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SHORT NOTE

Claws on the wings of kea parrots (*Nestor notabilis*)

AMELIA WEIN

RAOUL SCHWING
Comparative Cognition, The Interuniversity Messerli Research Institute of the University of Veterinary Medicine, Medical University and University of Vienna, Veterinaerplatz 1, A-1210, Vienna, Austria

While some authors believe the presence of vestigial wing claws in birds to be trivial (Fisher 1940; Nero & Loch 1984), they may in fact have phylogenetic (Olsen *et al*. 1987) or functional significance (Stephan 1992; Stephan 1997). Studying specific anatomical features across species may help determine the interrelatedness of taxa, and allow a description of the evolution of these features over time (Prum 1992; Mayr 2010). Thanks to two extensive studies of museum specimens (Fisher 1940; Stephan 1992) and published observations over the years on both live birds and preserved specimens (Wetmore 1920; Tordoff 1952; Nero & Loch 1984; Olsen et al. 1987; Frey *et al*. 2001), we know that claws occur on the wings of birds in at least 22 avian orders. One alular claw per wing is by far the most common condition, having been reported in at least 170 genera. Much rarer is the occurrence of two claws, one on the alula and another on the major digit, as this has previously been described in only 54 genera in 11 orders.

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Correspondence: *amelia.wein@vetmeduni.ac.at*

Relatively recent genetic findings suggest that the orders Falconiformes (true falcons), Psittaciformes (parrots), and Passeriformes (perching birds) together form the clade Eufalconimorphae (Suh *et al.* 2011). Further genetic studies support this hypothesis (McCormack *et al.* 2013; Jarvis *et al.* 2014) and show that within Eufalconimorphae, the Falconiformes were the first group to split off, followed by the Psittaciformes and finally the Passeriformes. In the Eufalconimorphae clade, alular claws are common on the wings of falcons, with well-formed claws being reported in adult skin specimens of five species of the genus *Falco* (*berigora, cenchroides, hypoleucos, peregrinus, subniger*), on live *F. berigora* nestlings and adults (Olsen *et al*. 1987), and on a live juvenile kestrel *F. tinnunculus* (Frey *et al.* 2001). Among the Psittaciformes, alular claws have been found on adult skin specimens in the families Strigopidae (*Nestor notabilis, Strigops habroptilus*), Cacatuidae (*Cacatua sulphurea, C. moluccensis, C. galerita*) and Psittaculidae (genera *Lorius, Psitteuteles, Trichoglossus, Psephotus*), but not Psittacidae (Fisher 1940; Stephan 1992).

Claws on both the alula and the major digit

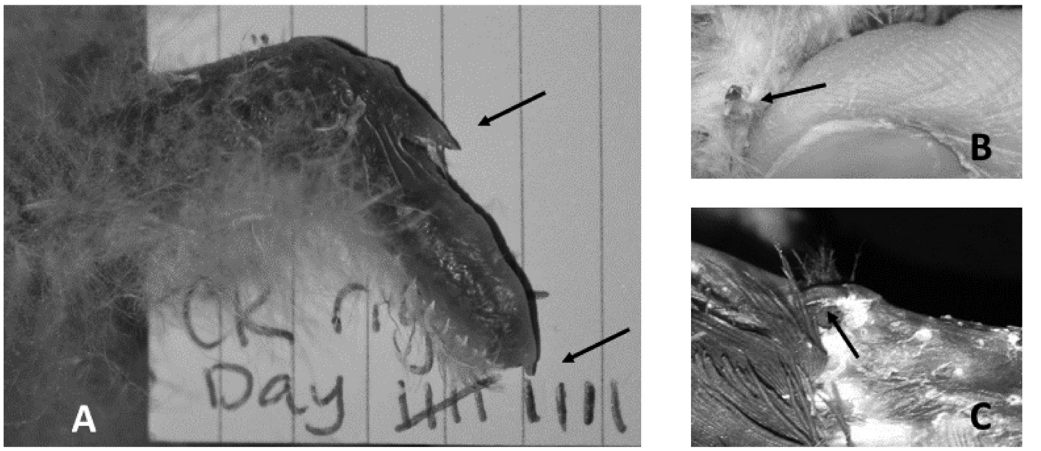

Fig. 1. Claws on the wings of kea: (A) Alular (above) and major digit claws (below) on right wing of a nine-day old nestling; (B) Alular claw on the right wing of a juvenile male. (C) Alular claw on left wing of a 15 year old female, with surrounding feathers missing.

have only been found so far in two species within Eufalconimorphae. A juvenile kestrel *F. tinnunculus* presented with claws on the alula, the major digit and the minor digit (Frey *et al.* 2001), to our knowledge a unique phenomenon in neoaves. A single parrot species, the kakapo (*Strigops habroptilus*), was described with claws on both the alula (1.5 mm and 3.0 mm) and the major digit (2.5 mm) (Stephan 1992).

Interestingly, wing claws do not seem to occur in passerines, as none were found on 'any members of this order, although 241 alcoholic specimens of 68 genera…were examined with a binocular dissecting microscope' (Fisher 1940, p. 242). This was confirmed by Stephan (1992) in his investigation of passerine species in 13 different genera. A single account of alular claws on three, probably related, male kiskadee flycatchers (*Pitangus sulphuratus caucensis*) (Friedman 1952) is most likely a local anomaly, as no further individuals possessed claws.

Thus, alular claws are common in falcons, at least occasional in parrots, and absent in passerines. Major digit claws are extremely rare in Eufalconimorphae, having so far only been described in two species.

Here we investigate the occurrence of wing claws on live kea of different ages. Kea are members of the phylogenetically oldest parrot family, Strigopidae, and one of the closest parrot relatives to both the falcons and the passerines (Suh *et al.* 2011; Wang *et al*. 2012; Jarvis *et al.* 2014). The subjects were four kea nestlings (Ck, Pp, Od and Kr), a juvenile male (Je) and an adult female (El). They were part of the captive kea group permanently housed at the Haidlhof Research Station near Bad Voeslau, Austria. All subjects remained at the research station after the study. The kea were housed together in a large outdoor aviary (52 x 10 x 4 m), in accordance with the Austrian Federal Act on the Protection of Animals (Animal Protection ActdTSchG, BGBl. I Nr.118/2004). Breeding pairs were separated into private compartments during the breeding season only. The aviary was equipped with a variety of environmental enrichment which was regularly renewed. Food was distributed three times daily, and consisted of fruits and vegetables, seeds, and a high-energy food once daily. Fresh water was available *ad libitum*.

Nestling subjects originated from three different nests, and were either unrelated (Ck and Pp were unrelated to Od and Kr), first cousins (Ck and Pp, fathers were full siblings), or full siblings (Od and Kr). Nestlings Ck and Pp were hand-raised from day one after hatching due to a high risk of parental rejection. Nestlings Kr and Od were parent-raised. The juvenile Je (full sibling to Pp) was hand-raised from six weeks due to negligence by the mother. The adult female, El, was from a different genetic line and unrelated to any of the other subjects.

In the case of parent-raised nestlings, the animal keeper looked for claws when checking their health and progress. Intervention was kept to a minimum, so no photographs were taken of parent-raised nestlings. The claws of hand-raised nestlings were photographed by the human caretakers. The juvenile, Je, did not need to be restrained to

search for claws because he was hand-raised by the authors, who identified and photographed them. The adult female, El, was examined during a veterinary procedure. As data collection was strictly non-invasive and performed during routine animal care and veterinary procedures, the study is classified as a non-animal experiment in accordance with the Austrian Animal Experiments Act (x 2, Federal Law Gazette No. 501/1989).

In all four nestlings, two claws per wing were observed; one at the tip of the alula and one at the tip of the manus on the major digit (Fig. 1A). No claw was present on the minor digit. Nestling claws were straight, translucent and <1 mm in length. One alular claw per wing was found on the juvenile male (Fig. 1B). The claw was 1.5 mm long, mostly translucent, curved and < 1 mm wide at the widest point. One alular claw was observed on the left wing of the adult female, but not on the right (Fig. 1C). The claw was dark grey, opaque, curved, 3 mm long, 2 mm wide at the widest point and easily visible because feathers were missing from that area. A search for major digit claws was not undertaken as this was not part of the veterinary procedure and would have caused undue stress to the kea.

Based on our observations, we surmise that vestigial wing claws in kea appear to grow with the bird, starting out as translucent and straight, becoming curved and dark grey by adulthood. Alular claws were found on all kea investigated, but a second one on the major digit was only discovered on nestlings. Although not described in this study, the second claw may persist into adulthood, hidden under the kea's thick layer of down. Even the alular claws of the juvenile were difficult to locate for this reason. Furthermore, it is unlikely that vestigial claws in kea are an anomaly confined to a few closely related specimens, as with the kiskadee flycatcher, because they were present in unrelated birds.

That kea nestlings possess two claws per wing is interesting from a phylogenetic point of view as the only other parrot species to have this trait, the kakapo, is also a member of the family Strigopidae. This suggests that the major digit claw was retained by members of Strigopidae, but subsequently lost in the more modern parrots. On the other hand, vestigial claws are fragile structures and previous studies that looked for them in parrots only had access to processed adult skin specimens (Fisher 1940; Stephan 1992). In order to determine whether major digit claws are truly unique to Strigopidae among parrots, a study of high-quality specimens or live individuals would be required.

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