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True Metabolizable Energy of Two Southern Aquatic Plants

Final Report

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Introduction

Extensive research and monitoring has provided accurate data on migration chronologies, population sizes, daily energetic needs, and food densities for use in waterfowl bioenergetics models used for conservation planning under the North American Waterfowl Management Plan. However, energetic values for shallow- and deep-water marsh habitats (hereafter, semi-permanent marsh) important to ducks are based on very limited data (Soulliere et al. 2017). Even slight inaccuracies in model parameters could drastically affect conservation objectives produced by bioenergetic models, predictions of habitat quality and quantity relative to climate change, future anthropogenic alterations of larger river systems or marshes, management practices (e.g., river or lake connectivity with marshes), or restoration and enhancement goals of federal and state agencies (Soulliere et al. 2017, Hagy et al. 2014, 2015). Before carrying capacity models can be used as the basis for habitat and climate change predictions or other modeling exercises, better input parameters are needed for semi-permanent marsh habitats.

In order to improve the accuracy of energetic models used to set habitat objectives, estimates of energy availability and metabolizability for a variety of aquatic plants are needed. While true metabolizable energy (TME) values are available for many species of moist-soil seeds, hard mast, agricultural grains, and invertebrates, few TME values exist in the published literature for submersed aquatic vegetation (SAV), despite SAV being a significant food item of many dabbling and diving duck species. Moreover, neither of the two plant species previous analyzed (i.e., shoalgrass [*Halodule wrightii*], Ballard et al. 2004; widgeon grass [*Ruppia maritime*], Coluccy et al. 2015) have values near means of other natural foods (Kaminski et al. 2003). Thus, there may exist significant energetic tradeoffs in managing wetland for SAV as opposed to moist-soil or agricultural crops. Moreover, TME values for both native and non-native species such as wild celery (*Vallisneria americana*) and hydrilla (*Hydrilla verticillata*) have not been previously published and are needed to assess the value for ducks and the

energetic tradeoffs of their control. Orth et al. (2017) suggested that scientists critically evaluate the ecosystem services provided by invasive vs native species before undertaking substantial efforts to manage an invasive. Therefore, we developed the following objectives aimed at estimating the TME of hydrilla for two waterfowl species and providing a comparison native vegetation for ring-necked ducks (*Aythya collaris*).

Objectives

1) Estimate true metabolizable energy of hydrilla shoots and tubers for mallards (*Anas platyrhynchos*), and
2) Estimate true metabolizable energy of hydrilla and wild celery shoots for ring-necked ducks.

Methods

We conducted feeding trials from mid-January to early March 2016–2018 at the Forbes Biological Station located near Havana, Illinois and Winous Point Marsh Conservancy near Port Clinton, Ohio. We captured wild mallards in August 2015 and ring-necked ducks during March 2016–2018. Both species were maintained in outdoor aviaries at ambient temperatures with flowing water and access to commercial poultry ration, an assortment of SAV, and grit *ad libitum* before and following trials. We housed ducks indoors during TME trials where photoperiod tracked natural diel cycles but temperature was controlled between 5-15 °C.

We conducted TME assays using standard methods (Checkett et al. 2002, Ballard et al. 2004, Dugger et al. 2007, McClain 2017). Briefly, we fasted birds for 48 hrs prior to feeding trials with no access to food or grit, but access to water *ad libitum*. After 48 hours, we used a modified precision feeding technique to feed an amount of vegetation equivalent to approximately 1% each individual's body mass (Sibbald 1986). An aliquot of vegetation was gently pushed into each bird's esophagus using a gloved finger. A typical feeding consisted of 3–

10 replications of this process and took approximately 5 minutes. Following feeding, we collected excreta for 48 hrs.

Vegetation used in feeding trials was cultured or collected from wetlands in Florida, overnight shipped, and was used in TME assay within 2 weeks of collection. We conducted 5 TME assays; 1) cultured hydrilla shoots fed to mallards, 2) natural hydrilla shoots fed to mallards, 3) hydrilla tubers fed to mallards, 4) cultured hydrilla shoots fed to ring-necked ducks, and 5) wild celery shoots fed to ring-necked ducks. All vegetation was inspected and rinsed to remove invertebrates, seeds, and epiphytic algae prior to being used in the feeding trials. We allowed ≥10 days to elapse between trials to allow birds to recover any lost weight. We determined endogenous urinary losses using the self-control method advocated by Sherfy et al. (2005) to reduce variation in TME values and decrease the total number of individual birds needed. However, when a self-control value was unavailable, we used a group-control value calculated across all individuals of the same duck species within the same year. Sherfy et al. (2005) found no difference in TME estimates among control methods, so incorporating a group control should not impact TME results.

Following excreta collection, feathers and grit were removed and excreta was oven-dried to remove water, scraped from drying pans, ground with mortar and pestle, and weighed to the nearest 0.1 mg (Checkett et al. 2002). We dried 1-g subsamples of excreta at 80°C to determine percent moisture content and used a Parr compensated jacket bomb calorimeter to determine gross energy. We repeated the drying and gross energy estimation process for each vegetation type. We employed the Animal Sciences Lab at the University of Illinois to calculate percent nitrogen of vegetation and excreta samples, and we corrected TME estimates to nitrogen balance to avoid overestimating energy derived from non-food origin (Sibbald and Morse 1982). The Animal Sciences Lab also calculated proximate analysis of all vegetation using standard methods. We evaluated models of TME using second order Akaike's Information Criterion

(AICc) tested for fixed effects of vegetation type, duck species, sex, and pre-trial mass on TME using a general linear model with individual bird as a random effect and present raw TME values and associated standard error.

Results

We conducted 65 TME assays from January 2016–2018. We excluded data from 10 assays in which fed vegetation was regurgitated or when TME estimates exceeded gross energy (i.e., >100% digestive efficiency). In the remaining 55 assays, we estimated TME_N of three forms of hydrilla fed to mallards: 1) natural hydrilla shoots ($\bar{x}$ = 0.21 kcal/g[dry], SE = 0.53, n = 10 [6 male, 4 female]), 2) cultured hydrilla shoots ($\bar{x}$ = 1.66 kcal/g[dry], SE = 0.20, n = 12 [6 male, 6 female]), and 3) cultured hydrilla tubers ($\bar{x}$ = 2.75 kcal/g[dry], SE = 0.05, n = 10 [5 male, 5 female]); TME_N of hydrilla shoots fed to ring-necked ducks ($\bar{x}$ = 2.14 kcal/g[dry], SE = 0.43, n = 9 [6 male, 3 female]); and TME_N of wild celery shoots fed to ring-necked ducks ($\bar{x}$ = 0.81 kcal/g[dry], SE = 0.49, n = 14 [9 male, 5 female]; Table 1). The best supported model estimating TME contained vegetation species (w_i = 0.28; Table 3). There was little support for a difference in the TME of cultured hydrilla shoots (wi = 0.08) between duck species and the combined cultured hydrilla shoots estimate was 1.93 kcal/g[dry] (SE = 0.20, n = 18).

Discussion

Except for hydrilla tubers, TME estimates for hydrilla fed to mallards and hydrilla and wild celery fed to ring-necked ducks were lower than values reported for most seeds and below the average seed value reported by McClain (2017; 1.78 kcal/g, range -0.18 – 3.10). However, our estimated TME of hydrilla tubers for mallards is the greatest TME value currently reported for a SAV species, and the usable energy rivals that of the most seeds. In total, the range of TME estimates for hydrilla and wild celery shoots is comparable to those for invertebrates and previously reported species of SAV (Ballard et al. 2004, Coluccy et al. 2015, McClain 2017). Interestingly, natural hydrilla shoots collected from wetlands in Florida were less digestible to

mallards than those that were cultured. Although we rinsed and inspected each type of hydrilla shoot, the natural shoots still contained foreign material that was not able to be rinsed without damaging vegetation integrity. This remaining material may have increased the passage rate of the vegetation through the alimentary canal or may have contained higher amounts of undigestible fiber than cultured hydrilla. Moreover, plant maturity, fertilization rates, or nitrate concentrations may play in a key role in the digestibility of vegetation samples.

We found the coefficient of variation (CV) to be low for hydrilla tubers (5.7%) and cultured hydrilla (41.4%) fed to mallards and ring-necked ducks (60.3%) compared to natural hydrilla fed to mallards (797.4%) and wild celery fed to ring-necked ducks (228.0%) and other SAV and duck species combinations (J. D. Lancaster, personal observation). Large CVs may be a result of variation in vegetation foliage among fed individuals which may have contained different proportions of stem vs. leaf material which likely vary in their digestibility. Moreover, the digestibility of vegetation varies throughout the growing season and with plant maturity, and cultured hydrilla may have contained less non-digestible fiber. Non-vegetative parts of plants, such as seeds and tubers, have a more consistent nutritional content, resulting in a smaller standard deviation for hydrilla tubers as well as for seeds found in the literature (Checkett et al. 2002, Coluccy et al. 2015, McClain 2017).

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Table 1. Gross energy (GE, kcal/g) and true metabolizable energy (TME_N, kcal/g) for hydrilla (*Hydrilla verticillata*) and wild celery (*Vallisneria americana*) fed to wild-caught mallards (*Anas platyrhynchos*; MALL) and ring-necked ducks (*Aythya collaris*; RNDU) at Forbes Biological Station, Havana, IL and Winous Point Marsh Conservancy, Port Clinton, OH 2016–2018.

Vegetation Species	Type/Common Name[a]	Duck Species	*n*	GE	TME_N	SE
Hydrilla verticillata	Natural Hydrilla Shoots	MALL	10	3.26	0.21	0.53
Hydrilla verticillata	Cultured Hydrilla Shoots	MALL	12	3.21	1.66	0.20
Hydrilla verticillata	Cultured Hydrilla Tubers	MALL	10	3.62	2.75	0.05
Hydrilla verticillata	Cultured Hydrilla Shoots	RNDU	9	3.24	2.14	0.43
Vallisneria americana	Wild Celery Shoots	RNDU	14	3.24	0.81	0.49

[a] Natural hydrilla shoots were collected from wetlands whereas cultured hydrilla shoots were tank grown. We rinsed and removed epiphytes from all vegetation prior to analyses.

Table 2. Proximate analysis results consisting of percent dry matter (DM), organic matter (OM), nitrogen (N), crude protein (CP), Soxhlet fat (SF), neutral detergent fiber (NDF), and acid detergent fiber (ADF) for (*Hydrilla verticillata*) and wild celery (*Vallisneria americana*) fed to wild-caught mallards (*Anas platyrhynchos*; MALL) and ring-necked ducks (*Aythya collaris*; RNDU) at Forbes Biological Station, Havana, IL and Winous Point Marsh Conservancy, Port Clinton, OH 2016–2018.

Type/Common Name	Duck Species	% DM	% OM	% N	% CP	% SF	% NDF[a]	% ADF[a]
Natural Hydrilla Shoots	MALL	88.77	–	4.06	25.35	–	–	–
Cultured Hydrilla Shoots	MALL	92.01	–	2.50	15.60	–	–	–
Cultured Hydrilla Tubers	MALL	85.69	–	0.96	6.03	–	–	–
Cultured Hydrilla Shoots	RNDU	91.03	83.69	2.09	13.06	5.04	44.88	28.39
Wild Celery Shoots	RNDU	93.60	81.76	2.56	15.98	5.85	41.24	28.83

[a] These values are ash corrected.

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