In-flight physiology and energy expenditure of northern bald ibises (*Geronticus eremita*) during human-led migration

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One of the “unknowns” in the understanding bird migration is how long-distance migrants perform flights of over 100-hour durations. Moreover, these birds complete each migratory journey with repeated flight bouts to allow for intermittent refueling in stopover areas. They must then alternate between physiological stages of flight and refueling. The physiology of birds in these stages is unique; migratory flight is characterized by prolonged bouts of energy expenditure at up to seven times basal metabolic rate, while refueling is characterized by unusually rapid energy deposition. Solutions to the physiological challenges associated with alternating between intensive exercise without feeding, and intensive feeding associated with refueling at stopover sites are difficult because the underlying physiological processes are incompatible. The control mechanisms used to change physiological states throughout migration probably reflect a combination of reactions to exogenous factors with underlying endogenous control mechanisms. Determining how birds overcome these physiological challenges and combine exogenous and endogenous mechanisms is one of the most demanding topics of bird migration research. Previous studies have either used birds flying freely in wind tunnels, or investigated the physiological state in migrants just after landing with unknown previous flight histories. For this study we took advantage of a human-led migration project with northern bald ibis. Because these birds are tame, with foster parents, we were able to bleed them immediately prior to and after flights that were experimentally set as short or long. In addition we bleed birds one day after to document recovery. Blood chemistry was documented and we used the doubly-labeled-water technique to assess in-flight energy expenditure and that during subsequent stopover.