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Bone damage patterns found in the avian prey remains of crested caracara *Caracara plancus* (Aves, Falconiformes)

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A B S T R A C T

The following paper presents the results of the analysis of the avian prey bones found in uneaten remains of crested caracara (*Caracara plancus*, Aves, Falconiformes) from La Pampa province, Argentina. Anatomical parts representation and taphonomic modifications were evaluated and compared to results of the evaluation of bone remains recovered from crested caracara's pellets and to previous studies of other diurnal birds of prey. The results suggest a preferential consumption of some body parts of avian prey, as evidenced in the high frequency of wing elements in the uneaten prey remains. This analysis helps to support interpretative data concerning the origins of avian remains in the zooarchaeological and paleontological record, and contributes to the knowledge of a common predator found throughout diverse environments in South America.

1. Introduction

From a zooarchaeological and paleontological perspective, understanding the origins of meso and microvertebrate bone accumulations is of great interest. Although avian remains are generally less numerous than those of mammals, the information that they can provide should not be discarded (Bochenski, 2005). Actualistic studies documenting taphonomic patterns on avian remains created by raptors and carnivorous mammals can help us to understand how the zooarchaeological and paleontological records have formed. However, taphonomic studies of avian remains are scarce in South American literature. In several of her publications, Cruz (2003, 2005, 2007, 2008) has devoted time to the analysis of taphonomic processes that affect avian remains by evaluating the anatomical part representation and other taphonomic modifications found in avian remains. However, her studies focused mainly on species from Patagonia. Elsewhere, Fernández et al. (2009) evaluated small avian accumulations from an archaeological site (Laguna El Sosneado-3) in southern Mendoza, and compared those results with bone assemblages originated by nocturnal bird of prey (possibly *Tyto alba*). It is only recently that studies which assess taphonomic accumulations of avian remains have become more frequent, many of which attempt to establish whether accumulations are of human origin or are produced by some predator or scavenger (Bochenski, 2005; Bochenski and Tomek, 1994, 1997; Bochenski and Nekrasov, 2001; Bochenski and Tornberg, 2003; Bochenski et al., 1993, 1997, 1998, 1999, 2009; Laroulandie, 2002).

In this paper, we present the analysis performed on the avian remains accumulated by crested caracara (*Caracara plancus*, Falconidae), well-known in Argentina as "carancho"; and which has a wide distribution in South America (Dove and Banks, 1999). These species nest and roost mostly in trees, and studies of their feeding habits define them as an opportunistic predator that habitually feeds on carrion (White et al., 1994; Travaini et al., 2001 and literature therein). Carrion constitutes between 20 and 40% of their diet (Rodríguez Estrella and Rivera Rodríguez, 1997; Travaini et al., 2001; Morrison and Pias, 2006; Vargas et al., 2007), while the remainder of their diet consists of hunting live prey. Rodríguez Estrella and Rivera Rodríguez (1997) found that this species

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normally hunted prey with a body mass of less than 500 g, including small rodents, lagomorphs, birds, amphibians, reptiles and fish. Vargas et al. (2007) mentioned that birds were consumed in low proportions.

Generally, it is common to see crested caracara occupying urban and suburban areas, likely the result of natural attraction to waste left by human's. As mentioned in previous works (White et al., 1994; Yorio and Giaccardi, 2002), some diurnal raptor (e. g. crested caracara), frequently take advantage of human waste. Likewise, such a situation may have occurred in the past, where groups of crested caracara came to waste dumps for food and any accumulation would have mixed with the human derived waste.

In the context of taphonomic studies of prey consumed by *C. plancus*, we analyzed avian remains produced by this predator. Although small mammals are the most frequent prey found in the samples (pellets and uneaten prey remains), avian remains were also present and constituted more than 45% of the vertebrate remains consumed in the sampling time. Previous taphonomic analysis was performed on the non ingested rodent prey as well as the recovered rodent remains found in the pellets of this predator (see Montalvo and Tallade, 2009, 2010). The analysis demonstrated that *C. plancus* not only produces strong modifications in the bones of its ingested prey, but also generates bone accumulations of uneaten prey remains with particular anatomical representation, breakage patterns and without evidence of corrosion by digestion. Results also suggested that *C. plancus* performs a selective consumption of some anatomical parts of the rodent prey, while discarding others (Montalvo and Tallade, 2009, 2010).

This study provides data regarding the consumption of avian prey by the *C. plancus* in central Argentina. The results derived from the analysis of the modifications that this predator produces on the bones of the avian prey are also presented.

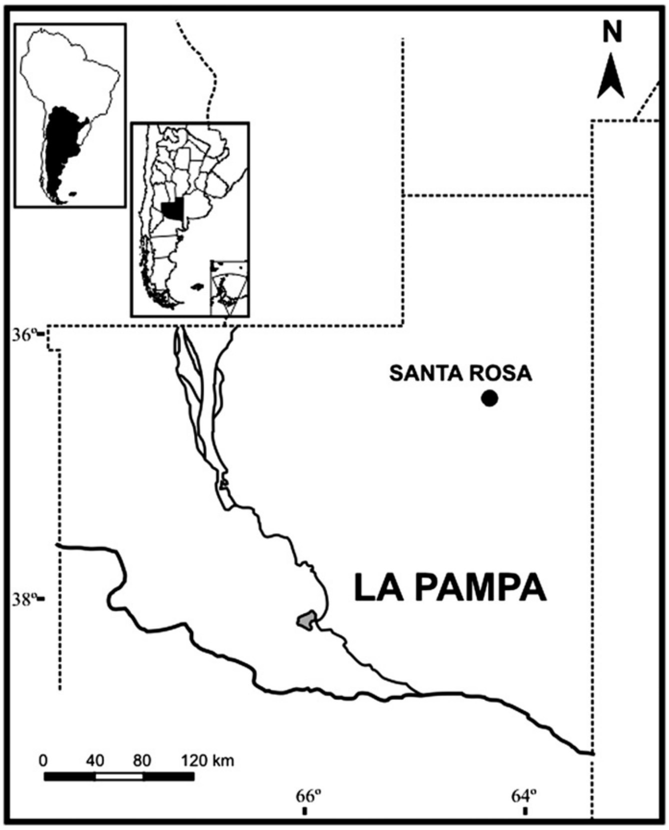

Fig. 1. Geographic location of Santa Rosa in La Pampa province, Argentina.

2. Material and methods

The uneaten prey remains sample was collected every week between February 2005 and March 2008, from an area just outside the city of Santa Rosa, La Pampa, Argentina (36°37′10″ S, 64°19′45″ W) (Fig. 1). All remains of the vertebrate prey were produced by two crested caracara. In this work we assessed only the remains of the avian prey.

In the sampling time, 111 uneaten avian remains were recovered. Of these, 76 individuals were identified and evaluated while the remaining 36 specimens were identified as feathers. Twenty-three pellets from the two crested caracara that contained avian bones were also evaluated. The pellet sample was collected every week from March to June 2005.

Uneaten prey remains and pellets were recovered in small superficial areas accumulated directly under trees of caldén (*Prosopis caldenia*), chañar (*Geoffroea decorticans*), and eucalyptus (*Eucaliptus* spp.). These trees are commonly used for alimentation and regurgitation perches for this raptor (POT pers. obs.).

All bone remains were analyzed under a Leica Ms5 binocular microscope and some of them were photographed under a Jeol 35 CF at 8 kV at the "Unidad de Administración Territorial (UAT) - Centro Científico y Tecnológico CONICET Bahía Blanca", in Bahía Blanca, Argentina.

All identifiable avian bones from the uneaten prey remains and pellets were anatomically and taxonomically identified with a comparative collection from the "Cátedra de Anatomía Comparada, Facultad de Ciencias Naturales y Museo, UNLP", as well as a modern osteological bird collection from the "División Paleontología Vertebrados, Museo de La Plata (UNLP)" and "Facultad de Ciencias Exactas y Naturales, UNLPam", and a private collection of one of the authors (POT). For the taphonomic analysis, we examined all the avian bones using the methodology proposed by Bochenski (2005) and Bochenski et al. (2009 and references therein).

In order to evaluate the minimal number of individuals (MNI) of the uneaten prey remains, each fragmented or whole avian skeletal element (articulated or isolated) collected in each sampling date was considered as one individual. In cases where the remains of more than one individual were collected, anatomical and taxonomic representation helped to discern if the sample contained multiple individuals. Thus, the total MNI of 76 corresponds to the sum of all individuals, and given the continuity of the samples, this number adjustably represented the minimal quantity of consumed avian prey during the collection period. The number of identified specimens (NISP) and the minimum number of elements (MNE) for each type of bone was evaluated by taxon (*Nothura* spp., *Columba* spp. and "other taxa"). The total is equal to the sum of complete bones and proximal or distal parts – whichever is more numerous (Grayson, 1984; Lyman, 1994). The MNI for the pellets sample was evaluated considering the element with the highest skeletal frequency (tarsometatarsus) (Grayson, 1984; Lyman, 1994).

The relative abundance of skeletal elements was calculated for the bones from the uneaten prey remains and the bones recovered from the pellets, taking into consideration the MNI of each sample. In the case of the uneaten prey remains, the different skeletal elements grouped by taxon were also analyzed. The evaluated categories were *Nothura* spp., *Columba* spp. and "other taxa". Since the relative abundance does a good job of showing the proportion of each of the preserved elements, and in view of the fact that the number of uneaten prey remains evaluated is known, the MNI by skeletal element was not calculated (Bochenski, 2005 and references therein). The following equation was used: MNEi/

(EixMNI) × 100 where MNEi is the minimum number of particular skeletal elements in the sample, and Ei is the expected number of that skeletal element per individual (Andrews, 1990).

The following indexes were calculated: (a) to give an idea of the differential preservation of wings and legs (Ericson, 1987): (humerus + ulna + carpometacarpus)/(humerus + ulna + carpometacarpus + femur + tibiotarsus + tarsometatarsus) X 100; (b) to evaluate the preservation of proximal and distal elements (Bochenski y Nekrasov, 2001): (scapula + coracoideum + humerus + femur + tibiotarsus)/(scapula + coracoideum + humerus + femur + tibiotarsus + ulna + radius + carpometacarpus + tarsometatarsus) × 100; and (c) to evaluate the preservation of core and limb elements (Bochenski, 2005): (sternum + pelvis + scapula + coracoideum)/(sternum + pelvis + scapula + coracoideum + humerus + ulna + radius + carpometacarpus + femur + tibiotarsus + tarsometatarsus) × 100. The ratios of proximal and distal portions of long bones (Bochenski, 2005) were analyzed in order to observe the difference between whole bone and proximal parts as well as whole bone and distal parts. The degree of bone breakage was analyzed taking into consideration the percentage of whole bones and the total of each type of long bone recovered.

In reference to the avian bones preserved in the pellets, the degree of digestion was assessed by analyzing the cortical surface and the breakage edges (Bochenski and Tomek, 1994; Bochenski and Tornberg, 2003; Bochenski et al., 1993, 2009).

Finally, a chi-square test was used to evaluate the possible deviation of wing to leg elements, proximal to distal elements, and core to limb elements from the expected 1:1 proportion.

3. Results

Seventy six uneaten avian remains were recovered in the sampling time (Table 1). The majority of the identified individuals were *Nothura* spp. and *Columba* spp. There were however a high percentage of individuals represented by isolated skeletal elements (27.63%), and these could only be assigned to the taxonomic category Aves indet.

In total, 680 skeletal remains were recovered (NISP). This value includes all indeterminable bone fragments, vertebrae fragments, ribs, and remains of cranial bones which were not analyzed here ("other bones" in Table 2). From the total NISP, an MNE of 500 skeletal elements was calculated (Table 2) that included 150 phalanges (60% feet and 40% wings).

In order to evaluate the relative abundance of skeletal elements, each element was assessed taking into consideration the total MNI of 76 (Table 2). With an average relative abundance of 17.25%, this indicates a low representation of all the skeletal elements. Along with the leg elements, the mandibles and furculas are among the least abundant elements. The most frequently found elements were the sternum, humerus, coracoids, scapula, and pelvis.

With respect to the differential representation of skeletal elements according to the taxon, the relative abundance was analyzed for *Nothura* spp. (MNI = 21, MNE = 106, average relative abundance = 13.99%), *Columba* spp. (MNI = 18, MNE = 190, average relative abundance = 27.73%), and "other taxa" (MNI = 37, MNE = 204, average relative abundance = 13.46%). Fig. 2 shows the differential representation of skeletal elements for these three categories.

The frequency of articulated skeletal elements may be related to the degree of completeness in the sample. In 50% of the individuals, the most numerous fragments were those of the pectoral girdle and wings (Fig. 3A), while 25% were from the posterior region. In four individuals, the skull was found complete and articulated with the mandibles. The hemimandibles were found articulated among themselves in only one individual.

In total, 30 sternum were recovered and five of them were found whole (Fig. 3B). When the posterior body region was present, the pelvis, as well as the synsacrum was preserved in all of the individuals (Fig. 3C); whole in three individuals, and articulated with the leg in two individuals.

The degree of bone completeness was also analyzed. The scapulas were recovered mostly broken, and the coracoids were the skeletal elements most commonly found whole (Table 3). In reference to the broken long bones, upon analysis of the fracture type, there was a clear predominance of spiral fractures (*sensu*

Table 2
Number of identified specimens NISP and minimum number of elements (MNE) recovered from the uneaten prey remains and their relative abundance considering a minimal number of individuals (MNI) of 76.

Element	NISP	MNE	Relative abundance
Mandible	12	12	7.89
Maxilla	10	10	13.16
Scapula	42	41	26.97
Coracoid	45	45	29.61
Furcula	8	8	5.26
Sternum	30	30	39.47
Humerus	59	58	38.16
Radius	33	33	21.71
Ulna	30	30	19.74
Carpometacarpus	18	18	11.84
Pelvis	22	22	28.95
Femur	15	13	8.55
Tibiotarsus	16	16	10.53
Fibula	4	4	2.63
Tarsometatarsus	10	10	6.58
Phalange	150	150	4.93
Other bones	176		

Table 1
List of uneaten avian remains recovered and the minimal number of individuals (MNI) evaluated for each taxa.

Taxon		MNI
Tinamiformes	*Nothura* spp.	21
	Rhynchotus rufescens	2
Charadriiformes	*Larus* spp.	2
Anseriformes	*Anas platalea*	1
	Anas spp.	1
Falconiformes	*Falco sparverius*	1
Strigiformes	*Athene cunicularia*	5
Columbiformes	*Columba* spp.	18
Psittasiformes	*Aratinga acuticaudata*	1
Cuculiformes	*Guira guira*	1
Passeriformes	*Sturnella* spp.	1
	Furnarius rufus	1
	Aves indet.	21

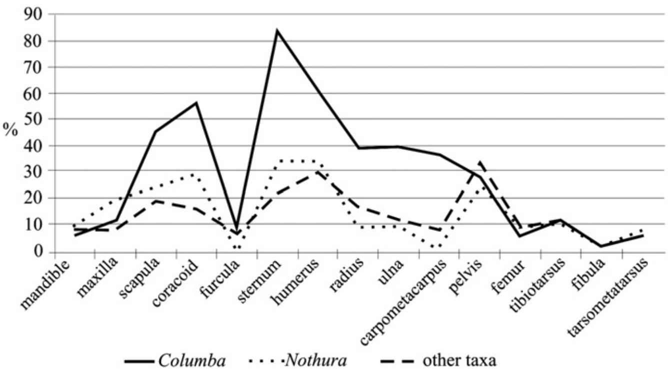

Fig. 2. Percentage of differential representation of skeletal elements according to the taxon of the uneaten prey remains.

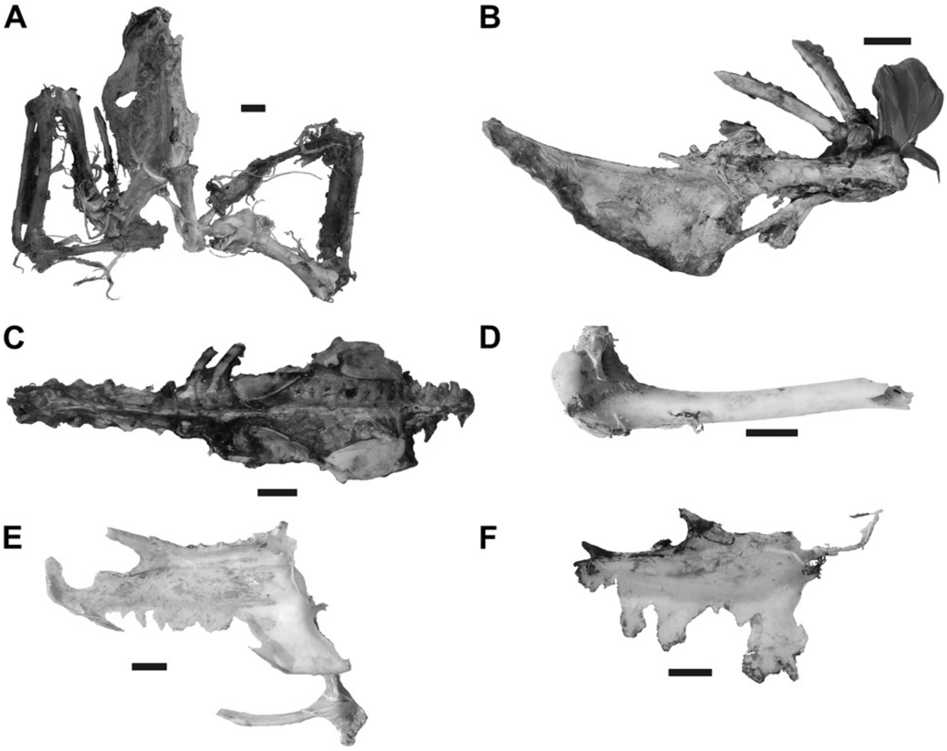

Fig. 3. A. *Columba* sp. girdle and wings; B. *Rhynchotus rufescens* whole sternum; C. *Columba* sp. whole synsacrum; D. Aves indet. humerus with spiral fracture; E. *Columba* sp. broken sternum; F. *Columba* sp. sternum with steeped fractures. Scale bar = 1 cm.

Marshall, 1989) identified in 85% of this elements (Fig. 3D), followed by a low percentage of stepped (7.5%) and longitudinal fractures (7.5%).

Wing elements represented 72.29% of the sum of wing and leg bones, which was highly statistically significant ($\chi^2 = 12.773$, $P < 0.01$, df = 1) and deviated from the expected 50% (1:1 proportion). Proximal elements of the skeleton represented 66.04% of the sum of proximal and distal elements (Table 4), which was also highly statistically significant ($\chi^2 = 7.9324$, $P < 0.01$, df = 1) and deviated from the expected 50% (1:1 proportion). The relationship in preservation between the core and limb elements was 43.43%, which indicated a better representation of core elements, was statistically significant ($\chi^2 = 1.3258$, $P < 0.05$, df = 1), and deviated from the expected 50% (1:1 proportion).

Finally, 21 elements presented some form of perforations with rounding or sub-rounding along the edges. These holes were normally found on the irregular borders and collapsed sections of the fractured bones. They were recorded at different locations in four skull bones: the orbital bone, the maxilla, and the cranium. Two pelvis elements were also heavily affected by perforations. In addition, the distal end of a tibiotarsus, the proximal end of a coracoid, and along the proximal and distal ends of two fragments of humerus showed signs of bone perforations. This feature was also frequent in the sternum ($n = 10$), principally on the keel and the borders of these elements presented steeped fractures that appeared to have habitually collapsed within the different sectors (Fig. 3E,F).

A total of 408 avian remains recovered from the 23 pellets were evaluated. An MNE of 296 and an MNI of 6 was calculated (based on the tarsometatarsus), but more than 50% of the bones could only be assigned to Aves indet. The average relative frequency of each registered skeletal element was 26.61%. No mandible, maxilla, furcula, sternum, radius, pelvis, or fibula bones were recovered in this sample. The most frequent elements were the tarsometatarsus, tibiotarsus, phalanges (95% from the feet) and femur (Fig. 4).

The number of articulated skeletal elements found in the pellets was high. Preserved elements included three complete autopodials, two scapulas and articulated coracoids, 21 groups of phalanges, and three groups of vertebra. Although complete elements were abundant (mainly phalanges), only one carpometacarpus, and a complete coracoid could be identified (Table 5). Some retaining skin, muscle, and tendons were also recovered which likely prevented their disarticulation.

The wing/leg index was calculated to 22.85%, which deviated from the expected 50% (1:1 proportion) and was highly statistically

Table 3
Degree of completeness in the uneaten prey remains sample.

Element	MNE	% Whole bone
Scapula	42	30.95
Coracoid	45	91.11
Humerus	59	62.71
Ulna	30	63.33
Radius	33	69.7
Carpometacarpus	18	66.67
Femur	15	53.33
Tibiotarsus	16	56.25
Tarsometatarsus	10	80.00

Table 4
Percentage of preserved long bone portions in the uneaten prey remains sample.

Element	% Proximal elements	% Distal elements
Scapula	93.18	97.73
Humerus	91.07	75.00
Ulna	73.33	90.00
Radius	81.82	87.88
Carpometacarpus	72.22	94.44
Femur	84.62	76.92
Tibiotarsus	75.00	81.25
Tarsometatarsus	100	80.00

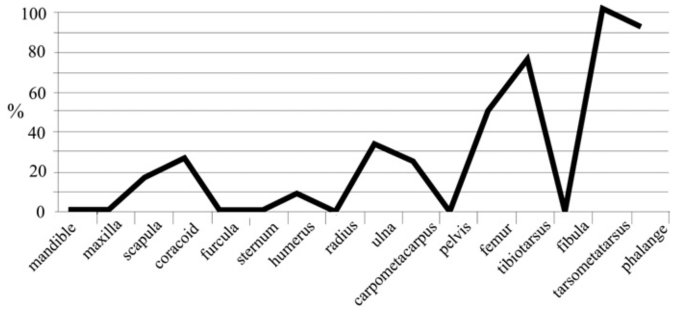

Fig. 4. Frequency of skeletal elements from the pellets sample based on the MNI of 6 and an MNE of 296.

significant ($\chi^2 = 7.7946$, $P < 0.01$, df = 1), suggesting an elevated abundance of leg elements in the pellet sample. The relation between proximal and distal skeletal elements showed the same proportion. The results from the evaluation of the proximal and distal portions of the long bones are shown in Table 5. With the exception of the tibiotarsus and tarsometatarsus, the proximal portions were the most abundant portions recovered. The relation between core elements with respect to limb elements was calculated to 7.89%, which also deviated from the expected 50% (1:1 proportion) and was highly statistically significant ($\chi^2 = 20.637$, $P < 0.01$, df = 1), indicating a better representation of limb bone elements. In all of the bone remains, evidence of corrosion by digestion was high, especially on the surface and breakage borders of bones (Table 6 and Fig. 5).

4. Discussion

Although it would be premature to disregard the possibility of scavenging, the continuity in the recollection of the uneaten prey and the pellets samples indicates that there was no scavenger activity beyond that of the crested caracara. In reference to the taphonomic analysis, none of the elements showed signs of weathering. In many cases the skin, feathers, and scales may have protected the bones from such agents, or the foliage from the tress may have slowed the weathering process.

Among the uneaten prey remains, *Nothura* spp. and *Columba* spp. were the more frequent taxa. In particular, *Columba* has one of the higher body masses (350–450 g) in the sample. It also has the greatest anatomical representation and its skeletal representation could indicate that its body was only partially consumed. From the bones recovered in the pellets sample, bone breakage and digestive corrosion made it difficult to assign taxonomic categories. Although the results from the pellets sample should be taken with caution because the sample is small, the data indicates that *C. plancus* modified the ingested bones of their avian prey. Results also show important differences in the anatomical representation with respect to the sample of the uneaten prey remains (Fig. 6).

Among the remains recovered from the pellets, the tarsometatarsus were the most frequent leg elements, a pattern which both

Table 5
Percentages of proximal and distal long bone portions in the pellets sample.

Element	MNE	% Proximal elements	% Distal. elements
Coracoid	3	100	33.33
Humerus	1	100	0
Ulna	4	50.00	50.00
Carpometacarpus	3	100	33.33
Femur	6	66.66	33.33
Tibiotarsus	9	37.50	62.50
Tarsometatarsus	12	30.00	70.00

Bochenski et al. (1993) and Laroulandie (2002) find in their samples of owl species (*Bubo bubo*). The scarce or lack of fibula in the uneaten prey remains and pellets samples may be related to their bone fragility.

The sternum, humerus, coracoids, and pelvis were the most abundant elements recovered from the uneaten prey remains. These four elements were also the most abundant in samples of uneaten prey remains from diurnal birds studied by Bochenski et al. (1999). Results from this author (Bochenski, 2005; Bochenski et al., 2009) indicate that the high frequency of sternum is a typical characteristic of uneaten prey remains of diurnal bird of prey. The high abundance of coracoids is also coherent with data collected by Bochenski (2005). With respect to the ulna, Bochenski (2005) found that this element is frequent in uneaten prey remains of various species of owls and diurnal raptors; however it does not exceed 15% of the *C. plancus* uneaten prey remains sample.

The low frequency of the cranium, mandible, and maxilla is an attribute present in uneaten prey remains of *C. plancus* that coincides with other diurnal raptor (Bochenski, 2005). There was also a clear absence of cranial and mandible elements in the pellets. In this sense, the pellets sample differ slightly from samples of various species of owls and gyrfalcon (*Falco rusticolus*) analyzed by Bochenski (2005), which show some proportions of these elements. Though it was mentioned in some cases (gyrfalcon in Bochenski et al., 1998) that the low frequency of these elements in pellets and uneaten prey remains are from the disarticulation of the head by the falcons; in the case of *C. plancus*, there is no evidence or bibliographic data that indicates this type of behavior.

Some skeletal elements of uneaten prey remains were still in articulation, mainly the pectoral girdle and wings. Evaluation of the bone breakage in this sample demonstrates that the coracoids were the less effected, while the scapulas were frequently broken. The avian scapulas are fragile elements, thus a high fragmentation frequency is expected.

Fig. 7 shows a comparison between the percentages of the complete bone in the uneaten prey remains of *C. plancus* and the bibliographic data of other diurnal bird of prey (Bochenski et al., 1997, 1999; Laroulandie, 2002; Bochenski and Tornberg, 2003).

Bochenski (2005) divided the birds of prey in three groups taking into consideration the grade of bone breakage in prey. The first group included all diurnal raptor considering the bones found in their pellets. In this category, a high percentage of broken bones were registered. In contrast, the category of less modification also included diurnal raptor when the uneaten prey remains were considered. Accordingly, similar results were found when considering the fragmentation caused by *C. plancus*.

Results from the wing/leg index indicate a higher abundance of wing elements in the uneaten prey remains sample. When comparing this data with the bibliographic records (Bochenski et al., 1997, 1999; Laroulandie, 2002; Bochenski and Tornberg, 2003; Bochenski, 2005), there is a clear resemblance with other diurnal raptors, especially with the prey remains of *F. rusticolus* (Fig. 8). In reference to the pellets sample, the results obtained in this index (higher abundance of leg elements) differ from the owl and diurnal raptor pellet values mentioned by Bochenski (2005) with equality or predominance of wing bones. Furthermore, in archaeological assemblages accumulated by humans, Ericson (1987) found a predominance of leg elements. This author indicates that the abundance of wing elements is characteristic of natural context of depositation. However, Livingston (1989) recorded a similar avian skeletal part frequency between natural and anthropic context. In addition, Livingston (1989) and Cruz (2005) have suggested that bird bone structure and functional anatomy are important factors affecting the skeletal part representation. Elsewhere, Bovy (2002)

Table 6
Percentages of corrosion by digestion and degree of breakage in bones recovered of the pellets sample.

	Bone surface				Breakage			
	Undamaged		Rounded		Sharp		Rounded	
	MNE	%	MNE	%	MNE	%	MNE	%
Vertebra			22	100			7	100
Ribs	4	100						
Scapula			2	100	2	100		
Coracoid			3	100	2	100		
Humerus			1	100	1	100		
Ulna	1	25.00	3	75.00	3	75.00		25.00
Carpometacarpus			3	100	2	100		
Femur			6	100			6	100
Tibiotarsus			9	100	2	22.20	7	77.80
Tarsometatarsus			12	100	9	75.00	3	25.00
Phalanges	125	56.30	97	43.70	6	35.30	11	64.70
Unidentifiableshafts	4	50.00	4	50.00	4	50.00	4	50.00
Total(MNE = 296)		45.30		54.70		44.30		55.70

proposed that the bone mineral density can not explain the abundance of wings found in numerous archaeological sites from the Pacific Northwest Coast of USA.

The relation between proximal and distal skeletal elements demonstrates a clear abundance of proximal elements among uneaten prey remains; while in the pellets sample, the proximal and distal elements showed the same proportion. In reference to this characteristic, results from Bochenski (2005) indicate that three groups of avian predators can be distinguished. When the pellet remains are evaluated, *C. plancus* would fit into the first group. This group included diurnal bird of prey when only their pellets are considered (ratio1:1). However, with the evaluation of uneaten prey remains, this species also fits into the third group (that included golden eagle, *Aquila chrysaetos*), mainly because the proximal skeletal elements are the most frequent.

The relation between the core and limb elements showed a greater representation in the core elements from the uneaten remains and limb elements from the pellets sample. These results were similar with those mentioned by Bochenski (2005) who indicated that in remains recovered from pellets of owls and birds of prey, limb elements greatly predominate, while a high proportion of core for uneaten prey of golden eagle.

Digestive traces are one of main diagnostic characteristic for distinguishing animal predation from human hunting (Andrews, 1990). As previously indicated, the greater proportion of the elements recovered from the pellets sample presented evidence of digestion. Only the elements that were found protected by skin were not affected. This in turn made it difficult to observe possible taphonomic modifications in elements recovered from the pellets samples. In bones of uneaten prey remains, mainly the sternum showed some dissolution holes as well as other marks produced during consumption. During taphonomic studies performed on penguin (*Spheniscus magellanicus*) breeding colonies in Patagonia, Cruz (2007) observed various avian carcasses that had taphonomic modifications principally concentrated in the sternum and keel. Based on their described characteristics, these modifications are similar to those found in *C. plancus* sample.

Superficial marks were likely to have been produced by the claws or beaks during the processing of the prey (Bochenski et al., 2009), including breakage and bone collapse marks found on the sterna and pelvis. It is interesting to note that perforations of these elements has not been recorded from human' bird assemblages, indicating that this feature could be a tool to distinguish nonhuman predation (Bochenski et al., 2009). Moreover, the sterna and pelvis of birds recovered from archaeological sites in Argentina are very low and do not have these types of marks (e.g. Cruz, 2003, 2006; Fernández et al., 2009; Giardina, 2010; Prates and Acosta Hospitaleche, 2010). Marks found close to the epiphysis on long bones are commonly found on the prey of other diurnal raptors

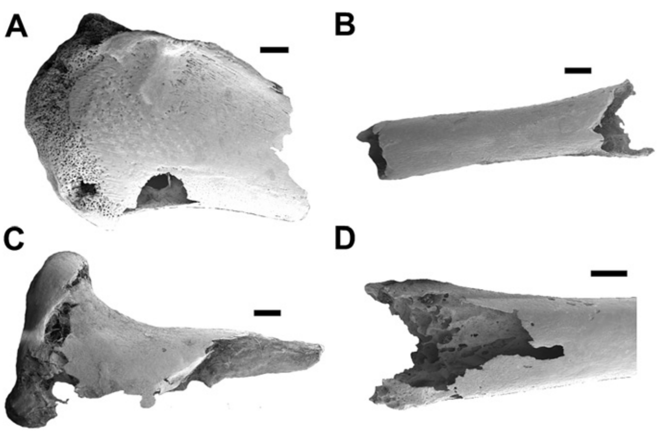

Fig. 5. Skeletal elements of Aves indet. recovered from the pellets sample with evidence of corrosion by digestion A. humerus; B. indet. shaft; C. femur; D. indet. shaft. Scale bar = 1 mm.

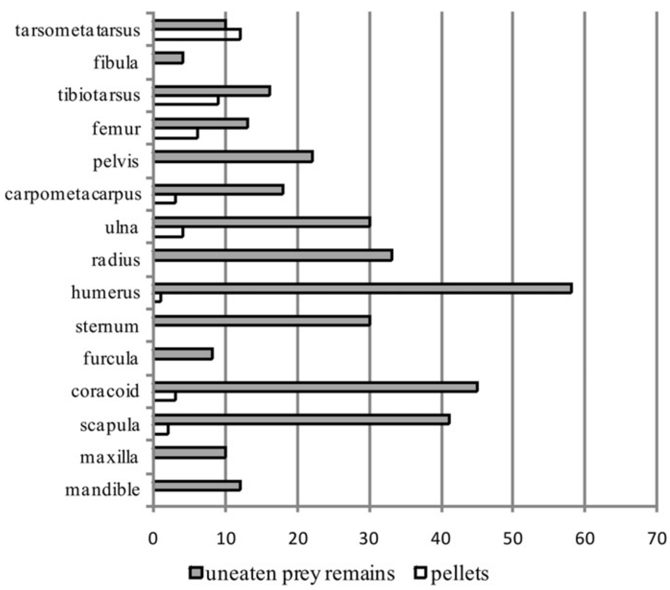

Fig. 6. Minimum number of elements (MNE) distribution in uneaten prey remains and pellets sample.

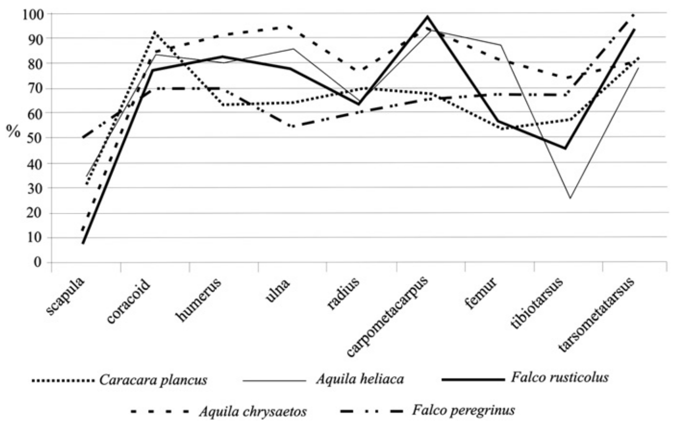

Fig. 7. Comparison of percentages of complete bone found in uneaten prey remains of *C. plancus* with other diurnal bird of prey taken by Bochenski et al. (1997, 1999), Laroulandie (2002) and Bochenski and Tornberg (2003).

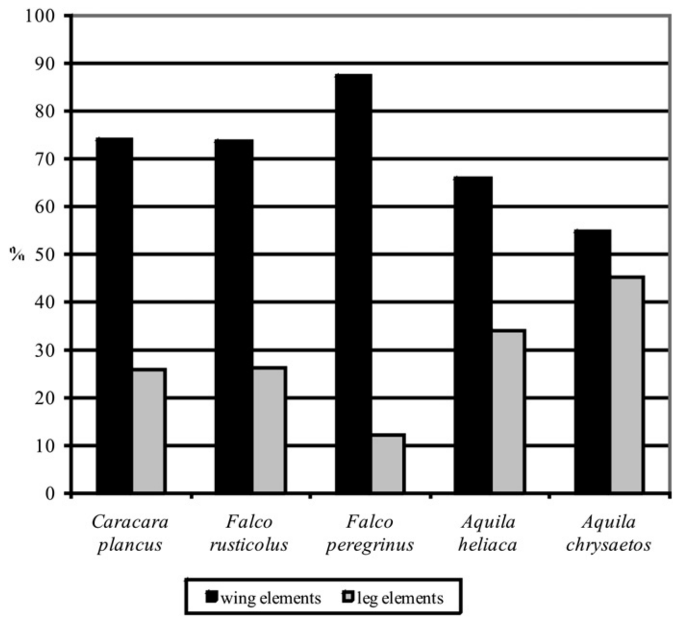

Fig. 8. Proportion of the total number of wing (humerus, ulna, carpometacarpus) to leg (femur, tibiotarsus, tarsometatarsus) bones in uneaten prey remains compared with data of other diurnal birds.

(Bochenski and Tornberg, 2003; Bochenski et al., 2009). It is however interesting to make note of the perforations found on the distal end of the humerus. Laroulandie (2005) mentions that disarticulation of a bird skeleton by humans may produce holes in the fossa olecrani of the humerus. She observed that the marks produced by beaks are related to the bones capacity to withstand this type of mechanical pressure (Laroulandie, 2002). Thus, the evidence for this type of damage is scarce in long bones, which tend to be denser and less likely to collapse under pressure. The differential bone density could also explain the low presence of these types of marks throughout the samples.

5. Conclusions

Results from this analysis help to identify and classify the characteristics of prey bones which have been either digested or discarded by the crested caracara. Among those bones recovered from the uneaten prey remains, there was a high frequency of sternum, humerus, and other wing elements. There was also a higher abundance of complete bones and a greater frequency of long bone proximal ends. In reference to the presence of holes and other damage marks, these appeared to be influenced by the differential bone survivorship and density of the elements. Furthermore, the majority of these marks were only observable on the sternum. The indexes and taphonomic analysis of the sample of prey remains are consistent with the results of previous studies on diurnal birds of prey (*i.e.*, Bochenski, 2005 and literature therein; Bochenski et al., 2009).

Although the pellets sample was small, the results showed a high frequency of leg elements, particularly the tarsometatarsus and feet phalanges. There was also a general absence of mandibles, maxilla and other cranial elements, furculas, sterna, radius, pelvises and fibulas. Also scarce were any complete elements, with the exception of the articulated phalanges which were likely protected by the skin of the prey. There was a slightly higher frequency of long bone proximal epiphysis, and as predicted, there was a high abundance of digestively corroded elements.

As seen in other diurnal raptor studies (*i.e.*, Bochenski, 2005; Bochenski et al., 2009) *C. plancus* appears to affect the bones of its avian prey in a differential mode, which causes a skeletal element representation pattern when the prey has been consumed and deposited in a pellet or when uneaten prey parts are left behind. In consequence, the eating habit of this diurnal raptor affects both what is found in the pellets as well as accumulations of the uneaten prey remains. Given the frequency and characteristics of both samples, the uneaten prey remains provide a strong basis for analysis. Taphonomic analysis by Montalvo and Tallade (2009, 2010) of consumed rodents by *C. plancus* indicates that the mixing of remains from pellets and uneaten prey remains can cause interpretative errors, such as attributing the skeletal representations to more than one predator.

When considering the results of Bochenski et al. (1998) and Bochenski (2005), *C. plancus* would be catagorized as a maximum modifier of bones of its digested avian remains and a slight modifier of those uneaten prey remains. Thus, *C. plancus* can be added in the listing presented in Bochenski et al. (2009) as a raptor which produces marks on bones of its uneaten prey remains.

Bearing in mind that the number of avian remains in the archaeological and paleontology record is generally small compared to mammals, this analysis helps to support interpretive data concerning their origins. More specifically it could be used as an actualistic model and help contribute to the knowledge of a common predator found throughout diverse environments in South America.

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