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Morphometric Characterization of the Grasshopper Sparrow (*Ammodramus savannarum*) and Baird's Sparrow (*Ammodramus bairdii*) during the Wintering Season

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Abstract

Grassland bird populations have declined more than any other group of bird species in North America. Some species such as the grasshopper (*Ammodramus savannarum*) and Baird's sparrows (*Ammodramus bairdii*) are of particular conservation concern, since they have shown negative trends in their population over the last 50 years. Their winter ecology has only begun to be studied recently and information is limited. The purpose of this study is to achieve the morphometric characterization of these two grassland species during the wintering season. The study is conducted in the Rancho Santa Teresa located in Villa Hidalgo, Durango, Mexico and the Ecological reserve "El Uno", located in Janos, Chihuahua, Mexico. During winter 2013-2014, 135 birds were captured; banded and zoometric measurements were taken such as total body weight, wing chord, tail length, culmen, and beak depth and width. Two indices of body condition (BCI) are also calculated. All measurements and indices are compared per species and per sex. Both species are sexed with molecular techniques, determining 20 females and 18 males for *A. bairdii* and 41 females and 56 males for *A. savannarum*. All variables are significant different between species ($p < 0.05$). Beak measurements are not signif-

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icantly different when comparing birds of different sexes (same species), with the exception of beak width of *A. bairdii* ($p < 0.05$). Male's weight, wing chord, tail length, as well as one of the body condition indices (BCI2) are significantly higher ($p < 0.05$) than females' for both species. BCI1 shows significant differences ($p < 0.05$) between species and sexes in *A. bairdii*. The biometric data obtained in this study can be used as reference values wintering populations of both species.

Keywords

Grasshopper Sparrow, Baird's Sparrow, Wintering, Morphometric, Body Condition Index

1. Introduction

Land use conversion and ecological drivers' alteration in North American grasslands [1] have generated a decrease in the populations of grassland birds, more evident than for any other group of birds [2]. Within this group of birds, Baird's (*Ammodramus bairdii*) and grasshopper sparrows (*Ammodramus savannarum*) were among the species with the strongest negative population trends (1966-2013), with −2.7% and −2.8% per year, respectively [2]-[4]. *Ammodramus bairdii* breeds in southern Canada and northern United States and winters in Arizona, New Mexico and Texas in the US, and Chihuahua, Sonora, Durango and Coahuila in Mexico [5], whereas *A. savannarum* has a wider range, breeding from southern Canada, largely from the United States and northern Mexico [6]. These two passerines bird species belong to the family Emberizidae (see complete taxonomy in **Table 1**). They are seed-eating birds with a distinctively shaped bill [7].

Baird's sparrow has a tail fairly short and spiky, crown flattish, bill flesh with dusky culmen, legs flesh. The face of this sparrow shows an ochraceous buff with black moustache and two dark corner marks on hind auriculars. In addition, it presents a crown streaked blackish and ochre with ochre median stripe; its nape is ochre to ochraceous-buff with streaked blackish. Upperparts cryptically pattern with blackish, chestnut-brown, and buff, typically with two buff braces. Brown wings edge buff to rufous-buff. The tail feathers are dark brown with paler edgings, outer rectricesare paler [7].

Grasshopper sparrow has also a tail fairly short and spiky, crown flattish. Adults have bill grayish flesh with dusky culmen, legs flesh. Their faces are plain buff with paler eyering, ochre wash in lores, also has acrown blackish brown with buff median stripe; its nape is streaked blue-grey and rufous. Upperparts cryptically pattern with blackish, chesnut, blue-grey, and buff. Wings and tail brown edges buff and pale brown, often with two buff wingbars, outer rectrices contrastingly paler. Their throat, chest, and flanks are buff, palest on throat, becoming whitish on belly [7].

Both species overwinter in the Chihuahuan desert grasslands [3] where it is known that there is a strong pressure on the ecosystem [8] that in addition to the selection process of wintering habitat can cause differences in the body condition of individuals, that will ultimately affect their survival [9]. The size and body mass are used to know the nutritional status and health of the birds, more recently changes in body condition of birds have been of interest in studies of evolutionary ecology, where the adaptation ability of birds to different environmental conditions is analyzed [10]. Unfortunately, in order to directly measure total body fat and protein, it is

Table 1. Taxonomy of baird's sparrow and Grasshopper sparrow.

Common name	Baird's sparrow	Grasshopper sparrow
Kingdom	Animalia	Animalia
Phylum	Chordata	Chordata
Class	Aves	Aves
Order	Passeriformes	Passeriformes
Family	Emberezidae	Emberezidae
Genus	*Ammodramus*	*Ammodramus*
Species	*Ammodramus bairdii* Audubon, 1844	*Ammodramus savannarum* Gmelin, 1789

necessary to collect individuals, which is not feasible when studying birds whose populations are threatened or endangered. Therefore, a number of models (indices) which allow estimating the condition of an individual from morphological measurements are commonly used. These indices allow evaluating the physical condition of birds, which is of great importance in the ecological sense, since it is related to the attributes of habitat and other environmental variables such as food availability, reproductive success, survival, parasitic load, etc. [11].

Morphological measurements are useful as well when it studied as adaptive traits associated to ecological and evolutionary parameters of populations. For instance, the study of the morphology of the wings is related to the ability to fly during migration and the selection of better overwintering or breeding sites [12] and to the capability to escape from predators [10]. Also, biometric differences between birds from allopatric populations are associated with environmental parameters or defined as subspecies [10]. Morphological measurements of birds can be helpful to determine the sex of some species of monomorphic birds, but values need to be validated [13].

Considering the above mentioned, the objective of this study was the morphometric characterization of two sparrow species of the genus *Ammodramus* during the wintering season by describing some morphological measurements and body condition indices in populations of two Grassland Priority Conservation Areas [3] in the Chihuahuan desert of Mexico.

2. Materials and Methods

2.1. Study Area

The study was conducted in two areas (**Figure 1**) during the winter season of 2013-2014 in two Grasslands Priority Conservation Areas (GPCAs) of the Chihuahua Desert; the first one in the Santa Teresa Ranch located in the northwestern state of Durango (26˚18'03"N, 105˚09'41"W) in the region of Cuchillas de la Zarca, vegetation consists of xeric scrub, and natural grasslands, where the shrub layer consisted of the genera: *Prosopis*, *Acacia*, *Juniperus* and *Quercus*, the herbaceous layer consisted of genera: *Bouteloa*, *Aristida* and *Hilaria* [14]. The altitude of the area is 1740 m asl. Climate is arid or dry with summer rains. The average annual temperature is 19.4˚C, with an average of 12.2˚C in January and an average of 25.9˚C in june. The annual rainfall is 472.4 mm [15].

The second study area is the ecological reserve "El Uno" located northwest of the municipality of Janos, Chihuahua, Mexico (30˚50'17"N, 108˚25'36"W) The vegetation consists of xeric scrub, and natural grasslands, where the shrub layer consisted of the genera: *Acacia*, *Prosopis*, *Ephedra*, *Opuntia* and *Mimosa*, the herbaceous

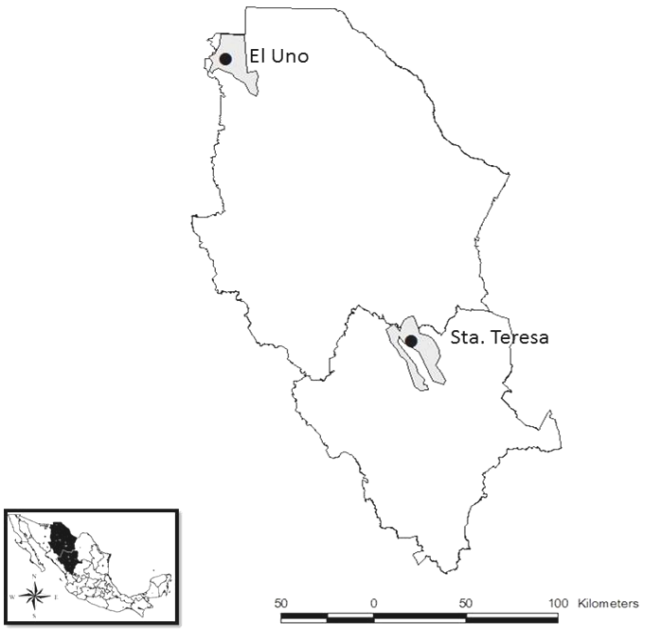

Figure 1. Study area location: Santa Teresa Ranch and the ecological reserve "El Uno".

layer consisted of genera: *Bouteloa*, *Aristida*, *Sporobolus* and *Hilaria* [16]. The altitude of the reserve is 1300 m asl. The climate is arid with hot summers and winter rains. The average annual temperature is 15.7˚C, with an average of 6.0˚C in January and an average of 26.1˚C in June. The annual rainfall is 381 mm [15].

2.2. Capture of Birds

The During the winter of 2013-2014, between 1 December 2013 and 15 March, 2014, 135 birds of the genus *Ammodramus* were captured in both study areas; 42 at the Santa Teresa ranch and 93 in the ecological reserve "El Uno". The capture of birds was done using 4 to 5 mist nets made of black polyester model KTX of Avian Research Supplies, AFO, 36 mm mesh, 2.6 m high by 12 m long and four bags, participating groups of 10 people and the method of herding birds into nets [17], with collection permission of SEMARNAT, SPGA/DGVS/13360/14.

2.3. Morphometric Data

Birds were banded using a metal ring #1 of United States Geological Survey (USGS). Morphological measurements, such as weight (g), wing chord (mm), tail length (mm), culmen (mm), beak width (mm) and depth of beak (mm) were taken, A metal ruler of 150 mm model WING15ECO of AVINET® was used to measure wing chord and tail length; a vernier caliper model SPI 150 mm of AVINET® was utilized for beak measurements; and a compact scale OHAUS® (Mod.CS2000, 2000 g capacity and 1 g readability) was used to determine the weight of birds. Once the data was registered, individuals were released in the same place of capture.

2.4. Sex Determination

A feather per individual (right fourth rectrix) was collected, which was stored in a paper envelope at room temperature; then feathers were sent to the Autonomous University of Nuevo Leon for analysis. Genomic DNA was obtained using the KIT "DNeasyTissue Kit" following the protocol of the commercial shop (Qiagen, Valencia, CA, USA). For molecular sexing primers 2250F/2718R [18] with the following sequences 2550F = 5'-GTT ACT GAT TCG TCT ACG AGA-3' and 2718R = 5'-ATT GAA ATG ATC CAG TGC TTG-3'.

2.5. Body Condition Indices (BCI)

From the total number of indices for calculating body condition two indices using variables collected during the sampling period were chosen. The first was calculated as BCI1 = weight (g)/wing length (mm) [10], and the second as BCI2 = ((weight (g)/Winglength^3 (mm)) * 10,000 [19].

2.6. Statistical Analyses

The data exhibited a normal distribution when tested with the Shapiro-Wilk test ($p > 0.05$), and homoscedasticity and an ANOVA was applied to the morphometric variables mentioned above and to the BCI calculated to determine whether there are significant differences between species and sexes. All statistical calculations were performed with SPSS version 14.0.

3. Results and Discussion

3.1. Morphometric Data

Results obtained of the measurement of morphometric traits of the genus *Ammodramus* sparrows, during this study are shown in **Table 2**.

It is observed that the variable weight was different for both species and approaches the values published by other authors, who report for *A. bairdii* values of 17.5 ± 1.34 g with a range of 15.0 - 20.3 g [20] [21] and for *A. savannarum* 17.0 ± 2.75 g for both sexes [6] [21] with data obtained from breeding areas.

These two species of sparrows are very similar morphologically [22], however the *A. bairdii* was higher in the wing length variables and it was consistent with the data published by [5], where for males *A. bairdii* is of 67 - 75 mm (n = 30) and 65 - 72 mm in females (n = 30). For *A. savannarum* there are fewer references, however, [21] obtained values of 62.0 ± 0.33 (SD) (n = 8) and 59.0 for females (n = 1).

Table 2. Mean (± standard error) morphometric values (mean) and body condition indices of females and males of two sparrow species of the genus *Ammodramus*, during the wintering season (2013-2014) in two GPCAs of the Mexican Chihuahuan desert.

Species	Weight (g)	Wing (mm)	Tail (mm)	Beak Culmen (mm)	Beak Width (mm)	Beak Depth (mm)	Body Condition Index 1	Body Condition Index 2
A. savannarum (n = 97)	16.93*a* ± 0.09	61.73*a* ± 0.23	45.85*a* ± 0.49	10.65*a* ± 0.09	7.78*a* ± 0.48	6.03*a* ± 0.03	0.27*a* ± 0.002	0.71*a* ± 0.005
A. bairdii (n = 38)	17.52*b* ± 0.15	68.48*b* ± 0.36	49.47*b* ± 0.79	8.86*b* ± 0.15	5.48*b* ± 0.77	5.52*b* ± 0.05	0.25*b* ± 0.001	0.54*b* ± 0.009
A. savannarum								
F (n = 41)	16.69*a* ± 0.12	60.87*a* ± 0.26	45.12*a* ± 0.34	10.63*a* ± 0.13	5.81*a* ± 0.87	6.04*a* ± 0.05	0.27*a* ± 0.002	0.73*a* ± 0.008
M (n = 56)	17.11*b* ± 0.10	62.35*b* ± 0.22	46.39*b* ± 0.29	10.67*a* ± 0.11	5.76*a* ± 0.75	6.03*a* ± 0.04	0.27*a* ± 0.001	0.70*b* ± 0.007
A. bairdii								
F (n = 20)	16.79*a* ± 0.18	67.0*a* ± 0.61	47.9*a* ± 1.81	8.64*a* ± 0.26	5.31*a* ± 0.10	5.42*a* ± 0.07	0.24*a* ± 0.002	0.55*a* ± 0.01
M (n = 18)	18.33*b* ± 0.19	70.88*b* ± 0.65	51.16*b* ± 1.91	9.10*a* ± 0.27	5.67*b* ± 0.10	5.63*a* ± 0.08	0.26*b* ± 0.002	0.52*b* ± 0.01

Values with different letter between species and between sexes are statistically different ($p < 0.05$); F: females; M: males (determined with molecular techniques).

The tail length (mm) is also a physical trait that distinguishes these two species, the references consulted [5] indicate that for *A. bairdii* is 49 - 57 (n = 20) in males and 45 - 54 (n = 20) in females. For *A. savannarum* the only reference of this variable is 44.14 ± 0.93 for males and 41.5 for females [6], values consistent with those reported in this study.

Wing chord and tail of the bird is subject to different types of selective pressure. Research on these traits mostly addresses the design of the wing, but certainly, the tail (which acts as a rudder) is also involved in the properties of the flight as speed and maneuverability [23].

In relation to the wing chord, juveniles generally have shorter and round wings when compared with adult individuals [24].The long and pointed wings allow increasing the speed of flight, while short round wings allow greater maneuverability flight [9]. These two aspects have consequences of ecological importance. To fly faster decreases the duration of the migratory journey, which means a reduction in energy cost [9]. It is also possible that birds anticipate their arrival in the resting and wintering sites, which represents an advantage over their congeners to occupy the best sites [11]. On the other hand, short and rounded wings facilitate escape from predators, due to the ability to perform evasive maneuvers during flight, thus reducing their mortality rate [9].

Sparrows of the *Ammodramus* genus like all birds rely on their beaks not only to obtain food, but also to fix and clean their feathers, build nests, courting hold demonstrations and defend against predators or rivals [23]. In the collected birds, the average length of the culmen (mm) for the species *A. bairdii* was slightly lower than that published by [20] who reported for males a value of 10.7 (range 10.4 - 10.9, n = 8) and for females 10.4 (range 10.2 - 10.7, n = 5). For the species *A. savannarum* reference data were not found. Beak traits were similar when comparing birds of different sex (same species), except that the width of the beak of *A. bairdii* males was higher in relation to the same trait in females.

3.2. Sex Determination

Both species under study have a monomorphic plumage and their sex cannot be determined by their color or other characteristics observable to the naked eye. It is precisely in these cases when the biometric characteristics can be used as a differentiating criterion of sex, this has been documented in shorebirds [25], raptors [26] and passerines [27].

In this study the comparison of the biometric traits of birds of the same species but of different sex, consis-

tently showed that the variables weight, wing chord, tail length, as well as the BCI2 of females collected were lower than the same traits of males (see **Table 2**). Thus, sexual dimorphism observed in these traits could be used to identify sex of birds.

Derived from the sexed analysis using molecular techniques for *A. savannarum* (n = 97), 41 females and 56 males were found. For species *A. bairdii* (n = 38) 20 females and 18 males were observed. This alternate method to determine the sex of birds is more secure than biometric calculations, however it has certain disadvantages, among which may be mentioned 1) the need for more time for analysis; 2) a higher cost since it requires specialized laboratory equipment and reagents; 3) it is an invasive technique that requires blood or feathers from live birds [9] [28].

3.3. Body Condition Indices (BCI)

The calculated BCIs allowed observing differences between species and between individuals of different sex. *A. bairdii* weight was higher in relation to the same trait in *A. savannarum*, however, the BCIs of *A. savannarum* were higher, manifesting that not necessarily those who had a greater weight obtained a higher BCI. This is precisely the purpose of a BCI which is to separate the aspects of body mass that are rather due to an aspect of the structural size from the aspects showing the amount of fat and other energy reserves. Fat, protein and calcium found in body reserves have a limiting potential in female reproduction, providing a lipid source for the synthesis of egg [29], it is also a source of energy during migration [30], food shortages [31] and also as an insulator [32].

4. Conclusion

There are significant differences in morphometric measures and body condition indices between the two species whose values are similar to those reported in studies done in breeding areas of birds. Therefore, the biometric features and the BCIs obtained in this study can be used as reference values in the winter season of birds of the genus *Ammodramus*, and may help to determine the sex of birds in a simple, fast and economic way. Taken together these data can be useful in studies related to ecology of both species.

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