

Predation of a Grey Goshawk *Accipiter novaehollandiae* with a Powerful Owl *Ninox strenua* as the likely predator

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Abstract. Strong circumstantial evidence is presented for a case of predation of a Grey Goshawk *Accipiter novaehollandiae* by a Powerful Owl *Ninox strenua* along Cattai Creek in the Mitchell Park section of Cattai National Park in the Greater Sydney region, New South Wales, in October 2017. Evidence includes the feathery remains of a Grey Goshawk originating from a plucking post on the forest floor, located within an active Powerful Owl roosting site indicated by Powerful Owl feathers, pellets and whitewash. Although the Powerful Owl is known to prey on large birds, our observations constitute the first evidence of predation of a Grey Goshawk by a Powerful Owl.

Introduction

The Powerful Owl *Ninox strenua* predominantly feeds on arboreal mammals and, to a lesser extent, birds (e.g. Higgins 1999; Debus 2009; Fitzsimons & Rose 2010; Olsen *et al.* 2011; Bilney 2013a,b). Birds included in its diet are typically mid- to large-sized birds (50–1000 g), with known prey including several cockatoo and corvid species (Higgins 1999). A Brown Goshawk *Accipiter fasciatus* was twice reported as a prey item in south-eastern Queensland (Pavey 1994; Pavey *et al.* 1994). However, there are no other reports of raptor or owl species as prey items.

Although birds can constitute up to ~30% of the Powerful Owl's prey, reports on feeding behaviour involving avian prey, such as plucking, are rare. Fleay (1944) reported delivery of a plucked bird by a male Powerful Owl at the nest-hollow. Mo *et al.* (2016) reported a Powerful Owl partially plucking the wing of an Australian Magpie *Gymnorhina tibicen* and subsequently feeding the kill to two juveniles.

Here we report observations which, although circumstantial, strongly suggest predation of a Grey Goshawk *Accipiter novaehollandiae* by a Powerful Owl along Cattai Creek, in the Mitchell Park section of Cattai National Park in the Greater Sydney region, New South Wales. Powerful Owls have been resident at this location for at least several decades, since 1961 (Debus & Chafer 1994) and more recently (e.g. Morris 2016; eBird 2017). Grey Goshawks are also regularly sighted at this location (eBird 2017; Rees 2017).

Field observations

Observations were made in Cattai National Park (30°34'S, 150°56'E), along Cattai Creek in a habitat of subtropical riverine rainforest. Sandpaper Fig *Ficus coronata*, Common Lilly Pilly *Syzygium smithii* and paperbark *Melaleuca* spp. form the closed canopy. The understorey is relatively open, with saplings of the overhead species, occasionally with entanglements of Austral Sarsaparilla *Smilax australis*. A dense layer of invasive Small-leaf Spiderwort *Tradescantia fluminensis* covers the forest floor.

On 15 October 2017, among the spiderwort on the forest floor, we detected pluckings over an area of ~50 cm diameter that contained many diagnostic feathers (Figure 1). No larger remains such as claws, wingtips or breastbone were present. The spiderwort had already formed new shoots, ~10 cm long, growing through the layer of feathers, suggesting that these remains had been present on the forest floor for at least 1 week. The dry conditions in the region antedating our observations left the forest floor only slightly damp, which contributed to the excellent state in which the remains were found.

In the surrounding area, up to ~30 m from the plucking post, several spots of whitewash were found, consistent with a roosting owl. Five pellets were found among the whitewash, of a size, shape and texture fitting the Powerful



Figure 1. Plucking post in an active Powerful Owl territory containing remains of a Grey Goshawk, along Cattai Creek in the Mitchell Park section of Cattai National Park, Greater Sydney region, 15 October 2017. Invasive spiderwort is growing through the feathers, indicating that the predation event occurred several days before our observations. Photo: Vincent Mourik

Owl. A small Powerful Owl body-feather was attached to one pellet. The greyish colour and loose texture of two of the pellets suggest that they were not fresh and had probably been present for >1 week. The pellets and large feathers were collected for further analysis. A roosting Powerful Owl was not located in the dense canopy.

In a follow-up visit on 21 October 2017 (1200–1400 h, overcast conditions with significant rainfall the previous day), we searched the rainforest section for several hundred metres surrounding the initial position. No fresh indications of a roosting Powerful Owl were found, nor was a roosting Powerful Owl located. One more pellet in degraded condition, not found during our first visit, was recovered, as was another Powerful Owl feather. Outside the rainforest section, on a 2-m-wide walking track across an adjacent slope in tall open forest, the plucked remains of a Cattle Egret *Bubulcus ibis* were found. Head and gut were present and looked fresh, dating this plucking event to at most a few hours earlier. This suggests a kill of a diurnal raptor in the early morning.

Analysis of Grey Goshawk feathers

All feathers found at the plucking post belonged to a grey-morph Grey Goshawk; no feathers of other bird species were found. Beyond typical plucking damage (see below), the feathers found were generally in good condition, except for those in direct contact with the damp forest floor. Those feathers degraded faster, leading to separated barbs and a dirtier grey-brown colour.

Table 1. Measurements of left wing primaries found at the plucking post. All measures represent the total length of the rachis when straightened along a ruler, estimated accuracy ± 1 mm. Italic font indicates uncertain allocation of feather, or measurement affected by plucking damage.

<i>Feather</i>	P10	P9	P8	P7	P6	P5	P4	P3	P2	P1
<i>Length (mm)</i>	164	260	271	272	266	252	242	232	164	198

Table 2. Measurements of left wing secondaries found at the plucking post. All measures represent the total length of the rachis when straightened along a ruler, estimated accuracy ± 1 mm. Italic font indicates uncertain allocation of feather. Note that among S1–S8 secondaries missing because of moult cannot be excluded.

<i>Feather</i>	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
<i>Length (mm)</i>	217	212	207	200	193	186	183	176	165	160	158	150	157

Table 3. Measurements of right wing secondaries found at the plucking post. All measures represent the total length of the rachis when straightened along a ruler, estimated accuracy ± 1 mm. Roman indices are attributed to feathers as precise allocation is not possible because of incompleteness of the sequence. Sii–Sv are a continuous sequence extracted from an intact feather cluster (see text). Left to right ordering in the table is mirrored in Figure 2.

<i>Feather</i>	Si	Sii	Siii	Siv	Sv	Svi	Svii	Sviii	Six	Sx
<i>Length (mm)</i>	211	201	194	191	186	179	172	161	162	149

Table 4. Measurements of rectrices found at the plucking post. All measures represent the total length of the rachis when straightened along a ruler, estimated accuracy ± 1 mm. Italic font indicates uncertain allocation of feather. Left to right ordering in the table corresponds to ordering of rectrices in Figure 2.

<i>Feather</i>	T6	T5	T4	T3	T2	T1	T1	T3	T4	T5	T6
<i>Length (mm)</i>	242	243	244	247	244	244	242	240	244	242	242

Feather identification

The flight-feathers (remiges) were identified from measurements, structure and comparison with descriptions and measurements in Marchant & Higgins (1993) as follows. The Grey Goshawk has 11 primaries, P11 being minute. Ten left primaries were recovered, of which P3–P10 were readily identified based on the emargination of inner and outer webs and feather length (Figure 2, Table 1). The two remaining primaries recovered cannot be identified with certainty, as they were heavily damaged. Other identified flight-feathers of the left wing were 13 secondaries and tertials (Figure 2, Table 2), matching Marchant & Higgins (1993, p. 131): “fourteen secondaries, including three to four tertials”. Of the smaller left wing-feathers, alula and upper- and underwing-coverts were identified.

Ten secondaries and tertials were found from the right wing (Figure 2, Table 3). Four of these formed a cluster attached to a piece of skin, together with a few upper- and underwing-coverts, torn off the wing by the predator. The dried-out condition of the skin suggests that the remains were present for at least several days.

Of the tail, all but one of the 12 tail-feathers (rectrices) were recovered (Figure 2, Table 4). The increasing asymmetry between the inner and outer webs going from T1 to T6 allows for identification of individual feathers, leaving most likely the right T2 missing.

Figure 2 and Tables 1–4 summarise the findings on identification of individual flight-feathers and rectrices.

Other than large feathers originating from wings and tail, only three identifiable smaller body-feathers were found.

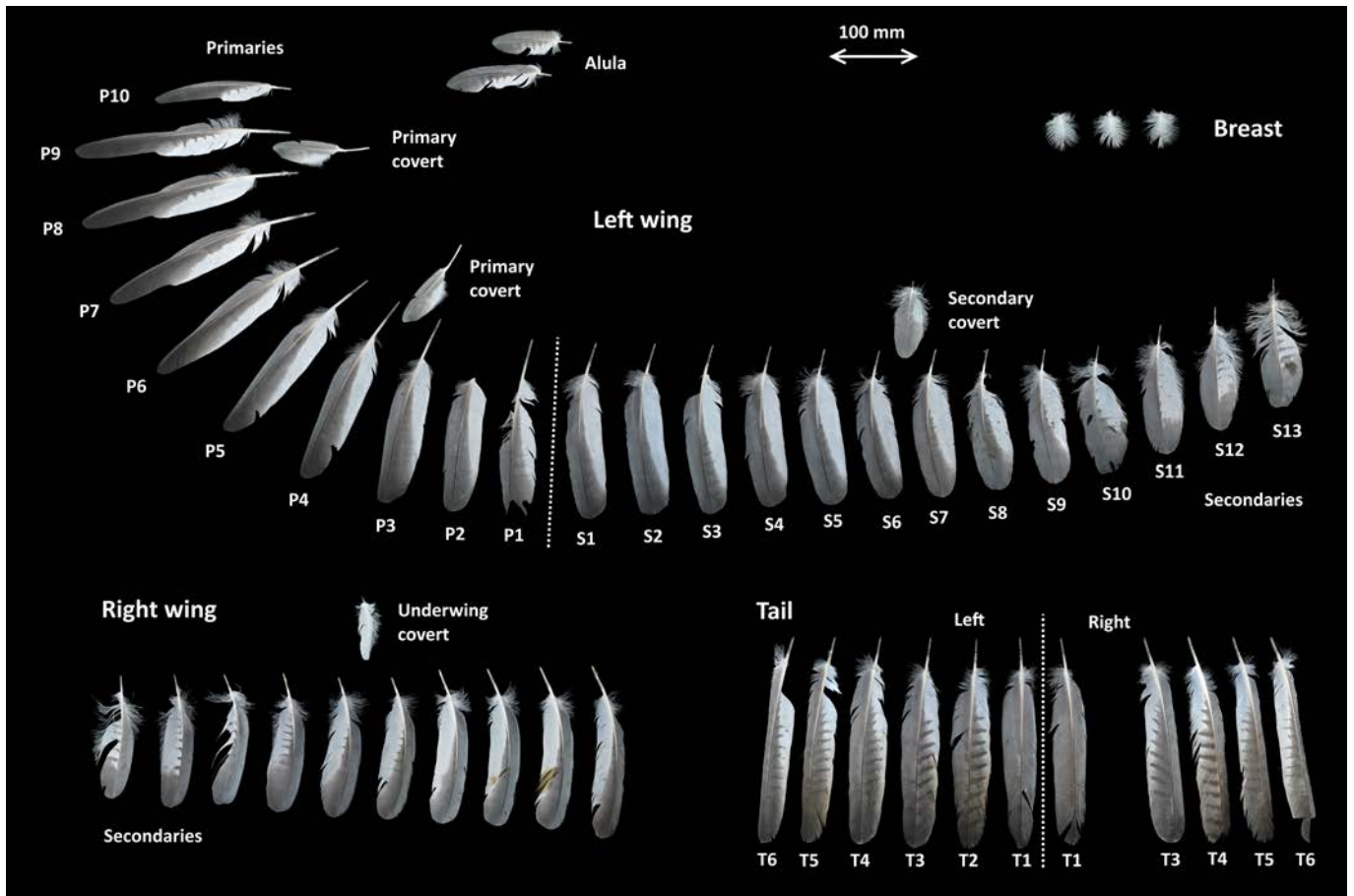


Figure 2. Overview of Grey Goshawk feathers found at plucking post. Of the left wing-feathers, exact allocation of P1 and P2 is uncertain because of plucking damage. Exact allocation of the inner secondaries and tertials (S9 and onward) is uncertain if not assessed on an intact wing, and secondaries missing because of moulting cannot be excluded. Exact allocation of the right wing secondaries is not possible as the sequence is incomplete. For rectrices, allocation of T2–T4 is somewhat uncertain as these are morphologically similar. This figure is composed from photographs of individual feathers, all to scale. Photos: Vincent Mourik

These had fine horizontal barring on a white background, as found on the breast and lower underparts of a Grey Goshawk.

We speculate that the absence of right wing primaries at the plucking post suggests that the predator might not have finished plucking, but flew off with the carcass to continue plucking and feeding elsewhere.

Feather damage because of plucking

Many of the feathers were damaged. The least-damaged feathers typically lacked a few barbs in the lower halves of the webs. More-extensive damage consisted of larger sections of a web missing, broken-off tips (left P2, left T1 and T5, right T1, T4, T6), a missing bottom half (left P2), and a split shaft (left P9, left P1) (Figure 3). All damage suggests a narrow, 1–2-cm-wide area of infliction along the shaft, consistent with force applied by a raptor beak. Crucially, without any exception, all quills were left intact. This last observation rules out a mammalian predator, as such a predator typically bites the feather off at the point of emergence from the skin. We therefore conclude this Grey Goshawk was preyed upon by a raptor.

Sexing

The Grey Goshawk is a typical raptor in having reversed sexual size dimorphism: females are larger than males

(Marchant & Higgins 1993). Reliable sexing of a Grey Goshawk is possible based on the wing- or tail-length, the latter applying here.

Marchant & Higgins (1993) reported tail-length (as measured on skins) being not the same as the total length of a rectrix reported here (as measured by straightening the rachis along a ruler: Table 4). Instead, it closely approximates the distance between the point of emergence of the central pair of rectrices from the skin, and the longest feathertip in the tail. Marchant & Higgins (1993, p. 131) stated “T1 9–14 mm longer than T6”, whereas our measurements show no significant variation in length of the rachis between different rectrices. This is expected, as the measurements taken on an intact tail incorporate a slight wedge-shaped implantation of the rectrices across the tail for horizontally laid-out tails such as that of a Grey Goshawk. Consequently, the tail measurements reported by Marchant & Higgins (1993) should be interpreted as the length of the rachis of the central rectrices T1 minus the section of the calamus below the point of emergence from the skin.

On individual feathers, and particularly on plucked ones, the point of emergence from the skin is often well visible as a concentric ring of loose keratin flakes on the calamus (Figure 4), allowing determination of this point with a precision of a few millimetres. We found the section of the calamus below this estimated point of emergence from

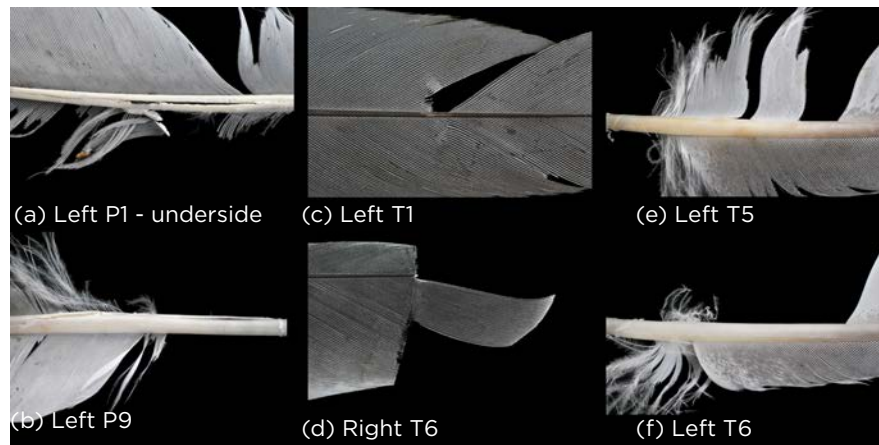


Figure 3. Plucking damage to Grey Goshawk feathers found at the plucking post. The various examples show split shafts (a, b), damage to feather tips (c, d) and missing sections of webs (e, f). Labelling of feathers is consistent with Figure 2. Photos: Vincent Mourik

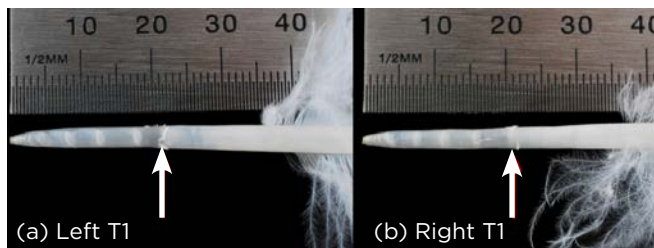


Figure 4. Determination of tail-length as measured on a live bird or conserved skin from the central pair of rectrices found at the plucking post. The arrows indicate a ring of loose keratin flakes corresponding to the point of emergence of the feather from the skin. This section of the calamus has a length of 22 mm for both left (a) and right (b) T1, and should be subtracted from the total length of T1, resulting in an estimated tail-length of 222 mm. The error using this method is expected to be no more than a few mm. Photos: Vincent Mourik

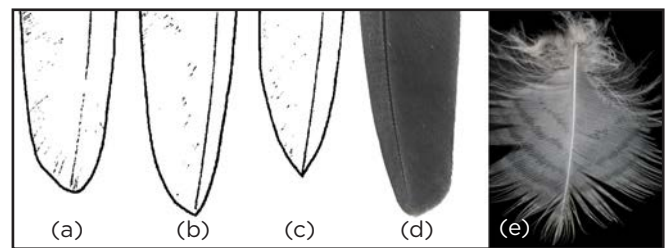


Figure 5. Age characteristics of the plumage. A direct comparison between the expected shape of the primary tip for different age and sex [(a) adult female, (b) juvenile female, and (c) juvenile male] and the tip of P10 found at the plucking post (d) suggests adult plumage of the Grey Goshawk. This identification is confirmed by the fine barring typical of the breast-feather (e) typical for adults. Note that some of the inner secondaries and rectrices shown in Figure 2 have a prominent barring characteristic of the juvenile plumage. a-c adapted from Marchant & Higgins (1993); d-e Photos: Vincent Mourik

the skin to be 20–25 mm long in all rectrices, and 22 mm specifically in left and right T1. The length of the rachis of left and right T1 is 244 mm and 242 mm, respectively, leading to an estimated tail-length of 222 mm. A comparison with the reported values in Marchant & Higgins (1993) places this individual well within the range of the female Grey Goshawk, and well outside the range of a male, as the longest reported value for male tail-length is 204 mm, with a mean of 190 mm. Given that the above reasoning leaves room for a margin of error >10 mm, we conclude that the individual considered here is a female.

Ageing

An assessment of feather structure, coloration and patterning may indicate the developmental status of the Grey Goshawk. Marchant & Higgins (1993, p. 131) stated that the “shapes of primaries, especially P10; in adults tips of primaries appear rather square-cut, largely because inner web is broad at distal end; in juveniles, tips of primaries fairly pointed.” Figure 5 shows a comparison between the schematic of the primary tips given by Marchant & Higgins

(1993) and those discussed here. The primary tips closely resemble those of an adult female.

Another useful characteristic is the presence of synchronous growth-bars across secondaries and rectrices, characteristic of a juvenile. Since these are not clearly visible, this characteristic cannot be used to further discriminate between the different age groups, as not all juveniles have synchronous growth-bars.

Lastly, we assessed the overall appearance of the feathers with regard to coloration and barring. The breast-feathers recovered show a fine barring characteristic of the adult plumage (see Figure 5), suggestive of a mature bird. However, juveniles have more prominent and complete barring of remiges and rectrices than do adults (adults almost lack such barring: Marchant & Higgins 1993). As some of the inner secondaries and rectrices have such barring (see Figure 1), we speculate that this bird had not yet completed its moult into full adult plumage, suggesting that this was a subadult bird at the end of its first or in its second year. This interpretation, as well as its sex, is supported by comparison with a juvenile female Grey

Goshawk specimen in the Zoology Museum, University of New England, New South Wales.

Analysis of Powerful Owl pellets

The six pellets recovered were analysed to identify prey, based on skeletal remains and hairs present. The minimum number of prey items across the six pellets were five Common Brushtail Possums *Trichosurus vulpecula*, two Common Ringtail Possums *Pseudocheirus peregrinus*, one Sugar Glider *Petaurus breviceps*, one European Rabbit *Oryctolagus cuniculus*, and one unidentified bird.

Although feathers or their remains were found in two of the pellets, these could not be conclusively attributed to a Grey Goshawk, because of severe degradation in one case and a likely different, small bird species as the prey item in the other case.

Discussion

From Grey Goshawk remains at a Powerful Owl roost, and the results of analysis of the Grey Goshawk feathers and Powerful Owl pellets from the site, we conclude (1) predation of a female subadult Grey Goshawk by a raptor and (2) this happened at an active Powerful Owl roost.

Although the evidence is circumstantial, we further conclude that the only likely candidate for the predator species is the Powerful Owl. In a riverine rainforest habitat, the only other plausible avian predator with the capacity to kill a female Grey Goshawk would be a conspecific (females being the largest accipiter in Australia, up to ~900 g: Marchant & Higgins 1993). However, there has not been evidence of cannibalism in any goshawk species in Australia. From the literature, the Powerful Owl is known as a predator of large birds, on rare occasion including the Brown Goshawk (Pavey 1994; Pavey *et al.* 1994), and this places the Grey Goshawk within the possible prey spectrum. Lastly, direct evidence is presented here for the presence of a roosting Powerful Owl in the same area, very likely during the same period of time when the Grey Goshawk was preyed upon. Hence, although a degree of uncertainty remains, we conclude predation of a Grey Goshawk by a Powerful Owl.

Predation of the Grey Goshawk by other raptors is rare. The only cases known to us are a Peregrine Falcon *Falco peregrinus* fatally striking a Grey Goshawk in territorial defence but not retrieving or feeding on the body; male Grey Goshawk remains found at a Peregrine Falcon eyrie (Nielsen & Spencer 1995); capture of a Grey Goshawk by a Wedge-tailed Eagle *Aquila audax* (O'Reilly 1994); and an attack by two Wedge-tailed Eagles on a Grey Goshawk, with unknown outcome (Torr 2006). The current report is the first containing strong evidence of Grey Goshawk predation by a Powerful Owl. These are important findings adding to the understanding of the biology of both species, emphasising the Powerful Owl as an apex predator.

Currently, no measurements of the total length of individual flight-feathers of the Grey Goshawk are reported, and for Australian birds in general no comprehensive set of such measurements is available. Instead, measures taken on live birds or skins are reported, which means that the length of shed or plucked feathers can only

be compared with known values with considerable uncertainty. Where significant sexual dimorphism allows for a large error margin, such measurements allow for further conclusions. A comprehensive database including length, shape, coloration and patterning of the individual flight-feathers would be useful, potentially allowing fieldworkers to establish the bird species, age (in case of distinct juvenile and adult plumage) and gender (in case of a species exhibiting sexual dimorphism), based on a single flight-feather. Particularly for raptor research, where sexual dimorphism is widespread and significant, and where the birds under research may be sensitive to disturbance, this may be a useful method to establish the presence and gender of individual birds, without need to take measurements on a live bird.

Lastly, although the behaviour is rarely reported, the observed predation between different raptor species raises the question if this is a random event, or a more systematic one, and in the latter case one wonders about the conditions for and implications of such events.

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