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THE EFFECT OF DIETARY PROTEIN SOURCES AND pH ON SPECIFIC DYNAMIC ACTION IN THE AFRICAN CATFISH, *Clarias gariepinus* [BURCHELL, 1822].

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ABSTRACT

Specific dynamic action [SDA] was measured in *Clarias gariepinus* within the weight range of 48.1 to 66.0g , by the increase in oxygen consumption at 2.5 to 27.0 mg . Three types of complete diets having different levels of protein [low level at 7.0% , medium level at 25.0% , and high level at 40.0%] , and at three pH regimes [5.5 , 7.3 ,and 8.6] were investigated . They were fed at 2% body weight.. The greatest effect was obtained with the high protein level diet [40% protein , 8% lipid] , which produced a maximum increase in oxygen consumption corresponding to approximately one third times the resting rate . SDA magnitude increased with the % of protein in the diet. The gross energy ranged from 2.2% to 8.6% . The role of food consumption and dietary caloric energy on SDA were considered with reference to the influence they might have on intensive fish culture. A scientific aquaculture should strive to minimize the effect of SDA which is an unavoidable constant drain on net energy.

INTRODUCTION

The ingestion of food by an animal which has been fasting results in increase in heat production . The heat production or energy expenditure due to feeding is variously referred to as Specific Dynamic or Thermodynamic Effect [Broody , 1945] , Calorigenic effect [Garrow , 1974] . Specific Dynamic Action [Jobling and Davies , 1980] , or Heat Increment of feeding [Cho and Kaushik , 1985] . This heat change can be measured using either indirect calorimetry [oxygen consumption] , or direct calorimetry [heat production] . method . This has been observed in molluscs [Crisp et al 1978] , insects [Heiman and Knight , 1975] , and crustaceans [Aldrich , 1975 ; Nelson et al , 1977] . A number of workers have made attempts to quantify Specific Dynamic Action , SDA [Muir and Niimi , 1972 , Hamada and Ida , 1973] ; Muir et al , 1976 ; Fletcher , 1983], all of whom investigated the effects of different feeding levels on the magnitude of the SDA .

Apparent SDA is influenced by fish size [Spencer , 1984] , meal size [Muir and Niimi , 1972 ; Pierce and Wissing , 1974], environmental temperature [Brett , 1976] and nutrient composition as well as dietary energy level [Jobling and Davies , 1980 ; Jobling , 1981; Fletcher 1986] .

Specific Dynamic Action is commonly expressed in energy terms as a percentage of the ration intake, the SDA coefficient [Smith et al , 1978]. These SDA coefficients are important in fish culture , as they are taken into consideration when constructing energy budgets for feeding and growth during holding and growing to table size [Solomon and Brafield , 1972; Pierce and Wissing, 1974] .

The aim of the present study was to investigate SDA in the African mud catfish, *Clarias gariepinus* . In contrast to most species previously investigated , *Clarias gariepinus* is largely an omnivorous and opportunistic feeder . The effect of protein level and pH on SDA were examined with a view to quantifying the oxygen consumption increment likely to be encountered in such a warm water species normally grown in an oxygen limiting environment .

MATERIALS AND METHODS

The fish

All experiments were conducted on *Clarias gariepinus* in the weight range , 48.1 - 66.0 g . the fish were tank - reared on fish meal pelleted diet and acclimated to laboratory conditions in rectangular glass tanks [160 x 30 x 30 : L X B X H], for two weeks, based on protein content

Experimental Diets

The diets were formulated in such a way as to produce 3 types of diets .based on protein content, namely : low protein [7% protein] , medium protein [25% protein] , high protein [40% protein] . A fish meal diet was included as control . The diets were extruded as pellets , dried and stored until needed .

Proximate analyses of the diets were done as follows : Moisture content [loss on drying at 105 o C for 12 hours] , Protein [Kjeldahl nitrogen x 6.57 for cereal - based ingredients / diets and x 25 for others [Osborne and Voogt , 1978] , Ash [residue after heating at 450 oC for 12 hours] , and Crude fibre was determined after AOAC [1990] .

All four diets were pelleted, dried and proximate analyses performed on them [Table 1].

Acclamitation of fish to the diets

The fish were fed on the control diets three times a day at 5% body weight . Any uneaten food was removed from the tanks by siphoning . When the fish began to feed on the pellets, feeding was reduced to twice per day .

Measurement of oxygen consumption

Changes in oxygen levels were measured using the micro- titration technique of Hach [1980] at 15 minute intervals one hour prior to feeding and 10 hours after feeding. Subsequently, determinations were made at 2 hourly intervals . The ' sampling regime was used for the determination of Ammonia produced , Spillet [1978] .

Experimental Protocol .

Each experimental fish was immersed in a bucket b containing 0.1 mg / l solution of benzocaine for two minutes by which time the fish was fully anaesthetised . The fish was then removed carefully wrapped in soft tissue paper to remove excess water . The fish were transferred to a top loading balance and weighed to the nearest 0.01 g , placed in a 1000 cc measuring cylinder cotaining a known volume of water to determine the fish volume . They were then transferred to a a five- litre glass aspirator and respirometer chamber each and left overnight to acclimatise.

Each experiment lasted for 24 hours . After an experiment , the respirometer chambers were filled with 1% Sodium hypochlorite solution for I hour , and then flushed thoroughly several times with cold water before being set up for the next run .

A background run was carried out making determinations continously at 2 hourly intervals for 24 hours . This was to investigate the diurnal variations in oxygen consumption at respiratory rate .

Sham - feeding Experiments

The fish were manipulated in the same manner as for the true - fed runs , the omission of the ration . This was to allow an estimation of the rise in oxygen consumption due to the behavioural activity of the fish during feeding .

Experiments to determine SDA:

Each fish was fed at 2% body weight . The pre-weighed food was introduced through the aperture on the top of the chambers . The oxygen consumption determinations were then carried out throughout the period, using the method of Adeyefa [1983] . Ammonia production was also measured to improve respiratory rate determination, using the method of Spillet [1978] .

Statistical Analyses

The means of the data generated compared using analysis of variance [ANOVA]. When a significant difference [$P < 0.05$] was noted a Scheffe test was applied to compare the means of the treatments .

RESULTS

The levels of carbohydrate , fat and protein used in this study were in the proportion of 1 : 0.3 : 2.0 for the control diet [Do] ; and 1 : 0.3 : 0.4 for test diet [D1] ; 1 .1.9 : 0.4 : 1.4 for test diet [D2] and 1 : 0.4 : 2.2 for test diet [D3 ; Table 1] .

The Specific Dynamic Action [SDA] magnitude [mg/kg/h] varied from 5.20 in the test diet D1 to 8.98 for pH 5.5 ; 5.49 in control diet Do to 6.48 in test diet D1 for pH 7.3 ; and 7.48 in control diet Do to 8.46 in test diet D3. SDA appeared to be higher in acidic and alkaline water than in neutral water environments [Table 2] . Oxygen consumption was very variable between individual fish in the sham feeding trials [Table 2] . Oxygen consumption was highly elevated after feeding the high protein control diet [D3] . In the low protein diet treatment , oxygen consumption was slightly elevated [Table 2] . In the medium protein diet [D2] treatment , oxygen consumption was highly elevated [Table 2] . In the high protein treatment, SDA was

observed after 1 hour in pH 5.5 and 8.6 treatments ; and 36 minutes in the pH 7.3 treatment , reaching a peak level of 126 %, 132 % , and 123% in the pH 5.5 , 7.3 , and 8.6 treatments respectively. The Sham feeding experimental and the resting stage SDA did not differ significantly. There was no significant effect associated with pH in all the treatments . The SDA coefficient which was the portion of ingested energy expended as SDA , ranged from 2.20 % 8.6 % [Table 2] .

Table 1 : Composition of experimental diets fed to *Clarias gariepinus* .

	DIETS			
INGREDIENTS	D0	D1	D2	D3
Fish meal	50.0			
Rice bran			5.0	5.0
Maize bran	30.0	60.0		
Sorgum bran			30.0	
Gruond nut leaf		20.0		
Ground nut hull			5.0	5.0
Ground nut cake			20.0	35.0
Cow pea hull			10.0	
Brewers waste				10.0
Feather meal			10.0	25.0
Corn oil	4.0	4.0	4.0	4.0
Cod liver oil	6.0	6.0	6.0	6.0
Mineral premix	4.0	4.0	4.0	4.0
Vitamin premix	2.0	2.0	2.0	2.0
Gum Arabic	4.0	4.0	4.0	4.0
Analysed				
Composition	100	100	100	100
Crude protein	40.1	7.3	25.4	39.6
Crude lipid	8.5	6.1	5.6	7.1
Gross Energy	18.4	18.0	18.8	18.2

DISCUSSION

The need to minimise stress in respiration experiments has been noted by Ahmed and Magid [1969] . Ross and Ross [1983] showed that an increase in respiration rate of up to 30 % was measurable in *Oreochromis niloticus* after handling . In this study , the stress-induced increase in oxygen consumption returned to normal during the acclimation period and did not affect SDA .

This result indicates a positive relationship between dietary protein levels and SDA in *C. gariepinus* as those fed the highest level of protein resulted in in the highest SDA responses . The results are similar to those of Jobling and Davies [1980] , and Jobling [1981] for Plaice ; and Spencer [1983] for *Oreochromis spirulus* .

The duration of the SDA are variable amongst fish , with values of 2 hours at 25% in *Oreochromis aureus* [Adeyefa , 1983] , and 26 hours at 20% in Plaice [Jobling , 1981] . In this study, it varied between 3 hours at pH 73 to 26.50 hours at pH 8.6 [at the temperature range of 25.5 - 270.

Table 2 : The effects of diet composition and pH on magnitude , duration and peak of SDA [values in the same column with the same superscript are not significantly different ; P > 0.05]

DIET	pH	Fish wt [g]	Diet ingre-dient [g]	Time of onset of SDA [h]	Duration [h]	Peak Level [%]	Time to attain peak level [h]	SDA [mgO2/k/ h	SDA Coeffici-ent [%]
	5.5	48.1^{a}	0.36	0.50	9.5^{b}	121^{a}	3.0	8.12	3.3^{b}
D0	7.3	50.3^{a}	0.22	0.50	13.5^{a}	113^{b}	3.50	5.49	2.2^{b}
	8.6	46.2^{a}	0.21	0.50	16.5^{a}	123^{a}	5.00	7.48	8.1^{a}
	5.5	53.0^{a}	0.21	0.50	7.5^{c}	123^{a}	3.00	5.20	7.6^{a}
D1	7.3	51.2^{a}	0.22	1.00	3.00^{d}	123^{b}	5.00	6.74	8.6^{a}
	8.6	50.4^{a}	0.20	0.50	10.50^{b}	113^{b}	5.00	7.51	7.0^{a}
	5 .5	61.3^{b}	0.34	0.50	16.00^{a}	113^{a}	5.00	6.98	7.6^{a}
D2	7.3	66.0^{b}	0.30	0.50	15.00^{a}	123^{a}	3.50	6.27	7.3^{a}
	8.6	60.2^{b}	0.33	0.50	14.00^{a}	123^{a}	2.50	2.35	7.4^{-}
	5.5	62.1^{b}	0.36	1.00	10.00^{b}	126^{a}	2.50	7.20	6.7^{a}
D3	7.3	64.3^{b}	0.34	0.50	5.00^{c}	132^{c}	4.50	5.99	4.9^{ab}
	8.6	61.0^{b}	0.34	1.00	7.50c	123^{a}	3.50	8.46	5.7^{ab}
SEM		6.60	0.25	0.22	4.10	5.14	0.97	1.19	1.80

Published values of SDA coefficient vary from 1.30% for *Lepomis macrochirus* fed on mayfly larvae [Pierce and Wissing , 1974] to 16.1% for Plaice fed on minced sprat [Jobling and Davies , 1980] and 1.72 - 13.7% obtained for *Oreochromis spirulus* fed mixed substrates by Spencer [1984]

In the present study , values obtained ranged from 2.2% in fish fed fishmeal diet to 8.6% in fish fed low protein with no animal protein .

A direct relationship between SDA and pH has not been found in this study . This agrees with Muir and Niimi [1972] . Brett [1976] , and Jobling and Davies [1980] , who associated SDA with meal size , fish size , ambient temperature , food composition and energy content respectively , but not pH . SDA has obvious implications for fish culture in terms of the design and management of intensive culture systems . Such intensive culture systems might be the next step in the farming of catfish, *C . gariepinus* in Nigeria and other developing countries .

REFERENCES

Adeyefa , A .[1983] : Studies on Specific Dynamic Action in *Oreochromis aureus* Unpublished M . Sc . Thesis 173pp .

Ahmed, M. D.[and Magid, A. M. A.[1969]: Oxygen consumption in *Tilapia* L., *Hydrobiologia* **33**:523 - 532 .

Aldrich , I . C [1975] : On the relationship between oxygen consumption and feeding level in decapods . In proceedings of the 9th European Biological [H . Barnes ed .] pp 407 - 418 Aberdeen University Press .

AOAC [Association of Official Applied Chemists] [1990] : Official methods of Analyses of the *AOAC. W. Horwitz [Editor] Arlington , Washington , D . C .*

Brett I . R . [1976] : Feeding metabolic rates of young sockeyesalmon, *Onchorhynchus nerka* in relation to ration level and temperature. *Fish . Mar. serv. Res . Tech . Report* . 673 ; 43 pp .

Broody . S .[1945]: Bio- Energetics and Growth . Hafeur publ . Inc . New York 1032 pp .

Cho . C . Y . and Kaushik , S . J . [1985]: Effects of protein intake on metabolisable net energy Values of fish diets . In Nutrition and feeding in fish . Academic Press , London . 489pp .

Fletcher, D . J [1983] : Digestion and the Dynamic control of appetite in the dab [*Limanda limanda* L .]. Unpublished Ph . D . Thesis of Aberstmth University 187pp .

Garrow J . S . [1974] Energy Balance and obesity in man . Armsted and London,North - Holland .

Crisp , M . ; Davenport , J . & Shummay , S . E . [1978] : Effects of feeding and of Chemical Stimulation on the oxygen uptake of *Nassarius resticulates* *Journal of Marine Association of U . K* . 52 : 387 - 399 .

Hach [1980] Field kit manual for Analyses of water samples. Hach company. Germany.

Hamada , A . & Ita , T . [1973] : Studies on Specific Dynamic Action : Of factors affecting Values of measurements . *Bulletin of the Japanese Society of Scientific Fisheries* **35** : 1231 - 1235 .

Heiman , D . R . & Knight , A . M . [1975] : The influence of temperature on the Bio - Energetics Of the carnivorous stonefly nymph [*Actoneuria carlifornia.* Banks, Placoptera; parlidae], *Ecology* **56** : 105 - 116 .

Jobling , M . [1981] The influence of feeding on the metabolic rate of fishes : A short review . *Journal of fishery Biology* **18** :385 - 400.

Jobling , M . & Davies P . S . [1980] Effects of feeding on metabolic rate and Specific Action In Plaice , Pleunectes platessa L . *Journal of Fisheries Biology*, **223**: 549 - 555 .

Muira , T ; Suzuki , N ; Nagoshi N . & Yamamura , K . [1976] : The rate of production and food Consumption of the bimamasu , *Onchorynchus rhodurus* population in lake Biwa , Reg . pop . *Ecol* . **17** : 1355 - 1364 .

Muir , B . S . & Niimi , A . J . [1972] Oxygen consumption of the eurhaline fish aholehole [*Khulia sanduiceosis*] , with reference to salinity , swimming and food consumption . *J . Fish . Res . Bd . Can* . **29** : 57 - 77 .

Nelson , S . G . Knight , A . M . & Li , H . W . [1977] ; The metabolic cost of food utilisation And Ammonia production by juvenile Macrobranchium rosambergi [crustacean , paleomonidae] Comp . *Boichem . Physiol* . **57 A** : 67 - 72 .

Oaborne , D . R . & Voogt , P . [1978] *The analyses of Nutrients in foods* . Academic press, London ,84 pp

Pierce , R . J . & Wissing , T . S . [1974] Energy cost of food utilisation in the luegill, *Lepomis macrochirus] . Trans . Am . Fish . Soc* . 103 : 38 - 45 .

Ross B . & Ross L .[1983] : The oxygen requirements of *Oreochromis niloticus* under adverse Conditions . 1st Int . Symposium on tilapia culture; Nazareth , May.

Smith , R . R . ; Ramsay , G . L . & Scott , M . L . .[1978] Heat increament associated with dietary Protein , fat , carbohydrate , and complete diets in salmonids: Comparative Energetic Efficiency. *J . Nutr* . **108** : 1025 - 1032.

Solomon D . J . and Brafield , A . E . [1972]: The Energetics of feeding : Metabolism and Growth of perch, [*Perca fluviatilis*] *Journal of Applied Ecology* , **41** : 699 - 718 .

Spencer R . J . [1984] The effect of dietary protein level and meal size on Specific Dynamic Action , In *Oreochromis spirulus* Unpublished B . Sc . Thesis ,University of Stirling , 63 pp .

Spillet P . D . [1978] The nutrition and energy relationship of the fish , *Perca fluviatilis* and *Carassius auratus* .Unpublished Ph . D . Thesis , University of London , 189pp .