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Research Article
Zootechnical Parameters and Feed Utilization in African Snakehead Fish (*Parachanna obscura*) Fed on Earthworm Based Diet

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Abstract

Background and Objective: Earth worm meal is rich in nutritional substance and can be used at the same time for substitute fishmeal in animal feeding. This study aimed to determine the effect of substrates on the zootechnical performances of *P. obscura* fries fed on earth worm based diet. **Materials and Methods:** The effect of substrates on zootechnical performances and feed utilization in *P. obscura* fries fed on earth worm based diet was determined in the current study for 42 days. Earth worms were produced for 3 months by using animal dejection such as: Goat manure, rabbit manure, poultry manure, cow dung and pig dung. So, earth worms were produced with different substrates. Protein rate was determined in the earth worms' flour. Significant differences were observed in relation to substrates ($p<0.05$). About 375 *P. obscura* fries with 1.09 ± 0.08 g initial mean weight were distributed at 25 per pond. Five treatments were applied in triplicate. **Results:** Results showed different treatments have a significant effect ($p<0.05$) on the zootechnical performances and feed utilization parameters. Survival rate was 100% in the whole treatments. Highest values of specific growth rate and feed efficiency were, respectively 2.44 ± 0.14%/D and 0.63 ± 0.04. These values were obtained in treatment T_2 in which it included flour of earth worm pig dung genuine. **Conclusion:** So this study concluded that the earth worm meal as substituent to fish meal in *P. obscura* fries feed affected the zootechnical performances.

Key words: Production substrate, earth worm, fries fed, zootechnical parameters, pig dung, *P. obscurai*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

During the three last decades, worldwide fish production was multiplied by 12 with a mean annual growth rate 8.8% especially for fresh water fishes. Indeed, these latter dominate the worldwide fish production and represent average 56.4% either 33.7 million t of the total production[1]. This growth could be explained by the high interest tied to this sector due to population increase and the transformation of about 50% of fishery production in oil and flour used in animal feeding[2,3]. Fresh water aquaculture interest is mostly tied to its easiness and low price.

In Africa, salt water aquaculture is less developed and quasi in existent in Benin especially. Fresh water aquaculture in Benin concerns keystone species such as Tilapia and Clarias. Now, fish farming promotion depends on its diversification. Fish farming development in Benin requires the promotion of native species that are more adapted to local conditions[4-6]. In addition to fish species reared in Benin, *Parachanna obscura* is threatened to disappearance and highly appreciated by populations[7]. *Parachanna obscura* has a rapid growth, good resistance to stress, high commercial value and high nutritive value[8-11]. An effort to its domestication through its nutritional needs determination and stocking density were carried out in Benin[12]. To promote this new species facing the lack of good quality fish meal, a substitution of fish meal to earth worm meal was carried out[13]. Indeed, fish meal constitutes an essential ingredient to fish feed making due to its richness in essential amino-acids, essential fats, vitamins and minerals[14-16]. Earth worm meal has amino-acid composition similar to most of animal genuine proteins and rich in omega-3 fats like fishes[17].

So, earth worms may be valorized in *P. obscura* fries feeding to determine production cost. Now, earth worms production depends not only on species but also the biochemical nature of substrate[18-20]. Their production by using different animal dejection provides different yields[20]. By the same way, earth worm nutritional quality is related to the substrate nature[20]. The rationale behind of this study was to found the substitute of fish meal with earthworm meal come from earthworm production by many substrate of earthworm production. This study aimed to determine the effect of substrates on the zootechnical performances of *P. obscura* fries fed on earth worm based diet.

MATERIALS AND METHODS

Production of earth worms and its meal making: Earth worms were produced with a five treatments bloc of Fisher in triplicate. Sub-strates were made of cow dung, pig dung, poultry manure, goat manure and rabbit manure. Ripe worms (*E. fetida*) were seeded within 15 g kg^{-1} substrate density[20]. Before production, all substrates were analyzed for organic matter dosage, moisture, ash, carbon, nitrogen and phosphorus. By the same way, ratios such as Carbon/Nitrogen, C/Phosphorus and Carbon/Nitrogen/Phosphorus have been determined (Table 1). A suitable watering was implemented to maintain constant moisture. After three months, harvest was carried out manually[20]. Earth worms were rinsed with clean water, dripped, refrigerated and lyophilized. After lyophilization, earth worms were crushed by using a shredder to make flour. Ash, nitrogen and protein rate of earth worms were determined in relation to substrates (Table 2).

Experimental design: The experiment was carried out in 15 non-earthen circular ponds in open circuit. Each pond was filled to average 1/5 volume, either 90 L of water. Ponds were made of water flow tap and a central PVC evacuating system protected by a fine net preventing fries escape. They were mid-covered by grip to prevent direct sun light penetration.

Table 1: Chemical quality of substrates

Substrates (animal dejections)	Moisture (%)	Ash (%)	Organic matter (%)	Phosphorus (P) (%)	Carbon (C) (%)	Nitrogen (N) (%)	Ratio C:N	Ratio C:P	Ratio C:N:P
Rabbit	12.66	35.62	64.38	1.04	37.34	2.46	15.18	36.38	14.59
Goat	11.76	39.55	60.45	0.59	35.06	2.99	11.73	59.42	19.88
Cow	8.71	60.24	39.76	0.37	23.06	2.06	11.19	62.32	30.24
Pig	10.29	31.48	68.52	0.42	39.74	2.05	19.39	94.61	46.16
Poultry	6.84	63.27	36.73	0.60	21.31	1.82	11.71	35.51	19.51

Table 2: Protein rate of earth worm meal in relation to substrates

Parameters	EWM 1	EWM 2	EWM 3	EWM 4	EWM 5
Protein	42.84±0.05	51.38±0.05	46.07±0.04	44.87±0.05	42.45±0.08

EWM 1: Earth worm meal proceeded form cow dung, EWM 2: Earth worm meal proceeded form pig dung, EWM 3: Earth worm meal proceeded form poultry manure, EWM 4: Earth worm meal proceeded form rabbit manure, EWM 5: Earth worm meal proceeded form goat manure

Table 3: Different experimental diets

Diets	T_1	T_2	T_3	T_4	T_5
Cotton cake	20.00	20.00	20.00	20.00	20.00
Corn flour	12.00	12.00	12.00	12.00	12.00
Fish meal	22.50	22.50	22.50	22.50	22.50
EWM 1	22.50	0.00	0.00	0.00	0.00
EWM 2	0.00	22.50	0.00	0.00	0.00
EWM 3	0.00	0.00	22.50	0.00	0.00
EWM 4	0.00	0.00	0.00	22.50	0.00
EWM 5	0.00	0.00	0.00	0.00	22.50
Soya cake	17.00	17.00	17.00	17.00	17.00
Cod liver oil	2.00	2.00	2.00	2.00	2.00
*Premix min and vit	2.50	2.50	2.50	2.50	2.50
Iron sulphate	0.50	0.50	0.50	0.50	0.50
CMC	1.00	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00
Protein rate	44.12	45.93	44.84	44.73	43.97
Lipid rate	7.49	7.65	7.55	7.53	7.40

*Premix (vitamin-mineral) contains (‰): Vitamin A: 4000000 U.I, Vitamin D: 800000 U.I, Vitamin E: 40000 U.I, Vitamin K3: 1600 mg, Vitamin B1: 4000 mg, Vitamin B2: 3000 mg, Vitamin B6: 3800 mg, Vitamin B12: 3 mg, Vitamin C: 60000 mg, Biotin: 100 mg, Inositol 10 000 mg Pantothenic acid 8000 mg, Nicotinic acid: 18000 mg, Folic acid: 800 mg, Cholin chloride: 120000 mg, Cobalt carbonate: 150 mg, Ferrous sulphate: 8000 mg, Potassium iodide: 400 mg, Manganese oxide: 6000 mg, Copper: 800 mg, Sodium selenite: 40 mcg, Lysine: 10000 mg, Methionine: 10000 mg, Zinc sulphate: 8000 mg

Treatments: Five treatments were applied in triplicate (Table 3). Feeding frequency was three times daily (8 am, 1 pm and 6 pm). Experiment duration was 42 days. Stocking density was 25 fries per pond though mean weight is 1.09±0.08 g. Fries distribution was carried out after sorting to prevent cannibalism. Biomass, individual weight and total length were measured in each pond before charging. A one week acclimation period was observed before experiment start up. During this period, the mixture of experimental feeds was distributed three times daily.

Experimental feeds: Fish lots were fed on five different diets to meet the nutrient requirements of *P. obscura* fingerlings. These five diets provided practically the same protein rate and lipid rate to *P. obscura* fingerlings (Table 3). Each diet contained the earthworm meal come from of earthworm production by on substrate.

Fishes feeding on experimental feeds: Pelleted feed was distributed with a 5.01 (fish biomass)$^{-0.23}$ ration per pond. Rations were distributed three times daily. Feed was distributed grain by grain to insure good take up.

Experiment monitoring: Physico-chemical parameters of water were measured during the experiment period. A portable multimeter served to measure temperature, pH and dissolved oxygen (Table 4).

Test fishing was carried every 7 days. Ponds were emptied and washed. Fishes were counted and weighted per pond. Test fishing enabled ration re-adjusting in relation to biomass. At the end of experiment, biomass, total fries number, weight and individual length were measured in each pond.

Zootechnical parameters and feed utilization: From data collected during experiment, zootechnical parameters and survival rate were calculated. Mathematical formulas serving to these parameters determination are as follow:

$$\text{Survival rate (SR)} = \left(\frac{\text{FN}\times 100}{\text{N}}\right)$$

$$\text{Final mean weight (FMW)} = \frac{\text{FB}}{\text{FN}}$$

$$\text{Specific growth rate (SGR)} = \frac{\text{Ln (FMW)} - \text{Ln (IMW)}}{\text{T}}\times 100$$

$$\text{Feed efficiency (FE)} = \frac{\text{FB+DB-IB}}{\text{dR}}$$

$$\text{Consumption index (CI)} = \frac{1}{\text{FE}}$$

Where:

FN = Final fish number per pond
IN = Initial fish number per pond
FB = Final biomass per pond
Ln = Logarithm
T = Time (experiment duration)
DB = Dead fish biomass (g)
IB = Initial biomass per pond (g)
dR = Distributed ration (g)

Data manipulation: Data were collected during experiment were encoded in Excel software version 2010. Different zootechnical parameters, physico-chemical and morpho-metrical were calculated. Mean and range of each parameter were calculated and graphs were drawn. Statistical analyses were carried out by using STATVIEW software (version 5.01) at 5% probability threshold. A one way analysis of variance (ANOVA) was carried out to compare zootechnical performances of different treatments. In case of significant differences, the Fisher LSD (Least Significant Difference) test was served to means comparisons.

RESULTS

Water quality in ponds: The water physico-chemical parameters were recorded in ponds during the experiment period to insure optimal living conditions to fishes. Mean temperature value was 27.60±0.36°C. Dissolved oxygen mean value was 6.26±0.23 mg L^{-1} though mean pH was 6.67±0.13 (Table 4).

Zootechnical parameters, feed utilization and survival rate: Results obtained for main zootechnical parameters and survival rate in *P. obscura* after 42 days experiment period are mentioned in Table 5. Indicated values represent means±range obtained in each treatment.

Specific growth rates: Specific growth rates recorded during the experiment varied significantly ($p<0.05$) in relation to treatments (Table 5). However, there were significant differences ($p<0.05$) among treatment T_2 and the all other treatment (T_1, T_3, T_4 and T_5). But there was no significant difference among treatments T_1, T_3 and T_4. Also, there were significant differences ($p<0.05$) among treatment T_5 and the all other treatment (T_1, T_2, T_3 and T_4).

Feed efficiency: Feed efficiency obtained for the 5 treatments varied from 0.51±0.01 (T_5) to 0.63±0.04 (T_2). However, it noticed significant differences ($p<0.05$) among treatment T_2 and all the other treatments T_1, T_3, T_4 and T_5 (Table 5). There was no significant difference among treatments T_1, T_3, T_4 and T_5.

Survival rate: There was no mortality recorded during the experiment period. Survival rate didn't vary among treatments and was 100% (Table 5) in all treatments. So, the different treatments didn't impact fish's survival.

Final mean weight: The final mean weight had varied significantly ($p<0.05$) in relation to treatments (Table 5). Mean weight had varied from 3.05±0.26 in treatment T_2 to 2.47±0.28 in treatment T_5. Significant differences were noticed among treatment T_2, treatment T_5 and all the other treatments ($p<0.05$). It weren't able to show significant differences ($p>0.05$) among final mean weights in treatments T_1, T_3 and T_4.

DISCUSSION

Mean temperature 27.60±0.36°C recorded in this study was situated in the range 26-28°C suitable for *P. obscura* in the natural medium[8]. Mean pH value 6.67±0.13 was nearby the slightly acid range (varying from 6.6-6.9) tolerated by the species in the natural medium[8]. By the same way, mean dissolved oxygen rate 6.41±0.15 mg L^{-1}. This latter tolerable by *P. obscura* that not requires high oxygen level because it possesses accessory organs enabling aerial respiration[8]. Indeed, due to pharyngeal organs in *P. obscura*, aerial respiration enables it to survive in low oxygenated media.

Survival rate didn't vary significantly among treatments ($p>0.05$). It was 100% in all treatments. This is a proof of good physico-chemical quality of rearing media due to continuous water renewal and feed nutritional value. So, *P. obscura* has a great potential for aquaculture due to its resistance. Fries are so resistant and support easily stress conditions frequently observed in rearing media. The same trend was observed by Vodounnou *et al.*[21] and Vodounnou *et al.*[22] on *P. obscura* with 98.99% survival rate[23].

Table 4: Water quality in ponds

Parameters	T1	T2	T3	T4	T5	Mean±SD
Temperature (°C)	26.70±0.12	27. 50±0.23	28.54±0.34	27.39±0.33	27.88±0.54	27.60±0.36
pH	6.61±0.09	6.62±0.14	6.91±0.15	6.62±0.12	6.61±0.15	6.67±0.13
Dissolved oxygen (mg L^{-1})	6.41±0.17	6.43±0.14	6.39±0.16	6.42±0.15	6.40±0.11	6.26±0.23

Table 5: Zootechnical parameters, feed utilization and survival rate

Parameters	T1	T2	T3	T4	T5
Initial biomass (g)	27.00±1.00^a	27.33±1.35^a	27.50±0.85^a	27.60±1.00^a	27.40±1.00^a
Initial mean weight (g)	1.08±0.04^a	1.09±0.08^a	1.10±0.06^a	1.10±0.07^a	1.09±0.05^a
Final biomass (g)	66.45±1.62^b	76.33±3.5^a	68.25±3.62^b	66.66±4.58^b	61.86±3.36^c
Final mean weight (g)	2.65±0.33^b	3.05±0.26^a	2.72±0.43^b	2.66±0.64^b	2.47±0.28^c
Specific growth rate (%/D)	2.13±0.13^b	2.44±0.14^a	2.15±0.15^b	2.10±0.17^b	1.94±0.06^c
Consumption index	1.80±0.16^b	1.61±0.13^a	1.76±0.26^b	1.85±0.16^b	1.98±0.17^b
Feed efficiency	0.55±0.03^b	0.63±0.04^a	0.56±0.03^b	0.54±0.02^b	0.51±0.01^b
Survival rate (%)	100.00±0.00^a	100.00±0.00^a	100.00±0.00^a	100.00±0.00^a	100.00±0.00^a

Values are expressed in Mean±range. Values on same line and affected by same letter aren't significantly different ($p>0.05$)

After evaluating the effect of substrates on earth worm production[20] on earth worm nutritional quality[24] and on the ideal rate of fish meal substitution to earth worm meal in *P. obscura* fries feed, the current study aims to evaluate the effect of substrates on zootechnical parameters, feed utilization and survival rate on *P. obscura* fries. From these different studies, it was proven that substrate nature affects significantly ($p<0.05$) earth worm yield and their nutritional quality[20,24]. The earth worm production yield is related to the biochemical composition of substrates, especially the availability, the form and the accessibility of these chemical elements to earth worms[18,19,24]. Nutritional quality of earth worm is also related to substrate biochemical nature, especially C/N/P ratio[24]. Concerning fish meal substitution to earth worm meal, the optimal[13] rate is 50%. Evaluation of the effect of substrate on the zootechnical performances of *P. obscura* fries fed on earth worm based diet (50% substitution of fish meal to earth worm meal) showed significant differences compared to zootechnical parameters.

Specific growth rate that is a keystone growth parameter varied significantly ($p<0.05$) in relation to different treatments. The highest value of Specific Growth Rate (SGR) was 3.05 ± 0.26%/D and was obtained in diet from worms produced with pig dung. This rate is upper than those obtained by Samocha *et al.*[13] (2.11 ± 0.11%/D) during the determination of fish meal substitution to earth worm meal optimal rate. The earth worm meal produced by using pig dung contains the highest protein rate, the highest specific growth rate and presented a significant difference with other treatments.

CONCLUSION

The use of earth worm meal as substituent to fish meal in *P. obscura* fries feed favored its growth. This latter depended on the nutritional quality of earth worm meal that also depended on the biochemical quality of substrates. So, substrate nature affected the zootechnical performances and feed utilization in *P. obscura* fries throughout the earth worm meal nutritional quality.

SIGNIFICANCE STATEMENT

This study discovered the possibility to produce the earthworm with animal dung, that can be beneficial for the substitute fish meal by the earthworm meal in fish feed. This study will help the researchers to uncover the critical areas of the production and the using of earthworm meal in animal feeding that many researchers were not able to explore. Thus a new theory on earthworm in fish feed for decrease the production cost may be arrived at.

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