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Short Note
Australian Raven (*Corvus coronoides*) Scavenges on all Five Major Vertebrate Groups at Urban Sydney, Southeast Australia

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Crows and ravens (Corvidae) occur in all biogeographic realms and are renowned for their omnivory and opportunistic foraging habits[1]. Most, if not all, species of the genus *Corvus* scavenge on vertebrate carrion[1], and roadkill is an important source of carcasses[2,3,4,5,6]. Aside from roadkill, cold or warm water spells, toxic blooms, hypoxia, and pollution are a source of fish mortality and carrion availability[7]. In many instances the carcass consumed by crows and ravens cannot be identified to species level due to absence of diagnostic features as a result of the trampling or the consumption extent by scavengers[2,8]. Several studies on scavenging by crows on vertebrate carrion only mention species level for carcasses of large mammals recognisable even if reduced to skeleton, freshly killed animals or those that have unmistakable diagnostic features[2,8,9,10,11].

In a study on feeding habits of the five Australian crows based on stomach contents[2], the authors remark on the limitations to identify carrion to species level. Among native vertebrates consumed by crows as carrion[2], the mentioned authors illustrate a group of these birds feeding on the carcass of a red kangaroo *Macropus rufus*, the only vertebrate identified to species level in the study. I report here on the Australian raven *Corvus coronoides* scavenging on five major vertebrate groups, all of them native and identified to species level, at an urban area in Sydney, Australia.

I observed the ravens feeding on vertebrate carrion at a small stretch of a road (*ca*. 50 m), another such stretch of a paved path, and a pathway through two small stretches of mangrove mudflats in the urban area (33°50′01.86-40.29″S, 151°04′36.93-50.35″ E, 4-6 m altitude) of Sydney, New South Wales, Eastern Australia. The Parramatta River runs through the mangroves and influences the water level on the mudflats. I recorded the behaviour of the ravens on carcasses almost daily from 26 December 2018 to 29 April 2019 at early and late morning (09:00-11:00 h), at various meteorological conditions (sunny, clouded, and rainy), as well as at variable road traffic (light, heavy). I observed the birds with unaided eyes and through telephoto lens at 4-10 m, as the ravens habituate to people and vehicles at the observation sites, and documented their behaviour with photographs. During the observational sessions, I used the *ad libitum* sampling[12], which is adequate to record fortuitous events. I provisionally identified the carcasses in the field, and later confirmed their identification with photographs and use of regional identification guides[13,14,15,16,17,18].

I recorded *Corvus coronoides* scavenging on 13 carcasses of 10 native vertebrate species. These included three fishes, one

FIGURE 1. Australian ravens (*Corvus coronoides*) scavenge on carcasses of four major vertebrate groups at urban Sydney. A juvenile bird feeds on a common ringtail possum (*Pseudocheirus peregrinus*) fresh roadkill at the edge of a main road (**a**). An adult pecks at an eastern blue-tongued lizard (*Tiliqua scincoides*) dried and flattened roadkill at the edge of a paved path (**b**). A juvenile feeds on a sea mullet (*Mugil cephalus*) moderately fresh carcass on a mangrove mudflat at low tide (**c**). A juvenile bird feeds on a silver gull (*Chroicocephalus novaehollandiae*) nearly skeletonised carcass on a mangrove mudflat at low tide (**d**).

amphibian, two reptiles, two birds, and two mammals. The fishes were a flat-tail mullet *Gracilimugil argenteus* about 20 cm total length TL, a sea mullet *Mugil cephalus* about 25 cm TL (Fig.1c), and a yellowfin bream *Acanthopagrus australis* about 25 cm TL. The amphibian was a striped marsh frog *Limnodynastes peronii* about 7 cm snout-vent length SL. The reptiles were two individuals of the eastern blue-tongued lizard *Tiliqua scincoides* about 25 cm TL (Fig.1b), and an eastern water-skink *Eulamprus quoyii* about 20 cm TL. The birds were two juvenile individuals of the silver gull *Chroicocephalus novaehollandiae* about 40 cm TL (Fig. 1d), and a juvenile of the Australasian swamphen *Porphyrio melanotus* about 35 cm TL. The mammals were two individuals of the common ringtail possum *Pseudocheirus peregrinus* about 30 body length BL (Fig. 1a), and a grey-headed flying fox *Pteropus poliocephalus* about 25 cm BL (Fig.2). The fishes, the gulls, and the bat were exposed on mangrove mud at low tide (Figs. 1-2), whereas the remainder were roadkill (Fig. 1).

The two smallest carcasses (marsh frog and water-skink), identified prior to the arrival of the birds, were carried away in the bill before consumed and I was unable to

FIGURE 2. An Australian raven (*Corvus coronoides*) juvenile feeds on grey-headed flying fox (*Pteropus poliocephalus*) almost empty skin and flying membranes on a mangrove mudflat at low tide. Note the bat's extended wing on the right lower corner.

see how the ravens handle small carcasses, but presume that the frog is swallowed whole. The larger carcasses were consumed *in situ*, generally by one to two ravens (Figs.1-2), but groups of up to five birds could congregate at a carcass. Most observed ravens were juveniles (about 80 % of recorded scavenging birds), which often squabbled at the carrion, although adults were observed as well (Fig. 1b). Adults dominated the carcasses over the juveniles, chasing them away on foot or with short flights, and the latter waited nearby and fed when the former were sated or retreated from the carrion. Much dried carcasses, such as one of blue-tongued lizards (Fig. 1b), were pecked for up to 2-3 min, whereas those that had enough flesh, skin, or tendons, such as the possums, the bat, the gulls, and the fishes, were pecked for up to 20-90 min in a feeding session. When excessively close, traffic and people sometimes disturbed the birds, which retreated for a while and resumed the carrion feeding shortly afterwards. At the same place I observed the ravens scavenging on a flying fox carcass, I recorded a group of three birds ripping a bat carcass two days later. The carcass likely was the same observed earlier, but I have never observed ravens return to any other carcass in such lengthy a period between the visits.

Besides carrion, I observed ravens foraging on arthropods, fruits, seeds, and human refuse, mostly on the ground. Tossing litter aside with the bill or pushing it in cracks of dead wood or soft ground, as well as pecking and dismantling rotten wood were the commonest tactics to extract beetle larvae. Besides this ground-foraging, I observed ravens plucking live or dead

furled leaves to deftly unfurl them and extract caterpillars and spiders from these retreats. One raven dismantled a nest of the Superb fairy wren *Malurus cyaneus*, took a nestling, and flew away with it in the bill. The birds picked small fruits such as those of *Enchylaena tomentosa* and *Myoporum boninense*. Seeds of two unidentified grass species were plucked from the infrutescence or picked on the ground. Human refuse included chicken bones, portions of bread and crackers, of which even the tiniest crumbles were deftly picked from the ground, sometimes with the side of the bill. These foraging modes were observed on most occasions but some of them depended on the availability of a particular resource, e.g., fruits, seeds, and human refuse. Foraging on the ground as described above was the commonest behaviour observed and occurred daily (100 % of the observations).

The 10 vertebrate species whose carcasses I recorded scavenged by ravens are common at the observation site[3,19]. Roadkill is one of the main suppliers of carrion for scavenger birds worldwide, and urban and peri-urban Sydney is no exception[3,4]. However, I was unable to find carrion scavenged by Australian ravens identified to species level, with very few exceptions of a species or two[2]. Thus, the observations reported herein seem one novel information on feeding habits of the Australian raven at urban areas. I presume that methodical surveys of roadkill at urban Sydney will reveal a richer carrion fauna that the one reported here, including snakes, which were not recorded during my observations. However, small carcasses such as those of frogs, lizards, and passerine birds will prove difficult to work properly as these are quickly eaten or carried away by scavengers, or reduced to unidentifiable remains[5,8,20].

Roadkill was the cause of death and consequent carrion availability of half the vertebrate species presented herein. For the remaining half, other causes should be adressed. During the observation period I recorded three juvenile gulls that showed a form of progressive paralysis that eventually lead to their death, and this may be one cause for two gull carcasses reported herein. Flying foxes experience massive die-offs due to temperature extremes[21], but this was not the case during the observation period. These bat die-offs during heat spells may be a predictable source for carrion availability to scavengers. Cold or warm water spells, toxic blooms, hypoxia, and pollution are a source of fish mortality and carrion availability[7]. Pollution of the Parramatta River is emphasised by warning signs close to the observation site, and this factor combined with diseases could contribute to fish carrion availability for the ravens.

Carrion eating by ravens and crows seems overemphasized in the literature, as carcasses and the birds assembled there are an easy sight compared with the other, varied behavioural ways corvids obtain their food[1,2]. Moreover, an observer can spot medium-sized to large roadkill even from a car at speed limits[22,23]. As noted previously, small carcasses are more difficult to spot or identify at species level, yet they may compose a sizable amount of carrion ingested by Australian ravens[2].

Australian ravens feeding on invertebrates, fruits, raiding nests, and taking advantage of human refuse, which I recorded at the observation site is in line with previous reports[2,25], and contribute to their reputation as omnivorous opportunists[1,25]. Although the Australian raven is regarded as an urban pest[25], an important point about corvids and other scavengers is their contribution to human

well-being through so-called ecosystem services, such as reduction of animal remains and decrease of zoonotic diseases[26,27]. As a final remark, it is noteworthy that interactions between humans and scavenger birds seems to be very old, about three million years[28].

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