Journal of
Fisheries and Aquatic Science

ISSN 1816-4927

Academic
Journals Inc.

www.academicjournals.com

Journal of Fisheries and Aquatic Science 2 (2): 156-161, 2007
ISSN 1816-4927

Effect of Dietary Moisture and Volume on Specific Dynamic Action in *Silurus meridionalis* Chen

Zhen-Dong Cao and Shi-Jian Fu
Laboratory of Evolutionary Physiology and Behaviour, College of Life Sciences, Chongqing Normal University, Chongqing, 400047, China

Abstract: The effect of dietary moisture and volume on specific dynamic action (SDA) was investigated in the southern catfish *Silurus meridionalis* Chen at 27.5°C by filling the formulated diet, water and cellulose in a section of grass carp intestine (0.25 g). The results showed that there were no significant differences in any SDA variables among fish fed diets with different moisture ($p>0.05$). Duration, energy expended on SDA and SDA coefficient for fish fed with the cellulose diet (1 g cellulose filled in 0.25 g intestine) were significantly higher than those of the control group (0.25 g intestine) ($p<0.05$). Duration, energy expended on SDA and peak metabolic rate of fish fed with intestine diet (1 g intestine filled in 0.25 g intestine) was much higher than those of cellulose group. The results of this study suggest dietary moisture has little effect on SDA response and dietary cellulose induce extra mechanical SDA energy cost.

Key words: Dietary moisture, dietary volume, metabolic rate, *Silurus meridionalis* Chen, specific dynamic action

INTRODUCTION

The increase in metabolic Rate (R) due to feeding is commonly referred to as Specific Dynamic Action (SDA), which represents the total energy to be expended on the ingestion, digestion, absorption and assimilation of a meal (Jobling, 1981; Beamish and Trippel, 1990; Brown and Cameron, 1991; Lyndon *et al*., 1992). Therefore, SDA might provide useful data in assessing the dietary nutrition value. The southern catfish, *Silurus meridionalis* Chen, a carnivorous fish, is the most widely cultured catfish in China. Studies on SDA of this catfish suggest that dietary composition, feeding level, feeding frequency and fasting all have significant effects on SDA (Fu *et al*., 2005a, b, c). Although the protein content of flesh was much higher and growth performance of fish fed with flesh was much better than formulated diet, the SDA response of this catfish fed with freshly killed loach flesh was significantly lower than those fed with formulated diet (Fu *et al*., 2005a, b, c). It was suggested that the physical property such as dietary moisture and volume might have an effect on specific dynamic action of this catfish. The effect of dietary volume on SDA was studied in largemouth bass, *Micropterus salmoides* by altering the dietary cellulose level (Tandler and Beamish, 1979), but no data about the effect of dietary moisture on SDA was documented before. So southern catfish was selected as an experimental model, aim to test whether dietary moisture and volume had effects on specific dynamic action.

MATERIALS AND METHODS

Animals and Acclimation

Experimental juvenile southern catfish were obtained from the local hatchery. They were acclimated to the experimental rearing system for four weeks prior to the experiment. During this

Corresponding Author: Zhen-Dong Cao, Laboratory of Evolutionary Physiology and Behaviour, College of Life Sciences, Chongqing Normal University, Chongqing, 400047, China
Tel/Fax: 8623-65363633

period the fish were fed to satiation on cutlets of freshly killed loach, *Misgurnus anguillicaudatus*, every other day. Water temperature was maintained at 27.5±0.2°C and oxygen content was kept >5 mg L^{-1}.

Measure of Oxygen Consumption

Oxygen consumption for individual fish was measured by a 40-chamber (0.12 L), continuous flow respirometer (Fu *et al*., 2005c). In brief, a feeding tube was mounted at the front of the respirometer chamber to allow feeding of the fish in the chamber and feces were discharged by a tube mounted at the rear of the respirometer chamber. Experimental fish were used in these chambers and one chamber without a fish acted as background oxygen consumption. The following formula was used to calculate oxygen consumption (R, mgO_2h^{-1}) of individual fish:

$$R = \Delta O_2 \times v \tag{1}$$

where ΔO_2 is the difference ($mgO_2 L^{-1}$) in oxygen concentration between an experimental chamber and the empty chamber (for background value), v is the velocity of water flow in a chamber (L h^{-1}). Metabolic rate was represented by oxygen consumption and was adjusted to a standard body mass of 1kg using a mass exponent of 0.75 as following (Xie and Sun, 1990; Fu and Xie, 2004).

$$Rs = (1/m)^{0.75}R \tag{2}$$

where Rs is the standardized metabolic rate, R is the measured oxygen consumption per fish (mgO_2h^{-1}) and m is the body mass of the fish (kg).

The Preparation of Diet

In experiment 1, the dry diet (40% protein, 15% carbohydrate and 10% lipid, Fu *et al*., 2005a) with different moisture was filled in a section of grass carp intestine with same shape and weight (0.25 g), which was bundled by the cotton thread at both ends. The filled dry diet and water were 0.3 g diet/0.3 g water, 0.3 g diet/0.15 g water and 0.3 g diet/0.075 g water and referred to as 1D/1W, 2D/1W and 4D/1W, respectively. The measured moisture was listed in Table 1.

In experiment 2, 1 g cellulose and intestine were filled in a section of grass carp intestine (0.25 g) and referred to as cellulose and intestine diet, respectively. A section of 0.25 g intestine without filler was used as the control group. The intestine, diet and cellulose were sampled for measurement of gravity and moisture. The volume was estimated by specific gravity of each component. The volume, mass and energy content of each diet were listed in Table 2.

Table 1: Variables of SDA in southern catfish fed diets with different moisture

No.	1D/1W	2D/1W	4D/1W
N	8	8	8
Body mass (g)	19.29±0.40	18.51±0.98	17.67±0.76
Treatment	0.3 g diet+0.3 g water	0.3 g diet+0.15 g water	0.3 g diet+0.075 g water
Measured moisture (%)	49.79	37.84	21.59
Energy ingested (kJ)	6.57	6.57	6.57
Rs (mg O_2 h^{-1})	35.83±1.02	36.98±1.73	36.73±1.68
Rp (mg O_2 h^{-1})	90.47±4.04	93.39±2.02	89.28±3.77
Duration (h)	35.43±2.26	38.29±3.34	33.00±1.77
Energy expended on SDA (kJ)	0.86±0.03	0.84±0.06	0.87±0.04
SDA coefficients (%)	13.01±0.46	12.75±1.02	13.47±0.87

Values in each column without a common superscript are significantly different ($p<0.05$); Data ere presented as means±SE; The approximate composition of the experimental diet are 40.13% protein, 10.50% lipid, 15.72% digestible carbohydrate and 17.75 kJ g^{-1} bio-available energy; Fu *et al*. (2005a)

Table 2: Variables of SDA in southern catfish fed diet with different bio-available energy and volume

No.	Control	Cellulose	Intestine
Treatment	0.25 g intestine	0.25 g intestine+1.00 g Cellulose	1.25 g intestine
Dietary mass (g)	0.25±0.01	1.34±0.13	1.31±0.14
Dietary volume (cm^3)	0.26±0.01	1.25±0.12	1.30±0.14
Energy ingested (kJ)	1.34±0.04	1.34±0.05	7.71±0.79
Body mass of fish (g)	15.39±0.99	18.17±1.04	17.63±0.68
N	10	10	10
Rs (mg O_2 h^{-1})	38.09±0.76	36.58±0.83	38.09±0.76
Rp (mg O_2 h^{-1})	66.86±2.58^b	70.28±1.93^b	102.87±5.02^a
Duration (h)	12.38±2.00^c	21.60±1.63^b	27.56±1.63^a
Energy expended on SDA (kJ)	0.11±0.01^c	0.17±0.03^b	0.68±0.08^a
SDA coefficients (%)	8.91±0.52^b	12.77±1.03^a	9.44±0.50^b

Values in each rank without a common superscript are significantly different ($p<0.05$); Data ere presented as means±SE

The bio-available energy of the diet (15.97 kJ g^{-1}) used in experiment 1 was calculated as protein: 23.6, lipid: 39.5, starch: 17.2 kJ g^{-1}. A 5g intestine was sampled in trial and was dried to constant mass at 70°C for analyzing energy content using oxygen bomb calorimetry (Model 6300, Parr Instrument Company, Moline, Lllinois, USA). The average energy content of 3 samples (5.36 kJ g wet-mass^{-1}) was used as energy content of intestine.

Experimental Protocol

Experiment 1

After 24 h fasting, the fish (N = 8, 18.5±0.4 g, Means±SE) were placed in the respirometer chamber (0.1 L) and allowed to acclimate for 48 h. Oxygen concentration was measured four times at 2 h intervals and converted to standard metabolic rate (Rs). Then the diet with different moisture was offered to the experimental fish. After the fish finished the diet, the chambers were closed immediately and the oxygen consumption rate was monitored for 48 h.

Experiment 2

After 24 h fasting, the fish (17.2±0.6 g, Means±SE) were placed in the respirometer chamber and allowed to acclimate for 48 h. Oxygen concentration was measured four times at 2 h intervals and converted to standard metabolic rate (Rs). Then the prescribed diet was offered to the experimental fish. After the fish finished the diet, the chambers were closed immediately and the oxygen consumption rate was monitored for 36 h.

Data Handling and Analysis

Four variables were quantified as described by Jobling (1981) and Fu *et al*. (2005a): (1) peak metabolic rate (Rp), the observed maximum metabolic rate in the SDA process; (2) duration, calculated as the time from feeding to when metabolic rate return to within the S.D. of Rs of a given fish; (3) energy expended on SDA, calculated as the total energy expended above Rs during the duration of SDA, The oxygen consumption was converted to energy by using a conversion factor of 13.84 J mg O_2^{-1} (Guinea and Fernandez, 1997); (4) SDA coefficient (%), energy expended on SDA quantified as a percentage of the energy content of the meal. STATISTICA 4.5 (StatSoft Inc) was used for data analysis. A one-way ANOVA and Least Significant Difference (LSD) were applied to distinguish significant difference among mean values. A p-value <0.05 was considered statistically significant. All data are presented as means±SE.

RESULTS

Experiment 1

The body mass and Rs of fish in our studies did not differed significantly among the experimental groups prior to the feeding experiment (Table 1). Two hours after feeding, the oxygen consumption rate was increased significantly, peaked 6 to 16 h after feeding and gradually decreased to the fasting level (Fig. 1). However, there were no significant differences in any SDA variables among experimental groups.

Experiment 2

Neither body mass nor Rs differed significantly among the experimental groups prior to the feeding experiment (Table 2). Duration, energy expended on SDA and SDA coefficient for fish fed with the cellulose diet were significantly higher than those of the control group ($p<0.05$). Rp, duration and energy expended on SDA for fish fed with the intestine diet were significantly higher than those of the control and cellulose groups ($p<0.05$). SDA coefficients of the intestine and control groups were significantly lower than that of the cellulose group ($p<0.05$) (Fig. 2).

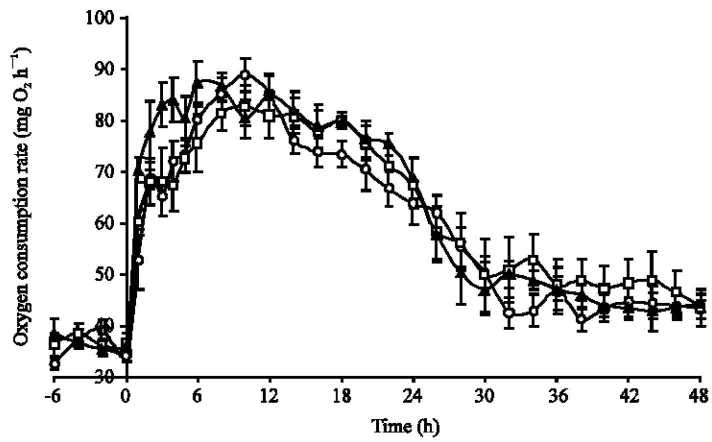

Fig. 1: Specific dynamic action in southern catfish *Silurus meridionlis* Chen fed diet with different moisture (Mean±SE, n = 8); Feeding (0.3 g diet plus water) was at 0 h and 1D/1W (open circles), 2D/1W (open squares), 4D/1W (closed triangles); D: Dry diet; W: Water

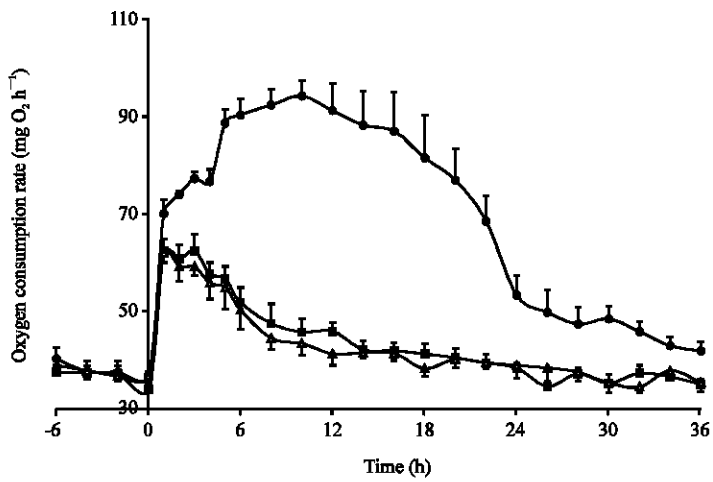

Fig. 2: Effect of dietary volume on specific dynamic action in southern catfish *Silurus meridionalis* Chen (Mean±SE, n = 10); Intestine (closed circles), cellulose (closed square), control (open triangle)

DISCUSSION

The Effect of Dietary Moisture on SDA

It was found in previous experiment that SDA of southern catfish was positively related with the energy ingested when fed the formulated diet (Fu *et al*., 2005a). However, the SDA of southern catfish fed with the formulated diet was significantly greater than those of fish fed with the freshly killed loach flesh (about 75% moisture) even the ingested bio-available energy was similar (Fu *et al*., 2005a). So southern catfish fed with the formulated diet expended more energy on digestion process compared to those fed with the loach flesh. To test whether dietary moisture accounted for such difference was one aim of this study. But in this study, the total energy expended on SDA of southern catfish fed with different moisture diet was not significantly different.

The Effect of Dietary Volume on SDA

Studies attempting to elucidate the relative contribution of the various components of digestion to SDA have divided SDA into mechanical SDA and biochemical SDA (Tandler and Beamish, 1979; Jobling and Davies, 1980). Mechanical SDA represents the cost of physical processing of food (i.e., chewing, swallowing and peristalsis), whereas biochemical SDA is the postabsorptive cost of assimilation (including nutrient transport and the synthesis of proteins and tissues). In this study the SDA coefficient of the cellulose group was significantly higher than those of the other groups. It suggests the filled cellulose (hence increase of dietary volume) induced additional mechanical SDA, as documented in *Micropterus salmoides* before (Tandler and Beamish, 1979). It was found in the previous study that the southern catfish might have a SDA component to initiate the digestive bout (Fu *et al*., 2005a). We thought such pre-absorption energy expenditure might correlate with the external biochemical composition and the volume of diet rather than the inner biochemical composition. In this study, the cellulose and intestine diets have similar external biochemical composition and volume. But the SDA response was totally different. The energy expended on SDA was more closely related to the ingested bio-available energy rather than the dietary volume (Table 2). It suggests such pre-absorption energy expenditure had little effect on SDA response and biochemical SDA was the main energy component of SDA. Studies on other fish species also showed that the postabsorptive costs (biochemical SDA,) dominate SDA (Jobling, 1981; Brown and Cameron, 1991; Lyndon *et al*., 1992).

ACKNOWLEDGMENTS

This study was funded by the Science and Technology Committee and Education Committee of Chongqing, China.

REFERENCES

Beamish, F.W.H. and E.A. Trippel, 1990. Heat increment: A static or dynamic dimension in bioenergetics model? Tran. Am. Fish. Soc., 119: 649-661.

Blaikie, H.B. and S.R. Kerr, 1996. Effect of activity level on apparent heat increment in Atlantic cod, *Gadus morhua*. Can. J. Fish. Aqua. Sci.., 53: 2093-2099.

Brown, J.R. and J.N. Cameron, 1991. The relation between specific dynamic action and protein synthesis rates in channel catfish. Physiol. Zool., 64: 298-309.

Fu, S.J. and X.J. Xie, 2004. Nutritional homeostasis in carnivorous southern catfish (*Silurus meridionalis* Chen): Is there a mechanism for increased energy expenditure during carbohydrate overfeeding? Comp. Biochem. Physiol., 139A: 359-363.

Fu, S.J., X.J. Xie and Z.D. Cao, 2005a. Effect of feeding level and feeding frequency on specific dynamic action in southern catfish *Silurus meridionalis*. Chen. J. Fish Biol., 67: 171-181.

Fu, S.J., X.J. Xie and Z.D. Cao, 2005b. Effect of fasting on resting metabolic rate and postprandial metabolic response in southern catfish (*Silurus meridionalis* Chen). J. Fish Biol., 67: 279-285.

Fu, S.J., X.J. Xie and Z.D.Cao, 2005c. Effect of dietary composition on specific dynamic action in southern catfish, *Silurus meridionaliss.* Aqua. Res., 37: 1384-1390.

Guinea, J. and F. Fernandez, 1997. Effect of feeding frequency, relative meal size and temperature on energy metabolism in *Sparus aurata.* Aquaculture, 148: 125-142.

Jobling, M. and P.S. Davies, 1980. Effects of feeding on metabolic rate and the specific dynamic action in plaice, *Pleuronectes platessa* L. J. Fish Biol., 16: 629-638.

Jobling, M., 1981. The influences of feeding on the metabolic rate of fishes: A Short Review. J. Fish Biol., 18: 385-400.

Lyndon, A.R., D.F. Houlihan and S.J. Hall, 1992. The effect of short-term fasting and a single meal on protein synthesis and oxygen consumption in cod, *Gadus morhua*. J. Comp. Physiol., 162 B: 209-221.

Tandler, A. and F.W.H. Beamish, 1979. Mechanical and biochemical components of apparent specific dynamic action in largemouth bass *Micropterus salmoides* Lacepede. J. Fish Biol., 14: 343-350.

Xie, X.J. and R.Y. Sun, 1990. The bioenergetics of the southern catfish (*Silurus meridionalis* Chen). I. Resting metabolic rate as a function of body weight and temperature. Physiol. Zool., 63: 1181-1195.