ORNITOLOGIA NEOTROPICAL 9: 31–40, 1998

VOCALIZATIONS OF BLUE-CROWNED CONURES (*ARATINGA ACUTICAUDATA*) IN THE CHANCANÍ RESERVE, CÓRDOBA, ARGENTINA

Esteban Fernández-Juricic[1], Eugenia V. Alvarez[2], & Mónica B. Martella[2]

[1]Facultad de Biología, Departamento de Biología Animal I, Universidad Complutense de Madrid, E. 28040 Madrid, Spain.
[2] Centro de Zoología Aplicada, Universidad Nacional de Córdoba, Casilla de Correo 122, 5000 Córdoba, Argentina.

Resumen. Este trabajo describe los vocalizaciones del Calancate Común (*Aratinga acuticaudata*) y los contextos de emisión. Las grabaciones fueron realizadas en la Reserva de Chancaní (Córdoba, Argentina) durante la temporada reproductiva y no-reproductiva. El repertorio vocal (ocho vocalizaciones) es un sistema combinado de llamados, la mayoría de ellos utilizado en diferentes contextos. *Wee* y *wii* fueron empleados para la agregación de individuos y el mantenimiento de contactos a corta y larga distancia; *whreee* y *wrra* se asociaron con situaciones de alarma; los llamados *gutural*es fueron entremezclados con el resto de las vocalizaciones; y tres llamados (*whii, whhee* and *wrri*) formaron un sistema asociado y combinado (WWW) registrado en varios contextos, ya sea durante el vuelo o el descanso en los árboles. La concentración de la energía acústica fue un parámetro útil para la identificación de la especie debido a su reducida variabilidad. Los vocalizaciones de alarma podrían funcionar como un sistema gradual, el cual variaría de acuerdo a la localización y distancia con respecto al intruso. El sistema WWW puede tener un rol importante en la coordinación y cohesión de las bandadas, y sus combinaciones acústicas podrían ser específicas de cada situación, dependiendo del contexto de emisión.

Abstract. We describe the calls of Blue-crowned Conures (*Aratinga acuticaudata*) and their contexts of emission. Recordings were made in the Chancaní Reserve (Córdoba, Argentina) during breeding and non-breeding seasons. The vocal repertoire (eight vocalizations) is a conflated system of calls, most of them employed in different contexts. *Wee* and *wii* served to aggregate individuals and to keep long and also short vocal contacts; *whreee* and *wrra* were closely associated with alarm situations; guttural calls were intermingled with the rest of the categories, and three calls (*whii, whhee* and *wrri*) formed an associated and combinatorial system (WWW) heard in several contexts, either flying or perching. Energy concentration may be a useful parameter to identify the species due to its low variability. Alarm vocalizations could function as a graded system, which varied according to the location and distance to the intruder. The WWW combinatorial system may play an important role in flock coordination and cohesion, and its acoustic combinations may be situation-specific, hinging upon different contexts. *Accepted 6 October 1997.*

Key words: Behavior, vocalizations, parrot, Aratinga acuticaudata, *vocal repertoire, alarm calls, Argentina.*

INTRODUCTION

The Blue-crowned Conure (*Aratinga acuticaudata*) is a tropical parrot whose distribution covers a wide sector of South America: Venezuela, Bolivia, Paraguay, Mato Grosso (Brazil) and Argentina from the north to La Pampa and south of Buenos Aires (Forshaw 1977).

In the Margarita Island, Venezuela, it has been assigned high conservation priority (Desenne & Strahl 1994) and it is the third most imported species in South America as a pet (Bucher 1992).

During the non-breeding season (March to August), Blue-crowned Conures are organized in flocks of variable number which can be seen perching and eating in trees and shrubs (Forshaw 1977, Rojas-Suárez 1994). Its diet consists mainly in seeds, fruits and tree berries (Smith 1975, Forshaw 1977). During the breeding season (September to February), flocks are less detectable, since pairs spend most of their time in reproductive activities, nesting in isolated tree hollows (Forshaw 1977).

Most of its vocal behavior is unknown, and because of its high degree of sociality it becomes an interesting subject for acoustic studies. The purpose of this work was to analyze the vocalizations of Blue-crowned Conures and the contexts in which they were given.

STUDY AREA AND METHODS

The study was conducted in the Natural Provincial Park and Natural Reserve of Chancaní, Córdoba, Argentina (65º26'W; 30º22'S), which encompasses 4920 ha of undisturbed Chaco forest and where the dominant plant community is the "quebracho-blanco" (*Aspidosperma quebracho-blanco*) forest (Carranza *et al.* 1992). Annual precipitation ranges from 300 to 550 mm (Capitanelli 1979).

We visited the reserve during breeding and non-breeding seasons (December 1993, and March, May, August, and October 1994), totaling about 100 sampling hours. In each visit, we first determined the areas within the reserve where parrots were more actively seen or heard to concentrate our sampling efforts. We recorded vocalizations in the morning (from 30 min before sunrise to mid-morning) and in the afternoon (3 h before and until sunset). Behavioral observations were accomplished according to ad libitum and focal sampling techniques (Altmann 1974).

Vocalizations were recorded with an UHER 4000IC tape recorder at a speed of 19.05 cm/s and a directional microphone (Electro-Voice Model 644). We used a 16-bit stereo Sound Blaster advanced signal processor to digitize sounds up to 22.05 kHz to exceed Nyquist frequency (Evans & Evans 1994, Wilkinson 1994). Signals were filtered at the Centro de Investigaciones Acústicas y Luminotécnicas (C.I.A.L., Córdoba). Sonograms were made at the Instituto de Medicina y Biología Experimental (IBYME) (Buenos Aires) with the software ADDA 16 (Laboratorio de Investigaciones Sensoriales 1992).

We adopted the following terms to describe calls (Kreutzer 1983, Martella 1985): "note", a short sound not interrupted by a silence; and "bands", sectors where acoustic energy is concentrated. The most important band was designated as energy concentration and the others were named in order of intensity as band 1, 2, etc. Multiples of the fundamental frequency were called harmonics. We used onomatopoeias to name each call, instead of interpretive terms and/or discreet categories which might have implied some motivation of the individuals to behave in a certain way (Stirling & Roux 1987, Miller 1992).

We first accomplished a structural analysis in order to identify units and then related them to the contexts in which vocalizations were uttered. Structurally, we measured the following variables: low frequency [the lowest frequency record in the sonogram, in Hertz (Hz)], high frequency (the highest frequency record in the sonogram, in Hz), frequency range (the difference between the latter variables, in Hz), energy concentration (where most part of the acoustic energy is concentrated, in Hz) and duration (in ms). In cases where energy was concentrated in several bands, the quantity and frequencies of these bands were measured. For these variables, we calculated: mean values (x), standard deviations (SD) and coefficients of variation (C.V.)

We estimated the vocalization rate as the number of notes per s during alarm, flying, and perching contexts. We employed Kruskal-Wallis and Mann-Whitney tests to determine differences between vocalization rates and the Pearson correlation coefficient to verify the relationship between note duration and its repetition in alarm situations.

RESULTS

The vocal repertoire of Blue-crowned Conures (8 vocalizations) has some general characteristics: 1) it is an interlinked system of calls in which categories are repeated and mixed in various contexts; 2) two vocalizations were clearly heard in contact circumstances (*wee* and *wii*), and served to aggregate individuals and to keep especially long vocal contacts; 3) two calls were closely associated to alarm situations (*whreee* and *wrra*); 4) guttural calls were intermingled with the rest of the categories identified; and 5) three calls (*whii*, *whhee* and *wrri*) formed an associated system (WWW). Its notes strung together, alternated with gutturals (usually as the number of individuals increased), and were heard in several contexts, particularly flying, but sometimes perching. These calls have shorter duration and were not so specific as the previous ones. It is well worth pointing out that both *whhee*'s and *whii*'s were more frequent in short-range communication.

Wee. It was the most frequently used call by Blue-crowned Conures. It is a wide frequency note with a variable number of harmonics (from two to six), where the fundamental frequency is located at 3070 Hz (Fig. 1a) (Table 1). Sometimes, *wee*'s were given together with guttural calls. This note was uttered by one or more perching parrots, and in the latter case the acoustic overlapping produced a shape modification of the standard note, modifying the final sound (Fig. 1b). Usually, when an individual vocalized a *wee*, it received the same call as an answer from another animal perching in the surroundings (whether visible or not). It seemed to be used in not only long but also short contacts, since it was also recorded in roosting areas. At that moment, parrots engaged in prolific successions of *wee*'s and gutturals before departing to feed.

Wii. It was less frequently registered and commonly uttered in the same contexts as *wee*'s calls. Three straight bands constitute the main part of this call, which has longer duration and fewer harmonics than *wee*'s (Fig. 1c) (Table 1). *Wii*'s were particularly heard when few parrots perched in tree canopies.

Whreee. This harsh sound note intensifies its acoustic energy at 3300 Hz and spans from about 260 to 460 ms (Fig. 1d) (Table 1). Perching parrots vocalized *whreee*'s in alarm situations, specially when they detected intruders (namely the observer). While loudly uttering *whreee*'s, pairs of Blue-crowned Conures often stared at the possible threat and flew to a common branch, if separated, until the danger disappeared.

Wrra. This is a narrow-frequency call where acoustic energy is mainly localized at lower frequencies (2980 Hz). Note duration varied highly from 160 to 620 ms (Fig. 1e) (Table 1). Like *whreee*'s, these vocalizations were heard in the same sort of alarm situations and were alternated with guttural calls. During a response to an approching observer, parrots gave *whreee*'s, then uttered *wrra*'s and gutturals before flying away.

We recorded an additional alarm call that we

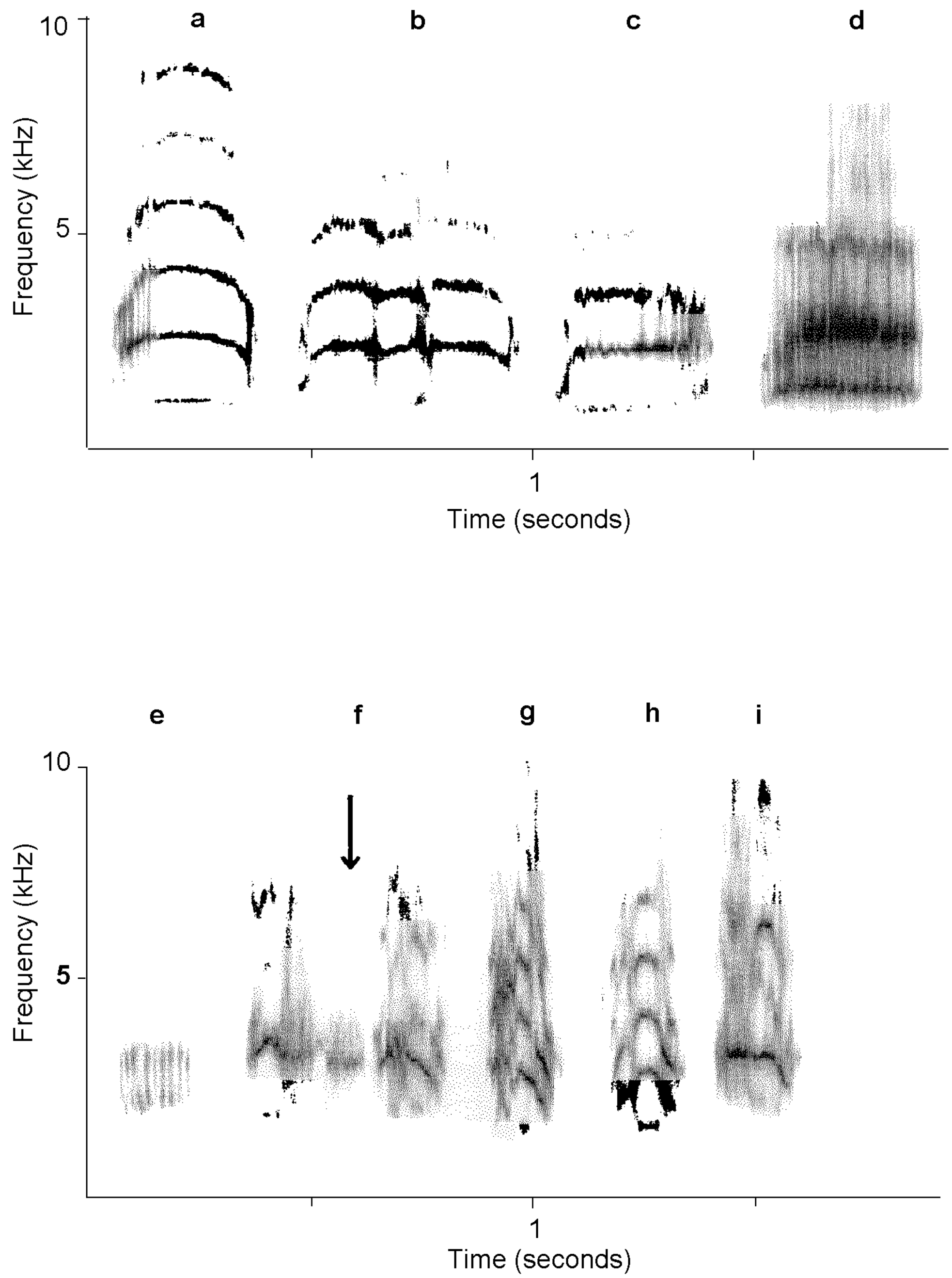

FIG. 1. Blue-crowned Conure vocalizations identified in the Chancaní Reserve, Córdoba, Argentina: a) *wee*, b) *wee*'s uttered by two individuals, c) *wii*, d) *whreee*, e) *wrra*, f) a guttural note (arrow) between two *whhee*'s, g) *whii*, h) *whhee*, i) *wrri*.

TABLE 1. Structural characteristics of *wee*, *wii*, *whreee*, *wrra*, gutturals, *whii*, *whhee*, and *wrri* calls of the Blue-crowned Conure in the Chancaní Reserve, Córdoba, Argentina.

Vocalization (sample size)		High frequency (Hz)	Low frequency (Hz)	Frequency range (Hz)	Concentration of energy (Hz)	Duration (ms)	Number of bands
Wee (n = 14)	Mean	8555.1	1423.6	7131.6	3069.4	333.7	3.6
	SD	1328.8	223.1	1251.0	388.5	38.2	0.9
	CV	15.5	15.7	17.5	12.7	11.5	26.3
Wii (n = 5)	Mean	8392.2	1280.8	7111.4	2841.0	357.0	2.8
	SD	1389.2	87.4	1367.8	152.8	68.9	0.5
	CV	16.6	6.8	19.2	5.4	19.3	15.9
Whree (n = 18)	Mean	8501.9	1473.2	8029.3	3297.7	363.4	
	SD	970.6	188.2	1034.8	154.0	108.7	
	CV	11.4	12.8	14.7	4.7	29.9	
Wrra (n = 6)	Mean	4061.0	1407.7	2655.0	2980.2	390.2	
	SD	478.9	183.7	566.5	198.2	231.4	
	CV	11.8	13.0	21.3	6.7	59.3	
Gutturals (n = 17)	Mean	44554	1914.3	2541.6	2784.5	100.2	
	SD	1021.6	238.2	1144.4	433.1	32.7	
	CV	22.9	12.4	45.0	15.5	32.6	
Whii (n = 13)	Mean	9422.5	12587.6	8175.4	2796.2	174.6	
	SD	13242.4	249.5	1495.6	162.2	17.9	
	CV	14.2	19.8	18.2	5.8	10.3	
Whhee (n = 15)	Mean	8305.8	1516.3	6794.9	3209.9	192.7	
	SD	1892.4	218.7	1936.9	157.5	36.0	
	CV	22.8	14.4	28.5	4.9	18.7	
Wrri (n = 6)	Mean	8733.5	1355.0	7548.2	2723.2	151.8	3.8
	SD	1729.0	274.2	1593	99.3	31.2	1.5
	CV	19.8	20.2	21.1	3.6	20.5	38.4

Abbreviations: SD = standard deviation; CV = coefficient of variation; Hz = Hertz; ms = milliseconds.

were unable to analyze because of its quality. A flying pair uttered it when they detected a Turkey Vulture (*Cathartes aura*). After contrasting this call with those used in this context, we noticed some pitch differences, suggesting the possibility of distinct alarm calls for ground and air predators.

Guttural. It is a low intensity, short call with a great deal of variation in several features, such as high frequency, frequency range, and duration (Table 1). Never did it appear before another note or singly; it was always given combined with other calls (Fig. 1f). It is noteworthy that these vocalizations were produced by means of the air exchange that took place in the phonation apparatus of these parrots; the sound thereby resembled that brought about during inspiration movements. They could not be associated with a particular situation; indeed, its significance depended on which notes it was linked to.

The WWW system was composed of the following sort of calls: *whii*, *whhee*, and *wrii*.

Whii. This call has a metallic sound, an intricate pattern of frequency modulations, and a steady duration (Fig. 1g) (Table 1). *Whii*'s were recorded in string or combined with *whhee*'s; however, their combinations did not maintain a fixed pattern. Blue-crowned Conures uttered this note during long-distance flock movements, particularly at the end of long bouts. Isolated birds also gave *whii*'s while contacting other parrots which were heard but not seen. Moreover, this vocalization seemed to mantain pair contact during foraging among clustered trees.

Whhee. Its acoustic energy is concentrated at 3200 Hz, and its duration is rather variable (from 155 to 225 ms) (Fig. 1h) (Table 1). It was repeated in sequences; and generally combined with *wrri*'s, setting the following pattern: *whhee*-guttural-*wrri*. Mainly perching Blue-crowned Conures vocalized this call. Also, *whhee*'s were repeated several times to coordinate changes of flight direction or landing of large flocks. Occasionally, pairs gave *whhee*'s before taking off.

Wrri. This shorter vocalization (150 ms) has a variable number of parallel and convex bands (Fig. 1i) (Table 1). It was far less frequently heard and never isolated from other calls; as a rule it was combined with *whii*'s or *whhee*'s, and usually separated by gutturals. After departing because of the observer activity, Blue-crowned Conures included *wrri*'s in the long bouts which followed alarm calls. This bouts encompassed *wee*'s, *whii*'s, *whhee*'s and gutturals, and were given until parrots reached another tree.

Blue-crowned Conures vocalized more frequently during flights (v.r. = 2.39 notes/s, n = 12) than in alarm (v.r. = 1.64 notes/s, n = 16) or perching contexts (v.r. = 1.61 notes/s, n = 17) (Kruskall-Wallis test, F = 3.92, $P < 0.05$). We did not find differences in delivery rates neither in presence nor in absence of the observer, while the parrots were perching (Mann-Whitney test, U = 1.33, $P = 0.18$). During alarm circumstances, vocalization rates varied highly (coefficient of variation = 61.95), which was related to the duration of the notes (Pearson coefficient of correlation = –0.5698, $P < 0.05$). As a result, the greater the vocalization rate in alarm contexts, the shorter the duration of notes would become and vice versa. Therefore, the variations detected in vocalization rates may be thought of as a signal of the intensity of the arousal (in this case, the approach of intruders).

DISCUSSION

The Blue-crowned Conure broadly emphasizes low frequencies (approximately 2900 Hz), possibly to avoid the effects of sound attenuation in high canopies, typical of the forest it inhabits (Morton 1975). Considering all structural parameters of the Blue-crowned Conure vocalizations, energy concentration has the lowest variation. These low coefficient of variation values could be associated with species recognition; and thus, may be considered as a useful parameter to identify this species (Catchpole 1979, Saunders 1983, Sparling 1983).

Solely based on note shapes, contact calls (*wee* and *wii*) differ greatly from alarm vocalizations (*whreee* and *wrra*). Such a distinction is relevant when parrots are not in the visual range of communication; an usual situation in the sort of habitat (Chaco vegetation) where this study took place. After reaching a feeding patch, flocks broke up, and parrots relied upon acoustic signals to alert one another of possible dangers or to provide a clue for aggregation.

Whreee and *wrra* may be understood as a graded alarm system, which comprises two steps. First, when parrots detect the peril, they loudly vocalize *whreee*'s. Second, as the intruder approaches, this sequence is turned into a series of alternated *wrra*'s and gutturals, which increases in repetition and intensity, and decreases in note duration, until the parrots leave the area. Such a system seems to be useful for regulating alarm responses, and for conveying information of the closeness of a given danger. A similar graded system was found in Pinon Jays (Berger & Ligon 1977).

Considering alarm calls, a noteworthy relationship can be outlined among Blue-crowned Conures and two other parrot species that inhabit the same Chaco region: the Monk Parakeet (*Myiopsitta monachus*) and the Blue-fronted Amazon (*Amazona aestiva*). The calls given by the three species in alarm contexts share some structural characteristics; namely, wide frequency range, abrupt onsets and ends, and repetition of notes in relation to the intensity of the threat (Martella & Bucher 1990, Fernández 1994). These properties allow conspecifics to quickly locate the calling bird, which constitutes a selective advantage in this sort of contexts (Thorpe 1961). Furthermore, this basic structure of alarm calls may permit communication among species (Catchpole 1979). Such was the case when groups of Blue-crowned Conures and Blue-fronted Amazons reacted vocally to alarm calls after Monk Parakeets first detected the observer near nest sites.

Variables that convey information about individual identity are expected to have high coefficients of variation (Catchpole 1979, Saunders 1983). Blue-crowned Conures' guttural calls demostrate this point, because the variation of frequency range is nearly twice as large as that of the other calls (see coefficients of variation in Table 1). However, since these vocalizations are related to anatomical characteristics of the parrots (air exchange movements), their variation could also be related to sex or age differences. Furthermore, like the Blue-crowned Conure guttural calls, the *Ji* note of the Magellanic Penguin (*Spheniscus magellanicus*) (Romero & Tapella 1996) is vocalized during inspiration movements and is alternated with other calls.

The most commonly heard call of the WWW combination (*whii*) has certain features (wide frequency range and frequency fluctuations) that make it easy for conspecifics to locate calling individuals (Marler 1955), facilitating social coordination of activities, as occurs with the *chrp* call of the Budgerigar (*Melopsittacus undulatus*) (Wydhman 1980).

Other species, particularly of the *Parus* genus (Hailman 1989, Ficken *et al.* 1994), give combined calls to transmit different messages, as the Blue-crowned Conure's WWW system seems to do. Our data cannot assess the level of complexity of this system, but it may surely be important in group cohesion and coordination. Moreover, combinations could involve subtle variations in the transmission of certain kinds of information, depending on the context.

Compared with alarm and perching contexts, vocalization rates were higher in flying contexts, which would correspond closely with the maintenance of cohesion among the members of a group, since Blue-crowned Conures move in large flocks (Fernández-Juricic *et al.* 1997). The fact that vocalization rates do not change with the presence of the observer corroborates the idea that this parrot is not as shame upon human presence as other parrot species (Forshaw 1977).

The Blue-crowned Conure seems to rely on its different calls for the vast majority of its activities. Particularly important are the coordination of flock movements and the response to alarm situations. Several vocalizations were given in a vast array of contexts; hence, the possibility that some combinations display different meanings according to particular situations, or that individual or group differences account for these variations, remain unknown. Further efforts will be useful to address such specific acoustic questions within the social organization of this parrot species.

ACKNOWLEDGMENTS

We are grateful to Direccción de Áreas Naturales de la Provincia de Córdoba for having given us the permission to work in the Chancaní Reserve, to René Serra and Aldo Ortíz (Centro de Investigaciones Acústicas y Luminotécnicas, Córdoba) for having lent us the recording equipment, and to Pablo Tubaro and Fabián Gabelli (I.B.Y.M.E., Buenos Aires) for having allowed us the use of the software for sonograms. We also thank Gabriela Sincich and Ivan Cavic for their collaboration in the preparation of the figures and Marina Gentile for the reviewing of the manuscript. This work has been supported by the Olrog Fellowship 1994 of the Asociación Ornitológica del Plata (Argentina).

REFERENCES

Altmann, J. 1974. Observational study of behavior: sampling methods. Behaviour 49: 227–267.

Berger, L. R., & D. Ligon. 1977. Vocal communication and individual recognition in the Pinon Jay, *Gymnorhinus cyanocephalus*. Anim. Behav. 25: 567–584

Bucher, E. H. 1992. Neotropical parrots as agricultural pests. Pp. 201–219 *in* Beissinger, S. R. & N. F. R. Snyder (eds.). New world parrots in crisis: solutions from conservation biology. Smithsonian Inst. Press, Washington, D.C.

Capitanelli, R. 1979. Clima. Pp. 45–138 *in* Vásquez, J., R. Miatello, & M. Roque (eds.). Geografía física de la provincia de Córdoba. Ed. Boldt, Buenos Aires.

Carranza, M. L., M.R. Cabido, A. Acosta, & S. A. Paez. 1992. Las comunidades vegetales del Parque Natural Provincial y Reserva Forestal Natural Chancaní, Provincia de Córdoba. Lilloa 38: 75–92.

Catchpole, C. K. 1979. Vocal communication in birds. Edward Arnold, London.

Desenne, P., & S. Strahl. 1994. Situación poblacional y jerarquización de especies para la conservación de la familia Psittacidae en Venezuela. Pp. 231–272 *in* Morales, G., L. Novo, D. Bigio, A. Luy, & F. Rojas-Suárez (eds.). Biología y conservación de los psitácidos de Venezuela. Graficas Giavimar, Caracas.

Evans, M. R., & J. A. Evans. 1994. A computer-based technique for the quantitative analysis of animal sounds. Bioacoustics 5: 281–290.

Fernández-Juricic, E. 1994. Análisis ecológico y funcional de las vocalizaciones del Loro Hablador (*Amazona aestiva*) en el Chaco Occidental Argentino. Grad. thesis, Univ. Nacional de Córdoba, Córdoba, Argentina.

Fernández-Juricic, E., E. V. Alvarez, & M. B. Martella. 1997. Variación estacional en la abundancia del Calancate Común (*Aratinga acuticaudata)* en la Reserva de Chancaní, Córdoba, Argentina. Hornero 14: 259-262.

Ficken, M. S., E. D. Hailman, & J. P. Hailman. 1994. The chick-a-dee call system of the Mexican Chickadee. Condor 96: 70–82.

Forshaw, J. H. 1977. Parrots of the world. Landsdowne Editions, Melbourne.

Hailman, J. P. 1989. The organization of major vocalizations in the Paridae. Wilson Bull. 101: 305–343.

Kreutzer, M. 1983. El canto de los pájaros. Mundo Científico 3: 548–560.

Laboratorio de Investigaciones Sensoriales. 1992. Informe XXV. Escuela de Salud Pública. Fac. de Medicina. Univ. de Buenos Aires, Buenos Aires.

Marler, P. 1955. Characteristics of some animal calls. Nature 176: 6–8.

Martella, M. B. 1985. Observaciones sobre el comportamiento de la cotorra *Myopsitta monachus* con especial énfasis en la comunicación vocal.

Ph.D. thesis. Univ. Nacional de Córdoba, Córdoba, Argentina.

Martella, M. B., & E. H. Bucher. 1990. Vocalizations of the Monk Parakeet. Bird Behav. 8: 101–110.

Miller, E. H. 1992. Acoustic signals of shorebirds. Royal British Columbia Museum, Victoria, British Columbia.

Morton, E. S. 1975. Ecological sources of selection on avian sounds. Am. Nat. 109: 17–34.

Rojas-Suárez, F. 1994. Situación actual y aspectos de la biología del Ñangaro (*Aratinga acuticaudata neoxena*) en la Isla de Margarita. Pp: 57–63 *in* Morales, G., L. Novo, D. Bigio, A. Luy & F. Rojas-Suárez (eds.). Biología y conservación de los psitácidos de Venezuela. Graficas Giavimar, Caracas.

Romero, M. C., & F. Tapella. 1996. Vocalizaciones del Pingüino de Magallanes (*Spheniscus magellanicus*) durante el período reproductivo. Grad. thesis. Univ. Nacional de Córdoba, Córdoba, Argentina.

Saunders, D. A. 1983. Vocal repertoire and individual voice recognition in the Short-billed White-tailed Black Cockatoo. Aust. Wildl. Res. 10: 527–536.

Smith, G. A. 1975. Systematics of parrots. Ibis 117: 18–68.

Sparling, D. W. 1983. Quantitative analysis of prairie grouse vocalizations. Condor 85: 30–42.

Stirling, I., & J. O. Roux. 1987. Fur seal vocalizations. Pp. 21–202 *in* Croxall, J. P., & R. L. Gentry (eds.). Status, biology and ecology of fur seals. U. S. Dept. Com., NOAA Tech. Rep. NMFS 51.

Thorpe, W. H. 1961. Bird song; the biology of vocal communication and expression in birds. Cambridge Univ. Press., Cambridge.

Wilkinson, G. S. 1994. Canary 1.1: sound analysis software for Macintosh computers. Bioacoustics 5: 227–241.

Wyndham, E. 1980. Diurnal cycle, behaviour and social organization of the Budgerigar *Melopsittacus undulatus*. Emu 80: 25–33.