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# Scavenging Diet of Brown-necked Raven *Corvus ruficollis* Lesson, 1830 (Aves: Corvidae) in a Hyper-arid Region of Central Algerian Sahara

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**Abstract:** The diet of the brown-necked raven was studied analysing 175 pellets with 1047 prey items collected in an arid region of Central Algerian Sahara during both breeding and non-breeding seasons. The breeding season diet was composed mainly by invertebrates, vertebrates, plants and inert material and the food waste of people (pasta and chicken), which appeared with a high occurrence: 58.8 and 38.2%, respectively. Other prey species included the sun spider *Galeodes* spp. (relative abundance, RA%=7.8%), beetles (Dermestidae RA%=8.6% and Curculionidae RA%=7.7%). Dates were also eaten by ravens and appeared in 26.5% of all the analysed pellets. In the non-breeding season, the diet was based also mainly on the rejected carcasses (chicken and some mammals) but a great number of larvae of Diptera were also observed (RA%=72.9%) as a result of carcasses consumption. The brown-necked raven is an omnivorous scavenger that prefers dump sites for feeding. The food waste of humans and vertebrates carcasses are known to be an easy food resource. It is complemented with other prey items appearing with a less frequency, mainly arthropods. While otherwise ravens are highly influenced by people, they refused eating on their rubbish dumps during the breeding season.

**Key words**: Pellet analysis, feeding ecology, corvid diet, Timimoun, Adrar

## Introduction

Spatial variation in habitat quality and its demographic consequences have important implications for the regulation of animal populations (Burgess *et al*. 2011), although to birds that attendance at parcels highly depends on food resources and their diet (Donald *et al*. 2001). Urban development has a marked effect on the ecological and behavioural traits of many living organisms, including birds (Tryjanowski *et al*. 2015).

The brown-necked raven is a primarily desert and semi-desert bird that avoids areas of cultivation. It is distributed in North Africa, the Middle East and Central Asia, overlapping in some places with the common raven (*Corvus corax* Linnaeus, 1758) and replacing it in the south (Madge *et al.* 1996, Foufopoulos & Litinas 2005). It is one of the typical Eremian region species, occurring throughout the desert belts of range except for north-east Africa and Somalia where the Somali raven, *Corvus edithae* Lort Phillips, 1895 occurs. The latter has been treated previously as a race of the common raven but now is widely regarded as a distinct species; it tolerates much more arid conditions that the fan-tailed raven (*Corvus rhipidurus* Hartert, 1918), another raven that is often observed associating with brown-necked ravens (Anonyme 1998). The

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brown-necked raven occupies a large area in Algeria (Isenmann & Moali 2000) where the desert takes up four fifth of the country with more than 2,000,000 sq. km (Dubost 1986).

Brown-necked raven (*Corvus ruficollis* Lesson, 1830) can be encountered in small numbers at the fringes of human settlements where feeding opportunities such as refuse dumps may draw in birds from the neighbouring desert. The species is adaptable and opportunistic and feeds on a variety of food items ranging from insects and plants material to carrion. Where not prosecuted, desert raven can be very tame, foraging fearlessly near humans (Foufoupoulos & Litinas 2005). During the breeding season this bird species goes to natural habitat to find a place for the nest away from people. According to Atayev (2007) the hunting in the spring season is not just nearby the humans building but in the desert to chase the big invertebrates and vertebrates. As an intelligent, versatile and highly adaptable species, this bird displays a great variety of foraging strategies, often visiting mangroves to steal from bird nests, scavenging for food from rubbish dumps and visiting roads, where it searches for road kill and also probes underneath rocks for insects and grain, The breeding season typically lasts for three to four months (Del Hoyo *et al.* 2009).

The diet of the brown-necked ravens was analysed studying the contents of their pellets which were commonly used because they could give details about the diet of ravens (Laudet & Selva 2005). Pellets are regurgitated oblong masses of the undigested components of a bird's food, usually consisting of fur, bones, claws and teeth, and thus are thought to provide a more complete sample of the local fauna, the raven too eject the undesirable contents through the pellets after the digestion (Lyman 1994, Laudet *et al*. 2002).

The aims of the present study are to (i) determine the diet of the brown-necked raven, (ii) test its ecological role in the environment and (iii) revise its abilities to live in hard climate conditions.

# Material and Methods

### *Study area*

The research was carried out from March 2014 to February 2015 in Adrar in the south west of Algeria. Adrar has a hot desert climate (Köppen climate classification *BWh*; Peel *et al*. 2007), with extremely long and hot summers and short, very warm winters. Average annual rainfall is just 16 mm and summer temperatures are consistently extremely high (commonly 50 C). This hyper-arid region is characterised by scarce vegetation owing to its geography consisting mostly of sand dunes (erg, chech, raoui), stone plateaus (hamadas), gravel plains (reg), dry valleys (wadis) and salt flats. Due to the low precipitation, the region and agriculture depend on groundwater from the Continental Intercalary, an area that includes parts of Algeria, Libya and Tunisia (Sokona & Diallo 2008).

Pellets were collected into two sites: (1) the first one was located nearby the city of Timimoun (29°14´N 00°14´W; 283 m a.s.l.: Fig. 1), a city known for its red oasis located between the plate of Tademaït

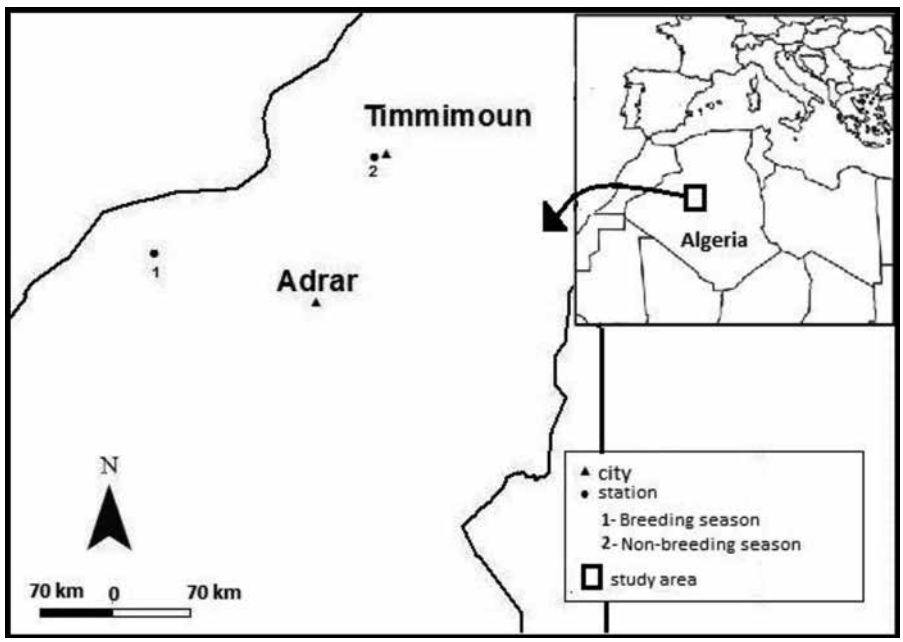


**Fig. 1.** Map of the study area

and the south-western edge of the Great Western Erg. A very large part of the population (33000) resides in the Ksour and its garbage dump can attract the ravens. There are nearly 600,000 palm trees in the Gourara (Timimoun), which constitute a source of feeding for a pest like this species (Hacene 2008). (2)The second site belonged to the region of Touat in the western half of the Algerian Sahara, limited to the south by the Grand Erg Occidental, to the east by the Erg Chech and to the south-east by the Tademaït Plateau (Fig. 1). It contained a string of small oases strung out along the eastern edge of the Wadi Messaoud, an extension of the Wadi Saoura. The site was an open space of desert characterised by some small rocky mountains with sand dunes and also by rare plants resistant to the dry climate, such as *Acacia* and *Artemisia* species (Dubost & Moguedet 1998).

The brown-necked ravens avoid human populations in the cities during the breeding season and are found around the accommodation bases of companies and on lands immediately near the bases. They are attracted to the area by the easily accessible food resource from rubbish dumps of the small accommodations for workers of road's asphalting between Adrar and Tindouf (Fig. 1).

**Data collection and diet analysis**

Pellets were collected near raven's roost (big stones and small knolls) nearby a small water reservoir while at the second site pellets were collected under numerous electric poles. All pellets were weighed and measured (length and diameter) before the analysis. After that, we placed them into ethanol (70°) to facilitate decortication and conservation of prey items. These items were isolated, identified at the species level when possible (only nine species of plants were listed) and enumerated.

Diagnostic remains of insects (e.g. heads, mandibles, elytra, legs, etc.) were counted in order to identify the number of prey items: the number derived for the legs was divided by six, unless they formed a specialised pair (e.g. fore legs of crickets, hind legs of grasshoppers and locusts), in which case they were divided by two. Each head-capsule and distal segment of the abdomen (i.e. telson) represented one individual. The obtained values were compared and the highest one was considered as the estimate of the number of eaten insects (Calver & Wooller 1982).

Vertebrates were identified throughout bones, hairs, wools and feathers. Prey items were identified by collections of reference and manual guides. In the case of plant remains, we used the method proposed by Butet (1985) comparing their epidermis with histological fragments of plant epidermis when necessary using plant material available in the rubbish dumps, or with the intact vegetable parts (seeds, fruits or leafs).

For each food item, we calculated Frequency (F%) as percentage of pellets in which a certain item occurred and Relative Abundance (RA%) as percentage of remains of the individuals of a certain species from the total number of prey individuals found in the pellets.

**Statistical analyses**

Statistical analysis involved chi-square (when d.f. =1, we used Yates correction for continuity) and likelihood ration tests (used when there was at least one value minor than 5) to compare the consumption of different prey types, using the number of prey items registered in the pellets. Analysis consisted of comparing the number of a certain prey item with the total number of the remainder prey identified (Medina *et al*. 2006); the significance level was $p< 0.05$. We used Student-T test to compare the parameters of the pellets. All statistical analyses were performed using the SPSS computer program.

# Results

A total of 1047 prey items were identified during the analysis of 175 pellets: 34 pellets in spring at Touat site and 141 pellets at the site of Timimoun (45, 55, 41 pellets in summer, autumn and winter, respectively). We counted 130 prey items in the breeding season and 917 individual items during the other seasons.

**Description of pellets**

The pellets had different shapes and sizes from one season to another (Fig. 2). Furthermore, inside the breeding season pellets were smaller than non-breeding season. The same applied for the pellet widths , in spring we recorded a small mean, the other seasons were characterised by bigger means of width. Big differences in the dry mass of pellets between seasons were also observed. The pellets collected during the non-breeding season nearby the city were heavier than those collected at the other site during breeding season (Table 1). We confirmed statistically that the pellets from the breeding period were significantly smaller and lighter in comparison with others ($p < 0.0001$).

**Diet composition**

The diet of ravens was mainly composed of vertebrates, especially nearby the dump of the city, and was characterised by a high number of remains of rejected animals from the abattoirs (chicken, sheep and dromedary). At the other study site the primary food

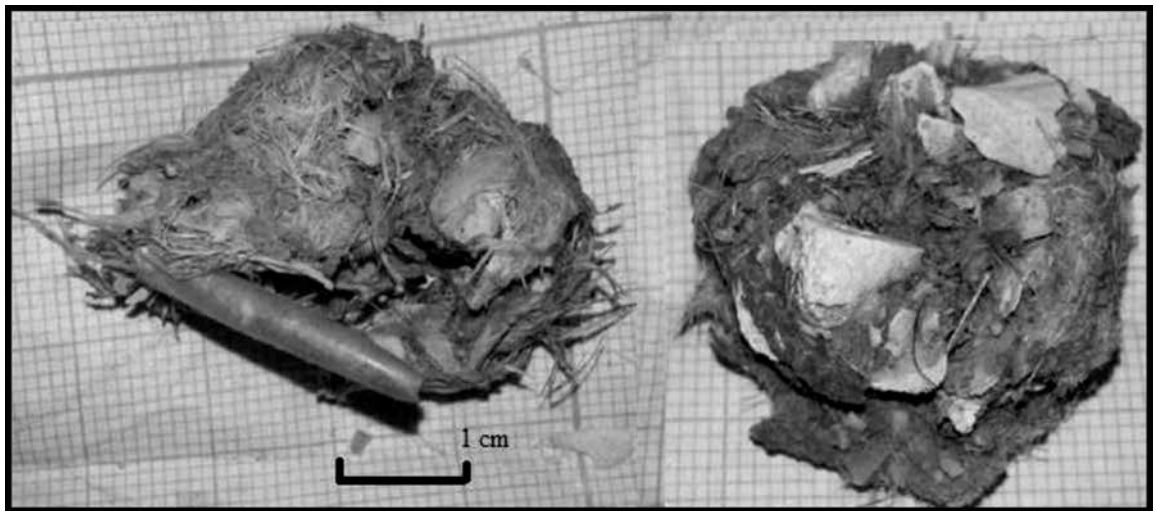


**Fig. 2.** Typical pellets of the brown-necked raven collected in the course of the present study

**Table1.** Measurements of pellets of the brown-necked raven *Corvus ruficollis* in Central Algerian Sahara: arithmetic mean± standard deviation; minimal – maximal values

| Measurements | Breeding season | Non-breeding season | | |
|---|---|---|---|---|
| | Spring | summer | Autumn | winter |
| Length (mm.) | 29.6±7.4 (20-47) | 35.2±7.7 (25-58) | 36.7±7.1 (23-50) | 37.7±11.4 (22-64) |
| Width (mm.) | 16.1±2 (13-22) | 21.8±4.9 (14-34) | 23±5.1 (16-34) | 22±4.4 (13-29) |
| Weight (g.) | 1.7±0.8 (0.5-3.6) | 2.2±1.1 (0.7-5.4) | 2.4±1 (0.9-6.6) | 3.1±1.7 (0.5-6.1) |

source was the rejected food by people. Vertebrates represented 18% of the total diet (30% during the breeding season and 16.2% out of it), the most eaten food was chicken *Gallus gallus domesticus* (L., 1758) remains (from human rejection and chicken carcasses: F%=62% in breeding season and 41% for non-breeding season), Galliformes (RA%=11%), Passeriformes (RA%=8.5% during breeding season; RA%=0.4% non-breedingseason).

Reptiles (Order Squamata) were highly predated during the breeding season (5.4%): vertebrate remains appeared testimonial, such as indeterminate bird species and indeterminate Artiodactyla. Only during the non-breeding season, other mammal orders such as Rodentia and Chiroptera were also present in the diet, while birds (Columbiformes, 0.8%) were found during the breeding season.

No significant differences were found between the two periods for the mammals (G = 2.52; d.f. = 1; p = 0.112). Contrarily, birds were mainly predated on in the breeding season ($\chi^2$ = 10.431; d.f. = 1; p = 0.001), The consumption of reptiles was very low but they were significantly more predated in breeding season than in the non-breeding period (G =20.81; d.f. = 1; p < 0.001).

Invertebrates constituted 82% of all (N = 859) prey items identified during the analysis. In the different seasons larvae of flies (Diptera) accounted for almost four fifths of the prey but there was a big and significant difference between breeding and out of this season ($\chi^2$ = 14.88; d.f. = 1; p = 0.00011). This was owing to the fact that invertebrates were most consumed during the breeding season which could be related with the feeding behaviour of chicks characterised by a high number of Coleoptera species with 33.8% (mainly Dermestidae, Tenebrionidae and Curculionidae) followed by Diptera (14.6%) and Solifugae (10%), other prey orders appeared only in the other seasons (Table 2).

Plant items in the diet comprised mainly cultivated fruits (28.6%, n=54) and seeds from the garbage dumps (39.7%, n=75) with predominance of date palm *Phoenix dactylifera* L., 1753 and barley *Hordeum vulgare* L, 1753 (Table 3). Date palm was significantly more predated in breeding season than in the non-breeding period ($\chi$2 = 4.2; d.f. = 1; p <0.05). We can explain that by the high availability of this plant outside the city in the desert and the rarity of other plants contrariwise for the barley considered to be very significantly predated in non-breeding season ($\chi^2$ = 6.9; d.f.

= 1; p <0.01). Barley was used for feeding the animals and when they will be killed the ravens would find these seeds frequently in the waste collection.

Inert materials were found in the pellets with a high number, with plastic, paper and aluminium being found with frequency of occurrence (%F) 22%, 7.1% and 6.4% from all the pellets, respectively. The brown-necked raven was attracted to the aluminium, glass and the plastic characterised by different colours. These things could be an important source for toxic elements and compounds.

# Discussion

### Description of pellets

Larger pellets contain more individual prey than smaller ones (Lyman & Power 2003). Analysis of the pellets contents showed that the qualitative and quantitative composition of the desert raven diet changes seasonally (Atayev 2007). Our data showed that there were differences in pellet sizes between periods but similar size in pellets appeared when the ravens were close to the city (the length varied from 35.2 to 37.7 mm; width from 21.8 to 23 mm and weight from 2.2 to 3.1 g). This was owing to the different components eaten, such as human refuse and decomposing organic material, in addition to the big number of vertebrate carrions. Contrarily, in the breeding season (length 29.6 mm, width 16.1 mm and weight of 1.7 g) the pellets were characterized by different types of vertebrates and invertebrates and they were smaller than in the other seasons, perhaps because these pellets were mainly expelled by juveniles as well as due to the small prey content. In general, we can justify this difference by the great diversity in food availability during the second period, where we found different arthropod preys or food waste with high nutritional value (compared with the reproductive period characterized by the presence of insects and various waste, and with the deficiency of great prey such as vertebrates). We found notable variation in the forms and sizes of the brown-necked raven pellets, which proved the great diversity in content.

In general the ravens are common at dumps (Heinrich 1989), including the brown-necked raven (Bergier *et al*. 2013, Pienkowski 1972). According to Madge *et al.* (1996), this bird prefers open deserts close to human settlements where it finds easily accessible food resources, where the main quantity of pellets were collected for this study.

### Diet composition

We noted the high number of carrions in the diet of the brown-necked raven. Firstly, in the non-breeding season we signalled different kind of vertebrates (19 species). The most commonly eaten vertebrate was the chicken carrion with 9.5% and frequency of apparition > 61%. We recorded the consummation of other vertebrates with low value like the carrions of dromedary (*Camelus dromedaries* L, 1758), sheep (*Ovis aries* L, 1758), goat (*Capra hircus* L, 1758) and their intestinal contents, mainly seeds of barley, which is the principal food of these animals. We also found pupas of flies (frequently occurring on carrions) as well as the presence of some small birds (Passeriformes and unidentified), gerbils (Gerbillinae) and unidentified bat species. Ixa & Robin (2004) reported the feeding of brown-necked raven on carcasses of young dorcas gazelle (*Gazella dorcas* L. 1758) in Niger.

In the east part of the Karakoum Desert in Asia, Atayev (2007) found the presence of remains of gerbils (34.0%), garbage and carrion (51.0%). Furthermore, El-Bahrawy *et al*. (2007) in Egypt found that animal matter showed to be a more preferred food source than plant matters; mammals were clearly less predated in the breeding season because they were abundant in the dump of the city as not in the other site (desert open space). Invertebrates we recorded belonged to twelve orders. The most commonly eaten were dipterans (pupae in general) with RA%=73.7%, coleopterans with RA%= 1.9% and hymenopteranas with RA%=3.2%. The other invertebrates were found with negligible values. Similarly to our observations, Atayev (2007) counted tenebrionid beetles (56.4%), Galeodidae (2.7%) and scorpions (0.7%) during the spring season.

During the reproduction season, we noted the presence of chicken with an abundance of 10.7% and apparition in 41.2% of the analysed pellets, together with rare findings of 14 vertebrate species (0.7%≤RA%≤4.6%), which are abundant in the dump of the city and not in the other site (open desert space). These were Columbidae, Turdidae and other undetermined passerine bird. In addition to the dromedary, other small vertebrates found were reptiles (Lacertidae and Agamidae). This predation upon birds and reptiles was owing to the absence of mammals during this period. These results agree with those obtained by Atayev (2007), who noted the presence of reptiles with a frequency of 3.9%. This author also found that desert ravens feed on the carcasses of dead animals (33.1%), bird eggs (5.6%) and rodents (1.7%). Yosef & Yosef (2010) described the cooperative hunting of this bird on Egyptian Mastigure *Uromastyx aegyptius* (Forskål, 1775). Other authors cited that vertebrate carrion constitute an important part in the diet of the brown-necked raven (Madge *et al*. 1996). In the Suez Canal region, a small fertile area in Egypt,

**Table 2.** Diet of the brown-necked raven *Corvus ruficollis* in Central Algerian Sahara: P% - frequency of occurrence in pellets; N – number of specimens; RA% – relative abundance

| Class | Ordre | Famille | Prey | breeding season | | non-breeding season | | total | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | P% | RA% | P% | RA% | N | RA% |
| Gastropoda | Stylommatophora | Sphincterochilidae | *Sphincterochila candidissima* (Draparnaud, 1801). | - | - | 1.4 | 0.2 | 2 | 0.2 |
| Acari | Sigmurethra | Subulinidae | *Rumina* spp. | - | - | 0.7 | 0.2 | 2 | 0.2 |
| | Ixodida | Ixodidae | *Rhipicephalus* spp. | - | - | 0.7 | 0.3 | 3 | 0.3 |
| | | | *Hyalomma* spp. | 2.9 | 0.8 | 2.1 | 2.5 | 23 | 2.2 |
| | | | *Dermacentor* spp. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| Arachnida | Solifugae | Galeodidae | *Galeodes* spp. | 38.2 | 10.0 | 0.7 | 0.2 | 15 | 1.4 |
| | Aranea | Lycosidae | Lycosidae spp. indet. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | F. indet. | Aranea spp. indet. | - | - | 3.5 | 0.6 | 5 | 0.5 |
| Insecta | Odonata | Aechnidae | Aechnidae spp. indet. | - | - | 0.7 | 0.2 | 2 | 0.2 |
| | Orthoptera | Gryllidae | Gryllidae spp. indet. | 2.9 | 0.8 | 0.7 | 0.1 | 2 | 0.2 |
| | | Acrididae | *Anacridium aegyptium* (L. 1764) | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | Eyprepocnemidae | Eyprepocnemidae spp. indet. | 5.9 | 1.5 | - | - | 2 | 0.2 |
| | Heteroptera | Myridae | Myridae spp. indet. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | Reduviidae | *Reduvius* spp. | 5.9 | 1.5 | - | - | 2 | 0.2 |
| | Coleoptera | Scarabeidae | *Rhizotrogus* spp. | 2.9 | 0.8 | - | - | 1 | 0.1 |
| | | | Scarabeidae spp. indet. | - | - | 1.4 | 0.2 | 2 | 0.2 |
| | | Cicindellidae | *Cicindella flexuosa* (L., 1758) | - | - | 1.4 | 0.2 | 2 | 0.2 |
| | | Tenebrionidae | *Pimelia* spp. | 2.9 | 0.8 | 2.1 | 0.3 | 4 | 0.4 |
| | | | *Erodius* spp. | 11.8 | 3.1 | - | - | 4 | 0.4 |
| | | | Teneberionidae spp. indet. | 11.8 | 3.9 | 0.7 | 0.1 | 5 | 0.6 |
| | | Carabidae | *Campalita* spp. | 5.9 | 1.5 | - | - | 2 | 0.2 |

**Table 2.** Continued

| Class | Ordre | Famille | Prey | breeding season | | non-breeding season | | total | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | P% | RA% | P% | RA% | N | RA% |
| | | | Carabidae spp. indet. | 11.8 | 3.1 | - | - | 4 | 0.3 |
| | | Histeridae | Histeridae spp. indet. | 5.9 | 1.5 | - | - | 2 | 0.2 |
| | | Dermestidae | *Attagenus* spp. | 32.4 | 8.5 | - | - | 11 | 1.1 |
| | | | Dermestidae spp. indet. | - | - | 1.4 | 0.2 | 2 | 0.2 |
| | | Buprestidae | Buprestidae spp. indet. | 2.9 | 0.8 | - | - | 1 | 0.1 |
| | | Curculionidae | *Bothynoderes* spp. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | | *Coniocleonus* spp. | 5.9 | 3.9 | - | - | 5 | 0.5 |
| | | | *Hypera* spp. | 2.9 | 0.8 | - | - | 1 | 0.1 |
| | | | Curculionidae spp. indet. | 11.8 | 3.1 | 1.4 | 0.2 | 6 | 0.6 |
| | | Apionidae | Apionidae spp. indet. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | Fam.indet. | Coleoptera spp. indet. | 8.8 | 2.3 | 2.8 | 0.3 | 7 | 0.7 |
| | Hymenoptera | Formicidae | *Monomorium* spp. | - | - | 1.4 | 0.2 | 2 | 0.2 |
| | | | *Messor* spp. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | | *Cataglyphis* spp. | 5.9 | 1.5 | 2.8 | 0.6 | 6 | 0.5 |
| | | | *Componotus* spp. | 2.9 | 0.8 | 6.4 | 1.0 | 9 | 0.9 |
| | | | *Pheidole* spp. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | | Formicidae spp. indet. | 8.8 | 2.3 | 5.7 | 0.9 | 11 | 1.1 |
| | | Andrenidae | Andrenidae spp. indet. | 5.9 | 1.5 | - | - | 2 | 0.2 |
| | | Pompilidae | Pompilidae spp. indet. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | Vespoidae | Vespoidea spp. indet. | 2.9 | 0.8 | 0.7 | 0.1 | 2 | 0.2 |
| | | Fam. indet. | Hymenoptera spp. indet. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | Diptera | Fam. indet. | Diptera spp. indet. | 26.5 | 14.6 | 26.2 | 21.4 | 694 | 66.6 |
| | O. indet. | Fam. indet. | Insecta spp. indet. | - | - | 1.4 | 0.2 | 2 | 0.2 |

**Table 2.** Continued

| Class | Ordre | Famille | Prey | breeding season | | non-breeding season | | total | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | P% | RA% | P% | RA% | N | RA% |
| Reptilia | Squamata | Scincidae | *Chalcides* spp. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | | Lacertidae | Lacertidae spp. indet. | 14.7 | 3.9 | - | - | 5 | 0.5 |
| | | Agamidae | Agamidae spp. indet. | 5.9 | 1.5 | - | - | 2 | 0.2 |
| | O. indet. | Fam. indet. | Reptilia spp. indet. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| Aves | Galliformes | Phasianidae | *Gallus gallus domesticus* | 41.2 | 10.8 | 61.7 | 9.5 | 101 | 9.7 |
| | | | *Gallus gallus domesticus (egg)* | 2.9 | 0.8 | 8.5 | 1.2 | 12 | 1.2 |
| | | | Phasianidae spp. indet. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | Passeriformes | Passeridae | *Passer* spp. | 2.9 | 0.8 | - | - | 1 | 0.1 |
| | | Fam. indet. | Passeriformes spp. indet. | 23.5 | 6.2 | 2.8 | 0.4 | 12 | 1.2 |
| | | Turdidae | Turdidae spp. indet. | 5.9 | 1.5 | - | - | 2 | 0.2 |
| | Columbiformes | Fam. indet. | Columbiformes spp. indet. | 2.9 | 0.8 | - | - | 1 | 0.1 |
| | O. indet. | Fam. indet. | Aves spp. indet. | 11.8 | 3.1 | 12.7 | 0.5 | 23 | 2.2 |
| Mammalia | Chiroptera | Fam. indet. | Chiroptera spp. indet. | - | - | 0.7 | 0.1 | 1 | 0.1 |
| | Rodentia | Muridae | *Gerbillus* spp. | - | - | 1.4 | 0.2 | 2 | 0.2 |
| | Artiodactyla | Bovidae | *Capra hircus* | - | - | 1.4 | 0.2 | 2 | 0.2 |
| | | | *Ovis aries* | - | - | 4.3 | 0.7 | 6 | 0.6 |
| | | Camelidae | *Camelus dromedarius* | 2.9 | 0.8 | 2.8 | 0.4 | 5 | 0.5 |
| | O. indet. | Fam. indet. | Mammalia spp. indet. | - | - | 4.2 | 0.3 | 6 | 0.6 |
| C. indet. | O. indet. | Fam. indet. | Vertebrata spp. indet. | - | - | 3.5 | 0.3 | 5 | 0.5 |

**Table 3.** The plant remains in the diet of the brown-necked raven *Corvus ruficollis* in Central Algerian Sahara: P% - frequency of occurrence in pellets; N – number of appearance; RA% - relative abundance

| Plants species | Breeding season | | Non-breeding season | | Total | |
|---|---|---|---|---|---|---|
| | P% | RA% | P% | RA% | N | RA% |
| *Phoenix dactylifera* | 29.4 | 47.6 | 31.2 | 26.2 | 54 | 28.6 |
| *Hordeum vulgare* | - | - | 30.5 | 25.6 | 43 | 22.8 |
| *Triticum* spp. | - | - | 4.9 | 4.2 | 7 | 3.7 |
| *Avena sativa* L., 1753 | - | - | 1.4 | 1.2 | 2 | 1.1 |
| Poaceae spp. indet. | 2.9 | 4.8 | 16.3 | 12.5 | 22 | 11.6 |
| Poaceae spp. indet.2 | - | - | 4.9 | 4.2 | 7 | 3.7 |
| *Vitis vinifera* L., 1753 | - | - | 10.6 | 8.9 | 15 | 7.9 |
| *Vicia fabae* L., 1753 | - | - | 0.7 | 0.6 | 1 | 0.5 |
| *Solanum lycopersicum* L., 1753 | 5.9 | 9.5 | 0.7 | 0.6 | 3 | 1.6 |
| *Capsicum annuum* L., 1753 | 2.9 | 4.8 | 0.7 | 0.6 | 2 | 1.1 |
| Solanaceae spp. indet. | - | - | 0.7 | 0.6 | 1 | 0.5 |
| *Citrullus lanatus* (Thunb.) Matsum. & Nakai. 1916 | - | - | 0.7 | 0.6 | 1 | 0.5 |
| *Lactuca sativa* L., 1753 | - | - | 0.7 | 0.6 | 1 | 0.5 |
| Plantae spp. indet. | 20.6 | 33.3 | 16.31 | 13.7 | 30 | 15.9 |

El-Bahrawy *et al*. (2007) recorded fresh fishes and cow liver in the alimentary of the brown-necked raven. Kubykin (1995) reported Middle-Asian tortoise as a food source of a nesting pair of *C. ruficollis* in the sands of Southern Prybalkhashie. The brown-necked raven has been recorded to consume the contents of ostrich eggs (Yosef *et al*. 2011). The carrions of big animals minimize the predatory of this bird and transform it into a scavenger According to Devault *et al*. (2003) scavengers play a significant role in the ecological stability of the environment. Thus scavengers were predicted to have evolved immune mechanisms to cope with a high risk of infection with virulent parasites (Blount *et al*. 2003). This bird feeds on the parasites of larger animals and even aggravates sores, so that it can feed on blood. Furthermore, as a result of its high degree of intelligence, the brown-necked raven has learnt to hunt cooperatively and may do so to flush insects out of long grass (Del Hoyo *et al*. 2009, Perrins 2009). Madden *et al*. (2015) studied the impacts of predator corvids on bird productivity and abundance. They reported that corvids are often viewed as efficient predators capable of limiting prey species populations. The brown raven in our region predated upon small birds during their period of reproduction causing limitation of the individuals' number but not with a big frequency.

The raven is also an efficient predator upon invertebrates, as demonstrated also by our results, mainly on arachnidans (*Galeodes*) and coleopterans (*Attagenus*) species, as well as beetles (mainly Dermestidae, Tenebrionidae and Curculonidae), Diptera and Hymenoptera. The major components of the diet of desert ravens are carrion and garbage, weakened and diseased rodents. During its increased activity, important seasonal forage are insects and reptiles (Atayev 2007).

The plants had a very big share (with 14 species) in the diet of this bird mainly close the city and during non-breeding season. Contrarily, in spring (breeding season), only four plant species were consumed and the availability of remaining of fruits was enormous at the site near the city, so the raven could find different kind of fruits in addition to oasis of palms. At the other site aliments were rare among which were rejected fruits, some food rejected by the workers but mostly fruits of palm (*P. dactylefera*). This is the most produced and eaten fruit in the south of Algeria and it was found in 31.2% of the pellets during the non-reproduction season and 29.4% during the reproduction one. The other plants that were eaten and were found in the dump like a waste, included barley and grape with 30.5% and 10.6%, respectively. In addition to the wheat with frequency of presence near to 5%, but they were not found during the reproduction season, the tomato and pepper were eaten during the different seasons but in little amounts (Table 3). Atayev (2007) confirmed that, in spring the barley was 77.7% and wheat was 53.3% during the non-reproduction season. He also found that rice and corn with 39.9% and 29.9%, respectively. El-Bahrawy *et al*. (2007) consider the brown-necked raven a serious pest which must be controlled as it affects the agricultural practices and urbanisation. According to Heinrich (1989), ravens learn to exploit new food resources very quickly.

# Conclusion

The present study is the first about the diet of the brown-necked raven in Africa. It is an opportunist bird predating upon different arthropods and, at the same time, acting as a scavenger eating on the waste dumps and corpses of different animals found in the field. On the other hand, the brown-necked raven acts as a pest on dates. In hard environmental and climatic conditions, this raven is capable to survive eating different types of the available food found in various seasons and sites. The brown-necked raven is very dependent on humans and it frequents anthropogenic garbage to find a high choice of food.

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