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Circadian and metabolic changes associated with seasonal physiological states in a night-migratory songbird, the blackheaded bunting (Emberiza melanoccephala)

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Migratory birds exhibit behavioural shifts in their daily activity patterns with predominant night activity during migration (whereas they are diurnal otherwise). However, the concomitant molecular and metabolic adaptations are unknown. Here we experimentally simulated four seasonal physiological states in the Palaearctic-Indian migratory blackheaded buntings and monitored their behaviour, physiology and diurnal gene expression patterns. Birds were exposed to short days (group 1; SD, 8L:16D; photosensitive simulating pre-spring migration state, “Pse”) or long days (groups 2-4; LD, 16L:8D) for different durations. Group 2 received only 7 days of LD (photostimulated, non-migratory phenotype, “Pstnm”), group 3 were in LD for about 3 weeks until when they had exhibited seven cycles of Zugunruhe (photostimulated migratory nighttime activity phenotype, “Pstnm”) and group 4 birds were kept on LD until they ceased to express Zugunruhe (photorefractory, “Pref”). There were remarkable changes in the activity, food intake, surface temperature, body fattening, testicular size, blood triglyceride and insulin levels among different physiological states. A significant increase in the hepatosomatic index in Pstnm birds suggested that LD induced fat deposition. However, plasma leptin levels did not significantly vary among the groups. Measurement of RNA levels of circadian clock and metabolic genes in the central (hypothalamus, pineal and retina) and peripheral (liver, muscle, fat and testes) tissues at six times of the day revealed a significant daily oscillation for most genes, except Clock. The gene expression patterns differed between SD and LD, but not between different photostimulated seasonal phenotypes, suggesting that metabolic adaptation to different LD states occur downstream of the core circadian oscillator. This is the first comprehensive study of daily changes in the clock and metabolic parameters underlying seasonal physiology in a migratory vertebrate species.