Journal of Zoo and Wildlife Medicine 30(1): 81–84, 1999

WEIGHTS, HEMATOLOGY, AND SERUM CHEMISTRY OF FREE-RANGING BROWN BOOBIES (*SULA LEUCOGASTER*) IN JOHNSTON ATOLL, CENTRAL PACIFIC

Thierry M. Work, M.S., D.V.M., M.P.V.M.

Abstract: Hematologic and serum chemistry values are reported for 105 brown boobies (*Sula leucogaster*) from Johnston Atoll, Central Pacific. Hematocrit, estimated total plasma solids, total and differential white cell counts, serum glucose, calcium, phosphorus, uric acid, total protein, albumin, globulin, aspartate aminotransferase, and creatinine phosphokinase were analyzed. Hematologic and serum chemistry values varied with age and sex. Values were compared with those of red-footed boobies and other tropical and temperate marine pelecaniforms.

Key words: *Sula leucogaster*, brown booby, hematology, serum chemistry.

INTRODUCTION

Brown boobies (*Sula leucogaster*) are the second most numerous sulid in the world after the red-footed booby (*Sula sula*).[8] This species is widely distributed throughout the Pacific Ocean both in mainland coastal and offshore nesting sites. Although there is information on abundance, nesting behavior, and reproduction in brown boobies, data on health and physiology are scarce.[8]

Baseline physiologic information includes clinical chemistry and hematology reference values, which can be used to assess the health status of both captive and free-ranging birds.[2,5] Clinical chemistry and hematology values have been reported for seven species of free-ranging seabirds in Hawaii.[11] This report includes reference values for brown boobies from Johnston Atoll in the Central Pacific.

MATERIALS AND METHODS

Boobies were sampled from a healthy colony of approximately 500 breeding pairs on East Island, Johnston Atoll National Wildlife Refuge (16°45′N, 169°31′W). The colony was monitored routinely by biologists from the U.S. Fish and Wildlife Service, which had reported no catastrophic reproductive failures or mortalities in the previous 5 yr.

Blood was collected from 35 adult male and 35 adult female boobies in April 1995 and from 35 chicks in July 1995. Adult birds were classified as male or female based on plumage, facial characteristics, size, and nature of call.[9] Age of chicks, based on date of hatching from marked nests, ranged from 77 to 95 days.

Birds were captured manually or with large hand-held hoop nets. Those not exhibiting behavioral or physical abnormalities were weighed to the nearest 50 g with a 2.5-kg spring scale. Five milliliters of blood was drawn from the branchial vein using 5-ml syringes and 0.5 mm/25 mm needles (Sherwood Medical, St. Louis, Missouri 63103, USA). Blood collection and weighing were done immediately upon capture, and birds were released after ensuring adequate clotting of the venipuncture site. Of the 5-ml sample of blood, 0.5 ml was placed in 500-μl ethylenediaminetetraacetate (EDTA) tubes and the remainder was placed in 5-ml plain tubes (Becton-Dickinson, Rutherford, New Jersey 07070, USA). Whole blood in EDTA was stored at 4°C for up to 8 hr prior to processing. The remaining blood was allowed to clot for 12 hr at 27°C before centrifugation. Serum was decanted into 1.5-ml cryovials (Corning, Corning, New York 02140, USA) and frozen at −20°C.

Combined heterophil and eosinophil counts were made with a Neubauer hemocytometer, eosinophil unopettes no. 5877 (Becton-Dickinson). Total white blood cells (WBC) ($\times 10^3/\mu l$) were then calculated.[2] Hematocrit values were obtained by spinning whole blood in heparinized capillary pipettes in a microhematocrit centrifuge for 5 min.[2] Plasma total solids were estimated using a temperature-adjusted refractometer (Schuco, American Caduceus Industries, Carle Place, New York 11514, USA).[2] Blood smears were made in duplicate from EDTA blood that had been refrigerated 6–8 h; smears were air dried.

Blood smears were coded, pooled, randomized, and stained with Leukostat (Fisher Scientific, Pittsburgh, Pennsylvania 15219, USA), and 200 WBC were counted at 1,000× for differential counts. WBC were classified as heterophils, eosinophils, lymphocytes, monocytes, or basophils based on morphology and staining characteristics.[2] The presence or absence of hemoparasites was noted.

Serum biochemistry values (total protein, albu-

From the U.S. Geological Survey, National Wildlife Health Center, Honolulu Field Station, P.O. Box 50167, Honolulu, Hawaii 96850, USA.

Table 1. Weights, hematology, and serum chemistry values for brown booby adults and chicks from Johnston Atoll, Central Pacific.

Measure	Female			Male			Immature		
	Mean ± SD	Range	n	Mean ± SD	Range	n	Mean ± SD	Range	n
Weight (kg)	1.5[a] ± 0.1	1.3–1.7	35	1.2 ± 0.1	1.0–1.4	35	1.4[a] ± 0.2	1.2–1.8	35
Hematocrit (%)	45[a] ± 2	41–50	35	45[a] ± 3	40–51	35	40 ± 3	32–47	35
Total solids (g/dl)	4.1 ± 0.4	3.2–4.8	35	4.0 ± 0.5	2.8–5.0	35	4.1 ± 0.5	3.2–5.8	35
Lymphocytes ($10^3/\mu l$)	1.22[a] ± 0.60	0.33–2.81	35	0.96[b] ± 0.47	0.20–1.99	35	2.90 ± 1.33	0.99–5.90	35
Heterophils ($10^3/\mu l$)	7.23 ± 2.23	2.58–12.37	35	6.19 ± 2.15	2.89–11.91	35	7.59 ± 3.66	1.48–15.53	35
Monocytes ($10^3/\mu l$)	0.38 ± 0.40	0.00–2.17	35	0.36 ± 0.29	0.00–1.48	35	0.36 ± 0.24	0.00–1.04	35
Eosinophils ($10^3/\mu l$)	1.28[a] ± 0.73	0.33–3.49	35	0.91[b] ± 0.58	0.23–2.58	35	0.57 ± 0.45	0.10–2.18	35
Basophils ($10^3\mu l$)	0.22 ± 0.12	0.00–0.50	35	0.18 ± 0.12	0.00–0.71	35	0.27 ± 0.23	0.00–1.31	35
Total white cells ($10^3/\mu l$)	10.33 ± 3.09	4.91–16.74	35	8.60 ± 2.94	4.08–17.77	35	11.69 ± 4.61	4.02–23.16	35
Glucose (mg/dl)	256[a] ± 48	143–348	17	275[a] ± 48	167–383	16	221 ± 34	130–309	27
Calcium (mg/dl)	10.9 ± 2.1	6.1–14.0	17	10.0 ± 2.6	4.4–13.1	16	10.9 ± 2.3	6.0–14.6	27
Phosphorus (mg/dl)	10.8[a] ± 3.9	5.3–19.9	17	6.9 ± 2.6	3.8–13.0	16	8.0 ± 2.7	4.0–13.6	27
Uric acid (mg/dl)	20.5 ± 9.2	9.6–41.2	17	16.7 ± 11.3	4–39	16	12.1 ± 5.7	2.9–24.4	27
Protein (g/dl)	4.0 ± 0.5	3.1–4.9	17	3.8 ± 0.7	2.5–5.2	16	3.7 ± 0.7	2.4–5.3	27
Albumin (g/dl)	1.6 ± 0.2	1.2–2.0	17	1.5 ± 0.2	1.1–2.1	16	1.5 ± 0.3	1.0–2.3	27
Globulin (g/dl)	2.4 ± 0.3	1.8–3.1	17	2.2 ± 0.4	1.4–3.1	16	2.2 ± 0.5	1.4–3.1	27
Aspartate aminotransferase (IU/L)	306[a] ± 129	151–690	17	320[a] ± 83	204–481	16	179 ± 44	105–285	27
Creatine phosphokinase (IU/L)	774 ± 361	172–1,743	17	427 ± 221	131–783	16	773 ± 403	269–1,611	27

[a,b] Values with different letters across a row were significantly different ($P < 0.003$).

min, uric acid, calcium, phosphorus, aspartate aminotransferase [AST], creatinine phosphokinase, and glucose) were measured at the University of Wisconsin School of Veterinary Medicine (Madison, Wisconsin) using a Kodak Ektachem 500 analyzer (Eastman Kodak, Rochester, New York 14650, USA). Globulin was calculated by subtracting albumin from total protein. Serum chemistry samples were randomized and analyzed blind.

Hematology and blood chemistry means, standard deviations, medians, and ranges were tabulated. Chemistry values from hemolyzed serum or analytes that were below the limit of detection were excluded from the analysis. Statistical comparisons among males, females, and immature birds were done using one-way analyses of variance, with the alpha adjusted for an experiment-wide error rate of 0.05 ($\alpha = 0.003$) as described previously.[11]

RESULTS

Male brown boobies weighed significantly less than females or chicks ($P < 0.05$). Chicks had significantly lower hematocrit, glucose, and AST levels than adults. Males weighed significantly less than either females or chicks. Females had significantly higher phosphorus levels than either males or chicks. Lymphocyte counts in chicks were significantly higher than those of females, which were in turn significantly higher than those of males. Female eosinophil counts were significantly higher than those of males, which were in turn significantly higher than those of chicks (Table 1). The only hemoparasite seen was an intracellular organism in red cells. Its morphology was compatible with *Babesia* spp.[4,12] No clinically abnormal birds were encountered, and no adverse effects of restraint and blood collection were observed.

DISCUSSION

The body weights of adult brown boobies in this study were higher than those previously observed,[3,8] although variables such as geography, season, or diet could account for the difference. The morphology of brown booby WBC was very similar to that of red-footed boobie WBC.[11] As observed in red-footed boobies, basophil granules were often bleached and resembled those of chickens.[6] As in other seabirds, adults had higher hematocrits and lower lymphocyte and WBC counts than chicks.[11] In tropical pelagic pelecaniforms, hematocrit, total protein, and albumin and globulin concentrations increase with age.[11] The same trend applied to the brown boobies, although it was less marked than in other species. As a comparison, in brown pelicans (*Pelecanus occidentalis*), hematocrit, globulin, and protein concentration increased with age but albumin concentration decreased.[10] Compared with black-faced cormorant (*Leucocarbo fuscescens*) fledglings, brown booby chicks had lower monocyte and lymphocyte counts and higher eosinophil counts.[7] Compared with brown pelican fledglings,[10] brown booby chicks had greater hematocrits and serum phosphorus concentrations. Adult brown boobies had greater hematocrits than adult North Atlantic gannets (*Sula bassana*).[1]

Brown booby chicks generally were heavier than red-footed booby chicks and had greater estimated total solids and heterophil counts and lower lymphocyte counts and AST levels.[11] Compared with red-footed booby adults, adult brown boobies generally had lower lymphocyte counts and higher calcium and phosphorus levels. Caution should be exercised with the comparisons of adult values, however, because previous reports did not distinguish adult male and female red-footed boobies.[11] Serum chemistry values should also be interpreted with caution because certain analyses change with duration of storage and clotting of blood.[5]

As in other marine pelecaniforms, brown boobie hematology differed between males and females.[2,10,11] Unlike frigatebirds, breeding female brown boobies did not have higher calcium levels than did males. Higher concentrations of phosphorus in breeding female boobies than in males has not been observed in other tropical marine pelecaniforms. These differences may be due to variation in diet between species. Only breeding females were sampled in this study, precluding comparisons with nonbreeding females.

Acknowledgments: I am grateful to Robert Rameyer and Chris Depkin, who provided much needed assistance in the field. Greg Massey kindly provided constructive comments on the manuscript.

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Received for publication 22 December 1997