FAT SCORING IN FOUR SPARROW SPECIES AS AN ESTIMATION OF BODY CONDITION: A VALIDATION STUDY

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Abstract
Body condition indices are used to assess individual health of wild and captive animals. The definition of body condition varies by researcher and study goals but typically refers to measures of energy reserves; most commonly fat stores (Labocha & Hayes, 2012). In avian biology, body condition has been correlated with individual survivability (Blums *et al*., 2005), reproduction (Chastel *et al*., 1995; Bêty *et al*., 2003) migration (Bêty *et al*., 2003; McWilliams *et al*., 2004; Laursen *et al*., 2019), and habitat quality (Angelier *et al*., 2011; Balbontín *et al*., 2012). One of the oldest and most common methods of determining avian body condition is fat scoring: using a qualitative scale to score visible subcutaneous fat (Blanchard, 1941; Helms & Drury, 1960). Scores are determined by using the fullness and color of furcular and/or abdominal regions of a bird to estimate fat reserve size and can be determined in under a minute. Fat pad size and fat score are highly correlated, making this a quick and effective means of determining body condition (Kaiser, 1993; Labocha & Hayes, 2012). Fat score can be used in tandem with other morphological measurements to more accurately predict fat mass (Labocha & Hayes, 2012; McWilliams & Whitman, 2013). However, it is important to note that fat score is a qualitative measurement, and therefore subjective, and there is not one single scale used (Rogers, 2003; Labocha & Hayes, 2012; McWilliams & Whitman, 2013). Furthermore, not all bird species carry fat in the same manner (Seewagen, 2008; Schamber *et al*., 2009).

The only accurate way to determine the lipid composition of a bird (including non-fat pad lipids) is to chemically extract it from the body, which is fatal to the bird and time-consuming for researchers. The number of studies using such methodologies is limited due to the ethical nature of killing subjects but exist for a few species of passerines and waterfowl (Conway *et al*., 1994; Seewagen, 2008; Schamber *et al*., 2009; McWilliams & Whitman, 2013; Beuth *et al*., 2016) The goal of this study is to determine the relationship between fat score and total body lipid composition via chemical extraction in four sparrow species: white-throated sparrows (*Zonotrichia albicollis*), song sparrows (*Melospiza melodia*), swamp sparrows (*Melospiza georgiana*), and Lincoln's sparrows (*Melospiza lincolnii*).

Methods
A total of 42 white-throated (hereafter referred to as WTSP), 19 song, 5 swamp, and 3 Lincoln's sparrows were collected opportunistically by City Wildlife as part of their Lights Out DC initiative in the spring and fall seasons of 2017-2019. All birds died due to building collisions and were donated to the Smithsonian National Zoological Park's (SI-NZP) Nutrition Department.

Visual Assessment
Birds were thawed and scored using the ESF system from the British Trust for Ornithology (0 - 8). The same procedures were followed as if scoring live birds and scoring was assumed to be the same as if done on live specimens (Krementz & Pendleton, 1990). To reduce inter-observer variation, all scoring was performed by one SI-NZP zoo nutritionist with extensive body scoring experience.

Fat Determination
Initial body weight was measured for all birds. Individuals were defeathered manually and dissected ventrally to remove their fat pads as completely as possible. Beaks were removed via scalpel, and legs were removed via severance at or just above the intertarsal joint to aid in the homogenizing process (note: lipid content in these areas are absent or negligible). Birds were then reweighed. The altered bodies were then blended with distilled water in a household blender until a homogenized slurry was produced. The slurries were dried in aluminum pans at 100°C in forced air convection oven for 24 hours and then manually homogenized into a powder. Crude fat (CF) content of the fat pads (abdominal and furcular combined per bird) and the homogenized carcass powder was measured using an ANKOM fat apparatus (ANKOM XT15 Extractor, Macedon, NY).

Results
All birds measured within the standard size and/or weight range for their species (Ammon, 2020; Arcese *et al*., 2020; Falls & Kopachena, 2020; Herbert & Mowbray, 2020) All birds scored within the 0.5-4 range, which falls in the lower half of the fat score scale and is indicative of a typical wild population (Witter & Cuthill, 1993). There was a wide range in total lipid content across the birds. The average % total lipid content in order of greatest to least was seen in swamp sparrows, song sparrows, WTSP, and then Lincoln's sparrows (32.8±5.3, 29.2±2.1, 27.6%±1.4, and 22.6±7.3%, respectively), but the ranges and sample sizes varied greatly. For the fat pads themselves, the average %CF ranged from 79.7-96.4% across species, with individual values ranging from 39% to 100%.

Fat score was not related to body mass in WTSP but was related to all of the percent fat values. Body mass was not correlated with carcass fat or total fat and, interestingly, negatively correlated with fat pad percent fat. The correlations for song sparrows were similar except that in this species body mass was correlated with measures of body fat. Correlations were not done on the swamp and Lincoln's sparrows due to small sample size, but their values follow the pattern for WTSP, with fat score appearing to be associated with measures of fat but not necessarily with body mass.

Discussion
Overall, our results indicated that fat scoring is a valid method for predicting body condition of these four sparrow species. This is consistent with literature regarding other small passerines (Conway *et al*., 1994; Stevenson & Woods, 2006; Seewagen, 2008; Labocha & Hayes, 2012).

Low percent fat in fat pads was found in birds with low body condition scores (0.5 or 1). Fat pads contain non-fat material (vascular and connective tissue) and dissection may remove some surrounding tissue, which possibly represented a greater proportion of tissue with small fat pads compared to large pads which routinely had high percentage fat values.

The average lipid content of the carcass ranged from 20.9-31.6% across species. The lowest percentage was 6.2% in a song sparrow (fat score = 0.5) and the highest 48.8% in a WTSP (fat score = 4). Upon dissection, additional lipid stores were primarily seen lining the intestines, at the shoulder joint, and above the caudal vertebrae. It is important for researchers to understand that while the subcutaneous fat pads are the primary lipid reservoirs of birds, mesenteric fat can play an important part when these stores are depleted.

Conclusion

Fat scoring offers a quick method of accurately assessing body condition in small passerines like these sparrows but does not provide exact lipid content.

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