Notes

Interannual Consistency of Gross Energy in Red Oak Acorns

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Abstract

Red oak *Quercus* spp., Subgenus *Erythrobalanus* acorns are forage for mallards *Anas platyrhyncos*, wood ducks *Aix sponsa*, and other wildlife that use bottomland hardwood forests in the southeastern United States. However, annual variation in true metabolizable energy from acorns would affect carrying-capacity estimates of bottomland hardwood forests for wintering ducks. Because gross energy and true metabolizable energy are strongly positively correlated and gross energy is easier to measure than true metabolizable energy, we used gross energy as a surrogate for true metabolizable energy. We measured gross energy of six species of red oak acorns in autumns 2008 and 2009. Within species, mean gross energy of these acorns varied less than 2% between years. The small interannual variation in gross energy of red oak acorns found in this study would have negligible effect on estimates of carrying capacity of bottomland hardwood forests for wintering ducks and other wildlife.

Keywords: acorns; carrying capacity; mallard; true metabolizable energy; Mississippi Alluvial Valley; red oak; wood duck

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Introduction

Bottomland hardwood forests in the Mississippi Alluvial Valley and elsewhere in the southeastern United States support several species of red oak *Quercus* spp., Subgenus *Erythrobalanus* (Fredrickson 2005). Common red oak species in bottomland hardwood forests include cherrybark *Quercus pagoda*, Nuttall *Quercus texana*, pin *Quercus palustris*, Shumard *Quercus shumardii*, water *Quercus nigra*, and willow *Quercus phellos* (Reinecke et al. 1989; Fredrickson 2005; Schummer et al. 2012). Acorns from these oaks are energy-rich foods for mallards *Anas platyrhyncos*, wood ducks *Aix sponsa*, and other wildlife (Reinecke et al. 1989; Dabbert and Martin 2000; Kaminski et al. 2003; Heitmeyer 2006). Kaminski et al. (2003) reported that mallards and wood ducks derived on average 2.67 kcal/g dry mass of true metabolizable energy (TME) from sound red oak acorns (i.e., having intact pericarp, without caps, and sinking in water; Allen et al. 2001). In comparison, mallards obtained 2.65–3.67 kcal/g from agricultural seeds and 1.08–3.10 kcal/g from moist-soil seeds (Kaminski et al. 2003).

Estimates of TME from acorns and other foods of waterfowl are used in calculating duck-energy days for planning and implementing habitat conservation (Reinecke et al. 1989; Kaminski et al. 2003; Miller and Eadie 2006). Currently, biologists and conservation planners are refining calculation of duck-energy days to include within- and among-year variation in food abundance, associated TME from foods, and other stochastic variables (e.g., frequency of winter inundation of foraging habitats; J. Tirpak, Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative, personal communication). Therefore, studies that estimate temporal fluctuations in TME potentially available to ducks from foods are necessary to accurately estimate carrying capacity of foraging habitats in the Mississippi Alluvial Valley and other regions that migrating and wintering ducks use.

Because gross energy (GE) and TME are strongly positively correlated and GE is easy to measure compared to TME, GE can serve as a surrogate for TME (Kaminski et al. 2003). Leach et al. (2012) determined that GE reductions in three species of red oak acorns was less than 0.6% after 90 days of ambient exposure in either flooded or nonflooded bottomlands hardwood forests during winter. They concluded these changes in GE of red oak acorns would have minimal effect on estimates of TME of acorns and carrying capacity of bottomlands hardwood forests for ducks within winters. Therefore, current TME values for these acorns would not require adjustment for winter decomposition. However, Kaminski et al. (2003) questioned whether TME from acorns may vary among years; if so, TME values of acorns may require adjustment for interannual variation. Accordingly, our objectives were to 1) estimate change in GE of sound red oak acorns between years and 2) infer effects of any interannual differences in GE on carrying capacity estimates of bottomland hardwood forests as foraging habitat for wintering ducks.

Methods

During autumns 2008 and 2009, we collected 10 sound acorns from the ground beneath and the limbs of each of 10 cherrybark, Nuttall, pin, Shumard, water, and willow oak trees on the campus of Mississippi State University, Noxubee National Wildlife Refuge (Mississippi), Delta National Forest (Mississippi), and in Starkville and Stoneville, Mississippi. We placed acorns from each tree in labeled plastic bags and submitted samples (n = 100 acorns/species/year; Table S1) to the Department of Animal and Dairy Sciences, Mississippi State University, for GE analyses (Kaminski et al. 2003; Leach et al. 2012). Laboratory staff processed samples by 1) drying acorns at 64°C until constant mass was achieved; 2) mincing dried acorns (i.e., the sample of 10 sound acorns from an individual red oak), including pericarps (but not caps), into a homogenous mixture; and 3) determining GE of samples using a Parr adiabatic oxygen bomb calorimeter (Kaminski et al. 2003; Dugger et al. 2007; Leach et al. 2012). We did not remove acorn pericarps prior to GE assays because ducks ingest acorns whole.

We used arithmetic sample means and 95% confidence intervals to examine the effect of year on GE in red oak acorns (PROC MEANS; SAS Institute Inc. 2012; Gardner and Altman 1986; Johnson 1999; Anderson et al. 2001; Johnson 2002). We also calculated a coefficient of variation (CV [%] = [SE/$\bar{x}$] • 100) for each yearly estimate of mean GE for each species of red oak acorns to evaluate relative precision of means. We made inferences about potential differences in group means based on effect sizes, precision of estimates (i.e., coefficient of variation), and overlap of 95% confidence intervals (Johnson 1999; Nakagawa and Cuthill 2007). If 95% confidence intervals of means overlapped, we concluded mean GE of red oak acorns was similar between years (Di Stefano 2004).

Results

Yearly species-specific GE values of red oak acorns were precise (i.e., CVs ranged from 0.2% [water oak, 2008] to 1.0% [Nuttall oak, 2009]). Within species, variation in annual means was small, with Nuttall oak acorns exhibiting the greatest variation in GE between years (ΔGE = 0.09 kcal/g dry mass; Table 1). However, despite slight variation in means, we conclude that mean GE of red oak acorns was similar between years because all 95% confidence intervals overlapped (Table 1).

Discussion

Given only slight variation in mean GE of red oak acorns between years and overlap of all 95% confidence intervals for our estimates, we conclude that TME that ducks derive from these acorns would also be similar. However, we only collected acorns from red oak trees at sites in Mississippi over two autumns; therefore, our results may not be representative of acorns produced by bottomland red oaks across the Mississippi Alluvial Valley and other regions over longer periods. Further, we recommend researchers investigate factors (e.g., site productivity, weather, and hydrology) that could result in spatio-temporal variation in GE and TME of acorns.

Based upon the results of this study, the Lower Mississippi Valley Joint Venture (http://www.lmvjv.org/; Joint Ventures are partnerships established under the North American Waterfowl Management Plan to help conserve the continent's waterfowl populations and habitats) and other habitat conservation partners need not adjust bioenergetic models to compensate for interannual variation in TME of red oak acorns, assuming correlations between GE and TME values of acorns are robust (Kaminski et al. 2003). However, among-year

Table 1. Mean ($\bar{x}$; 95% confidence interval [CI]) gross energy (kcal/g dry mass) of 10 sound acorns (i.e., having intact pericarp, without caps, and sinking in water; Allen et al. 2001) from six red oak species (*Quercus* spp. Subgenus *Erythrobalanus*; $n = 100$ acorns/species/year) collected in Mississippi, autumns 2008 and 2009.

		2008		2009	
Common name	**Scientific name**	$\bar{x}$	**95% CI**	$\bar{x}$	**95% CI**
Cherrybark oak	*Q. pagoda*	5.39	5.31–5.47	5.38	5.30–5.46
Nuttall oak	*Q. texana*	4.89	4.83–4.95	4.80	4.68–4.92
Pin oak	*Q. palustris*	5.07	5.02–5.13	5.14	5.07–5.20
Shumard oak	*Q. shumardii*	4.90	4.83–4.98	4.85	4.77–4.92
Water oak	*Q. nigra*	5.30	5.26–5.33	5.30	5.23–5.38
Willow oak	*Q. phellos*	5.34	5.28–5.39	5.33	5.22–5.43

variation in yield of acorns by red oak trees in the Mississippi Alluvial Valley does have significant implications for annual forage availability in and carrying capacity of bottomland hardwood forests for wintering ducks and other wildlife (Straub 2012).

Supplemental Material

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Table S1. Mean gross energy of *Quercus* spp. acorns ($n = 10$ acorns/tree) collected from individual red oak trees in 2008 and 2009.

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Reference S1. Straub JN. 2012. Estimating and modeling red oak acorn yield and abundance in the Mississippi Alluvial Valley. Dissertation, Mississippi State University, Mississippi State, Mississippi.

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