Subspecific diagnoses in the Scarlet-breasted Lorikeet *Trichoglossus forsteni*

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I reviewed 53 specimens representing the four subspecies of *Trichoglossus forsteni* (27 *mitchellii*, 8 *forsteni*, 9 *djampeanus* and 9 *stresemanni*) in order to determine the characters by which to assign captive birds correctly to subspecies-specific breeding programmes. The subspecies form a cline of increasing size from west to east but, contrary to indications in the literature (even in original descriptions), they can only be diagnosed on a few characters in combination with their minor size differences: *mitchellii* is smallest, with olive-green crown-streaks, brownest-looking head, least blue-tinged black belly-patch, least amount of dark bars that tend, in the other taxa, to coalesce into a blackish mantle-patch, and often a rufous-tinged occiput; *forsteni*, slightly longer-winged and -tailed, has a relatively large bill and an often much more obvious dark mantle-patch; *djampeanus* consistently shows a pronounced blackish mantle-patch usually flecked with red feathers, typically with the strongest blue streaking on the crown and the most obvious blue tinge to the black belly-patch, and is larger than *forsteni* except in bill; while *stresemanni* is longest-winged and -tailed, with the largest bill, but has a variable dark mantle-patch as in *forsteni* and an often green-tinged occiput. Separate breeding programmes for each subspecies are desirable, but if too few birds are available then mixing them to maintain the species may be unavoidable.

INTRODUCTION

The taxonomic revision of the Rainbow Lorikeet *Trichoglossus haematodus* into seven species (del Hoyo & Collar 2014; see also their Introduction, p.32) resulted in three of the newly elevated taxa, all in Indonesia, being treated as at risk of extinction: Scarlet-breasted Lorikeet *T. forsteni* and Biak Lorikeet *T. rosenbergii* Vulnerable and Flores Lorikeet *T. weberi* Near Threatened (BirdLife International 2017a). Of these, the Scarlet-breasted Lorikeet, endemic to western Nusa Tenggara, is of particular concern because it comprises four subspecies, each with conservation problems of varying magnitude: nominate *forsteni* is still found in parts of its native Sumbawa, but *mitchellii* is judged to be extinct on Bali and only found in a small part of Lombok, while *djampeanus* appears to be extinct on the one island, Tanahjampea, from which it was certainly known, although a population might exist on the west side of Kalao, and *stresemanni* has not been recorded on its native Kalaotua since 1993, and even then the evidence simply consisted of calls being heard (Eaton *et al*. 2015).

The main cause of the decline of the Scarlet-breasted Lorikeet is evidently trapping for the cage-bird trade (Eaton *et al*. 2015), although on Tanahjampea local people blame its disappearance on the loss of large nest-trees (Arndt & Bashari 2016). There has been no attempt to secure any populations in the wild, but interest in captive breeding as a possible measure has been growing in the past decade (Gilardi 2011, Collar *et al*. 2012, Bruslund 2016). However, in parallel with the case of the Yellow-crested Cockatoo *Cacatua sulphurea* (Collar & Marsden 2014), the characters that distinguish the four subspecies of the lorikeet have been reported rather variously in the literature, with potentially serious consequences for work relating to legal requirements, the transfer, treatment and release of living birds, and *ex situ* management programmes. A clearer understanding of these characters—and indeed, clarification that the distinctions between the taxa are not simply an artefact of small sample sizes—is therefore in order.

METHODS

I assembled the original descriptions of the four taxa, considered the subsequent literature (chiefly Forshaw 1973, Juniper & Parr 1998; also Cain 1955, Low 1977, Arndt 1990–1996, Eaton *et al*. 2016) and examined and measured specimen material in three museums with important relevant holdings. These were the American Museum of Natural History (AMNH), New York, USA, the Natural History Museum (NHMUK), Tring, UK, and the Zoologisches Museum, Berlin (ZMB), Germany. After excluding damaged, unsexed, young (clearly undersized) and captive (hence provenance questionable) birds, 53 individuals, including all type specimens except of *forsteni* itself, were used in the study: 8 *forsteni*, 27 *mitchellii*, 9 *djampeanus* and 9 *stresemanni* (Table 1).

Further material is expected to exist at least in Naturalis (Leiden, Netherlands) and the Museum of Zoology (Bogor, Indonesia), but the former is at the time of writing closed for several years and the latter has proved unfeasibly distant. However, the specimens reviewed in this study are sufficiently numerous to allow conclusions to be reached with at least a moderate degree of confidence.

For each specimen I measured the length in mm of bill (upper mandible tip to edge of nareal skin), wing (curved) and tail (tip to point of insertion). Digital images were taken of the majority of specimens for further reference, and used extensively.

RESULTS

Diagnoses in original descriptions

The original description of the form *forsteni* involved a brief comparison with *T. haematodus* (i.e. the form restricted to the southern Moluccas east to western New Guinea), from which it was considered (my translation from French) 'well differentiated by its red breast and its yellow and black (not green) belly' (Bonaparte 1850). The accuracy and completeness of this diagnosis may not be high, but it was sufficient to tie all birds from Sumbawa to the name *forsteni*.

Nine years later the form *mitchellii* was considered 'very similar' to *forsteni* 'but the bill is smaller; the head and cheeks purplish black, streaked with green, and the front streaked with light blue; the breast crimson, slightly edged with pale green; the middle of abdomen

Table 1. Number, sex (males + females) and museum location of specimens representing the four subspecies of *Trichoglossus forsteni* used in this study. Measurements of this material are in Table 2.

	AMNH	NHMUK	ZMB	Total
forsteni	6 + 1		0 + 1	6 + 2
mitchellii	7 + 12	2 + 3	2 + 1	11 + 16
djampeanus	4 + 3	1 + 0	0 + 1	5 + 4
stresemanni	2 + 1		3 + 3	5 + 4
Total	36	6	11	53

varied with purplish black' (Gray 1859). The extent to which each of these characters is diagnostic rather than merely descriptive is not entirely clear (is 'crimson' really intended as a distinction from 'red'?), but collectively they form a reasonable basis on which to work.

The discovery on the Tanahjampea Islands south of Sulawesi of a population of *Trichoglossus* much more closely resembling *forsteni* of Sumbawa than the very distinctive *weberi* (described in 1894) of the geographically closer Flores must have come as a surprise. Hartert (1897) named the form *djampeanus* and retained it as a subspecies of *forsteni*, diagnosing it in a reverse comparison with *forsteni*, the latter having a forehead that 'is not so deep blue..., the wing... shorter [131–135 mm *vs* 141–145 mm], the band behind the yellowish green ring on the neck... never so distinctly and pure purple, and never so broad as in all the birds from Djampea'.

Finally, Meise (1929) found cause to distinguish the birds of Kalaotua, the most easterly island in the Tanahjampea archipelago, from those of Tanahjampea itself, by their (my loose translation from German) 'similar size, but crown with greenish-blue *vs* purple shaft-streaks that disappear on the green-flecked deep purple nape, patch on mantle blue-violet as in *djampeanus* but irregularly edged brown (with some yellow and red), breast slightly paler red and barred, underwing-coverts as red as the breast, partly barred yellow, axillaries yellow with reddish barring'. He noted that younger birds have green feathers intermixed on the dark belly-patch but also lack the dark interscapular mantle-patch (Hartert's [1987] 'band behind the yellowish green ring on the neck'); green belly-feathering is certainly related to immaturity in all four forms of *T. forsteni* (Rensch 1930, Forshaw 1973, Low 1977), but whether there is a correlation in all subspecies between age and the presence and intensity of the dark mantle-patch appears less certain (but see Discussion).

Diagnoses in later literature

Diagnosing the forms from west to east, Forshaw (1973) began with *mitchellii* ('head dark blackish-brown with greyish-green streaking on crown and cheeks; rufous tinge on occiput; breast rich red with only slight bluish edging to the feathers in some birds; abdomen purple-black; smaller than *haematodus*'), then *forsteni* ('similar... but without barring on darker red breast; forehead and cheeks streaked with violet-blue; more yellowish nuchal collar; some birds have purple on hindneck below collar; abdomen purple'), *djampeanus* ('similar to *forsteni*, but head darker and more strongly streaked with violet-blue; dark purple on hindneck below collar; no trace of barring on uniformly red breast', adding 'doubtfully distinct from *forsteni*'), and *stresemanni* ('similar to *forsteni*, but breast is more orange; yellow bases to feathers of mantle; occiput tinged with green'). He gave mean measurements in mm (with range) for males of *mitchellii* (n=11) of exposed culmen 18.1 (17–19), wing 132.2 (129–136), tail 98.8 (94–104); *forsteni* (n=6) 19.8 (19–21), 135.2 (132–139), 97.5 (87–103); *djampeanus* (n=8) 18.9 (18–19), 142.4 (140–146), 102.8 (96–112); and *stresemanni* 20.7 (20–21), 148.7 (142–152), 116.0 (105–124).

Juniper & Parr (1998) gave no sizes but distinguished *forsteni* from *T. h. haematodus* by its 'redder, unbarred breast, extensive dark blue patch in centre of belly extending onto abdomen, dark purple-blue band on upper mantle, and largely yellow lower flanks and undertail-coverts with slight green barring', and from *mitchellii* by its 'dark blue band on upper mantle and darker red and completely unbarred breast (head also more strongly streaked violet-blue, rather than green, particularly on forehead and cheeks)'. They described *djampeanus* as similar to *forsteni* 'but head streaked brighter blue' and *stresemanni* as having 'breast orange with virtually no darker edgings; green streaking on rear crown; sides of belly-patch suffused greener than in previous three races; poorly defined blue mantle-band; yellow or orange bases to mantle feathers'.

Eaton *et al.* (2016) briefly characterised *forsteni* by its 'dark blue head, belly and upper mantle; red breast and bill; green upperparts and thin yellow nuchal collar', and indicated the differences of '*djampeanus* brighter blue head; *mitchellii* green upper mantle; *stresemanni* perhaps paler red breast and more green-tinged nuchal collar'.

In discussing *mitchellii*, *forsteni* and *djampeanus*, Cain (1955) contended that the decrease in size (*mitchellii* smallest; see below) was matched by a decrease in strength of colour: 'The intensity of red on the breast, the purple gloss [on head and belly], the darkening of the post-torqual region [i.e. mantle-patch], and the blue on the forehead are progressively lost, while the nape pales from purplish black to a very dark brown in *mitchellii*... and the collar goes from yellow to a greenish yellow'. He judged that '*stresemanni* differs from *djampeanus* in a general yellowing of red areas, greening of yellow ones, and reduction of purple gloss'.

Diagnoses from present review

The form *mitchellii* differs from nominate *forsteni* by its olive-green (and thus against a dark brown base colour rather less obvious) *vs* silvery-bluish semi-glossy narrow streaking on the forecrown (Plate 1) and smaller size (Table 2). It exhibits dark transverse markings on the hindcollar and upper mantle in variable amounts (absent in the type and four out of five other specimens in NHMUK, just visible in the three ZMB specimens, but present in most specimens in AMNH), and the belly-patch is typically with little or no bluish-purple gloss. It differs from *djampeanus* and *stresemanni* by the same two characters as it does from *forsteni* plus,

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Plate 1. Olive-green streaking on the fore- to mid-crown of *Trichoglossus forsteni mitchellii* (left) and silvery-blue streaking on that of *T. f. forsteni* (right).

Table 2. Mean, range and standard deviation (SD) of measurements (mm) of specimens of the four subspecies of *Trichoglossus forsteni* (see Table 1). [1] n=9; [2] n=15; [3] n=14; [4] n=5; [5] n=4; [6] n=3.

Taxon	Sex	n	Bill	Wing	Tail
			mean (range) ± SD	mean (range) ± SD	mean (range) ± SD
mitchellii	m	11	17.9 (17.1–19.3) ± 0.71	128 (124–133) ± 3.01	96.4 (93–105) ± 3.68[1]
	f	16	17.4 (16.2–18.7) ± 0.61[2]	125 (122–131) ± 2.58	93.3 (87–99) ± 3.10[3]
forsteni	m	6	19.6 (19.2–20.3) ± 0.42	132 (129–134) ± 1.87	100 (93–104) ± 4.36[4]
	f	2	19 (18.6–19.4)	130 (129–131)	99 (98–100)
djampeanus	m	5	18.8 (18.2–19.2) ± 0.38	138 (136–141) ± 2.41	105 (101–112) ± 4.76
	f	4	18.1 (17.3–19.1) ± 0.80	139 (134–142) ± 3.40	106 (100–111) ± 5.8
stresemanni	m	5	20.5 (19.5–21) ± 0.58	147 (145–148) ± 1.29[5]	119 (116–123) ± 2.94[5]
	f	4	19.4 (18.9–19.7) ± 0.42[6]	142 (137–148) ± 4.97	111 (105–119) ± 6.06

vs djampeanus, its more matt black belly-patch and absent/relatively weak *vs* always strong (often bluish-tinged) blackish mantle-patch with no *vs* usually present semi-concealed red feathers beneath it, and, *vs stresemanni*, by its blacker-looking belly-patch and distinctly smaller size (Table 2).

The form *djampeanus* differs from *mitchellii* by characters given above; from *forsteni* by its darker and larger blackish mantle-patch with numerically more part-concealed red feathers on the lower edges, typically but marginally stronger blue streaks on the crown, and slightly larger size; and from *stresemanni* by its generally much bolder blackish mantle with numerically more part-concealed red feathers on the lower edges (some *stresemanni* come close), typically but slightly stronger blue streaks on the crown and more bluish-purple on the belly-patch, and slightly smaller size (Table 2).

The form *stresemanni* differs from *mitchellii* and *djampeanus* by characters given above; and from *forsteni*, with which it shares a fairly distinctive but highly variable dark mantle-patch, by its rather longer wings and tail (Table 2).

DISCUSSION

Phenotypic characterisation of *Trichoglossus forsteni*

This review of specimen material of the Scarlet-breasted Lorikeet, while not comprehensive, involves a large enough sample to demonstrate that several characters by which subspecies have been distinguished in the past are not fully diagnostic but merely represent collective points on the spectrum of individual variation.

Nominate *forsteni*

Without seeing the type of *forsteni* in Paris it is impossible to be clear how much information Bonaparte (1850) failed to mention when saying that its belly is 'yellow and black (not green)'. The belly of *forsteni* in all its subspecies is a (blue-tinged) purplish-black, with irregular broad green-and-yellow barring on the flanks, thighs, vent and undertail-coverts. Forshaw's (1973) assertion that the nuchal collar is 'more yellowish' is not upheld (Plate 2), and his claim, repeated in Juniper & Parr (1998), that *forsteni* has a darker red (and entirely unbarred) breast than *mitchellii* simply reflects individual and/or age-related variation in the breast colour and pattern which appears to characterise all subspecies—best illustrated in my sample by *stresemanni* (Plate 3). The notion that the lower flanks and undertail-coverts are 'largely yellow... with slight green barring' (Juniper & Parr 1998) is also mistaken.

Subspecies *mitchellii*

The finding that *mitchellii* does not differ consistently from *forsteni* in its green *vs* blackish hindneck and upper mantle (see Results and Plate 2), as illustrated in Collar (1997), del Hoyo & Collar (2014) and Eaton *et al*. (2016), where a 'green upper mantle' is explicitly mentioned, greatly reduces its distinctiveness. Moreover, the pattern and shade of the breast and the colour of the nuchal collar are as in *forsteni* (see preceding paragraph), although Low (1977) presented evidence from two aviculturists and from her consideration of specimen material that females of *mitchellii* might, in breeding condition, be marginally less bright and show more yellow on the breast than males. The 'rufous tinge on occiput' (Forshaw 1973) is present in varying degrees of intensity in about 50% of specimens and was much less obvious and far less frequent in other taxa, and hence represents a potential confirmatory albeit not diagnostic character. Although this subspecies appears typically to have little if any blue wash on the black belly-patch, in plumage its only consistent distinguishing character appears to be the olive-green *vs* silvery-blue streaking on the fore- to mid-crown, but this is also slightly less extensive, leaving the underlying dark brown of the head a little more exposed and obvious (Plate 1).

Subspecies *djampeanus*

Hartert (1897) cited two plumage characters to distinguish this form from *forsteni*, a deeper blue forehead and the 'distinctly and pure purple' patch on the hindneck and upper mantle. Forshaw (1973) elaborated on Hartert's view of the head ('darker and more strongly streaked with violet-blue'), this translating into 'pronounced violet-blue streaking' in Arndt (1990–1996), and simply a 'brighter blue' head in both Juniper & Parr (1998) and Eaton *et al*. (2016), but the slightly stronger blue streaking on the crown in my sample did not appear fully diagnostic and may not represent a dependable difference. By contrast, the bold (often blue-tinged) purplish-black patch below the yellowish nuchal collar is consistently darker and more extensive, with greater evidence of irregular red feathering underneath it, than in any other subspecies; this character and the slightly longer wings and tail seem sufficient to dispel Forshaw's doubts about the validity of this form.

Subspecies *stresemanni*

Juniper & Parr (1998) considered this form to have 'sides of belly-patch suffused greener', but this was not apparent in my comparisons (see Plates 2, 3 and 4). More curiously, some of Meise's (1929) defining characters are also open to question. The form may in a general sense be 'similar in size' to *djampeanus* but it is discernibly larger and the breast is not always slightly paler or barred. A paler (i.e. more orange-tinted) breast is repeated as a character in Cain (1955), Forshaw (1973), Arndt (1990–1996)—who illustrates the form with a bright orange-breasted but evidently immature individual—and Juniper & Parr (1998), but while some specimens, probably younger birds (they also possess only weakly darker mantle-patches; see last paragraph in this section), show this, it is not a constant character and in other material the form achieves exactly the same shade of lobster-red as the other three subspecies (see Plates 3 and 4). Meise's distinction between 'greenish-blue' (*stresemanni*) and 'purple' (*djampeanus*) streaks on the crown is not upheld (was he perhaps influenced by Hartert's original description of *djampeanus*?). His 'green-flecked deep purple nape', which evidently translated into 'green streaking on rear crown' in Juniper & Parr (1998), is also in doubt, unless it is the 'occiput tinged with green' of Forshaw (1973) and the 'more green-tinged nuchal collar' of Eaton *et al*. (2016). This latter character, like the rufous-tinged occiput in *mitchellii*, is present in roughly half the specimens of *stresemanni* examined, and therefore has a potential confirmatory but assuredly not decisive role in subspecies identification; at least one *forsteni* shows this feature (second specimen from right in Plate 2).

Meise (1929) judged the variability in Kalaotua birds so striking that he speculated that several 'phases' might be involved or that it might be the product of hybridisation with another immigrant form. Indeed, although *stresemanni* is relatively long in wing and tail, the degree of overlap in characters with both *djampeanus* and *forsteni* is such that some specimens might be hard to assign to one form or another with real confidence; for example, the type in AMNH (register number 266491; but note that all specimens in ZMB also bear type labels) has a markedly large, dark mantle-patch, exactly as found in *djampeanus* (e.g. AMNH 266593).

Clinal variation

Forshaw (1973) clearly measured much the same material as I used in the present study, and it is gratifying that our results almost entirely coincide (his slightly larger values for wings are the product of measuring them flat). What these mensural data reveal is a cline of advancing size from west to east, with the mean for wing and tail in both sexes increasing by very roughly 0.5 cm per subspecies (Plate 4). These differences are not enough on their own to diagnose a subspecies from its geographically closest neighbour, but should be sufficient to distinguish *stresemanni* from either *mitchellii* or nominate *forsteni*. The one anomaly in the mensural data concerns

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Plate 2. All seven specimens of male *Trichoglossus forsteni mitchellii* in AMNH (upper row) and all seven specimens of male *T. f. forsteni* in AMNH (lower row; six wild males and a cage-bird, excluded from analysis in this paper, on far right), showing the same basic but variable pattern of dark transverse barring (tending to coalesce as a 'mantle-patch') on the lower hindneck and upper mantle.

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Plate 3. All five specimens of *Trichoglossus forsteni stresemanni* in AMNH (type on left), showing the variability in the breast colour and pattern.

the bill size of nominate *forsteni*, which proves to be larger than in the otherwise larger *djampeanus* and almost as large as in *stresemanni*. Gray (1859) was certainly right when he diagnosed *mitchellii* from *forsteni* by its smaller bill, although it seems that his sample size was 1!

The matching cline in colour intensity detected by Cain (1955), considering *mitchellii*, *forsteni* and *djampeanus*, is only partially upheld here. His 'very dark brown nape' in *mitchellii* is evidently Forshaw's (1973) 'rufous tinge on occiput' and is, as discussed, perhaps better judged less clinal as a character than an inconstant feature of the species most apparent in *mitchellii*. The red of the breast and the yellow of the nuchal collar, while individually variable, are not subspecifically diagnostic. The 'purple gloss' appears as strong in *forsteni* as in *djampeanus*. This leaves the change in colour of the crown-streaks (slightly stronger silvery-blue in *djampeanus*, silvery-blue in *forsteni* and olive-green in *mitchellii*) and of the mantle-patch (respectively always bold and dark, usually bold and dark, and weak and inconstant); but in any case the notion of a cline in plumage colour is entirely spoilt by *stresemanni*, which rather better matches *forsteni* than *djampeanus*, except in wing and tail length.

Mantle-patch as an age character

Both T. Arndt and S. Bruslund (commenting as referees) mention that the dark patch or set of transverse dark bands on the upper mantle of all four taxa appears to be acquired with age (TA tracked birds from a Bali market which, from their lack of a dark mantle-patch and their presence on Bali, he thought might be *mitchellii*, but a year later they possessed a 'clear and quite broad blackish-purple' mantle-patch and on this and other evidence were identified as nominate *forsteni*). Thus the aforementioned variability in this feature may be at least partly a function of age.

Conservation and captive breeding

The mounting evidence of the threat posed to Indonesian bird species by the cage-bird trade leaves no room for confidence in the future of the Scarlet-breasted Lorikeet without substantial conservation intervention. Since the recent brief review of its status (Eaton *et al*. 2015), evidence has continued to accumulate that supports the treatment of the species as at serious risk of extinction. On Lombok several groups of *mitchellii* were observed in late 2016, but local tourist guides reported continuing trapping pressure in certain areas of the island (J. A. Eaton *in litt*. 2017). On Sumbawa the situation is unclear, but reports are consistently disconcerting: already in 1993 it was scarce/rare, 'which may indicate a heavy trapping pressure on the island' (Butchart *et al*. 1996), while numbers at Tatar Sepang,

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Plate 4. Representative specimens in AMNH of (left to right) *Trichoglossus forsteni mitchellii*, *T. f. forsteni*, *T. f. djampeanus* and *T. f. stresemanni*, showing a west–east cline in increasing size.

an Important Bird Area in the south-west (BirdLife International 2017b), have plummeted in surveys, from over 200 in 1997 to around 50 in 2003 and as few as six in November 2016, this trend being attributed to trapping (Muhamad Salamuddin Yusuf *in litt*. 2017), and a two-day visit to Marente Forest in western Sumbawa yielded no records (A. Reuleaux *in litt*. 2017). A visit to Tanahjampea in 2016 failed not only to produce any records but also to find any local person who knew the bird, suggesting that *djampeanus* was trapped out of existence many years ago (and although Kalao may be worth surveying, it is also to be noted that *Trichoglossus* was judged absent there in 1927: Meise 1929). A visit to Kalaotoa in 2016 failed to produce a record, but satellite imagery shows a large block of forest in the north of the island, so a population of *stresemanni* might survive there (J. A. Eaton *in litt*. 2017).

Clearly, there is a strong case for seeking to unite captive populations of these taxa in order to propagate a genetically diverse reserve stock for reintroduction in due course. To this end, I recommend what the modern zoo community calls a 'one plan approach', involving a collaboration between *in situ* and *ex situ* conservationists, in a concerted endeavour across Europe, North America and Asia, including Indonesia, to seek and obtain birds without driving further demand for wild ones. The results of this review will perhaps help assign any cage-birds found to the correct subspecies, which should of course be maintained as far as possible as separate populations. However, the results also indicate that the four forms of *T. forsteni* are phenotypically rather closer to each other than perhaps was thought. Indeed, it is possible that some captive birds of one subspecies have already been crossed with those of another. In practical terms, therefore, the conservation community may need to contemplate the miscegenation of subspecies if this is judged likely to give the species as a whole a greater chance of long-term survival (extinction being a far less desirable outcome than a hybrid population). Moreover, if conditions are ever sufficiently propitious to reintroduce the species to Bali and Tanahjampea, the use of *forsteni* for the former and *stresemanni* for the latter would not, in my view, be unacceptable.

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