Notornis, 2018, Vol. 65: 242–244
0029-4470

SHORT NOTE

Vertebrate prey in the diets of free-ranging kiwi (*Apteryx* spp.)

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Kiwi (*Apteryx* spp.) are a monotypic order (Apterygiformes) of flightless birds endemic to New Zealand. Most palaeognath lineages are diurnal including the extant ostrich (*Struthio* spp.), rhea (*Rhea* spp.), and emu (*Dromaius novaehollandiae*), while the majority of tinamous (family: Tinamidae) and kiwi are nocturnal (Mitchell *et al*. 2014). Due to their secretive nature and nocturnal lifestyle, it is challenging to study kiwi life history. They use their sensitive bill and olfactory system to identify and select food items on the ground or buried in the substrate (Wenzel 1968). Historically, kiwi – including the North Island brown kiwi (*Apteryx mantelli*) – have been considered invertebrate specialists (Buller 1888; Gurr 1952; Bull 1959; Reid *et al*. 1982). One diet study found >75% of the North Island brown kiwi diet to consist of cicada nymphs, scarabaeid beetle larvae, and annelid worms (Kleinpaste & Colbourne 1983). In other studies, earthworms were the main prey of *A. mantelli*, consisting of 80% and 94% of the total diet respectively (Reid *et al.* 1982; Colbourne & Powlesland 1988). Plant material is consumed to a lesser extent and typically consists of 10-15% of the total diet, with seeds and fruits preferred over greens (Reid *et al.* 1982). While kiwi consume a variety of invertebrates and plant material, published reviews of kiwi diets provides no mention of them ingesting vertebrate prey in the wild (Marchant & Higgins 1990; Heather & Robertson 2005; Sales 2005; Robertson 2013). Here, we summarise evidence of kiwi ingesting vertebrate prey and present the first photographic documentation of a kiwi (*A. mantelli*) ingesting vertebrate prey in the wild.

While there are no records in the peer-reviewed literature, there are anecdotal reports of vertebrate prey in the diets of free-ranging kiwi. In one instance, a little spotted kiwi (*Apteryx owenii*) was filmed attempting to consume a New Zealand common gecko (*Woodworthia maculatus*) on Kapiti Island, but the gecko escaped before the kiwi could ingest it (R. Hitchmough *pers. comm.*). In the mid 1980s small skink bones were found in the droppings of a little spotted kiwi on Red Mercury Island (R. Colbourne *unpubl. data*). The skink consumed was most likely a moko skink (*Oligosoma moco*), though this was unable to be verified with certainty (D. Towns *pers. comm.*). Another report noted that a little spotted kiwi destroyed a New Zealand robin (*Petroica longipes*) nest, which included probing the nestlings with its bill thus resulting in the death

Received 6 August 2018; accepted 2 September 2018
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of the nestlings; however, the nestlings were not consumed and this behaviour was concluded to be misdirected territorial aggression (Shaw & Mackinlay 2016).

Despite being the most abundant species of kiwi, records of North Island brown kiwi consuming vertebrate prey are also scarce. A New Zealand Forest Service report documented bones of green and golden bell frog (*Litoria aurea*) in kiwi faeces on two occasions in the Waitangi Forest, Northland (Colbourne 1982). This has not been previously reported in the peer-reviewed literature. However, ingestion of these frogs is presumed to be rare at least in part because the frog's parotid glands led to gastric distress for the kiwi that consumed them (Colbourne 1982). Beyond this, we were unable to locate any other examples of *A. mantelli* ingesting vertebrate prey.

On Little Barrier Island (Hauturu-o-toi) there is a stable population of brown kiwi numbering approximately 1,000 individuals (BirdLife International 2016). After nightfall, these kiwi can be easily seen on flat open habitat on the southwest edge of the island. On the night of 6 March 2017 between 2315 h and 2345 h an adult kiwi was observed and photographed feeding in the short grass. Upon reviewing the images it became clear that the kiwi had been photographed consuming at least two different skinks (*Oligosoma* spp.; Fig. 1A, B, C). The skinks consumed were most likely copper skinks (*Oligosoma aeneum*), though this could not be confirmed since the diagnostic characteristics were not clearly visible in the photographs (G. Patterson *pers. comm.*).

In compiling this and other aforementioned observations, we believe kiwi may have broader diets in certain regions than originally reported. In locations such as Little Barrier Island where there are several common terrestrial and fossorial reptile species, it is possible that this behaviour is not unusual. For example, skinks are known to live in the soil, occasionally utilize worm burrows, and are likely to be sluggish at night in colder temperatures (G. Patterson *pers. comm.*), thus making them potential prey for kiwi. Furthermore, there are several species of skink – including *O. aeneum* – that are abundant on Little Barrier Island (McCallum & Harker 1982). Though likely not a common

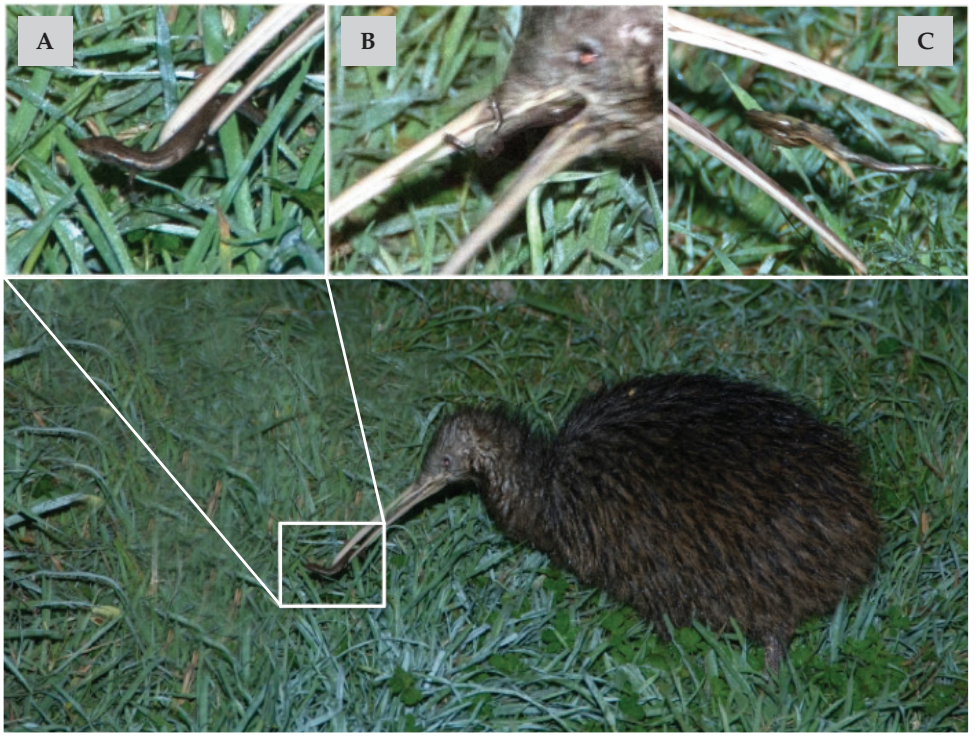

Figure 1: (a) A North Island brown kiwi (*Apteryx mantelli*) selects the first of two skinks (*Oligosoma* spp.) seen consumed that night. Photo taken on Little Barrier Island at 2317 h on 6 March 2017. (b) The kiwi ingests the first of two skinks it consumed that night. Photo taken on Little Barrier Island at 2317 h on 6 March 2017. (c) The same kiwi ingests the second of two skinks (*Oligosoma* spp.) seen consumed that night. Photo taken on Little Barrier Island at 2325 h on 6 March 2017.

diet item, on islands such as Little Barrier, skinks may be regularly encountered and occasionally consumed. Our findings suggest that kiwi diet may be more reflective of opportunistic foraging and consequently, vertebrates may be consumed by kiwi more commonly than previously thought.

There are few locations where there are both high densities of kiwi and small terrestrial vertebrates co-occurring, which may account for the lack of previous observations. Lizards can clearly co-exist in large numbers with kiwi, as is the case on Little Barrier Island, therefore our finding does not raise any obvious species conservation management implications at present. However, on many island reserves such as Little Barrier, the Kiore (Pacific Rat, *Rattus exulans*) have been successfully eradicated, which leads to higher densities of native fauna (Rayner *et al.* 2007), such as skinks and kiwi, and hence, the possibility of more encounters over time. As Reid *et al.* (1982) asserts, a 'typical' *A. mantelli* diet probably does not exist and diet composition likely reflects prey availability rather than choice. In that case, we expect an increase in skinks in kiwi diets on island reserves like Little Barrier as lizard populations recover following mammal eradication campaigns. Furthermore, as invasive herpetofauna (e.g. *Lampropholis delicata* and *Ichthyosaura alpestris*) increase on the mainland, they many interact with kiwi in areas where kiwi persist.

ACKNOWLEDGMENTS

We thank the Northern Seabird Trust, especially Chris Gaskin, for organising our visit to Little Barrier Island. We would also like to thank Geoff Patterson for his assistance identifying the skink species referenced in the paper. Discussions with David Towns and Rod Hitchmough were also vital in assembling this report. Finally we thank the editor and reviewer; their comments improved the final manuscript.

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Keywords: kiwi, *Apteryx mantelli*, ratite, skink, *Oligosoma*, foraging behaviour, Little Barrier Island