A parakeet specimen held at National Museums Scotland, is a unique skin of the extinct Réunion Parakeet Psittacula eques eques. A reply to Cheke & Jansen (2016)

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Cheke and Jansen (2016) questioned the identity of a parakeet specimen at National Museums Scotland (NMS), Edinburgh, which is considered in a paper by Jackson et al. (2015) to be a specimen of the extinct Réunion Parakeet Psittacula eques eques (Boddaert, 1783). They suggest that with the available information, its provenance cannot be ascribed with any certainty and it is most likely, on the basis of

probability, to be from Mauritius, although they do not exclude the possibility that the parakeet comes from Réunion, the neighbouring island of Mauritius. The provenance and identity of this specimen has previously been questioned (Jones 1987, Hume 2007, Hume & Walters 2012), with the possibility that it may be a Mauritius Parakeet Psittacula eques echo. Since these accounts were written, more work conducted on Psittacula parakeets of the Indian Ocean Islands indicates that the Edinburgh specimen is a Réunion Parakeet, and Cheke and Jansen (2016) would have been unaware of some of this work.

The presence of green parakeets on the islands of Réunion and Mauritius has long been known, and the Réunion Parakeet is believed to have become extinct in the eighteenth century (Cheke & Hume 2008, Hume & Walters 2012). These parakeets have in recent decades been considered to be similar, if not identical in plumage (Cheke & Hume 2008, Cheke 2009, Hume & Walters 2012, Cheke & Jensen 2016), although the early descriptions of the parakeets from Réunion and Mauritius clearly describe distinct differences in the collar patterns of the adult males. The bird from Réunion was known as la perruche à double collier, the double-collared parakeet, based on its complete pink and blue neck collars. This name was given to the Réunion Parakeet by Brisson (1760; Figure 1), Buffon (1770-1783; Figure 2) and Levaillant (1801-1805; Figure 3), while Buffon (1770-1783) also called it *perruche à collier de l'ile de Bourbon,* the collared parakeet of Réunion. It is telling that these authors emphasise the collar; however, the Mauritius Parakeet is described as having an incomplete pink collar (Finsch 1868, Rothschild 1907).

The Mauritius Parakeet is also known as the Echo Parakeet, a name derived from its sub-specific designation, and this has been used as an English name for the Mauritian bird since the 1970's. Cheke (2009) and Cheke & Jansen (2016) also use this name for the Reunion Parakeet, although it is only applicable to the Mauritius Parakeet.

The work of Jackson et al. (2015) was part of a broader molecular genetics research programme looking at the phylogenetics and morphology of Psittacula parakeets (Groombridge et al. 2003), other Indian Ocean

parrots (Kundu et al. 2012), and the population genetics and ecology of the Mauritius Parakeet and the Ring-necked Parakeet Psittacula krameri (Raisin et al. 2009, 2012, Jones et al. 2013a,b, Tollington et al. 2013, 2015). Additionally, JPH, JMF, RVT and RW have worked extensively on the history of the extinct birds of the Mascarenes, including the parrots (Hume 2007, Carter & Tatayah 2010, Winters 2011, Hume & Walters 2012, Forshaw & Knight 2017). Prior to the work of Jackson et al. (2015), we researched the history of the Psittacula parakeets from the islands of the Western Indian Ocean and should this have been published before the Jackson et al. (2015) paper, our justifications for claiming that the Edinburgh specimen is a Réunion Parakeet would have been clear.

THE NATIONAL MUSEUMS OF SCOTLAND PARAKEET SPECIMEN AND COMPARISONS WITH THE MAURITIUS PARAKEET

The parakeet study specimen (accession number NMS.Z 1929**.**186.2) held at NMS is part of the Dufresne collection which contains many bird specimens from Mauritius, and includes one other specimen from Réunion, the Olive White-eye Zosterops olivacea (Cheke & Jansen 2016). Jackson et al. (2015) concluded that this is a Réunion Parakeet, and here we present historical, plumage and morphological studies on the specimen to support this identification. Our work demonstrates there are sufficient differences between the NMS Réunion Parakeet specimen and the Mauritius Parakeet, together with agreement between the NMS skin and descriptions of the Réunion Parakeet (Brisson 1760, Buffon 1770-1783) to justify the conclusion of Jackson et al. (2015).

The NMS parakeet specimen reached Scotland before 1819 as part of the collection of Louis Dufresne purchased by the University of Edinburgh (Sweet 1970). Jones (1987) thought the specimen may have originated from Réunion since it was collected more than five decades before the Mauritius Parakeet was described (Newton & Newton 1876) and based upon the information written on Dufresne's specimen label where it is identified as '*La Perruche à double collier. Levt.'* The label also bears the number '245' and 'R-d'; these are of unknown relevance. In Dufresne's catalogue the entry for the parakeet reads 'La Perruche

à double collier. Levt. Pl. 39.', a plate number that refers to plate 39 in Levaillant (1801-1805), which is also referable to the Reunion Parakeet.

Jones (1987) discussed the NMS specimen and was equivocal about its identity, this account was written in 1984 and he had only seen photographs of the NMS skin and thought there were no differences in plumage between this specimen and the Mauritius Parakeet, and hence was not certain, although thought it likely that its provenance was Réunion. Similarly, Hume (2007) and Hume and Walters (2012) were unaware of any plumage differences between the Réunion and Mauritius Parakeets. In 1985, Jones had the NMS specimen sent to the Bird Group, Natural History Museum, Tring, UK, where it was compared with their four study skins of the Mauritius Parakeet, of which two were adult males (Knox & Walters 1994), and with two adult male skins on loan from the Mauritius Institute, Port Louis, Mauritius. It was also compared to other taxa of Psittacula parakeets and especially to the different races of Ring-necked Parakeet with which it shares many similarities.

The NMS specimen is similar to a male Mauritius Parakeet in most plumage features, although it has a darker ventral plumage. The most striking differences are in the collar structure, which was not obvious from the photographs. The specimen has a thin pink collar that encircles the hind-neck (Figure 4), while in the Mauritius Parakeet the collar tapers out at the hind-neck and is composed of distinctive crescent shaped patches of pink (or orange-pink in some museum skins, due presumably to change caused by the age of the specimens) on either the side of the head (Figure 5). This feature is represented in the illustration by William T. Cooper of the Mauritius Parakeet in Forshaw and Cooper (1973), which shows the American Museum of Natural History specimen of an adult male (ref. AMNH 621312). We have examined the 32 known museum study skins and mounts, and two spirit specimens of Mauritius Parakeets. Thirty one of these are listed in Cheke and Jones (1987), excluding the NMS skin which was then grouped in this list with the Mauritius Parakeets. Ten are adult males, and all these show the pink crescent shaped patch on the side of

the head with a gap in the collar at the hind-neck. In museum skins the extent of the visible pink varies, although this is largely due to the way the specimen was prepared and subsequent skin shrinkage.

COLLAR PATTERNS OF ADULT MALE MAURITIUS PARAKEET AND THE RÉUNION PARAKEET AND COMMENTS ON PLUMAGE

The neck and head patterns and colours, of the adult male Psittacula parakeets are important taxonomic characters (Groombridge et al. 2004). These are displayed during courtship and are characters under sexual selection and hence there is variation in the intensity and extent of some of the colours, presumably due to the "fitness" of the male (Andersson 1994, Searcy & Nowicki 2005), although the patterning is typically taxon specific (Forshaw & Cooper 1973, Groombridge et al. 2004). In the courtship and intra-specific dominance displays of the Ring-necked Parakeet and the Mauritius Parakeet, the pink collar feathers are raised making them more conspicuous, and this is accompanied by "eye blazing", where the iris is dilated and contracted (Jones et al. 2013a, b, Jones, pers. obs.).

About 50 live adult male Mauritius Parakeets have been examined in the hand, and we have observed > 100 in the field and captivity, at distances of two or three metres, as well as examining over 30 freshly dead birds. We have also examined the collar patterns of > 100 museum specimens of adult male Ring-necked Parakeets including birds from the four recognised sub-species (krameri, parvirostris, manillensis, borealis) (Forshaw & Cooper 1973). All of the adult male Mauritius Parakeets have shown the incomplete pink collar, with distinct crescent shaped patches on the side of the head, which tapers out dorsally, typically leaving a gap at the hind-neck. This gap in the pink collar was noted, or implied, by Finsch (1868), Rothschild (1907), Hachisuka (1953), Staub (1976), Jones (1987) and Jones et al. (2013a). Forshaw and Cooper (1973) describe the Mauritius Parakeet as having a complete collar, contrary to our observations, and to their illustration. Forshaw, who wrote the account, here acknowledges that the description is incorrect and that the illustration by Cooper, showing the incomplete collar is accurate. Forshaw & Knight (2017) suggest the Mauritius and extinct Reunion populations are differentiated sub-specifically, with differences

in the neck collar being the distinguishing plumage feature, and the Edinburgh specimen is accepted as P. eques eques from Reunion.

In their description of the Mauritius Parakeet, Newton and Newton (1876) did not give an account of the plumage but refer to Finsch (1868) who gave the first detailed description (our translation from the German). “From the base of the lower beak to each side of the neck there is a narrow black stripe, which is terminated by a narrow blue collar. At the end of the black stripe there is a vermilion-cinnabar red spot on either side of the neck, with the bases of the feathers yellow. From the nostril to the eye there is a thin black line.” Rothschild (1907) wrote a comparable account although with a different interpretation of the width of the black band, “broad black mandibular stripes passing down and across the sides of the neck where they meet a pink collar, which is interrupted on the hind neck.” While there is some variation in the extent of the gap on the nape of the adult male Echo (Mauritius) Parakeet, the shape of the incomplete pink collar is similar in all the birds we have seen, and the variation that Cheke and Jansen (2016) refer to, in photographs, is due to the angle of the image and the way the parakeets are displaying this feature.

In the Réunion Parakeet, neck collars have been described by Brisson (1760) (our translations from the French); “Below the occiput is a narrow band of pink colour, which extends around the neck to each side, becoming wider when approaching the throat, forming a sort of collar, above which the green is mixed with a little blue”, Buffon (1779) described the collars; “Two small ribbons, one of pink and the other blue, encircle the neck completely” and Levaillant (1801-1805, (in the English 1989 translation)) noted “two contiguous collars on the upper neck, one blue, the other red.” The blue collar may be less distinct and more variable than the pink collar as suggested by Levaillant (1801-1805). The blue collar, or blue suffusion to the feathers of the occiput, above the pink collar, is variable in other taxa within the same clade (P. eques echo, P. krameri ssp.) (C. G. Jones pers. obs.).

Some of these features are shown in the illustrations by François Nicolas Martinet in Brisson (1760) and Buffon (1770-83), and by Jacques Barraband in Levaillant (1801-1805). The collar patterns of the Reunion Parakeet were similar to those that are seen in adult male Ring-necked Parakeets. The forms of the collars shown by adult male Mauritius Parakeets and Ring-necked Parakeets are different in the structure of the pink collar. Both species showed little intra-specific variation in the pink collar pattern.

The body plumage of the NMS parakeet specimen was compared with a typical adult male Mauritius Parakeet (NHM1890.10.10.7.). The feather colours in the different tracts, for both parakeets, were similar although the NMS specimen had a darker green crown, breast and abdomen (Table 1).

Cheke and Jansen (2016) refer to brown centred head and back feathers in the NMS specimen. These may be an artefact from the preservation technique, or age and handling related damage. The green colour in parrots is not caused by a specific pigment but by the Tyndall effect of light scattering of psittacofulvin pigments of red and yellow (Hill & McGraw 2006). Green parakeet feathers turn brown when they are wet or have structural damage to the barbs and barbules (pers. obs.).

MORPHOLOGY AND DNA STUDIES

The Réunion Parakeet was similar to the Mauritius Parakeet in morphology, although measurements suggest it was on average slightly bigger (Table 2). Brisson (1760) provides some measurements. (Table 2). These are similar to, or in the case of wingspan, marginally outside the upper range, of adult male Mauritius Parakeet, the tail length was within the range for the Mauritius Parakeet. The wing length for the NMS specimen is longer than those values given for the Ring-necked Parakeet and Mauritius Parakeet. The NMS specimen is tail-less and the tarsus and exposed culmen measurements are similar to those in both the Ring-necked Parakeet and Mauritius Parakeet.

Jackson et al. (2015) successfully extracted DNA from the NMS specimen to look for evidence of genetic differentiation. There are low but detectable levels of genetic divergence between the NMS and the Mauritius Parakeet specimens (0.2%), whilst higher levels of divergence were observed between the NMS specimen and the continental Ring-necked Parakeet (2.4%). Since island populations naturally tend to have lower levels of genetic diversity than continental species (Frankham 1997), lower levels of differentiation would therefore be expected between the two island parakeets, that are sister taxa, whilst demonstrating clear evidence for morphological variation due to different selection pressures and reduced gene-flow (Dudaniec et al. 2011). Subspecies delineations are often based upon morphological and/or genetic differentiation. In some cases, such as the Superb Fairy-wren, Malurus cyaneus, morphological and molecular studies have found high degrees of morphological differences (Schlotfeldt & Kleindorfer 2006), but little or no genetic differentiation between subspecies (Etemadmoghadam 2004). We accept that the differences between the Réunion Parakeet and the Mauritius Parakeet are no greater than sub-specific.

DISCUSSION

Cheke and Jansen (2016) consider that, based upon the balance of probabilities, the NMS parakeet specimen is a Mauritius Parakeet, although they do not entirely dismiss the possibility that it could be from Réunion. They do not refer to the published differences in the collar patterns between the Réunion and Mauritius Parakeets.

The last recorded sighting of green parakeets in Réunion was in 1732 (Hume & Walters 2012, Cheke & Jansen 2016), over seven decades before the parakeet specimen reached Edinburgh. This cannot be taken as strong evidence that the specimen did not come from Réunion, since during the eighteenth and nineteenth centuries, species of Mascarene birds regularly went for decades without being noted in published accounts (Cheke & Hume 2008). We suspect the Réunion Parakeet may have persisted until the late eighteenth century, or into the early nineteenth century. In support of this, Cheke and Jensen (2016) refer to Oustalet (1896) who describes an unlabelled c. 1770 pencil drawing of what was probably P. eques eques. The

description notes “encircled by a black collar to the front, red at the back, widening at the nape” which they note fits neither taxon. This however is not necessarily so, and the widening of the red collar at the nape is consistent with what we would expect from the Réunion Parakeet that, in common with other Psittacula parakeets, would have been able to expand and contract the width of the pink (red) collar by raising and lowering the feathers during intra-specific interactions.

Cheke and Jansen (2016) note that Levaillant did not know the provenance of his double collared parakeet. Levaillant was confused because he did not believe that Brisson’s (1760) parakeet, was the same taxon as the bird described by Buffon (1770-1783); however, both Brisson’s and Buffon’s birds originated from Réunion. The confusion arose due to the different descriptions of the blue neck collar in the two accounts, this was likely because two different individuals were involved with differing amounts of blue.

Levaillant (1801-1805, 1989) recognised la perruche à double collier as being closely related to, while being a different taxon from, the Ring-necked Parakeet, and regarded it as being the same as perruche à *collier de l’ile de Bourbon* described by Buffon (1770-1783), which unequivocally came from Réunion. Levaillant clarifies what was then known about the taxonomy of the ring-necked Psittacula parakeets. He correctly merged Brisson’s collared parakeet and his pink collared parakeet into what we now recognise as P. krameri, and he recognised that the pink collared parakeet was a separate species to the great collared parakeet (= Alexandrine Parakeet P. eupatria) to which it had previously been considered a “variety”. Other than for the identity of Brisson’s parakeet, Levaillant was not confused as Cheke & Jansen (2016) claim.

Cheke and Jensen (2016) consider that only one Réunion Parakeet can be definitely claimed to have been imported to Europe, despite the former opinion of Cheke (1987: 46), who noted that three specimens arrived in Paris. The illustrations of Réunion Parakeet in Brisson, Buffon and Levaillant, which are all likely taken from mounted specimens, all show the three birds in different poses, suggesting that different individuals were involved. Levaillant knew of two specimens one in the collection of Mr Boer’s in Asserswoude, from

which he derived his description, and another in the collection of Mauduyt in Paris. There is also the NMS specimen, which came from Dufresne, suggesting that a minimum of five individuals reached Europe.

The variation in the descriptions of the collars between the three accounts, and differences in the illustrations that Cheke and Jensen (2016) describe, are possibly intra-specific variation, and/or, due to the way the specimens were prepared and mounted, observer bias, and artistic interpretation.

The plumage colours and patterns of the NMS specimen largely agrees with those described by Brisson (1760), Buffon (1770-1783) and Levaillant (1801-1805) and with the illustrations in those publications by Martinet and Barraband. The collar patterns in the NMS specimen, while similar to those in the Ring-necked Parakeet, are unlike any we have seen in either museum, freshly dead or living specimens of Mauritius Parakeet. We note that in the descriptions of the Réunion Parakeet (Brisson 1760, Buffon 1770-1783, Levaillant 1801-1805), the authors emphasise the complete pink collar that is not a feature of the Mauritius Parakeet. We are confident therefore that the provenance of the NMS specimen is Réunion, and that it represents the only known skin specimen of this now-extinct parakeet.

We are grateful to the staff at the Bird Group, Natural History Museum, Tring and at the National Museums Scotland who gave access to relevant specimens and literature over many years. Anthony Cheke has provided much lively and constructive discussion on this, and other related issues concerning the identity of extinct parrots for more than three decades.

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