

CHAPTER 5

NUTRITIONAL ASSESSMENT OF DISCING EFFECTS

ON WATERFOWL FOOD PRODUCTION

INTRODUCTION

The foregoing investigations were intended to provide empirical data necessary to conduct a nutritional analysis of moist-soil impoundment management practices. Such an exercise would ideally address all potential waterbird foods during time periods when their availability was of highest biological significance, and would be applicable to several avian foraging guilds. Given the difficulties encountered in obtaining reliable estimates of true metabolizable energy for invertebrate foods (Chapter 1), the diversity of invertebrate taxa encountered during field sampling (Chapters 2 and 4), and the lack of available invertebrate TME data from the literature, such an analysis for invertebrate data was impracticable. However, estimates of seed production in disced and control areas at Back Bay National Wildlife Refuge (Chapter 3) combined with TME data for many of these species (Chapter 1) should provide the basis for assessing the influence of habitat management practices in a nutritional context. The objective of this exercise was to integrate field measures of resource production with laboratory measures of nutritional value, thereby providing an analysis that accounts for both quantity and quality of foods.

METHODS

Field data for this analysis were obtained from estimates of seed production at Back Bay National Wildlife Refuge (Chapter 3), and laboratory data were obtained from feeding trials with captive blue-winged teal (Chapter 1). The goal of the feeding trials was to provide estimates of nutritional value for dominant plant species in Back Bay impoundments. However, feeding trials could not be conducted for all species due to the diversity of plants encountered during field work (Chapter 3), the difficulty of obtaining adequate seed for feeding trials, and methodological problems that limited the scope of feeding trials (Chapter 1). Despite these limitations, estimates of TME were obtained for most of the dominant plant species produced at Back Bay. For 2

genera (*Cyperus* and *Juncus*), TME estimates were obtained for 1 species but not for others that occurred on the study area. Thus, TME for some species within these genera was assumed to be equal to that of congeners (Table 5.1).

The raw dataset for seed production was employed for this analysis. This dataset contained an estimate of seed production (g / m^2) for each of 30 plant species on the study area (see Chapter 3 for details on seed production estimation, and Table 3.3 for mean production by treatment and year). Briefly, seed production was estimated in 5 0.0625-m^2 quadrats in each of 16 plots in 2 impoundments (i.e., 80 locations on the study area). Half of the plots in each impoundment were disced, and half were not disced. Seed production estimates were conducted 4 times (Sept and Oct of 1996 and 1997), generating a raw dataset with 320 sampling locations. For each sampling location, metabolizable energy production (MEP; $\text{kcal} / 0.01 \text{ ha}$) was calculated for each plant species as: $\text{TME} (\text{kcal} / \text{g}) * \text{Seed Production} (\text{g} / \text{m}^2) * 100 \text{ m}^2 / 0.01 \text{ ha}$. MEP was estimated using 3 separate estimates of TME for all species. The first estimate used the mean observed TME from feeding trials with blue-winged teal (Chapter 1). However, there was substantial variation in TME within plant species and among birds, including many negative values for some diets (see Chapter 1). Consequently, 2 predicted TME values were generated for each species using linear regression of mean TME on acid detergent fiber content of the seed diets. The first predicted TME value was generated using all species included in TME feeding trials (the “full dataset”), whereas the second predicted TME value was generated using only those species for which the CV of the mean observed TME was $< 20\%$ (the “reduced dataset”). Total MEP was calculated for each sampling location by adding the MEPs for each species.

Models used to evaluate discing effects on MEP were identical to those used for seed production (Chapter 3). Briefly, mixed linear models (PROC MIXED, Littell et al. 1996) were used to test for main effects and interactions with the blocking factor. Study plots ($n = 16$) were considered independent sampling units, with subplots ($n = 5$ per plot) and sampling periods within years ($n = 2$; Sept and Oct) as subsamples, Discing and Year as main effects, and Pools (i.e., $n = 2$ impoundments) as the blocking factor. Three separate models (1 using each of the 3 estimates

Table 5.1. Values of true metabolizable energy (TME; kcal / g) assumed for 18 species of moist-soil plant seeds from moist-soil impoundments at Back Bay National Wildlife Refuge, Virginia Beach, Virginia.

Species	Measured TME	Predicted TME		Source
		Full Dataset ^a	Reduced Dataset ^b	
<i>Bidens cernua</i>	0.55	1.20	1.74	Chapter 1
<i>Cyperus erythrorhizos</i>	1.96	1.14	1.69	Assumed equal to <i>Cyperus esculentus</i>
<i>Cyperus esculentus</i>	1.96	1.14	1.69	Chapter 1
<i>Cyperus iria</i>	1.96	1.14	1.69	Assumed equal to <i>Cyperus esculentus</i>
<i>Cyperus spp.</i>	1.96	1.14	1.69	Assumed equal to <i>Cyperus esculentus</i>
<i>Echinochloa crus-galli</i>	2.65	2.08	2.39	Chapter 1
<i>Fimbristylis annua</i>	0.49	0.40	1.14	Chapter 1
<i>Juncus canadensis</i>	1.21	0.37	1.12	Chapter 1
<i>Juncus coriaceous</i>	1.21	0.37	1.12	Assumed equal to <i>Juncus canadensis</i>
<i>Juncus marginatus</i>	1.21	0.37	1.12	Assumed equal to <i>Juncus canadensis</i>
<i>Juncus megacephalus</i>	1.21	0.37	1.12	Assumed equal to <i>Juncus canadensis</i>
<i>Juncus tenuis</i>	1.21	0.37	1.12	Assumed equal to <i>Juncus canadensis</i>
<i>Panicum dichotomiflorum</i>	2.54	2.43	2.65	Chapter 1
<i>Panicum virgatum</i>	2.05	1.83	2.20	Chapter 1
<i>Polygonum pensylvanicum</i>	0.97	0.97	0.97	Chapter 1
<i>Scirpus americanus</i>	0.64	0.85	1.48	Chapter 1
<i>Scirpus olneyi</i>	0.50	1.62	2.05	Chapter 1
<i>Spartina patens</i>	0.05	0.29	1.05	Chapter 1

^a TME predicted from regression of measured TME on acid detergent fiber (ADF) for all species for which TME was determined (Chapter 1).

^b TME predicted from regression of measured TME on acid detergent fiber (ADF) for those species with coefficient of variation for mean measured TME < 20% (Chapter 1).

of TME) were analyzed. Vegetation height was included as a covariate, and statistical significance was accepted at $\alpha = 0.10$.

Reinecke et al. (1989) propose that duck use-days per hectare can be calculated from seed production data, assuming 1) mean TME of 2.5 kcal / g for moist-soil plants, 2) no duck use of areas where seed production is < 50 kg / ha, and 3) mean daily energy expenditure of 292 kcal / day for a free-ranging adult mallard. These assumptions were used to estimate duck-use days per hectare for disced and control areas of impoundments at Back Bay NWR. Four estimates of duck use-days per hectare were generated, each with a different estimate of true metabolizable energy (assumption #1 of Reinecke et al. [1989]). Three estimates of duck use-days were generated using values of TME obtained in feeding trials with blue-winged teal (Table 5.1). The fourth estimate applied Reinecke et al.'s (1989) assumed mean TME of 2.5 kcal / g to all 18 moist-soil plants included in MEP calculations (Table 5.1). To account for assumption #2 of Reinecke et al. (1989), mean total seed production (i.e., all species combined) was calculated for each plot-year ($n = 32$). The dataset was then modified by setting total seed production = 0 for plot-years where estimated total seed production was < 50 kg / ha. This modification resulted in replaced values of 0 for 3 plots during 1996 (1 disced, 2 control) and 2 plots (control) during 1997. Estimated duck use-days per hectare were then calculated as Mean Energy Production (kcal / 0.01 ha) * 100 / (292 kcal / duck use-day).

RESULTS

Total MEP was 119% higher in disced than in control areas when MEP was based on measured values of TME, and was 110% higher in disced than in control areas for both estimates based on predicted values of TME (Table 5.2). The highest total MEP values for both disced and control plots were obtained when observed values of TME were used (Table 5.2); estimates for disced and control areas were 1.6 and 1.5x higher when observed TME values were used than when predicted values from the full dataset were used. Mixed model analysis of variance revealed significant ($P < 0.10$) Discing effects on MEP and Discing x Year interactions

Table 5.2. Mean metabolizable energy production (kcal / 0.01 ha) for seeds of 18 species of moist-soil plants in disced and control study plots in 2 impoundments at Back Bay National Wildlife Refuge, Virginia Beach, Virginia, 1996-97. Means were generated using estimated seed production (Chapter 2) and 3 estimates of true metabolizable energy (Chapter 1).

Species	Metabolizable Energy Production (kcal / 0.01 ha)											
	Based on Measured TME ^a				Based on Predicted TME from Regressions on ADF							
					Full TME Dataset ^b				Reduced TME Dataset ^c			
	Control		Disced		Control		Disced		Control		Disced	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
<i>Bidens cernua</i>	123	69	97	57	271	151	215	127	392	218	310	183
<i>Cyperus erythrorhizos</i>	6227	3505	13595	7602	3631	2044	7928	4433	5373	3024	11729	6558
<i>Cyperus esculentus</i>	117	84	160	91	68	49	93	53	101	73	138	79
<i>Cyperus iria</i>	940	353	3669	2950	548	206	2139	1720	811	305	3165	2545
<i>Cyperus spp.</i>	0	0	1	1	0	0	1	1	0	0	1	1
<i>Echinochloa crus-galli</i>	534	296	1309	663	420	233	1030	522	482	267	1182	599
<i>Fimbristylis annua</i>	62	41	166	96	50	33	134	78	143	94	381	221
<i>Juncus canadensis</i>	6	4	8	6	2	1	3	2	5	4	8	5
<i>Juncus coriaceous</i>	88	57	3	3	27	18	1	1	82	53	3	3
<i>Juncus marginatus</i>	1	1	2	2	0	0	1	0	1	1	2	1
<i>Juncus megacephalus</i>	38	22	33	16	12	7	10	5	35	21	30	15
<i>Juncus tenuis</i>	0	0	2	2	0	0	0	0	0	0	1	1
<i>Panicum dichotomiflorum</i>	169	62	734	298	162	59	702	285	176	65	764	311
<i>Panicum virgatum</i>	636	434	27	27	567	387	24	24	683	466	29	29
<i>Polygonum pensylvanicum</i>	86	59	17	13	86	59	17	13	86	59	17	13
<i>Scirpus americanus</i>	20	5	33	14	51	12	83	36	64	15	104	46
<i>Scirpus olneyi</i>	12	9	21	17	31	22	53	43	39	27	66	54
<i>Spartina patens</i>	5	2	5	2	31	9	29	13	115	33	105	46
Total	9065	3747	19880	10673	5958	2275	12461	6412	8587	3371	18036	9287

^a Production based on actual mean values of TME as measured in feeding trials (Chapter 1).

^b Production based on TME values predicted from regression of mean TME on acid detergent fiber for all species included in feeding trials with blue-winged teal (see Chapter 1).

^c Production based on TME values predicted from regression of mean TME on acid detergent fiber for those species with coefficient of variation for mean observed TME < 20% (see Chapter 1).

for all 3 models (Table 5.3). All other main effects and interactions were nonsignificant in all 3 models (Table 5.3).

Estimates of duck use-days per hectare ranged from 4236 ± 1925 to 8922 ± 4017 for discing areas and 2016 ± 865 to 4234 ± 1871 for control areas (Fig. 5.1). The assumed common mean of 2.5 kcal / g for all 18 species produced the highest estimates of duck use-days, whereas predicted TMEs based on the full feeding trial dataset produced the lowest estimates (Fig. 5.1). All 4 methods of calculating duck use-days produced similar estimates of the increment due to discing (range 2.1 – 2.2x; Fig. 5.1).

DISCUSSION

Metabolizable Energy Production

The highest estimates of metabolizable energy production (MEP) were produced by using the observed mean TME for each species from feeding trials with blue-winged teal. This is in seeming contradiction to the nature of the observed and predicted TME datasets, because most species had predicted TMEs that were higher than the observed values. The exception, however, was *Cyperus erythrorhizos*. This species was 1 of the dominant taxa on the study area, and had predicted TMEs that were lower than the observed values (Table 5.1), suggesting that this relationship was largely driven by this species. MEPs based upon measured TMEs were within 10% of estimates based upon predicted TMEs from the reduced dataset (Table 5.2), despite TMEs that differed substantially between the 2 methods for some species (Table 5.1). However, MEP estimates based upon TMEs predicted from the full dataset were substantially lower than the other 2 estimates (Table 5.2).

This exercise can not reveal further insight into the accuracy of observed and predicted TME values, nor suggest which value represents the “correct” TME for a given species. It does, however, show the lack of sensitivity of MEP estimation to using predicted values of TME that are based upon a limited dataset for which confidence in accuracy is high. The reduced dataset contained only 6 species (see Chapter 1), yet when its predictions were applied broadly to 12 additional species, the resulting MEP predictions differed little from those based on measured TMEs. This suggests that there may be value in further development and testing of regression

Table 5.3. Results of repeated measures mixed model analysis of variance for total metabolizable energy production of 18 species of moist-soil plants in impoundments at Back Bay National Wildlife Refuge, Virginia Beach, Virginia, 1996-97.

		Predicted TME from Regressions on ADF					
		Measured TME ^a		Full TME Dataset ^b		Reduced TME Dataset ^c	
Source	df	F	P	F	P	F	P
Discing	1, 12	4.37	0.059	3.64	0.081	3.68	0.079
Pool	1, 12	0.01	0.920	0.00	0.999	0.01	0.929
Pool * Discing	1, 12	0.01	0.931	0.08	0.781	0.22	0.650
Year	1, 75	1.11	0.296	1.04	0.312	0.81	0.371
Year * Discing	1, 75	3.43	0.068	3.35	0.071	3.80	0.055
Year * Pool	1, 75	0.48	0.492	1.25	0.266	1.24	0.269
Year * Pool * Discing	1, 75	0.49	0.485	0.25	0.622	0.19	0.663
Vegetation Height	1, 75	21.66	<0.001	25.06	<0.001	27.61	<0.001

^a Production based on actual mean values of TME as measured in feeding trials (Chapter 1).

^b Production based on TME values predicted from regression of mean TME on acid detergent fiber for all species included in feeding trials with blue-winged teal (see Chapter 1).

^c Production based on TME values predicted from regression of mean TME on acid detergent fiber for those species with coefficient of variation for mean observed TME < 20% (see Chapter 1).

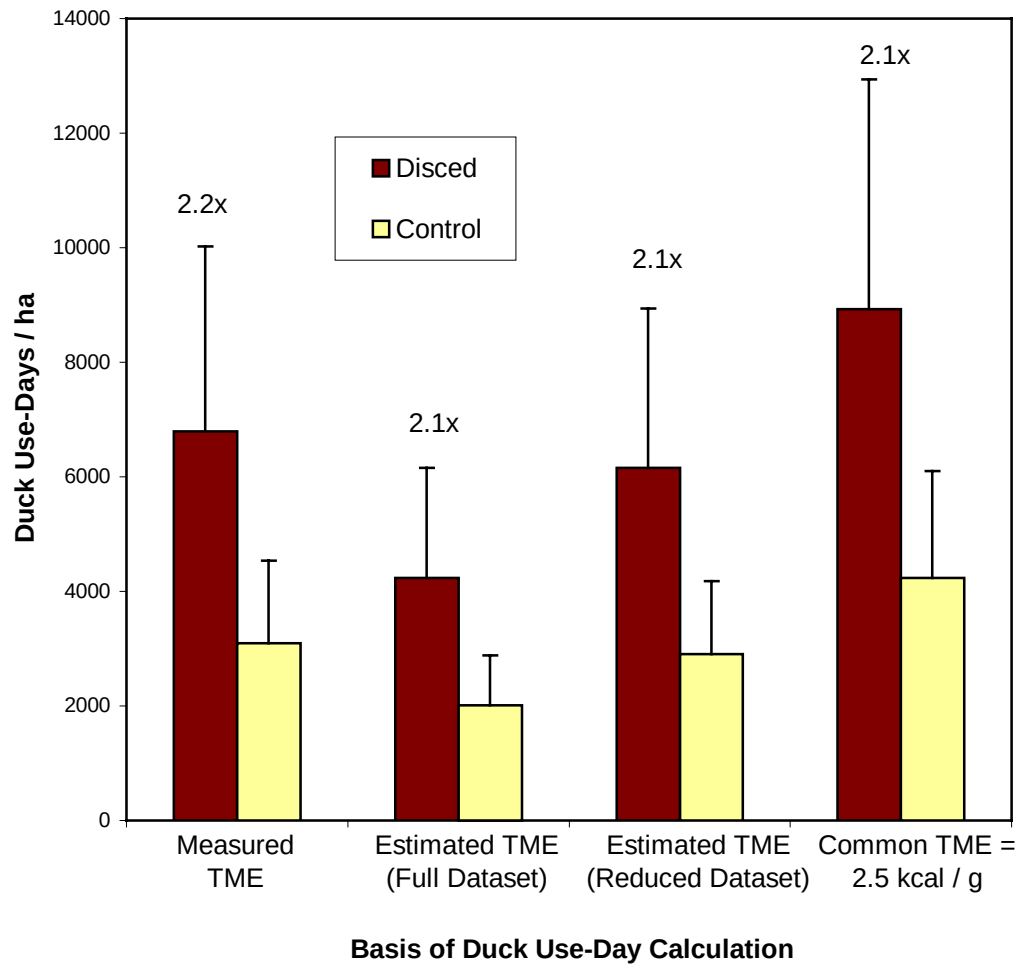


Figure 5.1. Mean (+ SE) duck use-days per hectare for 18 species of moist-soil plants in disced and control plots in impoundments at Back Bay National Wildlife Refuge, Virginia Beach, Virginia, using 4 different assumptions for true metabolizable energy. Calculations all assume 1) no duck use of areas where mean seed production is < 50 kg / ha, and 2) daily energy expenditure of 292 kcal / ha for an adult free-ranging mallard (Reinecke et al. 1989). Numbers above bars indicate the increment of discing effect on duck use-days per hectare for each TME assumption (i.e., [duck use-days in disced areas / duck use-days in control areas]).

models to predict TME of moist-soil plants, particularly for diverse plant communities such as those found at Back Bay NWR.

Duck Use-Days

Calculation of duck use-days revealed a pattern of variation that was quite similar to that shown by MEP calculations (Fig. 5.1). This was not unexpected, as duck use-days are largely a scalar multiple of MEP, with the exception that areas of low production (i.e., $< 50 \text{ kg / ha}$) are eliminated from consideration. What is perhaps more revealing is that an assumed common mean TME among species (2.5 kcal / g; Reinecke et al. 1989) produced estimates of duck use-days that were substantially higher than estimates based on empirical data (Fig. 5.1). Estimates of duck use-days for disced areas using the assumed common mean TME among species were 31 – 100 % higher than estimates based on measured or estimated TMEs (Fig. 5.1). Despite the limitations of the TME data used to develop these estimates, they are likely more reflective of the true value of these foods than an assumed mean that is based on only a few species. Further, a conservative approach to habitat management would dictate that even limited empirical data likely produce more meaningful estimates of duck use-days than do assumed mean values.

Estimates of duck use-days varied substantially among TME assumptions, yet variation between disced and control areas was nearly identical among assumptions (2.1 – 2.2x; Fig. 5.1). Thus, as a basis for assessing relative value of disced and control areas to waterfowl, duck use-days appear to be largely insensitive to assumptions regarding food quality. However, absolute judgements regarding potential waterfowl carrying capacity appear to be highly sensitive to underlying nutritional assumptions. Where absolute predictions of duck use-days are desirable, it is likely that accuracy will be improved by using empirical estimates of TME. In this context, it should be noted that neither of the other assumptions required to make such predictions (i.e., no duck use of areas where seed production $< 50 \text{ kg / ha}$, daily energy expenditure of an adult mallard = 292 kcal / day) has a basis in fact. Conversely, the body of literature on TME of waterfowl foods is growing (Hoffman and Bookhout 1985, Jorde and Owen 1988, Petrie et al. 1998, this study). Accuracy of waterfowl carrying capacity predictions will be improved where research can provide empirical estimates of all parameters needed.

What is the “Value” of Nutritional Value?

The results of this exercise might suggest that little practical knowledge is gained in the use of nutritional parameters to evaluate habitat management practices. Estimates of seed biomass production (Chapter 3), metabolizable energy production, and duck use-days per hectare all showed approximately a 2.1x increment due to discing. It should be noted, however, that the availability of nutritional data such as these may further enable managers to identify areas within impoundments that are potentially valuable foraging areas. Given the variation among plant species in nutritional value, high seed production alone is an inadequate criterion for predicting waterfowl use. That the nutritional and dry mass metrics in this study produced similar estimates of the experimental effect (discing) adds further credence to the conclusion that this habitat management practice is of value in increasing waterfowl food production. Expansion of these analyses to include other nutritionally significant parameters such as protein content (Anderson and Smith 1998) may provide further insight into the potential influence of discing on waterfowl nutrition and condition.

When used in conjunction with field measures of resource abundance, nutritional data are a valuable tool that enable managers to relate food production to potential wildlife use. This study has shown that these data are not without limitations, nor are they as easily obtained as might be suggested in the literature (Sibbald 1976). Further, attempts to accurately characterize impoundment food production on a nutritional basis require several other gross assumptions that are supported by few data. This should not, however, deter efforts to improve bioassay methods and expand the realm of wildlife foods for which empirical nutritional data are available.

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