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Growth and reproduction of female Nile tilapia fed diets containing different levels of protein and energy

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ABSTRACT

This study evaluated the effects of diets containing different levels of digestible protein (DP) and digestible energy (DE) on the growth and reproductive performance of female Nile tilapia. In this study, 567 females (weight, 95.2 ± 15.6 g) and 189 males (weight, 168.8 ± 37.7 g) of the Thai-Chitralata lineage were housed in 27 hapa pens (21 females:7 males per hapa pen). The experiment was conducted in a randomized block design using a 3 × 3 factorial structure. For 260 days, the tilapia were fed nine different diets containing combinations of 280, 340, and 400 g kg^{-1} DP and 11.72, 14.23, and 16.74 MJ kg^{-1} DE. The absolute fecundity of females was not altered ($P > 0.05$) by the different diets. On the other hand, only DE levels had an inversely proportional effect ($P < 0.05$) on the number of eggs produced per gram of body weight of mated females, which indicated a greater relative fecundity when females were fed diets containing the lowest level of DE. The levels of DP and DE in the diets independently affected egg weight and the weight of the larvae after hatching, with an inversely proportional linear relationship ($P < 0.05$) with DP levels and a directly proportional relationship ($P < 0.05$) with DE levels. Thus, heavier eggs and larvae were produced with diets containing lower DP content and higher DE level. The levels of DP and DE in the diets had an interactive effect ($P < 0.05$) on the weight and standard length of the females, with better growth resulting from diets containing the highest levels of DE and DP. Specific growth (SG) and viscerosomatic index (VSI) only experienced a quadratic effect from DE. Regardless of protein levels, the greatest SG was obtained with diets containing 15.23 MJ kg^{-1} DE (calculated value), and the greatest VSI values resulted from diets containing the highest level of DE. The condition factor, apparent feed conversion, survival, and gonadosomatic and hepatosomatic indexes of the females were not influenced ($P > 0.05$) by the diets. We concluded that feeding reproductively active female Nile tilapia diets containing lower amounts of DP and DE ensures egg production at the expense of somatic growth. Furthermore, diets with 280 g kg^{-1} DP and 16.74 MJ kg^{-1} DE are recommended because the lower egg productivity may be offset by the production of more vigorous offspring that have greater chances of survival.

1. Introduction

The ability to control sexual maturation and spawning to produce high-quality fry is essential to the success of aquaculture production (Migaud et al., 2013). Thus, adequate nutrition is essential for the breeding stock (Bhujel et al., 2007; Tsadik and Bart, 2007) because nutrition affects fertility, gametogenesis, and gamete quality (Bobe and Labbé, 2010) and consequently the initial development of the offspring (Izquierdo et al., 2001).

With respect to nutrition for the breeding fish, imbalanced diets and inadequate supply of nutrients can impair the growth and reproductive performance of males (Mewes et al., 2016) and females (Izquierdo et al., 2001; Johnston et al., 2007). Among various nutrients, proteins have an important role in the maintenance and repair of tissues and production of enzymes, hormones, and antibodies (Tu et al., 2015). In particular, in reproducing females, proteins play a fundamental role in

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Table 1
Percent composition of food components and nutrient content of the experimental diets containing different levels of digestible protein and energy used to feed female Nile tilapia (*Oreochromis niloticus*).

	Level of digestible protein (g kg^{-1})								
	280			340			400		
	Level of digestible energy (g kg^{-1})								
	11.72	14.23	16.74	11.72	14.23	16.74	11.72	14.23	16.74
Ingredients (g kg^{-1})									
Soybean meal	529.2	440.6	462.7	685.7	625.5	633.7	839.9	582.5	260.6
Corn	303.1	328.6	195.2	139.0	159.4	30.0	0.0	50.0	10.0
Fish meal	50.0	127.6	131.3	62.2	114.4	130.2	2.9	302.0	608.1
Bentonite clay (Inert)	52.4	0.0	0.0	60.0	0.0	0.0	50.0	0.0	0.0
Wheat gluten	0.0	0.0	0.0	0.0	0.0	0.0	43.8	0.0	0.0
Vitamin and mineral supplement[1]	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Dicalcium phosphate	19.2	0.0	0.0	13.0	0.0	0.0	28.4	0.0	0.0
Soybean oil	10.0	67.0	174.5	5.0	65.6	171.0	0.0	30.4	86.2
Common salt	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
DL-methionine	1.0	1.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
BHT[2]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Calculated nutrient content (g kg^{-1})[3]									
Linoleic acid	15.0	45.7	101.4	10.3	43.0	97.5	6.7	21.8	49.0
Starch	260.2	264.2	184.1	179.1	183.7	104.2	119.4	109.8	41.4
Calcium	11.0	12.8	13.2	10.9	12.2	13.6	10.0	28.6	54.6
Fat	33.4	102.2	206.0	28.3	96.7	200.4	13.6	89.7	190.4
Total phosphorus	10.0	10.0	10.0	10.0	10.0	10.0	10.6	19.2	33.0
CP[4]	312.6	311.9	312.5	379.8	379.3	379.7	444.9	445.4	443.1
CP analysed	311,1 ± 2.2	310,3 ± 3.1	311,1 ± 2.9	381,4 ± 3.2	378,7 ± 1.1	379.1 ± 1.8	443,8 ± 2.1	445,9 ± 3.0	441,9 ± 1.9
DP[5]	280	280	280	340	340	340	400	400	400
CE[6]	16.71	19.14	21.79	17.95	19.36	21.93	17.05	19.04	20.84
CE analysed	16.65 ± 0.13	19.09 ± 0.16	21.88 ± 0.11	17.89 ± 0.10	19.41 ± 0.13	21.99 ± 0.14	17.12 ± 0.12	19.10 ± 0.11	20.78 ± 0.11
DE[7]	11.72	14.23	16.74	11.72	14.23	16.74	11.72	14.23	16.74
Fiber	27.1	26.4	20.1	22.1	21.8	15.4	18.8	15.3	6.2

[1] Vitamin and mineral supplement, basic composition: folic acid: 200 mg, Pantothenic acid: 4000 mg; Biotin: 40 mg; Copper: 2000 mg; Iron: 12,500 mg; Iodine: 200 mg; Manganese: 7500 mg; Niacin: 5000 mg; Selenium: 70 mg; Vitamin A: 1,000,000 IU; Vitamin B1: 1900 mg; Vitamin B12: 3500 mg; Vitamin B2: 2000 mg; Vitamin B6: 2400 mg; Vitamin C: 50,000 mg; Vitamin D: 500,000 IU; Vitamin E: 20,000 IU; Vitamin K3: 500 mg; Zinc: 25,000 mg.
[2] Antioxidant.
[3] The nutrient contents were calculated using Super Crac Premium® software.
[4] CP: Crude protein.
[5] DP: Digestible protein.
[6] Crude energy (MJ kg^{-1}).
[7] DE: Digestible energy (MJ kg^{-1}).

Table 2
Parameters for reproduction and offspring of female Nile tilapia (*Oreochromis niloticus*) fed diets containing different levels of digestible protein and energy.

Parameters	Level of digestible protein (g kg^{-1})								
	280			340			400		
	Level of digestible energy (g kg^{-1})								
	11.72	14.23	16.74	11.72	14.23	16.74	11.72	14.23	16.74
AF	5.2	3.6	5.9	4.4	4.5	4.6	3.2	6.9	4.8
RF	2.44	1.70	1.53	1.57	1.35	1.19	1.96	1.28	1.70
MW eggs	6.42	6.25	6.75	5.82	6.24	7.46	5.83	4.98	6.23
MW larvae	7.62	7.33	7.96	7.05	7.31	7.90	7.58	6.83	7.43

	P values			
	AF	RF	MW eggs	MW larvae
DP linear effect	0.51	0.35	0.00	0.04
DE linear effect	0.49	0.00	0.01	0.04
DP quadratic effect	0.09	0.18	0.69	0.54
DE quadratic effect	0.56	0.25	0.66	0.70
DP × DE effect	0.53	0.64	0.99	0.61

AF: absolute fecundity (number of eggs × 10^3/hapa or total females mated); RF: relative fecundity (number of eggs/g of female mated); MW eggs: mean weight of eggs (MG); MW larvae: mean weight of larvae at the time of hatching (mg); DP: Digestible protein; DE: Digestible energy.