ESTIMATING NATAL ORIGINS OF MIGRATORY JUVENILE GOLDEN EAGLES USING STABLE HYDROGEN ISOTOPES

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The difficulty in determining the geographic origins of migratory birds and identifying their source populations has limited the understanding of the ecology of many North American species (Viverette et al. 1996, Meehan et al. 2001, Hobson et al. 2009). In North America, Golden Eagles (Aquila chrysaetos) are widespread; they breed predominately in the West from northern Alaska to central Mexico, and occupy a wide range of habitats from arctic tundra to deserts (Kochert et al. 2002). Most raptors, including Golden Eagles, typically occur in low breeding densities, have large home ranges, and nest in remote areas, making it difficult to assess populations using traditional methods such as Breeding Bird Surveys and Christmas Bird Counts (Fuller and Mosher 1981, Titus and Fuller 1990, Rosenfield et al. 1991, Meehan et al. 2001). Consequently, annual migration counts along ridges during fall migration are the traditional means of monitoring migratory Golden Eagle populations. Analysis of long-term migration count data suggests a downward trend in observed numbers for this species. This has raised concern about the status of migratory Golden Eagles in western North America (Kochert and Steenhof 2002, Hoffman and Smith 2005, Smith et al. 2008, Pagel et al. 2010). However, one of the biggest obstacles in accurately interpreting raptor migration counts in relation to population status is determining origins and destinations of migrants, and this poses difficulties when addressing conservation issues and developing management strategies (Kochert and Steenhof 2002, Hoffman and Smith 2005).

Stable hydrogen isotope analysis utilizing the weighed growing season average precipitation ($\delta^2$H$_p$) can help reveal natal origins of hatch-year (hereafter referred to as juvenile) Golden Eagles captured at annual migration count sites or on wintering grounds. In addition, it can be used to estimate the natal origins of eagles found as mortalities (e.g., on wind farms) and determine whether those individuals were from northern migratory or non-migratory populations. The analysis utilizes predictable continent-wide distributions of deuterium abundance occurring in rainfall. These geographically specific ratios of deuterium are then transferred from precipitation through the food chain to upper trophic level consumers such as birds and mammals (Hobson and Wassenaar 1997, 1999; Hobson 2005; Wassenaar 2008). A number of studies have used stable hydrogen isotope ratios to estimate the breeding latitudes of Neotropical migratory songbirds (e.g., Kelly et al. 2002, Rubenstein et al. 2002, Wassenaar and Hobson 2000a), and more recently an increasing number of raptor species (Meehan et al. 2001, Lott et al. 2003, Meehan et al. 2003, Smith et al. 2003, DeLong et al. 2005, Smith and Duffy 2005, Hobson et al. 2009, Ruyck et al. 2013, Wittenberg et al. 2013). Although relatively new, stable hydrogen isotope analysis has proven to be successful and revolutionized our understanding of trends in Golden Eagle numbers at migration count sites may be the result of factors on breeding or wintering grounds, or both, across western North America (Kochert and Steenhof 2002, Hoffman and Smith 2005, Smith et al. 2008, Pagel et al. 2010). However, one of the biggest obstacles in accurately interpreting raptor migration counts in relation to population status is determining origins and destinations of migrants, and this poses difficulties when addressing conservation issues and developing management strategies (Kochert and Steenhof 2002, Hoffman and Smith 2005).

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