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Physiological changes in the migratory redheaded bunting under natural conditions

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Abstract

Our study investigates the physiological changes in the migratory redheaded bunting, *Emberiza bruniceps* under natural conditions. The study was carried out on captive birds held under natural conditions to see their physiological changes in response to spring and autumn migration. Adult male redheaded buntings were captured from overwintering flocks in India and were acclimatized to captive conditions by keeping them in an outdoor aviary where they experienced natural variation of photoperiod, temperature and humidity. Observations on food intake, body mass and fat score were recorded twice in a year: during late March/early April (departure from India of buntings, spring migration) and late September/early October (arrival of buntings in India, autumn migration). Buntings showed deposition of fats during the spring migration (departure period from India). Deposition of fat was significantly high during spring migration as compared to their arrival period in autumn in India. The change in body mass and food intake was not significant.
Key words: Migration, fuel, physiology, metabolism, fat

Introduction

Migration in birds is an elegant example of relationship between organism and environment. Large numbers of birds migrate for a long distance every spring to avail the seasonally abundant resources that are otherwise unavailable in the year. Birds return to wintering grounds in autumn where resources are sufficient for their overwintering period and eventually, they prepare to migrate in the spring to the breeding grounds again. Through their distinct stages of an annual cycles migratory birds adjust their physiology and behavior (Jacobs and Wingfield, 2000; Ramenofsky and Wingfield, 2006; Piersma and Van Gils, 2011). Subtle distinctions could be found between spring and autumn migration. For many overland migrants the spring and autumn stages cover nearly the same routes and individuals may express similar preparations for departure (O'Reilly and Wingfield, 1995; Newton, 2008; Ramenofsky, 2011). Environmental conditions such as daylength and weather, orientation and navigation, speed of travel, reproductive state, intensity of fueling, available resources enroute, age and sex ratio of individuals of the flock can be different between the two spring and autumn migrations. Environmental cues and physiological processes influence the onset and progression of the spring and autumn migration.

Exposure to the long days of spring also influences migration during autumn. This happens with the development of photorefractoriness, when reproductive activity of bird is in halt through deactivation of the hypothalamic-pituitary-gonad axis and initiation of molt and autumn migration occurs (Moore et al., 1982; Nicholls et al., 1988; Dawson et al., 2001). Long photoperiods influence development of photorefractoriness. Patterns of change in the daylength vary with the change in season and latitude. The rate of change in daylength increases with northward movement for birds migrating to higher latitudes in the spring. At high latitudes, daylength increases slowly in autumn as compared to the increase in spring (King, 1963; Moore et al., 1982). Such seasonal distinctions may have contribution in various mechanisms of photoperiod affecting spring and autumn migrations. For instance, north-temperate, trans-equatorial migratory birds counter distinctive challenges as they overwinter in the southern hemisphere, when longer photoperiods start decreasing following the winter solstice. Such species seems to evolve different responses to photoperiod, avoiding a migratory disposition during winter. Study conducted by Hamner and Stocking (1970) on the bobolink (*Dolichonyx oryzivorus*) shows that this bird remains relatively refractory when it migrates to the south. At an appropriate migratory disposition, the bobolink regains it's photosensitivity during spring.

Endogenous rhythms are crucial for regulation of seasonal migration. Circadian or daily endogenous oscillators are involved in regulating day and night time activity in a number of seasonal migrants (Gwinner, 1996; Bartell and Gwinner, 2005; Rani et al., 2006; Coppack et al., 2008). Daylength acts as a Zeitgeber (or time giver) for endogenous circannual rhythm in the migratory birds (Gwinner, 1986; 1996). The dark-eyed junco (*Junco hyemalis*), a north temperate migrant, kept in continuous dim light shows recurring cycles of zugunruhe, molt and gonadal growth (Holberton and Able, 1992). Photoperiod is the initial predictive factor which regulates the onset of spring and autumn migration by entraining or synchronizing the endogenous rhythm.

There are differences in environmental conditions such as temperature and rainfall between autumn and spring migrations. The responses of migratory birds also vary with the change in environmental cues. Temperature can alter physiology and behavior of migratory birds. Temperature influences pre basic molt and breeding indirectly affecting timing of autumn migration. Warm temperatures induce early departure from wintering grounds in free-living birds (Lack, 1960) or early onset of zugunruhe in captive birds (King and Farner, 1963) in spring. Mass gain and deposition of fat in female white crowned sparrows are influenced by temperature with the help of photostimulation (Wingfield et al., 1996). Migratory movements of birds in spring are more rapid and synchronized than in autumn (Cherry, 1982; Morton and Pereyra, 1987). Therefore, spring migration is more rapid and driven than autumn migration. Migratory functions viz. rate of body fattening, departure from stopover sites and wintering or breeding grounds, termination of migration are most affected by local environmental conditions in autumn than in spring (Jenni and Schaub, 2003). Male dominance over females in the winter is not universal in migratory songbirds (Chaine et al., 2011), but winter dominance in male dark-eyed juncos may be selectively advantageous if wintering further north allows for earlier establishment of breeding territories (Ketterson and Nolan, 1982).

Several studies have been done on free-living migratory birds to see their physiological changes. So, it will be interesting to study captive birds held under natural conditions to see their physiological changes in response to spring and autumn migration.

Materials and methods

Model species

The present work was carried out on male redheaded bunting, *Emberiza bruniceps,* a small migratory passerine bird in the family Emberizidae. It has a slender and small body size of about 17-18 cm in length. This bird exhibits sexual dimorphism. The breeding male has bright yellow underparts, green upperparts and a brownish-red face and breast. The wings and tail are dark brown in colour and tail coverts are brown. It has a conical bill and a forked tail. The female and juvenile have paler underparts, a grey-brown back and greyish head. This avian species is a long-distance migrant with distinct breeding and wintering grounds. It breeds in central Asia- Afghanistan, Iran, Kazakhstan, Kyrgyzstan, Mongolia; Russian Federation (European Russia, Central Asian Russia), Tajikistan, Turkmenistan, Uzbekistan. This bird winters in India and Bangladesh. It covers a distance of about 7,000 km during the migratory journey. The redheaded buntings arrive in India in September/October, overwinter here and return to the breeding ground in March/April.

Adult male redheaded buntings were captured from overwintering flocks in India and were acclimatized to captive conditions by keeping them in an outdoor aviary where they experienced natural variation of photoperiod, temperature and humidity. Observations on food intake, body mass and fat score were recorded twice in a year: during late March/early April (departure from India of buntings, spring migration) and late September/early October (arrival of buntings in India, autumn migration).

Food (seeds of kakuni, *Setaria italica*) and water were available and replenished once daily during daytime. Supplementary food prepared by mixing bread crumbs, boiled eggs, cheese and vimeral (marketed by Virbac Animal Health India Pvt. Ltd, Mumbai) were also given to the birds twice a week. Once every month, birds received vitamins (Vimeral, GlaxoSmithkline Pharmaceutical Limited, Mumbai, India) and antibiotics (Tetracycline hydrochloride, Hoechst Roussel Vet. Ltd.). Birds maintained good health under captivity.

Body mass

Birds were individually weighed on a top pan digital balance to the nearest accuracy of 1.1 g. For this, the bird was placed in a cotton bag, the weight of which was tared to zero. Then the bird with the cotton bag was weighed.

Fat score

Fat deposition was scored from the furcular, scapular, and abdominal areas in an index of 0-5 as described by Boswell, 1991 and outlined below:

0- No subcutaneous fat
1- Light deposits underlying musculature and vasculature easily seen
2- Heavier deposits, underlying musculature and vasculature still visible
3- Fat deposits overlie entire region
4- Area filled with whitish, bulging fat deposits
5- Copious deposits overflowing onto outlying areas

Food intake

Fixed amounts of food in the food cups were provided to birds housed in activity cages. The difference between the initial and final weight of food gave the amount of food consumed by a bird. The food intake was measured according to the method described by Jain and Kumar (1995).

Statistical analysis

All data are presented as mean ± S.E.M. Student's t-test was used while comparing only two means. All statistical analyses were done using GraphPad Prism software (version 6.0, Sandiego, CA, USA). The significant was taken at the 95% confident level.

Results

The results are presented in the figure 1 (a-c). Student's t-test showed no significant differences in body mass of birds (P=0.8652). Buntings showed deposition of fats during the departure period from India. Deposition of fat was significantly high during departure as compared to arrival period in India (P=0.0256). Change in food intake during departure period was not significant as compared to arrival period (P=0.051).

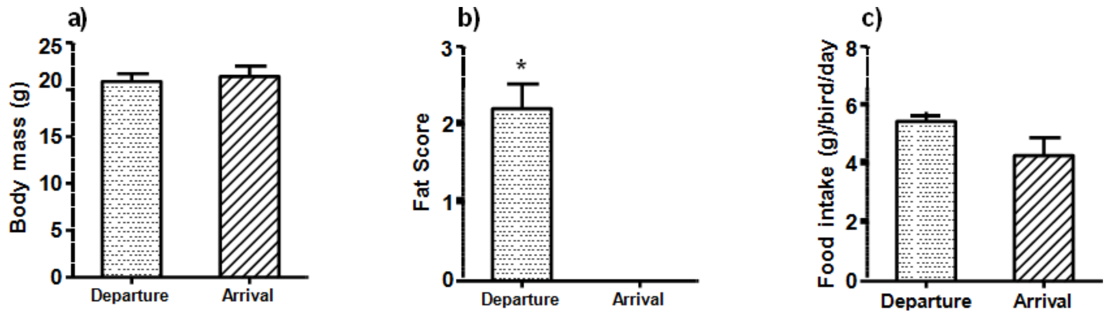

Fig. 1: (a) Body mass, (b) fat score and (c) food intake during arrival and departure period in India of the redheaded buntings under natural conditions. *P<0.05

Discussion

Buntings showed deposition of fats during the spring migration (departure period from India). Deposition of fat was significantly high during spring migration as compared to their arrival period in autumn in India. Birds migrate to the breeding ground in spring and in autumn they return to the wintering grounds where resources are accessible. Body fat stores increase in migratory birds before long-distance flight. This is an important metabolic feature to support the migratory flight (Dixit and Sougrakpam, 2013; Dixit et al., 2014). These body stores comprise mainly lipids and proteins (Lindstorm and Piersma, 1993; Piersma et al. 1999). A major amount of fat is stored in sub-cutaneous adipose tissue (Berthold, 1993; Maillet and Weber, 2006). Fat is also stored in flight muscles (pectoralis) and liver (Maillet and Weber, 2006; Guglielmo, 2018). These stored fatty acids are transported and oxidized at very high rates in the migratory birds to sustain flights for many hours or days. Through their distinct stages of an annual cycles migratory birds adjust their physiology and behavior (Jacobs and Wingfield, 2000; Piersma and Van Gils, 2011; Ramenofsky and Wingfield, 2006). The plasma glucose concentrations are higher in birds than other vertebrates of similar body mass. But birds store very small amount of glucose as glycogen. Birds utilize glucose mainly for energy production. Birds derive energy from lipids stored in the form of triglycerides in adipose tissue to support the migratory flight (Ramenofsky, 1990) and it occurs with the mobilization of lipids. Migratory songbirds may supplement fatty acids with triglycerides in plasma to provide more energy to muscles (Jenni-Eiermann and Jenni, 1992). Plasma triglycerides in migratory birds also increase during pre-migratory fattening and refueling at stopover sites (JenniEiermann and Jenni, 1996; Guglieilmo et al., 2002). In conclusion, catabolism of stored fat and body protein produces triglycerides and uric acid respectively. Triglycerides and uric acid act as important plasma metabolites for redheaded buntings. Deviations of these metabolites help this migratory bird to adapt with the necessary physiological changes during its migratory journey.

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