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Assessing Passeriformes health in South Texas via select venous analytes

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ABSTRACT

The handheld point of care analyzer is a quick and feasible option to obtain hematology data from individuals. The iSTAT-1® was used to evaluate select venous blood analytes obtained via jugular venipuncture from 238 passerine birds from South Texas. These data were used to assess the health of birds in the area while taking into consideration life history (migratory or sedentary), locale, seasonality, sex, and age. We attributed increased values of pO_2 and hematocrit, in addition to hemoglobin and glucose concentrations of migratory birds compared to sedentary birds as the increased need of oxygen carrying capacity and energy for long duration flights. Increased glucose and lower ionized calcium concentrations were observed in migratory birds likely based on breakdown of fat deposits in the body to fuel the muscular endurance of migration. During the hotter months of the year, birds' responses to handling were exhibited by relative respiratory acidosis. When sedentary birds sampled from South Texas were compared to a previous study from Central Texas, venous blood analytes differed by locale but were within the ranges of healthy populations. These findings lead us to conclude that sedentary avian communities can be used as ecosystem bioindicators.

1. Introduction

Effects of habitat alteration or destruction are frequently investigated, but many studies only approach the issue from a habitat management perspective. To fully understand the effects that environmental changes have, especially on organisms such as birds, we must address their physiological response to the change (Albano, 2012). Environmental change can cause stress to the inhabitants of the area and has been linked to nutritional deficiencies, hormonal imbalance, inflammation, and chronic infection (Briggs et al., 1996). Focusing on the ecosystem level, the classic idiom of the canary in the coalmine holds true. Many passerine birds preferentially seek out human habitations or areas of heavy urbanization, such as Great-tailed Grackles (*Quiscalus mexicanus*), European Starlings (*Sturnus vulgaris*), and House Sparrows (*Passer domesticus*). Birds are more sensitive to environmental changes (Morrison, 1986) and can show a physiological response before humans; this is the basis of a sentinel population. Birds ingest insects and plants affected by human activity such as pollutants and habitat degradation (Goulson, 2014; Liang et al., 2016). Several studies assessed the effects of an altered (polluted or degraded) ecosystem via the hematological response of bird inhabitants (Llacuna et al., 1996; Ruiz et al., 2002; Elezaj et al., 2013). These studies found differences of certain hematological analytes that impact bird health associated with the conditions affecting health of the ecosystem. Passeriformes represent a good study organism for this type of evaluation of ecosystems because there is a cornucopia of them with similar physiology through family and genera that is relatively easy to capture and handle with sample techniques established.

Hematological assessment is a popular method to assess health with minimal negative impact on the individual bird (Fokidis et al., 2008; Sheldon et al., 2008; Deem et al., 2011; Maceda-Veiga et al., 2015). Point of care analyzers allow for assessment of respiratory and cardiovascular systems via measurement of avian acid-base status, biochemical fluid balance, electrolytes, and blood gases (Heatley et al., 2013). The iSTAT-1® analyzer requires small amounts of blood and provides results within a short time for up to 10 blood analytes per sample. The iSTAT-1® has been used to determine multiple analytes for avian species such as chickens, passerine birds, and parrots (Steinmetz et al., 2007; Paula et al., 2008; Martin et al., 2010; Harms and Harms, 2012). This study aims to assess the health of free living passerine birds in southern Texas via select venous blood analytes, and by including life history traits (migration), locale, seasonality, and other intrinsic variables as covariates. We also compare our results from southern Texas to similar data collected from birds occupying a distinctly different habitat

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Table 1
Summary of 238 passerine birds sampled for hematology on East Foundation ranches in South Texas.

Family or location	Total	Males	Females	Adult	First year
Cardinalidae	72	37	34	38	12
Emberizidae	20	8	5	11	2
Fringillidae	3	2	1	1	2
Icteridae	36	10	18	17	5
Mimidae	25	3	4	7	6
Paridae	5	2	2	4	1
Parulidae	51	14	22	28	9
Troglodytidae	4	2	1	3	0
Turdidae	2	0	2	2	0
Tyrannidae	13	3	4	8	1
Vireonidae	7	1	2	3	1
El Sauz Ranch	194	71	72	99	24
San Antonio Viejo Ranch	44	11	23	23	12
Total	238	82	95	122	36

in Central Texas.

Several recent studies have investigated bird hematology with respect to migration and were able to conclude that the strenuous activity of migration contributed to the fluctuating parameters of the blood (D'Amico et al., 2010; Vinkler et al., 2010; Minias et al., 2014). We hypothesize that sedentary and migratory bird blood analytes will differ based on the physiological needs of migration. We further hypothesize that differences amongst analytes of birds from our South Texas sampling sites and between South and Central Texas will be minimal and generally reflective of good health. Finding significant differences of these hematological analytes could be important to the larger goal of understanding free-living passerine bird health and their interaction with environmental conditions. Should venous blood analytes of sedentary avian species be altered by local factors, these species could represent good local bioindicators of their ecosystem's health.

2. Materials and methods

2.1. Field sampling

Passerine birds (Tables 1, 2) were sampled on the East Foundation lands of San Antonio Viejo Ranch (located inland, in Jim Hogg and Starr Counties) and, El Sauz Ranch (located coastally in Kenedy and Willacy Counties) (Fig. 1) from March 2014 to November 2015. During field sampling the average temperature during spring, summer, and fall were recorded as 22.7 °C, 30.6 °C, and 24.4 °C (https://beaumont.tamu.edu/ClimaticData) and average precipitation for these sample seasons were 3.5 in., 1.5 in., 3.3 in. (http://www.usclimatedata.com). All birds were captured via mist net and placed in cloth bags for about 5 min, allowing them to calm before sampling occurred (Heatley et al., 2013). All birds were handled according to protocol from Texas A & M University Institutional Animal Handling and Use Committee. Birds were restrained by hand for collection of 0.2–0.5 ml of blood via jugular venipuncture with needle and syringe. Blood samples obtained from birds that were subsequently released back to the environment was always < 1.0 ml/100 g of body weight. Blood samples were transferred to lithium heparin microtubes (Terumo America Inc., Elkton, MD, USA) to prevent clotting.

2.2. Sample analysis

Blood sample analysis occurred within 5 min of sample collection using a handheld point of care analyzer, the iSTAT-1® system (Abbott Laboratories, Abbott Park, IL, USA). Venous blood, 0.15–0.2 ml was placed in the cartridge and the results were provided within 2 min of analysis. Blood sample analysis was performed with the blood gas cartridge (CG4 + or CG8 +) first, followed by the Chem 8 cartridge. Each cartridge has fresh sensors and calibration fluid and the iSTAT-1® performs a quality check/self-calibration before each test (Groves, 2002). Venous blood values (iSTAT-1® system manual, 2012) were determined for the following analytes: pH, pCO_2 (carbon dioxide partial pressure), pO_2 (oxygen partial pressure), lactate, bicarbonate, total CO_2, base excess, sO_2 (dissolved oxygen), ionized calcium, glucose, blood urea nitrogen (BUN), hematocrit, hemoglobin, sodium, potassium, and chloride. These parameters were chosen for assessment based on availability in this analyzer's platform and usefulness for clinical assessment of avian health. Previous work suggested that some analytes are more useful for assessment of passerine birds as indicators of local environmental health (Heatley et al., 2013). The iSTAT-1® system measures most values directly, but total CO_2, hemoglobin, base excess, and sO_2 are calculated based on assumptions of blood and plasma characteristics of clinically normal humans. Temperature correction of the measured analytes was not applied in this study. Blood samples were loaded into ammonium heparin microhematocrit (Drummond Scientific Co., Broomall, PA, USA) capillary tubes and centrifuged (Clay-Adams, Inc., New York, USA) at 15,000*g* for 5 min within 24 h of collection to assess packed cell volume. A physical examination and assignment of body condition score (BCS) was performed on each bird after blood collection (Tully, 2009). The body condition was scored on a scale of 1–5 by assessing the mass of the pectoral muscle and fat located on the chest, with BCS 1 being the lowest condition score and BCS 5 the highest. Scoring was performed by using the thumb and fore finger to palpate muscle along the keel, examining the contour of the breast muscle. In this technique, mid-range body condition scores (3) are representative of optimum health. After sampling, some birds were humanely sacrificed via thoracic compression (Leary et al., 2013; Paul-Murphy et al., 2016) and prepared as voucher specimens for the Biodiversity Teaching and Research Collection at Texas A & M University, while others were placed in the cloth bag for 10 min and released. Intrinsic variables such as species, sex, and age were recorded in the field (Dunn and Alderfer, 2011), if possible, by external field markings as well as age and sex confirmed during specimen preparation (Nero, 1951). Migratory or sedentary status was assigned using life history information (Dunn and Alderfer, 2011).

2.3. Statistical methods

Analysis of the data was performed using Analyse-it for Microsoft Excel® statistical software (version 2.20 Microsoft Office 2010, Analyse-it® Software Ltd., http://www.analyse-it.com/, 2009). Normality for each analyte was assessed by histogram and Shapiro-Wilk test ($P > 0.05$); for all other statistical analyses significance was accepted at $P < 0.05$. The effects of migratory status, age, sex, and locality were evaluated using Student's *t*-test ($P < 0.05$) for parametric data and by Kruskal-Wallis test ($P < 0.05$) nonparametric data (Kruskal and Wallis, 1952). Season (fall, spring, or summer) and BCS were assessed using a one-way analysis of variance ($P < 0.05$) and Tukey-Kramer method was used for the post hoc analysis to verify results of these two variables. The effect of species was also measured using a one-way analysis of variance for five sedentary species from South and Central Texas that had a minimum of 10 individuals sampled, for a total of 108 birds (Table 3). To assess whether habitat drives variation in analytes, the data from select sedentary birds sampled in South Texas (East Foundation properties) were analyzed in conjunction with data from a previous study in which birds were sampled from the ecologically and elevationally different Edward's Plateau in Central Texas (Fig. 1: Heatley et al., 2013).

The use of the iSTAT-1® in determination for hematocrit seems to require a correction factor for use in passerine birds. The output from the point of care analyzer uses a formula derived from humans using normal mean hemoglobin concentrations of 34 mg/dl (Heatley et al., 2013).