The subspecies of Yellow-crested Cockatoo *Cacatua sulphurea*

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Given its increasingly serious conservation status, there is a need to clarify the taxonomy of the Yellow-crested Cockatoo *Cacatua sulphurea* of Indonesia and East Timor, especially to enable subspecies to be identified with confidence for any future captive-breeding endeavours. Modern treatments recognise four subspecies: nominotypical *sulphurea* from Sulawesi and associated islands, *abbotti* on Masalembu Besar, *parvula* from Lombok to Timor, and *citrinocristata* on Sumba. We compared morphometric data (lengths of upper mandible, wing, tail and crest; colour and size of ear-covert patch) from 136 sexed museum specimens from across the range of the species. There were significant differences in wing and tail lengths across taxa and sexes, with *abbotti* and *citrinocristata* being particularly distinctive. Mandible sizes differed markedly between sexes, while there were also across-taxon differences in wing–tail ratios. Our analyses result in the reinstatement of the subspecies *occidentalis* (Lombok to Alor, leaving *parvula* confined to Timor) and *djampeana* (Tanahjampea Islands) and in the recognition of *paulandrewi* subsp. nov. (see p.26) on the Tukangbesi Islands. The race *citrinocristata* comes very close to species status, and further evidence on behaviour and juvenile colouration may clinch this. The form *abbotti* is also distinctive but may represent a population that rapidly evolved large size in response to its small-island circumstances. Each taxon needs as far as possible to be managed in the wild and in captivity as a separate unit of conservation concern.

INTRODUCTION

The Yellow-crested Cockatoo *Cacatua sulphurea* occupies an ostensibly large range from the Masalembu Islands south of Borneo and from Nusa Penida (by report formerly Bali) and Lombok eastwards through Sulawesi and the Lesser Sundas in Indonesia as far as East Timor, thus being virtually confined to the biogeographical region known as Wallacea (White & Bruce 1986, BirdLife International 2001). However, as a result of relentless and pervasive trapping for the cagebird trade the species has been dramatically reduced in numbers, such that since 1988 it has been on the IUCN Red List, and was classified as Critically Endangered at the start of the present century (Stattersfield & Capper 2000). The situation of the species in recent years has become so serious that moves to conserve it may now require captive (conservation) breeding, at least as a precautionary measure (Collar *et al*. 2012, Collar & Butchart 2014).

However, the species breaks down into a number of subspecies, with most recent treatments recognising four: nominotypical *sulphurea* from Sulawesi and certain associated islands, *abbotti* on Masalembu Besar (midway between southernmost Borneo and Madura, off north-east Java; well west of Wallace's Line), *parvula* from Nusa Penida (technically just west of Wallace's Line) and Lombok to Timor, and *citrinocristata* on Sumba (White & Bruce 1986, Forshaw 1989, Rowley 1997, Clements 2000, BirdLife International 2001, Dickinson 2003, Dickinson & Remsen 2013). In addition, however, Hartert (1897, 1898) described two further taxa, *djampeana* (for birds from the Tanahjampea and Tukangbesi islands south and south-east of Sulawesi respectively) and *occidentalis* (for all birds in the Lesser Sundas except Timor and Sumba). Given that (a) it is desirable to avoid cross-breeding between subspecies where possible, but that (b) the captive stock available for breeding almost invariably has no certain provenance, conservationists attempting to use existing captive birds to establish one or more *ex situ* flocks of Yellow-crested Cockatoos, whether as a long-term reserve or as a source population for reintroductions, need to know, as far as the evidence allows, which taxa are valid and how to discriminate them.

For two of them there ought to be no difficulty. The race *citrinocristata* is highly distinctive owing to its strong orange-apricot rather than lemon-yellow crest, while the race *abbotti* is such a large bird that it could not be confused except perhaps with the smaller races of Sulphur-crested Cockatoo *Cacatua galerita* from New Guinea. For completeness and interest, however, both *abbotti* and *citrinocristata* are included in the following analysis, not least as a means of testing species limits within the complex. The situation is, however, aggravated by sexual dimorphism in morphometrics, so sex is taken into account in the analyses.

METHODS

Preserved specimens of Yellow-crested Cockatoos were examined in: the American Museum of Natural History, New York, USA (AMNH); Natural History Museum, Tring, UK (NHMUK); Naturalis, Leiden, Netherlands (RMNH); Staatliches Museum für Tierkunde, Dresden (SMTD); National Museum of Natural History, Washington DC, USA (USNM); Zoologisches Museum, Berlin, Germany (ZMB); with data provided for one specimen in the Academy of Natural Sciences of Philadelphia (ANSP). Unsexed specimens were excluded from analysis, as were specimens without indication of provenance with the exception of those of the distinctive *citrinocristata*, resulting in a total of 136 specimens contributing data for analysis (see breakdown by taxon, sex and museum in Table 1).

Each specimen was measured (by NJC) for length of (1) upper mandible (from edge of nareal skin to tip), (2) wing (curved), (3) tail (tip to point of insertion) and (4) crest (from edge of nareal skin to tip, retaining its natural curve). The colour of the ear-covert patch was recorded subjectively (i.e. without recourse to a colour

Table 1. Numbers (males+females) of provenance-labelled specimens of *Cacatua sulphurea* used in the morphometric analysis, broken down by taxon and museum. (NB There are other provenance-labelled specimens of the species in ANSP, but measurements of just the one specimen were requested, to boost the sample size for *parvula*.)

taxon	AMNH	ANSP	NHMUK	RMNH	SMTD	USNM	ZMB	Total/sex	Total
sulphurea	2+4		3+2	5+9	1+1	8+11	2+5	21+32	53
abbotti						6+2		6+2	8
occidentalis	7+6		1+3	1+3			6+3	15+15	30
parvula	1+5	1+0	1+1				1+1	4+7	11
djampeana	4+8						2+2	6+10	16
citrinocristata	6+4		1+1	4+1			0+1	11+7	18
Total/sex	20+27	1+0	6+7	10+13	1+1	14+13	11+12		
Total	47	1	13	23	2	27	23		136

chart, which in any case would not be helpful in many cases where two colours, one tingeing the other, were present), and its size measured crudely with calipers (usually left side of head, but varying with condition of specimen), laterally for maximum length and vertically for maximum height, with the median of these two values being logged.

From these collections the numbers of specimens measured by island and taxon (in modern spelling, sometimes slightly different from specimen labels) were: Sulawesi 46 (17 males, 29 females), Buton 5 (3 m, 2 f), Muna 2 (1 m, 1 f) (*sulphurea*); Masalembu Besar 8 (6 m, 2 f) (*abbotti*); Wanci (on label; main town on the island of Wangiwangi) 1 (1 m), Tomea 3 (1 m, 2 f) and Binongko 2 (1 m, 1 f) in the Tukangbesi ('Wakatobi') group, plus Kayuadi 2 (2 m), Tanahjampea 2 (2 f), Kalaotoa 5 (5 f) and Madu 1 (1 m) in the Tanahjampea group (*djampeana*); Nusa Penida 7 (5 m, 2 f), Lombok 10 (4 m, 6 f), Flores 7 (3 m, 4 f), Pantar 3 (2 m, 1 f), Alor 3 (1 m, 2 f) (*occidentalis*); Timor 11 (4 m, 7 f) (*parvula*); and Sumba 18 (11 m, 7 f) (*citrinocristata*).

Differences in wing length, tail length, upper mandible size, and wing-to-tail ratio were explored using parametric ANOVAs with sex and taxon as groupings and the interaction between sex and taxon considered. Pair-wise differences between biometrics of individual taxa were then tested using Tukey–Kramer *post hoc* tests.

In anticipation that the distinctive *C. s. citrinocristata* might be considered for species status, its degree of phenotypic differentiation was scored against other taxa using the system outlined in Tobias *et al*. (2010). A major character (pronounced difference in body part colour or pattern, measurement or vocalisation) scores 3, medium character (clear difference, e.g. a distinct *hue* rather than different colour) 2, and minor character (weak difference, e.g. a change in shade) 1; a threshold of 7 is set to allow species status, species status cannot be triggered by minor characters alone, and only three plumage characters, two vocal characters, two biometric characters (assessed for effect size using Cohen's *d* where 0.2–2 is minor, 2–5 medium and 5–10 major) and one behavioural or ecological character (allowed 1) may be counted.

RESULTS

For each described taxon means of the five variables measured (bill, crest, ear-covert patch, wing and tail) are given for males in Table 2 and for females in Table 3, while colours of the ear-covert patch are listed in Table 4. There are degrees of overlap in morphometrics, but overall a distinct pattern emerges of consistent if small differences between each described taxon.

There were significant differences in wing length measurements for different taxa ($f_{5,123} = 65.6$, $p < 0.001$) and sexes ($f_{1,123} = 9.00$, $p < 0.001$), but there was no interaction between sex and taxon ($f_{5,123} = 0.20$, $p = 0.96$; Figure 1a). *Post hoc* tests showed *abbotti* and *citrinocristata* to be different from each other and all other taxa, and *sulphurea* to be different from *djampeana* and *occidentalis*. Tail length measurements also differed significantly across taxa ($f_{5,124} = 136.3$, $p < 0.001$), but not for sexes ($f_{1,124} = 0.001$, $p = 0.97$) or the interaction between sex and taxon ($f_{5,124} = 0.45$, $p = 0.21$; Figure 1b); on this variable the subspecies *abbotti* and *citrinocristata* were very different from all taxa but only marginally different from each other ($p = 0.038$); and *parvula* was greatly different from all taxa.

For upper mandible measurements, the greatest differences were between the sexes ($f_{1,116} = 80.0$, $p < 0.001$; Figure 1c). Taxa also differed significantly ($f_{5,116} = 27.9$, $p < 0.001$) with no interaction. *Post hoc* tests showed *sulphurea* to be different from all other taxa, and *citrinocristata*, *abbotti* and *occidentalis* no different from each other. As well as in size, there were also differences in body structure, with wing-to-tail ratios varying between taxa ($f_{5,122} = 27.7$, $p < 0.001$) and sex ($f_{5,122} = 7.16$, $p = 0.009$) with no interaction (Figure 1d).

Table 2. Means and standard deviations of five mensural variables in male *Cacatua sulphurea* described taxa. [1] = sample size reduced by 1; [2] = sample size reduced by 2. Note *djampeana* proves to be composed of two taxa (see Discussion).

taxon	n	bill	crest	ear-patch	wing	tail
sulphurea	21	38.3 ± 1.81[2]	101 ± 4.07[1]	29.8 ± 3.01[1]	225 ± 6.43[1]	113 ± 2.38
abbotti	6	35.1 ± 1.21	123 ± 4.8[1]	20.5 ± 4.14[2]	263 ± 5.82	138 ± 6.62
occidentalis	15	36.9 ± 0.76[2]	94.3 ± 5.42	23.7 ± 3.05	220 ± 5.13	110 ± 5.13[1]
parvula	4	33.5 ± 1.94	101 ± 6.61	20.1 ± 0.63	223 ± 5.5	121 ± 5.03
djampeana	6	34.1 ± 1.3	92.5 ± 3.77[1]	26.6 ± 2.38[1]	220 ± 7.34	111 ± 4.4

Table 3. Means and standard deviations of five mensural variables in female *Cacatua sulphurea* described taxa. [1] = sample size reduced by 1; [2] = sample size reduced by 2; [4] = sample size reduced by 4. Note *djampeana* proves to be composed of two taxa (see Discussion).

taxon	n	bill	crest	ear-patch	wing	tail
sulphurea	32	35.6 ± 1.79[2]	98.7 ± 4.55[1]	28.8 ± 3.07[4]	221 ± 6.54	112 ± 2.1
abbotti	2	33	117	15.5	260	146
occidentalis	15	33.8 ± 1.82[1]	93.2 ± 6.16	21 ± 2.3[2]	213 ± 7.75	109 ± 4.82
parvula	7	31.1 ± 0.66	97.4 ± 6.5	20.7 ± 1.7	219 ± 4.42	120 ± 2.45
djampeana	10	30.9 ± 1.66	90.1 ± 6.4	23.8 ± 2.67[1]	213 ± 5.04	108 ± 4.11
citrinocristata	7	31.8 ± 1.35[1]	108 ± 4.37[1]	24.5 ± 2.49[1]	236 ± 12.82[1]	131 ± 6.77

Table 4. Ear-covert patch colour and size in *Cacatua sulphurea* (sexes combined; commonest colour in bold italics). Under 'size', 6 = largest and 1 = smallest. Note *djampeana* proves to be composed of two taxa.

taxon	n	size	ear-covert patch colour
sulphurea	53	6	***orange-tinged lemon-yellow*** (33), lemon-yellow (15), strong lemon-yellow (4), brownish-orange and yellow (1)
abbotti	8	1	***pale brownish-yellow*** (6), white (2)
occidentalis	28	3	***pale lemon-yellow*** (18), very pale lemon-yellow (5), brown-tinged yellow (4), lemon-yellow (1)
parvula	11	2	***very pale lemon-yellow*** (11)
djampeana	14	4=	***strong lemon-yellow*** (8), lemon-yellow (4), orange-tinged lemon-yellow (1), pale lemon-yellow (1)
citrinocristata	18	4=	***pale orange-tinged lemon-yellow*** (6), very pale lemon-yellow (5), very pale brown-tinged yellow (4), pale brown-tinged yellow (2), orange-brown-tinged yellow (1)

There were also differences in ear-covert colour and size (Table 4). As a consequence, each taxon proves to have characters that appear (at least in combination) to be diagnostic, as follows:

C. s. sulphurea—largest bill, and consistently largest and richest lemon-yellow ear-covert patch (Plate 1);

C. s. abbotti—longest crest, wings and tail, mid-sized bill and small (if present) and brownish ear-covert patch;

C. s. occidentalis—large bill, short wings and tail, and relatively small, usually pale to very pale lemon-yellow ear-covert patch (Plate 1);

C. s. parvula—smallest bill and ear-covert patch, longer tail than all except *abbotti* and *citrinocristata*, and relatively small, consistently very pale lemon-yellow ear-covert patch (Plate 1);

C. s. djampeana—size like *occidentalis* but smaller bill and consistently larger, mostly more colourful ear-covert patch (Plate 1)—but see Discussion for the taxonomic implications of differences between populations;

Figure 1. Means ± 95% confidence intervals of a. wing length, b. tail length, c. upper mandible length, and, d. wing-to-tail ratio in different sexes and taxa within *Cacatua sulphurea*. Note that the *y*-axis does not start at zero. Note *djampeana* proves to be composed of two taxa.

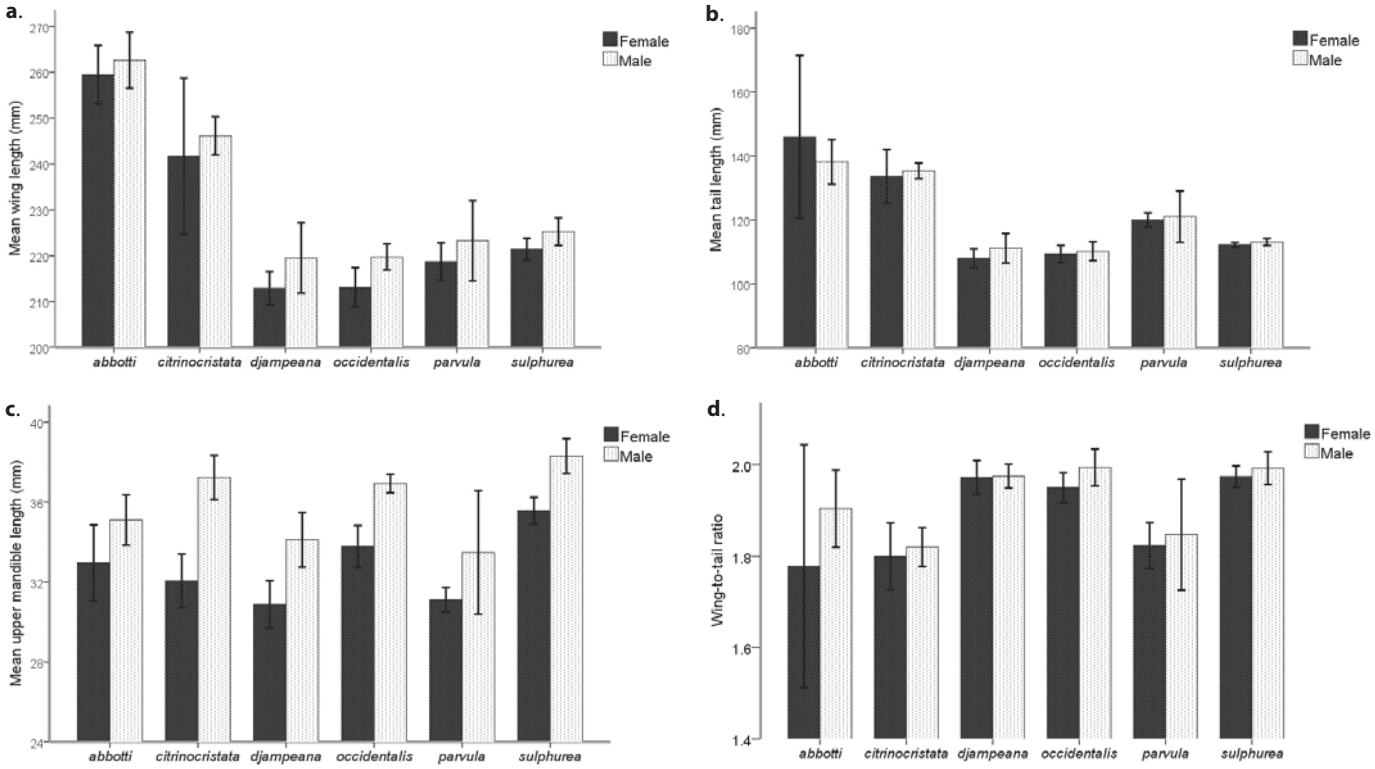

Plate 1. Specimens (all female except that from Sumba, for which sex unknown) representing five taxa of *Cacatua sulphurea*, left to right: *citrinocristata* Sumba (ZMB 30/3030); *parvula*, Timor (ZMB 56/288); *occidentalis*, Flores (ZMB 30/1091); *djampeana*, Kalaotoa (ZMB 28/755); and nominotypical *sulphurea*, Gorontalo, Sulawesi (ZMB 2000/20881).

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C. s. citrinocristata—large bill, long (and orange-apricot) crest, long wings and tail, and mostly pale orange-tinged lemon-yellow ear-covert patch (Plate 1).

Against the criteria established by Tobias *et al*. (2010) the form *citrinocristata* differs from all other taxa in the complex by its orange-apricot *vs* lemon-yellow crest (score 3). It differs from all other taxa except *abbotti* in its larger size, best expressed in the length of the tail (effect size for males 5.65 *vs occidentalis*, 7.25 *vs sulphurea*, 5.99 *vs djampeana*) (score 3—but see below for *parvula*). It differs from *abbotti* by males having a larger bill (effect size 1.53) (score 1) but smaller other proportions (effect size for male wing 2.75) (score 2). It apparently differs from other taxa observed in captivity (this comparison probably refers to *sulphurea* and *occidentalis* only, as *abbotti*, *djampeana* and *parvula* are almost certainly not held in captivity) by its much livelier, noisier disposition (S. Bruslund verbally 2012) (assuming all yellow-crested taxa are similar, score 1). On this basis *citrinocristata* achieves species status through a score of 7 against all taxa with the exception of *parvula*. Unfortunately the sample size for male *parvula* is particularly low (n = 4), but in any case neither male nor female *parvula* achieves an effect size based on morphometric differences from *citrinocristata* for the required major score (effect size for male tail 3.27, female tail 2.14; score only 2). Consequently, by virtue of the relatively long tail of *parvula* (by comparison with *occidentalis*, *sulphurea* and *djampeana*), in this analysis *citrinocristata* fails to reach species status under the Tobias criteria.

DISCUSSION

We opted not to subject the morphometric data to a principal components analysis (PCA) as is often done in taxonomic studies. We consider that the 'devil is in the detail' in individual measurements and ratios among the cockatoos, and that the differences would have been lost in the generality of a PCA. We used ANOVAs instead and found several important morphometric differences across taxa and sexes. These differences were quite complex: wing length differed across both taxon and sex; tail length differed across taxon but not sex; and the main differences in mandible size were across sex rather than taxon (with the otherwise 'average' *sulphurea* having a particularly large bill). Analysis of body structure also revealed important differences. With a larger sample size, associated environmental data from the islands, and perhaps genetic data illuminating branch lengths, it might be possible to pursue an explanation of what has driven these differences, but this would obviously carry the study to a new level of intensity.

While the distinctiveness of the forms *sulphurea*, *abbotti* and *citrinocristata* is obvious, that of the other three taxa is much less so, albeit still enough to reinstate *occidentalis* and *djampeana* as valid subspecies. Both of these were established on the basis of bill size by Ernst Hartert, who separated out *djampeana* first, on account of the smaller bills of birds from the Tanahjampea Islands than those

of birds on Sulawesi (*sulphurea*) (Hartert 1897). Later, however, he found that males from the Tukangbesi Islands possess the same-sized bills as those from Sulawesi while females from these islands have bills the same size as Tanahjampea birds, so he merged *djampeana* back into *sulphurea* (Hartert 1903). This was an inexplicable move on two counts: first, there is no particular reason why birds on one group of islands south-east of Sulawesi should annul the taxonomic distinctiveness of birds on another group of islands south of Sulawesi, and second because—using the same small sample that Hartert examined—the bills of males from the Tukangbesi group are in reality considerably smaller (mean 33.2, *n* = 3) than those from Sulawesi (38.3, *n* = 19) and closer to those from Tanahjampea (mean 35.0, *n* = 3). It is, however, intriguing that the birds from these two small island groups, which are separated by 250 km of open sea, should have the same taxonomic identity, and this bears further scrutiny.

Tukangbesi birds possess slightly smaller bills and decidedly smaller ear-covert patches than Tanahjampea birds, although their crests, wings and tails are fractionally longer (Table 5). The differences in size of bill and ear-covert patch are considerably more exaggerated between Tukangbesi and Sulawesi birds (compare males in Tables 2 and 5), even though Buton is only some 30 km distant from the nearest Tukangbesi island (Figure 2). The ear-covert patches of Tukangbesi birds are also paler than in Tanahjampea birds: combining the sexes, three are 'lemon-yellow', one 'pale lemon-yellow' and two have the area discoloured, possibly stained by fruit, whereas those from Tanahjampea are 'strong lemon-yellow' (eight), 'lemon-yellow' (one) and 'orange-tinged lemon-yellow' (one). Again, Sulawesi birds are still more divergent from those on Tukangbesi (compare data on *sulphurea* in Table 4 with the preceding information). Always acknowledging that the sample sizes involved are very small, we nonetheless judge that the consistency of these minor distinctions in combination amount to a subspecific difference worthy of recognition.

Cacatua sulphurea paulandrewi, subsp. nov.

This form is diagnosed from *C. s. djampeana* by its smaller bill and ear-covert patch (Table 5) and by the paler colouration of the latter (all these characters visible on Plate 2). We name it in honour of Paul Andrew, author among many other things of the first checklist of Indonesian birds (Andrew 1992), and designate as the type specimen AMNH 619651, a male taken at Wanci (Wangiwangi Island) on 3 December 1901 by H. Kühn.

The case of *occidentalis* is mildly more complicated. White & Bruce (1986), unaware of the consistently longer tails of Timor birds, merged it with *parvula* in the belief that bill size increases clinally westward from Timor. This is mistaken: measurements of bills of males ranging from Timor westward are: Timor 33.5 (*n* = 4), Alor 37.1 (*n* = 1), Pantar 37.3 (*n* = 2), Flores 37.1 (*n* = 3), Lombok 36.8 (*n* = 2) and Nusa Penida 36.7 (*n* = 5)—the non-Timorian sample thus being remarkably consistent. White & Bruce (1986) also mentioned that Meise (1930) 'considered birds from Pantar and Alor identical with those of Tanahjampea and Kalao, relying on the size of the bill', but this too is mistaken: Pantar and

Table 5. Mean sizes of male and female *Cacatua sulphurea* from the Tanahjampea and Tukangbesi Islands. [1] = sample size reduced by 1.

origin	sex	n	bill	crest	ear-patch	wing	tail
Tanahjampea	m	3	35.0	95.0	28.3	218	110
Tanahjampea	f	7	31.6	89.9	24.1	213	108
Tukangbesi	m	3	33.2	95.5[1]	24.0[1]	221	112
Tukangbesi	f	3	29.3	90.7	20.0[1]	213	109

MATTHEW SHANLEY, AMNH.

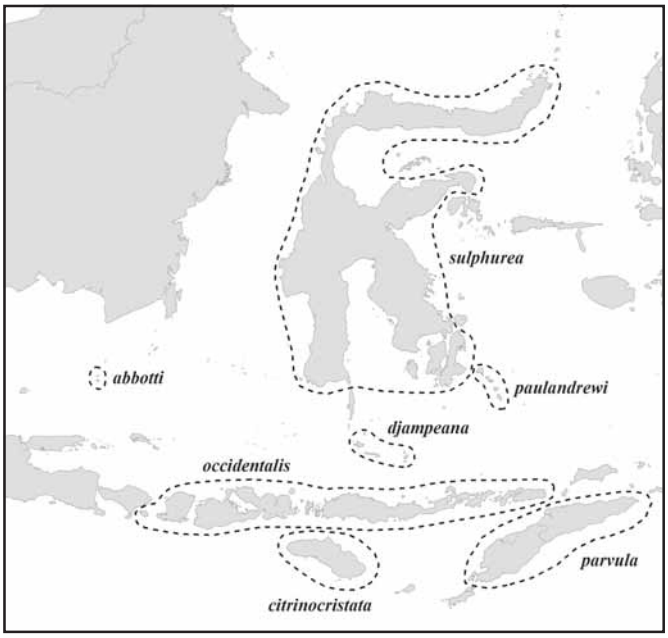
Plate 2. Males of three geographically adjacent taxa of *Cacatua sulphurea*: top *C. s. sulphurea* (AMNH 153742—old USNM number visible on label; Kwandang, Sulawesi); middle *C. s. djampeana* (AMNH 266486; Kayuadi, Tanahjampea); bottom *C. s. paulandrewi* (AMNH 619651; Wanci, Tukangbesi) type specimen.

Alor birds have not only marginally larger bills than *djampeana* in its newly restricted sense (males 37.2, *n* = 3, *vs* 35.0, *n* = 3; females 33.3, *n* = 3, *vs* 31.6, *n* = 7) but also considerably smaller (and markedly paler) ear-covert patches (males 22.2, *n* = 3, *vs* 28.3, *n* = 3; females 22.2, *n* = 3, *vs* 24.1, *n* = 7).

The proximity of Sumba's *citrinocristata* to species status indicates that further studies of the taxon are in order. There are suggestions that its juveniles differ from those of other taxa in the *sulphurea* complex in the darkness of the bill and down (P. Jørgensen and R. Wirth *in litt*. 2013), and these and other characters merit investigation. Confirmation of its livelier behaviour, mentioned above, is also desirable. It is, however, a significant obstacle that comparisons with all remaining taxa in the complex will in some cases be virtually or entirely impossible owing to their extreme rarity in the wild and their absence in captivity.

The distinctiveness of *abbotti*, in terms of its large size yet relatively small bill, is also of interest. It is something of a biogeographical mystery that the notably remote Masalembu Islands should possess a population of cockatoos in the first place, since these—c.350 km north-west of Lombok and c.250 km west of Wallace's Line—are not included in Wallacea (White & Bruce

Figure 2. Distribution of the subspecies of Yellow-crested Cockatoo *Cacatua sulphurea* in Wallacea and adjacent islands.



1986). In each of the eight known specimens of *abbotti*, all in USNM, the bases of the lesser and/or median under-primary coverts are discoloured a dirty mid-brown, and on three, including the type, short segments of the inner vanes of some primaries are similarly discoloured, asymmetrically. The significance of this is not clear, but it perhaps reflects a degree of inbreeding. Mensural increase in populations on remote islands is an established evolutionary condition (the 'island rule': Lomolino 2005), and certainly the Masalembu Islands are the most isolated of all populations of *Cacatua sulphurea*; but whether the population of *abbotti* is an ancient or a recent one can only be determined by genetic study.

The great disparity in bill size between the sexes and between taxa (see Tables 2 & 3) might confound attempts to identify unsexed captive birds to subspecies, but laboratories can now sex birds cheaply with just a feather sample. Moreover, Hartert (1903) reported that Kühn found the irides of males to be blackish-brown and those of females to be bright red to dark vermilion, so this character may also help aviculturists to establish taxonomically appropriate pairs.

The fact that the Yellow-crested Cockatoo proves to possess no fewer than seven diagnosable forms represents a considerable challenge to conservation, since each taxon ought as far as possible to be managed as a separate unit of concern. Already Critically Endangered at the start of the century, recent reports from a variety of sources cited by BirdLife International (2013) indicate the increasingly desperate plight of the species in all its taxa and populations: *sulphurea* perhaps 200 birds in 2012 including 'a few individuals' on Kadatua west of Buton (and one confirmed pair in the southern half of Buton itself: T. E. Martin *in litt*. 2014); *abbotti* 13 in 2011 (for which see Waugh 2013); *occidentalis* virtually or actually gone from Lombok and Pantar, 107 on Sumbawa, 500 on Komodo but with a decline of 60% in the years 2000–2005, 40–70 on Flores, 18 on Alor; *parvula* 20–50 on West Timor, 200–300 on East Timor; *djampeana* 'a few individuals'; *paulandrewi* 'tiny populations', including 3 on Oroho (alternatively Kampanaune) Island off Wangiwangi as recently as July 2013, 3–4 on Binongko, May 2013, 1 caged bird, Kaledupa, July 2013, and at least 1, Lintea Selatan, off Tomea, September 2005 (D. J. Kelly, S. B. A. Kelly, N. M. Marples, T. E. Martin and H. A. Singer *per* D. J. Kelly *in litt*. 2014); and *citrinocristata* a total of 563 in 2013. Although the accuracy and contemporaneity of these BirdLife datazone figures may be open to question, it is clearly desirable that every population of every taxon is improved through effective conservation measures. Where possible, conservation breeding to maintain strong bloodlines of those taxa already in captivity will also be of considerable precautionary value, and we hope perhaps now a little easier following this review of the characters that distinguish them.

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