), but in July, had moult scores of 7 and 33, respectively. The score of the third bird (03Y-006218) increased from 20 (four fully grown feathers) on 29 March to 45 (nine fully grown feathers) on 10 July, 103 days later.

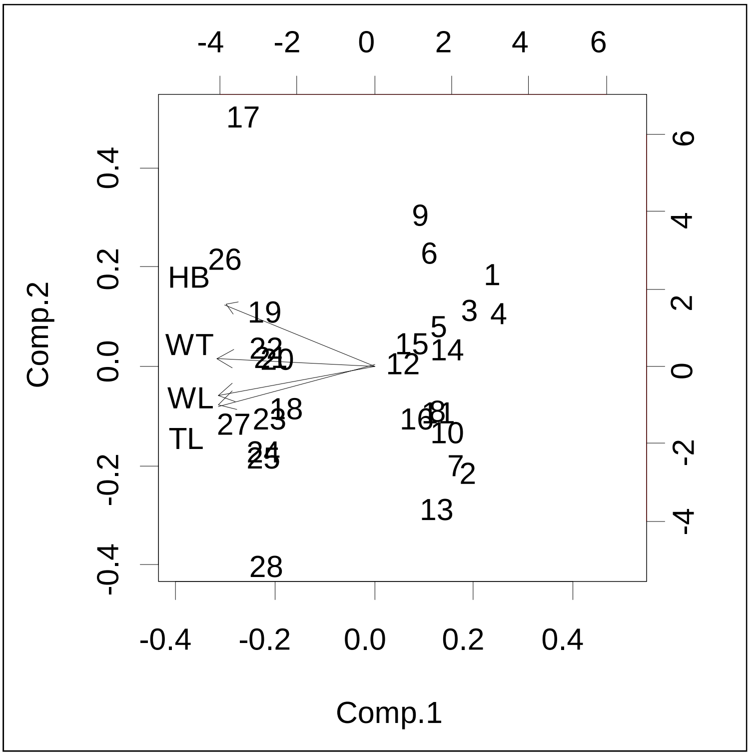

Fig. 1: Bi-plot of Principal Components 1 and 2 from PCA. Numbers inside the square represent individual birds; numbers 2, 7 and 15, females; 17 and 19, males.

Table 2: Comparison of morphometrics of inferred male and female Dark-eared Myzas *Myza c. celebensis* captured in this study. All lengths are given in millimetres. Weights are given in grams.

Parameter	Sex	n	Mean	SD	Min	Max
Wing-length	Female	19	76.3	1.66	72	79
	Male	15	87.1	2.53	84	93
Head–bill length	Female	18	46.8	0.88	45.5	48.7
	Male	16	50.5	1.11	49	53.3
Tail-length	Female	17	69.0	2.00	65	71
	Male	15	76.4	1.40	75	80
Weight	Female	18	17.2	1.01	15.5	19.5
	Male	14	22.1	0.74	20.5	23

Discussion

Sexual dimorphism and wing markings

Sexual dimorphism in size is the norm among honeyeaters, males being larger than females in nearly all species, although data are lacking for many species, especially those from New Guinea, Wallacea and the Pacific Islands (Higgins *et al*. 2008). For all 70 of the Australian and New Zealand species, males are larger than females in at least one measure or weight, and there are no species for which females are significantly larger than males. Marked sexual dimorphism in size is exhibited by several species, including the San Cristobal Honeyeater *Meliarchus sclateri* of the

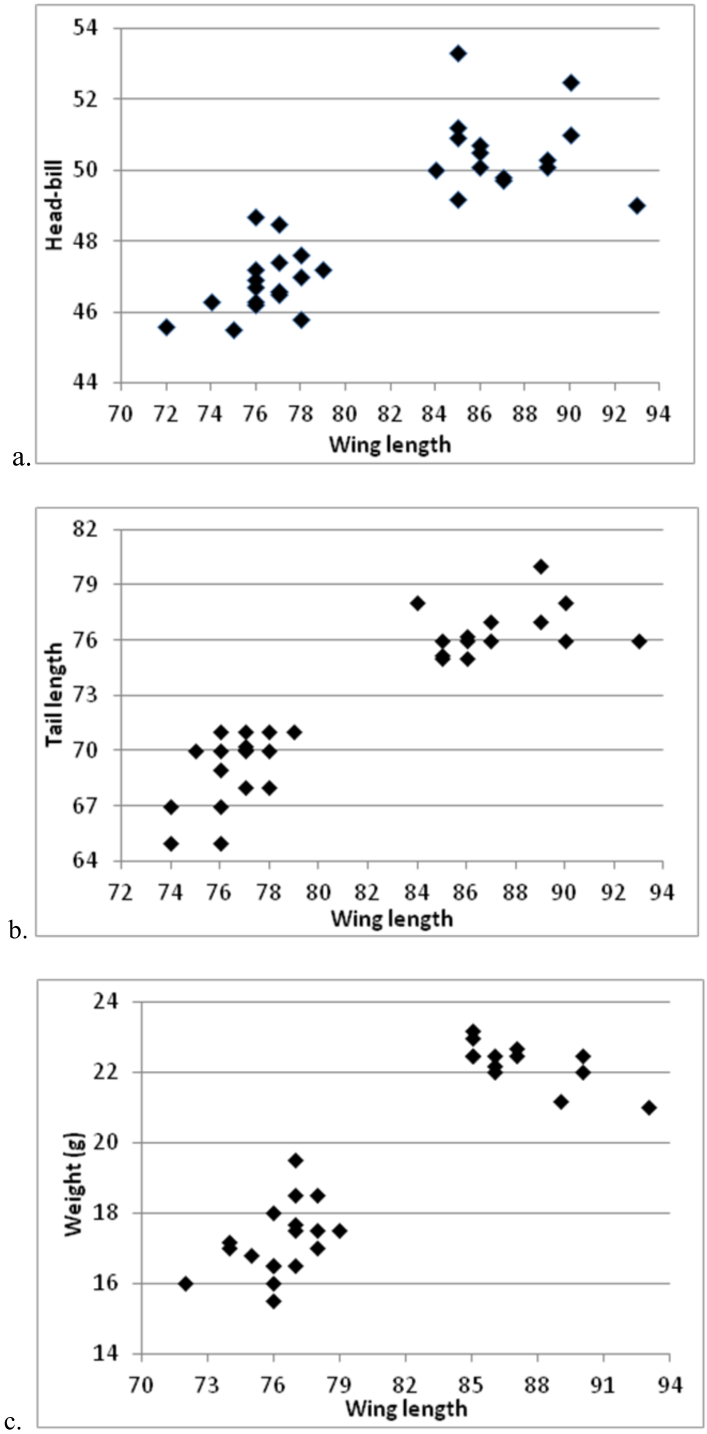

Fig. 2. Bivariate plots of length of head–bill (a), tail length (b) and weight (c) against wing length (mm) for Dark-eared Myzas captured during this study. Each diamond represents an individual bird; n = 33 (a) or 31 (b,c). Inferred males to right, females to left.

Solomon Islands, in which males are 47% heavier (on average) and 14-15% greater in wing and tail length than females (Higgins *et al.* 2001), and the Crescent Honeyeater *Phylidonyris pyrrhoptera*, in which males of the south-east Tasmanian population are 24.7% heavier, 11.9% longer in the wings, and 15.0% longer in the tail, than females (Higgins *et al.* 2001). Based on our assignment of sexes, the Dark-eared Myza is comparable to the latter species in its degree of sexual dimorphism, males being 28.7% heavier than females, 14.3% longer in the wings, and 10.7% longer in the tail, than females.

According to the literature, the upper wing of the Dark-eared Myza is "blackish, with edgings of the colour of the back [greenish tawny-olive] or, on the primaries, lighter" (Meyer & Wiglesworth 1898), "blackish edged with tawny olive" (White and Bruce 1986) and "dark olive-brown, [with] pale olive to yellow-olive outer edges of remiges" (Higgins *et al.* 2008). Yet the two photographs of the species in the Oriental Bird Club image database (http://orientalbirdimages.org, last accessed 6 July 2012), also taken on the Anaso track, show birds with the same buff spots on the secondary coverts that we observed. Indeed such markings may be a characteristic of this endemic genus as they are also evident on the species' only congener, the White-eared Myza *M. sarasinorum* (http://orientalbirdimages.org, last accessed 6 July 2012).

Annual cycle

As in Australian honeyeaters, primary moult in the Dark-eared Myza is of the typical basic passerine sequence (Ginn & Melville 1983), commencing at the innermost primary (P1) and finishing at the outermost (P10). In temperate south-eastern Australia, honeyeaters undergo a single, complete moult annually, typically during the austral summer and early autumn, soon after completion of breeding (Ford 1980; Higgins *et al.* 2001). In the south-east Asian tropics, too, moult usually follows breeding (Fogden 1972; Wells 1976). However overlap of moult and breeding is known to occur among at least some species of honeyeaters (Keast 1968; Dow 1973; Franklin *et al.* 1999), as well as some Asian families, such as the bulbuls (Pycnonotidae) and babblers (Timaliidae) (Ward 1969).

Of the 32 Dark-eared Myzas caught in the present study that were identified as adults or in which age was unrecorded, 11 (34%) showed primary moult during one or both sampling periods, including four in the final stage of moult (i.e. moult scores ≥45). One of the retrapped birds (03Y-006218) showed a 50% increase in its primary moult score over 103 days, but this seemingly slow rate of feather development may be due to many factors, such as moult suspension, although the latter phenomenon is rare among Australian honeyeaters studied to date (Paton 1982; Higgins *et al*. 2008). In south-eastern Australia, individuals of three resident honeyeater species took 75–113 days to replace all of their primaries (Dow 1973; Paton 1982; Franklin *et al.* 1999). Assuming that the primaries of Myzas normally grow at a rate similar to those of the Australian honeyeaters, the above four Myzas might have finished breeding at least 70 days before capture. Assuming further that the combined incubation and nestling period is at least 30 days (see Higgins *et al.* 2001), we may tentatively infer that these individuals started breeding c. 100 days (3.3 months) before capture. Thus the bird caught in March (04Y-006205) with a moult score of 47 may have been breeding in late December, and the three birds with similar scores from July possibly nested in early April. The latter period roughly coincides with the March–April banding trip, when indeed, two females showed brood patches. This period corresponds to the late wet season over much of Sulawesi, including parts of Lore Lindu National Park (Whitten *et al.* 2002).

Nevertheless more than half of the adults in both March–April (56%) and July (74%) showed no sign of moulting flight feathers, and one female had a brood patch in July, indicating that the breeding season may extend into the dry season (July–October). Breeding records of eight species of montane honeyeaters of New Guinea with a similar or slightly larger body size (17–24 cm) to the Dark-eared Myza show that these birds breed mainly during the dry season, between April and October (data from Coates 1990). Incidental nest records of 49 bird species in Sulawesi (Watling 1983; van den Berg & Bosman 1986; D.D. Putra, unpubl. Data; I. Hunowu, unpubl. data) reveal that avian breeding seasons in Central Sulawesi span all months of the year. Additional field work at other times of the year are needed to gain a better understanding of the annual cycle of this Sulawesi-endemic montane honeyeater, but it is clear that the breeding season is long, probably including both wet and dry seasons, and possibly unsynchronised within the population.

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References

Coates, B.J. 1990. *The Birds of Papua New Guinea*, Vol 2. Dove Publications, Alderley, Queensland.

Coates, B.J. & K.D. Bishop. 1997. *A Guide to the Birds of Wallacea*. Dove Publications, Alderley, Queensland.

Dow, D.D. 1973. Flight moult of the Australian honeyeater *Myzantha melanocaphala* (Latham). *Journal of Zoology* 21: 519-532.

Fogden, M.P.L. 1972. The seasonality and population dynamics of equatorial forest birds in Sarawak. *Ibis* 114: 307-343.

Ford, H.A. 1980. Breeding and moult in honeyeaters (Aves: Meliphagidae) near Adelaide, South Australia. *Australian Wildlife Research* 7: 453-463.

Franklin, D.C., I.J. Smales, B.R. Quin & P.W. Menkhorst. 1999. Annual cycle of the Helmeted Honeyeater *Lichenostomus melanops cassidix*, a sedentary inhabitant of a predictable environment. *Ibis* 141: 256-68.

Ginn, H.B. & D.S. Melville. 1983. *Moult in Birds*. BTO Guide 19. British Trust for Ornithology, Tring, UK.

Higgins, P.J., L. Christidis & H.A. Ford. 2008. Family Meliphagidae (Honeyeaters). Pp 498–691 *In* J. del Hoyo, A. Elliott & D. Christie (eds.) *Handbook of Birds of the World, Vol. 13, Penduline-tits to shrikes.* Lynx Edicions, Barcelona.

Higgins, P.J., J.M. Peter & W.K. Steele. (Eds) 2001. *Handbook of Australian, New Zealand and Antarctic Birds*, vol. 5. Oxford University Press, Melbourne.

Keast, A. 1968. Moult in birds of the Australian dry country relative to rainfall and breeding. *Journal of Zoology, London*, 155: 185-200.

Meyer, A.B. & L.W. Wiglesworth. 1898. *The Birds of Celebes, and the neighbouring islands, vols. 1 and 2*. R. Friedländer & Sohn, Berlin.

Noske, R.A. 2003. The breeding seasons of birds on Timor. *Kukila* 12: 27-38.

Noske, R., D.M. Prawiradilaga, D. Drynan, A. Leishman & W. Rutherford. 2011. Understorey birds of Cikaniki Research Station, Gunung Halimun-Salak National Park, West Java: Report of the Indonesian Bird Banding Scheme Training Programme. *Kukila* 15: 50-65.

Paton, D.C. 1982. Moult of New Holland Honeyeaters, *Phylidonyris novaehollandiae* (Aves: Meliphagidae), in Victoria I. Moult of adults. *Australian Wildlife Research* 9: 331-344.

Prawiradilaga, D. 2006. *Mengenal Burung di Taman Nasional Lore Lindu, Sulawesi Tengah* [A Guide to the Birds of Lore Lindu National Park]. Pusat Penelitian Biologi-LIPI, Bogor.

R Development Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Riley, J.H. 1924. A collection of birds from north and north-central Celebes. *Proceedings U.S. National Museum,* No. 2506. Vol. 64. Art. 16.

Rogers, K., A. Rogers, D. Rogers, B. Lane & B. Male. 1986. *Banders Aid: A Guide to Ageing and Sexing Bush Birds*. A. Rogers, St. Andrews, Vic.

Stresemann, E. 1940. Die Vögel von Celebes. Teil III. Systematik und Biologie. *Journal für Ornithologie* 88: 1-135.

Svensson, L. 1970. *Identification Guide to European Passerines*. Naturhistoriska Riksmuseet, Stockholm.

van den Berg, A.B. & C.A.W. Bosman. 1986. Supplementary notes of some birds of Lore Lindu Reserve, Central Sulawesi. *Forktail* 1: 7-13.

Verheijen, J.A.J. 1964. Breeding seasons on the island of Flores, Indonesia. *Ardea* 52: 194-201.

Waltert, M., A. Mardiastuti & M. Mühlenberg. 2005. Effects of deforestation and forest modification on understorey birds in Central Sulawesi, Indonesia. *Bird Conservation International* 15: 257-273.

Ward, P. 1969. The annual cycle of the Yellow-vented Bulbul *Pycnonotus goiavier* in a humid equatorial environment. *Journal of Zoology, London.* 157: 25-45.

Watling, D. 1983. Ornithological notes from Sulawesi. *Emu* 83: 247-261.

Wells, D.R. 1976. Resident birds. Pp 1-33 in Lord Medway & D.R. Wells. *The Birds of the Malay Peninsula,* Vol. V. Conclusion and survey of every species. H.F. & G. Witherby Ltd, London.

Whitten, T., G.S. Henderson & M. Mustafa, M. 2002. *The Ecology of Sulawesi. The Ecology of Indonesia series*, Vol. 4. Periplus Editions, Hong Kong.

White, C.M.N. & M. D. Bruce. 1986. *The Birds of Wallacea (Sulawesi, the Moluccas & Lesser Sunda Islands Indonesia). An Annotated Check-list*. British Ornithologists' Union, London (Check-list no. 7).