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SHORT NOTE

New Zealand king shag (*Leucocarbo carunculatus*) with deformed primary feathers

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The New Zealand king shag (*Leucocarbo carunculatus*), endemic to the Marlborough Sounds (New Zealand), is 'nationally endangered' (Robertson *et al*. 2017) with a current population estimate of about 800 birds (Schuckard *et al*. 2015; Bell *et al*. 2019). The species has been little studied, in part due to concerns that it was thought to be highly vulnerable to human disturbance (Taylor 2000). Recognising the urgent need to better understand the ecology of this species to inform future management decisions, the Department of Conservation authorised us to capture and band up to four full-grown New Zealand king shags.

We captured one full-grown juvenile New Zealand king shag at Duffers Reef, Marlborough Sounds (40.9562°S, 174.0379°E) on 19 January 2013 using a fishing pole and noose. The bird appeared to be in good condition, but on detailed examination it was found that the outer four primaries on both wings were abnormal (New Zealand king shags have 11 primaries, but the outermost [remicle] is much reduced and is not included in this account). The ventral base of the rachis (the calamus) was swollen and flaky due to what appeared to be deposits of keratin. On the right wing the outer-most primary (P1) was missing, while P3 (numbered ascendantly) was broken near the base (Fig. 1A); on the left wing the outermost primary was broken near the base (Fig. 1B). Apart from dystrophy of the calamus the other affected primaries were of full length, and appeared normal. The other six primaries on each wing also appeared to be in normal condition, as did the rest of the plumage, including the rectrices, which had some wear at the tips (Fig. 1C); there were no fault-bars (Riddle 1908). There was no evidence of mites on the flight feathers from visual inspection. The only other abnormality that we noted were several small lesions on the webs of both feet (Fig. 2).

At the time of capture we had no opportunity to seek veterinary advice or to contact the Department of Conservation as there was no cell phone coverage of the field site.

We collected some samples by taking feather shaft scrape samples of the waxy keratin tissue from the base of the affected primaries. These were submitted to Wildbase, School of Veterinary

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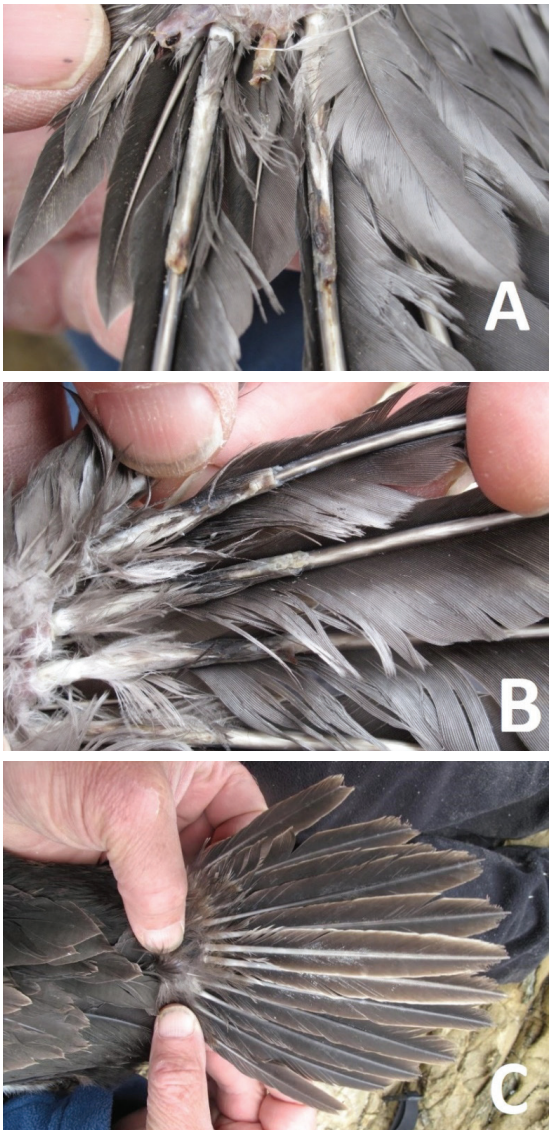

Figure 1. A - Outer primaries of right wing of juvenile New Zealand king shag (from below) showing damaged rachis; P1 (outermost primary) missing, P3 broken. **B** - Outer primaries of left wing of juvenile New Zealand king shag (from below) showing damaged rachis; P1 (outermost primary) broken. (**C**) Rectrices of juvenile New Zealand king shag (from above). These feathers did not show any unusual features

Science, Massey University. The results confirmed hyper-keratinisation of the feather shafts, but no cause could be established (Dr Brett Gartrell, *pers. comm.* via email 30 May 2013). Dr Gartrell advised to submit a feather follicle biopsy for histology and culture in future, as plucked or dropped feathers

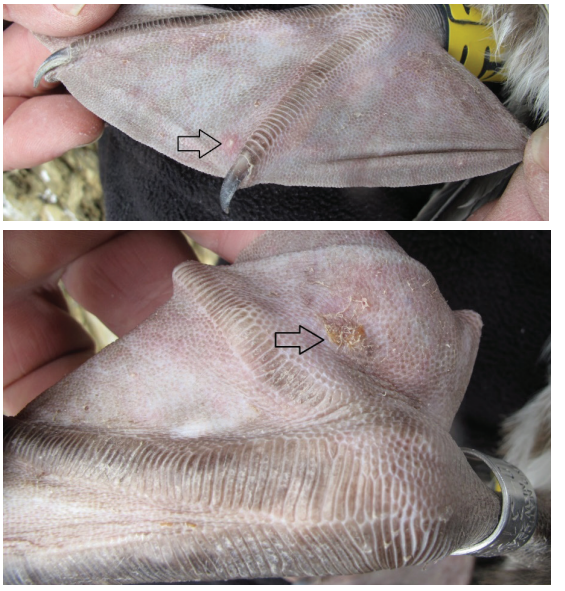

Figure 2. Lesions on the upper surface of the feet of juvenile New Zealand king shag.

are often not diagnostic (Dr Brett Gartrell, *pers. comm.* via email 30 May 2013).

Feather dystrophy, such as that found in our New Zealand king shag, can result from a variety of causes. Psittacine beak and feather disease (PBFD), caused by a circovirus (Todd 2000), can result in feather dystrophy similar that seen in the New Zealand king shag. Whilst primarily recorded in psittacines, PBFD-like symptoms and/or beak and feather disease virus (BFDV) are being recorded in an increasing number of other families and genera of birds (Raidal & Riddoch 1997; Woods & Latimar 2000; Stewart *et al*. 2006; Sarker *et al.* 2015, 2016; Amery-Gale *et al.* 2017). Circoviruses appear to be rarely reported from seabirds, currently only being recorded from three species of gull and two species of penguin (Twentyman 1999; Smyth *et al*. 2006; Morandini *et al*. 2019; Levy *et al*. 2020). The affected primaries appeared to be similar to those affected by 'pinching off syndrome' (POS) (Cooper 1978), which has been recorded in several species of birds of prey in both Europe and North America (Bijlsma & van den Burg 2006; Müller *et al*. 2007a, 2007b; Nemeth *et al.* 2008, 2009; Bijlsma & van de Mortel 2009). The aetiology of POS remains obscure. It was attributed to quill mites (*Harpyrhyncthus* spp.) by Heidenreich (1997), while Cooper (2002) and Redig & Cruz-Martinez (2009) suggested that it might be associated with virus infections; it has been found in various North American raptors infected with West Nile Virus (Nemeth *et al.* 2008, 2009).

Müller *et al*. (2007a, 2007b) were unable to attribute POS to any particular cause in European white-tailed sea eagles (*Haliaetus albicilla*) despite extensive investigation, and concluded that there might be a genetic cause, noting that: 'extremely low genetic drift, possible inbreeding, and the longevity of white-tailed sea eagles may have contributed to the persistence of this disorder' (Müller *et al*. 2007b).

The New Zealand king shag was formerly widespread around the southern coast of the North Island and the northern coast of the South Island (Rawlence *et al*. 2017), but it appears that the population has been restricted to the Marlborough Sounds 'though not in plenty' (Latham 1785), at least since the first specimen was collected in 1773 (Medway 1987). As such, the population may have been subject to a genetic bottleneck, as has been reported in the Stewart Island shag *Leucocarbo chalconotus* (Rawlence *et al*. 2015). If POS is associated with a genetic condition, then it may be found in other individuals within the population.

It seems unlikely that the bird we captured would have been capable of flight, although it did use its wings to help jump from the sea to the rock platform at Duffers Reef. Most New Zealand king shags fly up to 24 km from the colony each day to feed (Schuckard 1994, 2006; Bell 2020); swimming between a colony and a foraging area has been recorded but is uncommon (Bell 2019). Juvenile flight feathers would not normally be replaced until the first complete moult, which Falla (1933) suggests is at about 15 months of age, so it is expected that any juvenile suffering from feather dystrophy would have reduced survival.

Since this initial capture a further 152 New Zealand king shags have been caught and banded (28 adults, 113 chicks, 11 juveniles approximately 2–5 months post fledging) including birds at Duffers Reef. None has shown any evidence of feather dystrophy (Mike Bell *in litt*. 12 July 2021). Vigilance would, however, be advisable. Should any further case of a New Zealand king shag with a plumage disorder be discovered, it is recommended that the live bird be removed from the wild and submitted to an appropriate veterinary facility for detailed examination – future research authorisations should include the ability for such actions.

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