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WINTER FOOD PREFERENCE OF BLACK-FACED IBIS (*THERISTICUS MELANOPIS* GMELIN 1789) IN PASTURES OF SOUTHERN CHILE

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Resumen. – Preferencias tróficas invernales de la Bandurria (*Theristicus melanosis* Gmelin 1789) en praderas agrícolas del sur de Chile. – Durante el invierno de 1993 y 1994 se evaluaron las preferencias alimentarias de la Bandurria mediante el análisis del contenido estomacal de 32 especímenes. El alimento consistió exclusivamente de invertebrados terrestres. Se encontraron 2343 item presas en los estómagos. Los gusanos de tierra (*Lumbricus* spp., Lumbricidae, Oligochaeta) fueron las principales presas. Otras presas importantes incluyeron larvas de cuncunilla negra (*Dalaca palens*, Hepialidae, Lepidoptera), del gusano cortador (*Agrotis* spp., Noctuidae, Lepidoptera) y del gusano blanco (*Hylamorpha elegans*, Scarabaeidae, Coleoptera). No se encontraron diferencias significativas entre las dietas de ambos sexos. Machos y hembras mostraron preferencias por larvas de lepidóteras (*Dalaca palens*, *Agrostis* spp.) y por larvas de *Hylamorpha elegans.* El consumo de gusanos de tierra fue menor que lo esperado por azar. Las larvas de gusano blanco aportan la mayor biomasa media y contenido energético respecto a las otras presas. Esto me permitiría concluir que probablemente la Bandurria muestra preferencias por larvas de gusano blanco en las praderas agrícolas del sur de Chile, porque les aportarían el mayor beneficio energético neto.

Abstract. – By analyzing the stomach contents of 32 specimens of the Black-faced Ibis (*Theristicus melanopis*) the food preference during winter in 1993 and 1994 was evaluated. Food consisted exclusively of terrestrial invertebrates. We found 2343 prey items in the stomachs analyzed. Earthworms (*Lumbricus* spp., Oligochaeta: Lumbricidae) were the main prey. Other important prey included larvae of Black Pasture Caterpillar (*Dalaca palens*, Lepidoptera: Hepialidae), cutworm (*Agrotis* spp., Lepidoptera: Noctuidae), and Southern Green Chafer (*Hylamorpha elegans*, Coleoptera: Scarabaeidae). No significant differences were found between the diets of either sex and both males and females showed dietary preferences for lepidoptera and southern green chafer larvae. Earthworms consumed by both sexes were lower than expected by chance. The green chafer larvae have a higher mean biomass and energetic content than all the other prey consumed. Thus, I concluded that probably Black-faced Ibis show a preference for green chafer larvae because they provide a higher energetic net benefit to this bird species in southern Chilean pastures. *Accepted 1 May 2010.*

Key words: Black-faced Ibis, food preference, pastures, southern Chile.

INTRODUCCIÓN

The Black-faced Ibis (*Theristicus melanopis* Gmelin 1789) is distributed in Chile from Antofagasta to Tierra del Fuego. It is also found in Argentina from Tucumán to the south of the country as well as in Córdoba and Buenos Aires; small populations of this species are also resident along the Peruvian coast from Lima to Ica (Johnson 1965). In its distribution range in Chile, the Black-faced Ibis uses different types of habitats, including open fields, meadows, steppes, and river banks (Johnson 1965, Fjeldsa & Krabbe 1990, Mathew & del Hoyo 1992). In the south of Chile, this species occupies pastures as a feeding habitat (Housse 1945, Johnson 1965) where it preys mainly on invertebrates (Gantz & Schlatter 1995).

Background information available on the diet of the Black-faced Ibis is based principally on anecdotical reports. This information was obtained in the central region of Chile (Housse 1945, Johnson 1965) and in Argentina (Hudson 1920) where different habitat and climatic conditions determine different prey species and abundance. Gantz & Schlatter (1995) reported the first quantitative study of the diet of this bird species from pastures in Rio Bueno, southern Chile and found that the Black-faced Ibis mainly consumed insect larvae. Nevertheless, in their report these authors do not give any information about the prey preferences of this bird species. Thus, to my knowledge, there are no quantitative studies on the trophic preferences of this bird species in southern Chilean pastures.

Like most other ibises, the Black-faced Ibis is a tactile, non-visual predator, which searches for prey by probing the ground with its long and slender bill. Non-visual foraging behaviour affects the patterns of prey preferences by predators, limiting their ability to choose among potential prey (Kushlan 1979, Pianka 1982, Maheswaran & Rahmani 2002). So, this foraging tactic probably indicates that the Black-faced Ibis is a generalist predator in agricultural fields.

This is the first quantitative report on the food preference of the Black-faced Ibis in southern Chilean pastures. In this area, intensive agriculture uses significant quantities of pesticides that could pose a significant threat to these bird populations, especially if they consume insect species targeted for chemical control. In view of this, it seems important to conduct field studies on the ecology of the Black-faced Ibis, to increase the scarce knowledge existing on this bird species and contribute to development of strategies for their population management and conservation.

METHODS

Study area. The present study was conducted in pastures of private farms at Chahuilco (40°44'S, 73°10'W), 20 km south of Osorno, Chile (Fig. 1). These pastures are anthropogenic secondary gramineous associations, consisting mainly of *Agrostis tenuis*, *Holcus lanatus* (all Poaceae), and *Lotus uliginosus* (Fabaceae) (Subiabre & Rojas 1994). The climate of this region is warm-temperate with monthly mean temperatures between 10 and 12°C and mean annual precipitation between 1200 to 1800 mm (Subiabre & Rojas 1994).

Bird sampling. The diet of the Black-faced Ibis was studied through analyses of stomach contents in winter during 1993 and 1994. Thirty two (16 males, 14 females, and 2 immatures) Black-faced Ibises were collected in their feeding areas and their stomachs sampled for analyses. All birds were collected with S.A.G. (Agricultural and Husbandry Service, Chile) special authorization. The Black-faced Ibis is abundant in the study area, so I consider that the sample size had no impact on the population of this species. This method was applied because the complete and more precise stomach content is obtained (Rosenberg & Cooper 1990); the analysis of food preferences is not biased by differential digestibility of soft-bodied preys as in fecal analysis and can differentiate diet by sex. Other methods (stomach pumping, emetics, etc.) could not be applied for logistics reasons.

Analysis of stomach contents. Post-mortem digestion was prevented by injecting AFA (a solution of 2 parts acetic acid, 10 parts formaldehyde, 50 parts 96° alcohol, and 40

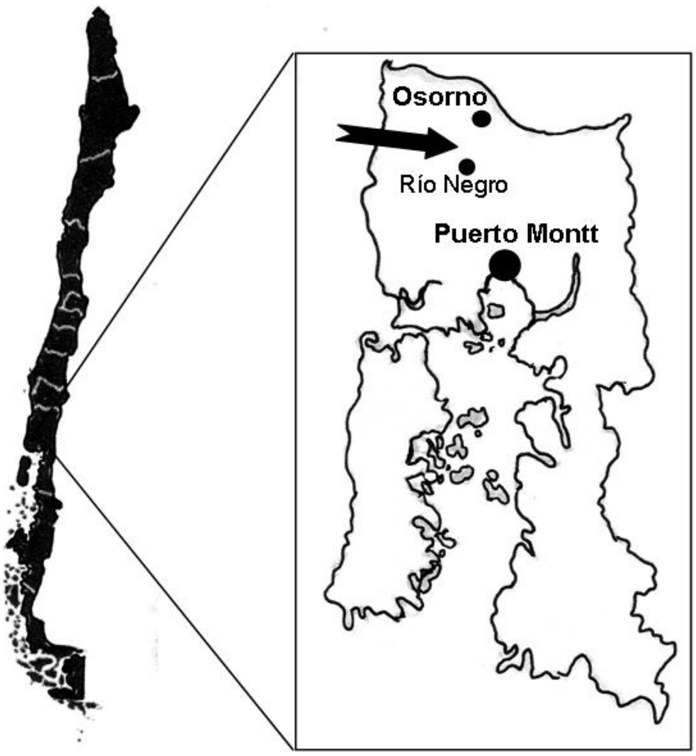

FIG. 1. Map of the study area (arrow) at Chahuilco, southern Chile.

parts distilled water; Wobeser *et al.* 1987) into the birds' stomachs immediately after their collection. Prey items were identified, as far as possible, to the species level using reference books (i.e., Angulo & Wiegert 1975, Peña 1998, González 1989), and with the help of the Laboratory of Entomology of the Institute of Farming and Animal Husbandry of Chile (Instituto de Investigaciones Agropecuarias (INIA), Remehue, Osorno, Chile). The number of earthworms (Lumbricidae) and beetles (Coleoptera) was obtained counting whole individuals, wings, and fragments of head capsules (Calver & Wooler 1982). Numbers of insect larvae consumed were determined by counting non digested larvae and head capsules. The stomach content was weighed after drying at 120°C for 9 hours to obtain ash-free dry weight (Ashmole & Ashmole 1984). The head capsule size (as an indicator of prey size) of the different prey species consumed was measured with a calliper to 0.01 mm accuracy. Diet composition was expressed as number of prey items per taxon and percentage of occurrence, i.e., the number of samples in which a prey taxon category is present (Rosenberg & Cooper 1990).

Data analysis. The difference between sexes, with regard to their prey's total dry weight, was estimated using the Mann-Whitney *U*-test, with normal approximation for large samples (Zar 1984), and the differences of the prey's head capsule frequency distribution were evaluated using the Kolmogorov-Smirnov test for two samples (Zar 1984).

The relative abundance of different prey species in the field was studied taking 30 soil samples (including vegetation over soil samples) of 19x19x10 cm. with a garden spade. All soil samples were obtained at random points in the study area the day after the birds were caught.

To evaluate the trophic preferences of the Black-faced Ibis, we used the Chi-square test for the goodness of fit of the prey distribution frequency, both in the stomach content and in the field (Jaksic 1979). Given that the Chi-square test does not discriminate among the selected prey, we constructed Bonferroni confidence intervals for the four most common prey taxa in the stomachs (Neu *et al.* 1974, Byers *et al.* 1984).

RESULTS

There were no statistical differences in prey number and availability between both study periods (1993-1994), so the data for analysis was grouped (diet 1993 vs 1994, Mann-Whitney *U*-test, $U = 277.500$, $P = 0.651$ - availability 1993 vs 1994, Mann-Whitney *U*-test, $U = 40.500$, $P = 0.470$) (Table 1).

In the 32 stomachs analysed, we found 2342 prey items of 24 different taxa, all of them representing insect larvae and earthworms. Earthworms (*Lumbricus* spp., Lumbricidae) were most important in number and dry weight and the Black Pasture Caterpillar (*Dalaca palens*, Hepialidae) was second in importance. Also cutworms (*Agrotis* spp., Noctuidae) and the Southern Green Chafer (*Hylamorpha elegans*, Scarabaeidae) were important prey in all stomachs. These taxa accounted for 76% of all the prey consumed by the Black-faced Ibis (Table 2) and, together with *Forficula auricularia* and Carabidae, were present in more than 69% of all stomachs analysed (Table 2). Excluding earthworms from the analysis, insect larvae were the most important dietary elements consumed.

As shown in Table 2, males consumed more earthworms, while cutworms were more abundant in the female stomachs. However, no significant differences were found in the diet consumed by either sex of the Black-faced Ibis (Mann-Whitney *U*-test, $U = 285.500$, $P = 0.455$). Neither males nor females differed as to the size of prey consumed nor in frequency distribution of the cephalic tagma size (Fig. 2), both consuming intermediate size of *Dalaca palens*, *Agrotis* spp., and *Hylamorpha elegans* larvae (Kolmogorov-Smirnov, males vs females, *Agrotis* spp., $Z = 0.143$, $P = 0.886$, *D. palens*, $Z = 0.671$, $P = 0.759$ and *Hylamorpha elegans*, $Z = 0.224$, $P = 0.998$). Immature specimens were not considered in the analysis because of the reduced sample size. However, as this is the first quantitative report on Black-faced Ibis food preferences I incorporated immatures in Table 2 as a source of information.

Table 3 shows the relative abundance of prey in the study area. Earthworms, black pasture caterpillars, and southern green chafers were the most abundant potential prey species in the soil samples. The proportion of this prey did not vary over the two years studied.

Although the Black-faced Ibis feeds on a wide variety of prey taxa available in the Chahuilco pastures, it showed preferences for particular prey taxa. The distribution of the expected frequency of four major prey items - earthworms, cutworms, black pasture caterpillars, and southern green chafers - was significantly different ($\chi^2 = 17{,}683.5$, $P = 0.001$) to that observed in the birds' stomachs. Earthworms, although being the most abundant prey in the stomachs, were consumed in a lower proportion than expected. The other important prey taxa available (cutworms, black pasture caterpillars, and southern green chafers) were consumed in greater

TABLE 1. Number, proportion (%) and total dry weight (DW) of all prey consumed by the Black-faced Ibis during winter 1993 and 1994 at Chahuilco pastures, southern Chile.

Prey Items	Winter 1993 N = 15	DW (g)	Winter 1994 N = 17	DW (g)
Agrostis spp. (larvae)	95	5.2	198	4.6
Belostoma bifoveolata	-	-	1	-
Calosoma vagans	7	-	29	0.6
Ceroglosus valdiviae	3	-	1	-
Dalaca palens (larvae)	155	2.4	356	4.17
Forficula auricularia	41	0.4	50	0.3
Hylamorpha elegans (larvae)	243	9.5	57	0.8
Listraderes dentipennis	11	0.2	-	-
Megathopa villosa	-	-	1	-
Orthyorynchus rugosastriatus	21	0.2	-	-
Tana paulseni (larvae)	3	-	2	-
Limax spp.	1	-	1	-
Lumbricus spp.	234	13.5	540	14.2
Asilidae (larvae)	6	0.1	5	-
Carabidae	52	0.6	31	0.1
Curculionidae (larvae)	2	-	8	-
Curculionidae	1	-	12	0.1
Elateridae	2	-	-	-
Hepialidae (pupa)	36	1.5	38	0.3
Pentatomidae	-	-	1	-
Araneae	14	-	8	-
Diptera (pupa)	-	-	1	-
Hirudinea	54	0.5	16	0.2
Myriapoda	2	-	2	-
TOTAL	983		1358	

numbers than expected by chance only (Table 4). Preferences for prey taxa did not differ between males and females and both sexes consume less *Lumbricus* spp. than expected (Table 4).

DISCUSSION

Previous studies have found that the Black-faced Ibis preys on a variety of species, including earthworms, beetle larvae (Hudson 1920, Johnson 1965), snails, some vertebrates like salamanders, reptiles (Housse 1945, Johnson 1965), and occasionally rodents (Mathew & del Hoyo 1992). In the present study I found that the winter diet of the Black-faced Ibis in the pastures consisted exclusively of invertebrates. Most previous studies on this species were from central Chile and southern Argentina and the availability of prey taxa may have been quite different in these areas.

The results of this study are consistent with those of Gantz & Schlatter (1995) in relation to the importance of cutworm, Black Pasture Caterpillar, and Southern Green Chafer in the diet of the Black-faced Ibis but also agree with those reported by Kushlan (1979) on the foraging behaviour of the White Ibis in Florida, USA. The White Ibis and the Black-

TABLE 2. Number and proportion (%) of prey items consumed by male, female and immature Black-faced Ibis, occurrence (Occ. %) percentage of stomachs containing this taxon, and total dry weight (DW) of prey items found in 32 stomachs, collected in Chahuilco southern Chile, during winter 1993 and 1994.

Prey Items	Male N = 16	%	Female N = 14	%	Immature N = 2	%	DW (g)
Agrostis spp. (larvae)	130	93.8	128	100	35	100	9.8
Belostoma bifoveolata	1	6.3	-	-	-	-	-
Calosoma vagans	22	31.3	12	21.4	2	50	0.6
Ceroglosus valdiviae	3	18.8	1	7.0	-	-	-
Dalaca palens (larvae)	163	100	343	78.6	5	100	6.0
Forficula auricularia	56	68.8	34	71.4	1	50	0.5
Hylamorpha elegans (larvae)	176	68.8	116	78.6	8	-	10.3
Listraderes dentipennis	9	25.0	2	7.1	-	-	0.2
Megathopa villosa	1	6.3	-	-	-	-	-
Orthyorynchus rugosastriatus	15	43.8	6	21.4	-	-	0.3
Tana paulseni (larvae)	4	25.0	1	7.1	-	-	-
Limax spp.	1	6.3	-	-	1	50	-
Lumbricus spp.	524	93.8	196	100	54	100	27.7
Asilidae (larvae)	3	12.5	5	14.3	3	100	0.1
Carabidae	31	75.0	52	85.7	1	50	0.7
Curculionidae (larvae)	4	18.8	6	21.4	-	-	-
Curculionidae	6	25.0	7	21.4	-	-	0.2
Elateridae	2	12.5	-	-	-	-	0.1
Hepialidae (pupa)	23	43.8	47	71.4	4	50	2.2
Pentatomidae	-	-	1	7.1	-	-	-
Araneae	11	50.0	10	35.7	1	50	0.4
Diptera (pupa)	1	6.3	-	-	-	-	-
Hirudinea	43	43.8	27	35.7	-	-	0.7
Myriapoda	2	12.5	2	14.3	-	-	-
TOTAL	1,232		996		114		

faced Ibis are non-visual predators that consume a wide variety of prey, but show preferences for some of them. However, the possibility of prey capture is the determining factor in the trophic preferences of the White Ibis, depending to some extent on the prey escape strategies (Kushlan 1979, Jaksic 1986), and probably the same factor influences the prey preference in the Black-faced Ibis. The escape tactic of the Southern Green Chafer and the Black Cutworm (fast vertical movement into their burrows; Durán 1954, Ihl 1947) is probably limited due to the flooding of their burrows during the rainy winter, forcing them to remain near the surface of soil and making them more prone to predation. Nevertheless, other factors may influence this prey preference of the Black-faced Ibis. This species may use its visual sense to detect key characteristics of the prey microhabitat. First, the larger size of the cutworms and the Black Pasture Caterpillar's burrows in late winter (Cisternas 1990, 1992) could be important in the detection of those prey taxa. Second, both these taxa, as well as the Southern Green Chafer, present an aggregate distribution and are grass consumers, thus producing patches of dry grass contrasting with the natural green

TABLE 3. Number and proportion (%) of potential prey taxa in Black-faced Ibis feeding habitat. Data from soil core samples of 19x19x10 cm. All invertebrates were counted in the field.

Prey Items	Winter 1993 N = 30	Winter 1994 N = 31
Agrostis spp. (larvae)	4	0
Dalaca palens (larvae)	47	37
Forficula auricularia	4	2
Hylamorpha elegans (larvae)	2	9
Lumbricus spp.	336	365
Curculionidae (larvae)	2	11
Elateridae (larvae)	3	3
Diptera (larvae)	1	3
Gastropoda	0	1
Hirudinea	1	5
TOTAL	400	436

TABLE 4. Food preference of the Black-faced Ibis during winter, analysed by Bonferroni simultaneous confidence intervals. In order to determine the hypotesis pi = pi_0, the estimated proportion of prey (pi_0), and the proportion of prey observed in stomachs (pi) were compared. Asterisk indicates a difference at the 0.05 level of significance; (-) = consumed less than expected by chance; (+) = consumed more than expected by chance. χ^2 males = 6078.122, P = 0.001; χ^2 females = 6507.849, P = 0.001.

Prey taxa	Sex	Observed proportion (pi)	Expected proportion (pi_0)	Bonferroni intervals for pi
Agrostis spp. (larvae)	Male	0.124	0.005	0.098–0.150* (+)
	Female	0.157	0.005	0.124–0.189* (+)
Dalaca palens (larvae)	Male	0.155	0.100	0.127–0.184* (+)
	Female	0.420	0.100	0.375–0.464* (+)
Forficula auricularia	Male	0.053	0.007	0.036–0.071* (+)
	Female	0.042	0.007	0.024–0.060* (+)
Hylamorpha elegans (larvae)	Male	0.168	0.010	0.138–0.197* (+)
	Female	0.142	0.010	0.111–0.173* (+)
Lumbricus spp.	Male	0.500	0.840	0.460–0.539* (-)
	Female	0.240	0.840	0.201–0.278* (-)

colour of the prairie (Ihl 1947, Durán 1954, González 1989) that the Black-faced Ibis may eventually detect.

Furthermore, one crucial factor which influences trophic preferences is the prey size (Rytkonen *et al.* 1998). The optimal foraging theory predicts that the prey benefit depends on the energy gained by the predator in relation to the costs of manipulation time (Krebs 1978, Morse 1980, Krebs & Davies 1993). In general, a predator must select an optimum prey size because bigger prey imply longer manipulation times (Krebs & Davies 1993). Black-faced Ibis eat medium body-sized prey that are consumed immediately after capture, with negligible manipulation time. Thus, this species apparently responds selectively to prey with the highest energy and biomass contri-

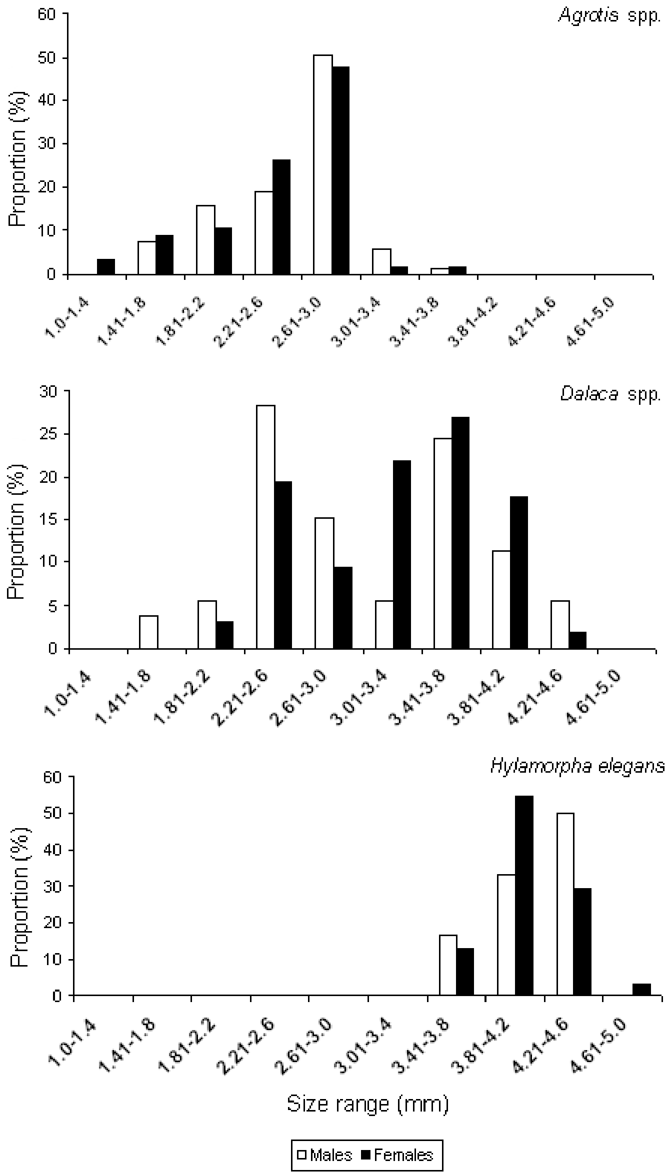

FIG. 2. Frequency distribution of head capsules size (mm) of the three main prey consumed by males and females of the Black-faced Ibis at Chahuilco during winter 1993–1994. A = *Agrotis* spp. (larvae); B = *Dalaca palens* (larvae); C = *Hylamorpha elegans* (larvae).

bution. The Southern Green Chafer has a greater energy content than earthworms (349 kcal/100 g dry basis vs 272 kcal/100 g dry basis, respectively) and a greater mean biomass (see Fig. 2) than any other prey taxa in the pastures (Gantz *et al.* unpubl. data). The high energy content of green chafer larvae probably suggests that the Black-faced Ibis preferred at least this species because it provides the greatest net energetic benefit. There is no information available on the energetic content and the benefits of other prey taxa preferred by the Black-faced Ibis.

However, differential digestion rates of dietary items impose potential biases to any study of gut content and preference analysis (Rosenberg & Cooper 1990; Kaspari & Joern 1993). So these results must be considered with some caution, in particular, if it is considered that chitinous cephalic capsules of *Dalaca* spp., *Agrotis* spp., and *Hylamorpha elegans* larvae would have a reduced digestion rate and a higher permanence time in the gut that soft bodied items such as *Lumbricus* spp. Thus, the former would be overrepresented and the later underrepresented in the gut analysis of the present study. However, if our results are correct, the main preferred prey of the Black-faced Ibis constitutes a significant agricultural plague in the pastures of the study area. The Black-faced Ibis is a large, abundant bird and select its preys in its feeding habitat, attributes that probably allow this bird to be considered as a predator that can regulate or limit its prey's population. Future experimental studies could help to elucidate, eventually with less biases, the trophic preferences and the role as predator of Black-faced Ibis in the pastures of southern Chile.

Nevertheless, I believe that juvenile diet is an interesting research area, given that the energetic requirements during the growth process, together with their lack of experience for capture the high quality prey, could result in a differential diet as compared to that of adult individuals.

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REFERENCES

Angulo, A. O., & G. H. T. Wiegert. 1975. Estados inmaduros de lepidópteros nóctuidos de importancia económica en Chile y claves para su determinación. Sociedad de Biología de Concepción (Concepción, Chile). Publicación Especial nº 2: 7–153.

Ashmole, N. P., & A. R. Ashmole. 1984. Feeding ecology of seabirds. Peabody Mus. Bull. 24: 12–17.

Byers, C. R., R. K. Steinhorst, & P. R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48: 1050–1053.

Calver, M. C., & R. D. Wooler. 1982. A technique for assessing the taxa, lengh, dry weight and energy content of the arthropod prey of birds. Austr. Wildl. Res. 9: 293–301.

Cisternas, E. 1990. Comportamiento de la cuncunilla negra, que incide en la profundidad de la toma de muestra. I. P. A. Remuehue 12: 22–26.

Cisternas, E. 1992. Caracterización biológica de las cuncunillas negras y su combate efectivo en praderas. Bol. Agr. Shell 1: 2–6.

Durán, L. 1954. La biología de *Phytoloema hermanni* (Germ.) y mención de otros escarabeidos perjudiciales a la agricultura en las provincias australes de Chile. Rev. Chil. Hist. Nat. 54: 5–20.

Fjeldså, J., & K. Krabbe. 1990. Birds of the high Andes. Zoological Museum, Univ. of Copenhagen and Apollo Books, Svendborg, Denmark.

Gantz, A., & R. P. Schlatter. 1995. La dieta de la bandurria (*Theristicus caudatus melanopis* Gmelin, 1789) en praderas agrícolas del sur de Chile. Medio Ambiente 12: 35–38.

González, R. H. 1989. Insectos y ácaros de importancia agrícola y cuarentenaria en Chile. Ediciones Ograma, Santiago, Chile.

Housse, R. P. 1945. Las aves de Chile y su clasificación moderna. Su vida y sus costumbres. Ediciones Univ. de Chile, Santiago, Chile.

Hudson, W. H. 1920. Birds of La Plata. Volume 2. J. M. Dent & Sons Ltd., London, UK.

Ihl, E. 1947. Cuncunilla de los pastos. Simiente 17: 78–79.

Jaksic, F. M. 1979. Técnicas estadísticas simples para evaluar selectividad dietaria en strigiformes. Medio Ambiente 4: 114–118.

Jaksic, F. M. 1986. Predator-prey interactions in terrestrial and intertidal ecosystems: are differences real?. Rev. Chil. Hist. Nat. 59: 9–17.

Johnson, A. W. 1965. The birds of Chile and adjacent regions of Argentina, Bolivia and Peru. Volumen 1. Ediciones Buenos Aires, Argentina.

Kaspari, M., & A. Joern. 1993. Prey choice by three insectivorous grassland birds: reevaluating opportunism. Oikos 68: 414–430.

Krebs, J. R. 1978. Optimal foraging: decision rules for predators. Pp. 23–63 *in* Krebs, J. R., & N. B. Davies (eds.). An introduction to behavioural ecology. Academic Press, London, U. K.

Krebs, J. R, & N. B. Davies. 1993. An introduction to behavioural ecology. 3rd ed. Blackwell, Oxford, UK.

Kushlan, J. A. 1979. Feeding ecology and prey selection in the White Ibis. Condor 81: 376–389.

Maheswaran, G., & A. R. Rahmani. 2002. Foraging behaviour and feeding success of the black-necked stork *Ephippiorhynchus asiaticus* in Dudwa National Park, Uttar Pradesh, India. J. Zool. (Lond.) 258: 189–195.

Mathew, E., & J. del Hoyo. 1992. Family Threskiornithidae (ibises and spoonbills). Pp. 472–490 *in* del Hoyo, J., A. Elliot, & J. Sargatal (eds.). Handbook of the birds of the world. Volume 1: Ostrich to ducks. Lynx Edicions, Barcelona, Spain.

Morse, D. H. 1980. Behavioural mechanism in ecology. Harvard Univ. Press, Cambridge, Massachusetts.

Neu, C. W., C. R. Byers, & J. M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38: 541–545.

Peña, L. E. 1998. Introducción a los insectos de Chile. 8a ed. Editorial Universitaria, Santiago, Chile.

Pianka, E. R. 1982. Ecología evolutiva. Editorial Omega, Barcelona, Spain.

Rosenberg, K. V., & R. J. Cooper. 1990. Approaches to avian diet analysis. Stud. Avian Biol. 13: 80–90.

Rytkonen, S., P. Koukkanen, M. Hukkanen, & K. Huhtala. 1998. Prey selection by sparrowhawk *Accipiter nisus* and characteristics of vulnerable prey. Ornis Fenn. 75: 77–87.

Subiabre, A., & C. Rojas. 1994. Geografía física de la región de Los Lagos. Ediciones Univ. Austral de Chile, Valdivia, Chile.

Wobeser, G. A., T. R. Spraker, & V. L. Harms. 1987. Colección y preservación de materiales biológicos en el campo. Pp: 563–577 *in* Rodríguez, R. (ed.). Manual de técnicas de gestión de vida silvestre. The Wildlife Society, Bethesda, Maryland.

Zar, J. 1984. Biostatistical analysis. 2nd ed. Prentice Hall, Englewood Cliffs, New Jersey.