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LITERATURE CITED

BECK, B. B., AND R. H. TUTTLE. 1972. The behavior of gray langurs at a Ceylonese waterhole. *In* R. H. Tuttle [ed.] Functional and evolutionary biology of primates. Aldine-Atherton, Chicago.

BENT, A. C. 1932. Life histories of North American gallinaceous birds. U.S. Natl. Mus. Bull., No. 162. As republished by Dover Publications, Inc. 1963.

BENT, A. C. 1937. Life histories of North American birds of prey. U.S. Natl. Mus. Bull., No. 167. As republished by Dover Publications, Inc. 1961.

CADE, T. J. 1965. Relations between raptors and columbiform birds at a desert water hole. Wilson Bull. 77:340–345.

ELDER, J. B. 1956. Watering patterns of some desert game animals. J. Wildl. Mgmt. 20:368–378.

FISHER, A. K. 1893. Hawks and owls of the United States in their relation to agriculture. U.S. Dept. Agric., Div. Ornithol. Mammal., Bull. 3.

FISHER, C. D., E. LINDGREN, AND W. R. DAWSON. 1972. Drinking patterns and behavior of Australian desert birds in relation to their ecology and abundance. Condor 74:111–136.

GORSUCH, D. M. 1934. Life history of the Gambel Quail in Arizona. Univ. Arizona Biol. Sci. Bull., No. 2.

MILLER, A. H., AND R. C. STEBBINS. 1964. The lives of desert animals in Joshua Tree National Monument. Univ. California Press, Berkeley.

SUMNER, E. L. 1935a. A life history of the California Quail, with recommendations for its conservation and management, Pt. 1. California Fish and Game 21:167–256.

SUMNER, E. L. 1935b. A life history of the California Quail, with recommendations for its conservation and management, Pt. 2. California Fish and Game 21:275–342.

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THE CAYENNE TERN IN BRAZIL

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The wide distribution of the Cayenne Tern (*Thalasseus eurygnathus* = *Sterna eurygnatha* = *S. sandvicensis eurygnatha*) has been shown by several authors to be on the Caribbean and Atlantic coasts of South America from the southern Caribbean Islands (12° N) and Trinidad along the coasts of Colombia, Venezuela, Surinam, Brazil, and Uruguay south to Argentina as far as Puerto Deseado (48° S, Santa Cruz Prov.). Junge and Voous 1955; Voous 1957, 1963, 1968; Phelps and Phelps 1958, 1959; Escalante 1959, 1962, 1970a,b; ffrench and Collins 1965; Sick and Lẽao 1965; Zapata 1965; Olrog 1967; Haverschmidt 1968; Korschenewski 1969; and Daciuk 1972). Breeding colonies were reported in four different areas: Netherland Antilles (Junge and Voous 1955; Voous 1957, 1963; Ansingh et al. 1960); near Cabo Frío, Brazil, 23° S (Sick and Lẽao 1965); Golfo San José, 43° S (Daciuk 1972); Punta Tombo, 44° S (Korschenewski 1969); and Punta de los Pájaros, in Argentina, 44°55′ S (Zapata 1965). Phelps and Phelps (1958, 1959) and ffrench and Collins (1965) mentioned isolated breeding pairs with eggs, and chicks on islands off Venezuela and on Trinidad. Voous (1968) and Escalante (1970:89–94; 1970:171–177) concluded that the Argentinian and Uruguayan birds differ from the Antillean ones, principally in possessing longer bills, and probably represent a distinct population. Most of the samples studied were obtained from well-defined areas (Netherland Antilles, 12° N; Uruguay, 35° S; Argentina, 43° S) but the Brazilian sample (Voous 1968) was not suitable for comparative purposes. Most of the specimens of this sample are in the British Museum (Junge and Voous 1955), and represent a composite assemblage obtained from localities between Bahia (12° S) and Santa Catharina (27° S), an area 2000 km in extent and with a 15° difference in latitude. According to Voous (1968), "the Brazilian birds show the largest coefficient of variation (7.7, exposed culmen)." This might be ascribed to geographical variation and the possible occurrence of northern and southern migrants. Therefore, the status of the Brazilian birds could not be clearly settled. This paper attempts to (1) analyze the characteristics of an adequate sample of specimens (adults) obtained from a well-defined latitudinal area within the Brazilian Atlantic coast, where breeding terneries have been recorded, and (2) to compare the data with those from southern and northern South America. Accordingly, the data considered are those obtained by the author from 10 adult specimens (nuptial and nesting plumages, etc.) in the collections of the Museu de Zoologia da Universidade de São Paulo (six skins) and Museu Nacional da Universidade de Río de Janeiro (four skins). These specimens were collected at Rio de Janeiro (Guanabara) and from Santos to Iguapé (São Paulo) localities at almost the same latitude. This is in the neighborhood of Ilha dos Papagahios (23° S) near Cabo Frío, where Sick and Lẽao (1965) showed the existence of a breeding colony on 12 July 1963. According to Sick (unpubl. data), the tern is a permanent resident in the area, but there is no clear idea about the variation in numbers throughout the year.

TABLE 1. Comparative measurements of the exposed culmen in different geographical samples of the Cayenne Tern.

Locality	*N* (size of the sample)	$\bar{x}$ (mean)	O.R. (observed range)	SD (standard deviation)	SD^2 (variance)	SE (standard error)	V (coefficient of variation)	CI (confidence interval, 95%)
1—Northern South America (South Caribbean, 12° N)	23	54.0	49.0–58.0	2.4	5.76	0.5	4.5	1.04 52.9–55.0
2—Brazil (Guanabara and São Paulo, 23°–25° S)	16	54.6	52.0–59.3	1.93	3.72	0.48	3.53	1.02 53.6–55.6
3—Brazil (Bahia, Rio de Janeiro, Santa Catharina, 12°–27° S)	19	54.5	47.0–61.0	4.2	17.64	1.0	7.7	2.02 52.5–56.5
4—Uruguay (35° S)	7	58.9	54.3–63.9	3.5	12.25	1.35	5.9	3.30 55.6–62.2
5—Southern Argentina (43° S)	10	58.7	53.5–62.0	2.8	7.84	0.9	4.8	2.00 56.7–60.7

Data for samples of: Northern South America (1); Brazil from Bahia, Rio de Janeiro to Santa Catharina (3) and Southern Argentina (5) are from Voous (1968). Data for Uruguay (4) are from Escalante (1970). Data for Brazil in Guanabara and São Paulo (2) are in part from Junge and Voous (1955) but most of them were obtained by the author from specimens in the museums of Zoologia in São Paulo and Museu Nacional in Río de Janeiro. Measurements are given in mm. Statistics follow Simpson et al. (1960).

Also, processed data on six adult specimens from Rio de Janeiro were mentioned in Junge and Voous (1955). Table 1 compares the measurements of the exposed culmen in adult specimens of both sexes in Brazilian birds (23° S–25° S) with similar data from samples from northern and southern South America (Voous 1968; Escalante 1970).

The data about the composite Brazilian sample given by Voous are included in table 1 only for reader information (1968). Skins from Bahia (12° S) and extreme southern Brazil (30° S) are not considered in Table 1 because of the small sample size, age, heterogeneity, and absence of reports on breeding colonies in those latitudes. Comparison between winglength of the Brazilian sample (23° S–25° S) with others from South America are not given. Adequate numbers of adult specimens in fresh plumage were not available because outermost primaries were worn, broken, or in molt between June and October. A dark pattern occurring on the inner webs of the outermost primaries (1–4), mentioned by Escalante (1970: 91) on the basis of data from Junge and Voous (1955), could not be observed regularly in the skins in the museums of São Paulo and Rio de Janeiro. Color of the soft parts in fresh skins were not recorded on the specimen labels studied. From the present study, some tentative conclusions are that the Brazilian sample from the latitude of Guanabara (Rio de Janeiro) and São Paulo (23° S–25° S) seems to be representative of the population in the area because the plumage sequence of adults is related to the breeding schedule of the bird. Also, the sample shows enough homogeneity, and it has a low coefficient of variation (3.5) in culmen measurements. A comparison, following Simpson et al. (1960), for mean exposed culmen indicates that the birds of Guanabara and São Paulo are closely related to those of the southern Caribbean Sea ($t = 0.82$, 37 df, $P > 0.4$). On the other hand, significant differences are shown when the sample is compared with those of southern South America (Uruguay: $t = 3.851$, 21 df, $P < 0.001$; Argentina: $t = 4.440$, 24 df, $P < 0.001$). Two extensive areas on the Brazilian coast, extreme southern Brazil (Santa Catharina and Río Grande do Sul, 27° S–32° S) and Bahia northward (12° S–4° N), deserve careful future field work.

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LITERATURE CITED

ANSINGH, F. H., H. J. KOELERS, P. A. VAN DER WERF, AND K. H. VOOUS. 1960. The breeding of the Cayenne Tern or Yellow-billed Tern in Curaçao in 1958. Ardea 48:51–65.

DACIUK, J. 1972. Pequeña colonia de nidificación del Gaviotín Brasileño en Isla de los Pájaros (Golfo San José, Chubut, Argentina). Neotrópica 18:103–106.

ESCALANTE, R. 1959. Some records of oceanic birds in Uruguay. Condor 61:158–159.

ESCALANTE, R. 1962. Frequency of occurrence of some seabirds in Uruguay. Condor 64:510–512.

ESCALANTE, R. 1970a. Notes on the Cayenne Tern in Uruguay. Condor 72:89–94.

ESCALANTE, R. 1970b. Aves marinas del Rio de la Plata y aguas vecinas del Oceáno Atlántico (private publication). Barreiro & Ramos S. A. Montevideo.

FFRENCH, R., AND C. T. COLLINS. 1965. Royal and Cayenne Terns breeding in Trinidad, West Indies. Auk 82:277.

HAVERSCHMIDT, F. 1968. The birds of Surinam. Oliver & Boyd, Edinburgh and London.

JUNGE, G. C. A., AND K. H. VOOUS. 1955. The distribution and relationship of *Sterna eurygnatha* Saunders. Ardea 43:226–247.

KORSCHENEWSKI, P. 1969. Observaciones sobre aves del litoral patagónico. Hornero 11:48–52.

OLROG, C. C. 1967. Observaciones sobre aves migratorias del Hemisferio Norte. Hornero 10:292–298.

PHELPS, W. H., AND W. H. PHELPS, JR. 1958. Lista

de las aves de Venezuela. Bol. Soc. Venez. Cienc. Nat. 19:1–317.

PHELPS, W. H., AND W. H. PHELPS, JR. 1959. La nidificación de las aves marinas en el Archipiélago de Los Roques. Bol. Soc. Venez. Cienc. Nat. 94:325–336.

SICK, H., AND A. P. A. LÊAO. 1965. Breeding sites of *Sterna eurygnatha* and other seabirds off the Brazilian coast. Auk 82:507–508.

SIMPSON, G. G., A. ROE, AND R. C. LEWONTIN. 1960. Quantitative zoology. Harcourt Brace, New York.

VOOUS, K. H. 1957. The birds of Aruba, Curaçao and Bonaire. Stud. Fauna Curaçao, Caribb. Islands 7:1–200.

VOOUS, K. H. 1963. Tern colonies in Aruba, Curaçao and Bonaire, South Caribbean Sea. Proc. XIII Intern. Ornithol. Congr., Ithaca, N.Y., p. 1214–1216.

VOOUS, K. H. 1968. Geographical variation in the Cayenne Tern. Ardea 56:184–187.

ZAPATA, A. R. P. 1965. Nuevas localidades de nidificación de *Leucophaeus scoresbii* y *Sterna sandvicensis eurygnatha*. Physis 25:383–395.

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BLOOD RESPIRATORY PROPERTIES IN SOME ANTARCTIC BIRDS

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INTRODUCTION

There exists a surprising shortage of information on the respiratory properties of avian blood. Although birds share homeothermy with mammals and require efficiency in O_2 transport matching or exceeding that of mammals, avian blood differs from that of mammals in important respects.

The present study compares blood respiratory properties in three species of penguins: the Adélie Penguin (*Pygoscelis adeliae*); the Gentoo Penguin (*P. papua*); and the Chinstrap Penguin (*P. antarctica*). Blood was obtained at various stages of development. The measurements and calculations included hematocrit (Hct), hemoglobin content (Hb), and mean corpuscular hemoglobin content (MCHC). The HbO_2 dissociation curves and their pH dependence (Bohr effect) were also determined. Less comprehensive information was obtained from the Giant Fulmar (*Macronectes giganteus*) and the antarctic Skua (*Catharacta skua*).

MATERIAL AND METHODS

The study was performed during the 1971 antarctic cruise of the research vessel *Alpha Helix* of the University of California. The animals were collected in the vicinity of Anvers Island near Palmer Research Station (64°45′ S–64°05′ W). The blood analysis was performed in the laboratories of *Alpha Helix*. The HbO_2 dissociation curves were determined employing the mixing method (Lenfant and Johansen 1965) and using a radiometer blood microsystem (BMS 3 and PHM 71) for measurement of blood gas tensions and blood pH. Hemoglobin content was measured spectrophotometrically after conversion to cyanmethemoglobin (Oser 1965). Hematocrit was measured in microhematocrit tubes after centrifugation for 10 min at 10,000 rpm.

The blood was collected from the brachial vein by percutaneous puncture. Heparin (1000 units per 5 ml blood) was used as an anticoagulant. Following collection, blood was stored on ice until used for analysis of respiratory properties.

RESULTS

Table 1 and figures 1 and 2 summarize the results. The three species of penguins studied are aquatic birds and practice habitual diving for feeding and migration. They all show high blood hemoglobin contents corresponding to O_2 capacities of about 22.5 vol% in Adélie and Gentoo Penguins and up to 27.5 vol% in the Chinstrap Penguin. It is of interest that the Chinstrap and to a lesser extent the Gentoo Penguin appear to practice longer periods of breath-holding between surfacings when diving, and they also dive to greater depths than the Adélie Penguin. The mean corpuscular hemoglobin concentration was closely similar in the species of penguins and averaged about 38%. The values for the nondiving petrel and Skua were lower (31–34%). The chicks of Adélie and Gentoo Penguins, 3–4 weeks old, both showed considerably lower hemoglobin concentrations than the

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TABLE 1. Blood respiratory properties of adult and young Antarctic birds.

Species	N	Hemoglobin content (g/100 ml blood ± SE)	Hematocrit (% ± SE)	MCHC (% ± SE)	P_{50} at pH 7.4 (mg Hg)	Bohr factor ($\Delta \log P_{50}/\Delta pH$)
P. adeliae[a]	8	16.49 ± 2.0	46.2 ± 2.5	37.6 ± 3.2	34.4	–0.505
P. adeliae[b]	12	11.05 ± 1.9	29.0 ± 3.8	37.6 ± 3.8		
P. papua[a]	5	16.44 ± 3.2	43.4 ± 6.7	38.0 ± 5.0	32.0	–0.562
P. papua[b]	6	11.88 ± 0.6	31.1 ± 3.0	38.5 ± 3.8		
P. antarctica[a]	6	19.57 ± 1.7	52.8 ± 3.4	37.7 ± 3.0	29.8	–0.618
Macronectes giganteus[a]	14	14.64 ± 2.6	43.4 ± 3.5	33.8 ± 3.8	42.5	–0.350
Catharacta skua[a]	2	13.97 ± 1.4	45.0 ± 2.0	31.0 ± 3.2	42.5	no data

[a] Adults.
[b] Chicks.