Bull. Fac. Agric., Cairo Univ., 51
(2000): 283-292.

ESTIMATES OF HERITABILITIES OF SOME MORPHOMETRIC AND BLOOD TRAITS IN JUVENILE NILE TILAPIA FROM HALF-SIB MATINGS

(Received:2.9.1999)

By
M.A. Elnady, A. M. Obeida and H.A. Hassanien

Animal Production Department, Faculty of Agriculture, Cairo University

ABSTRACT

In the present work the genetic variability of 17 body and blood traits in Nile tilapia was studied. Twelve half-sib families of Nile tilapia (*Oreochomis niloticus*) were constructed and reared separately to 23.27g. Estimation of genetic parameters was based on the performance of 25 offspring per family.

Estimates of heritability for body weight (0.34), standard length (0.53) and SGR (L) (0.99) showed reasonable values. Both body depth and body width showed reasonable estimates of heritability being around one third. The four blood traits studied were over one. Estimates of heritability for head length (0.11), total length (0.17) and gill rackers (-0.54) were small. Estimates of heritability for condition factor (1.71), trunk length (1.02), tail length (1.38) and SGR (W) (1.39) were over one. Estimates of genetic correlation between body weight and body length (0.86), standard length and total length (0.74), standard length and body width (0.813), body width and trunk length (0.758) and body depth and trunk length (0.676) were all positive, significant and very high. This means that selection for one of them will yield an increase in the other positively in the same direction.

The improvement in body weight will be much greater indirectly if we select for the standard length and directly for body weight since heritabilities for these characters are high and the genetic correlations among standard length, body weight, trunk length, body width and body depth were positive and high. These characters are genetically and phenotypically correlated with Nile tilapia production. It is concluded that the most important traits that should be used in genetic improvement for market weight in Nile tilapia are standard length and body weight which are

easy to measure on fish without injuring offspring. The results suggest that these two characters are the best indicators as selection index for Nile tilapia.

Key words: *blood traits, genetic correlations, heritabilities morphometry, tilapia.*

1. INTRODUCTION

Reliable estimates of genetic and phenotypic parameters are needed for all traits of economic importance to predict responses to selection, and see if they change through selection practiced on other traits (Gjerde and Schaeffer 1989). Consequently, research emphasis has been placed on estimation of the genetic parameters for growth traits and on the prediction and measurement of selection response (Hershberger *et al.*,1990). Most of the traits that are sought to improve through selection in aquaculture species can be desribed as metric characters, often involve the end result of complex physiological functions that are measurable as some simple parameters (Lutz, 1996).

The objectives of the present study were to determine genetic parameters for 17 traits in commercially cultured Nile tilapia (*Oreochromis niloticus*) to evaluate the genetic and phenotypic performance of this species and to identify the best traits to be used in breeding programs for greater growth. The experiment provided estimates of the variability of these traits including genetic and environmental variances. Consequently, more knowledge will be available for multi-trait selection programs to be used in future studies.

2. MATERIALS AND METHODS

The current study was performed in the Fish Culture Unit,Faculty of Agriculture,Cairo University.In the present study,the genetic parameters (heritabilities, genetic correlations,phenotypic correlations,and environmental correlations) for 17 traits were investigated. Twelve half-sib families of Nile tilapia (*Oreochromis niloticus*) were reared separately to 23.27g. Estimation of genetic parameters was based on the performance of an average of 25 offspring per family.

The following traits on offspring were recorded: body weight, body length, standard length, head length, tail length, trunk length, body depth, body width, snout length, number of gill rackers, specific growth rate for weight (SGR (W)), specific growth rate for length (SGR (L)), condition factor and: serum total protein, albumin, lactate dehydrogenase and alkaline phosphatase.

Brood stock were randomly selected for mating . Twelve concrete tanks (2.5 m^3 each) filled with water to 80 cm depth were used to breed Nile tilapia . Each concrete tank contained one family (one sire and three dams). Spawnig took place in August during summer 1997. The offspring (0.2 gram) were reared for 75 days in the same concrete tank after removal of the parents. When offspring were large enough (>5g), the number of fish in each half-sib family were randomly reduced to 25 fish per family to avoid critical rearing densities and reared in glass aquaria for 112 days post-transfer.

Water temperature ranged from 18 to 25 °C during rearing in concrete tanks and were maintained at 24 to 26°C in glass aquaria. All body traits as well as blood traits were recorded once at the end of the experiment. The additive genetic variance, the environmental variance and the phenotypic variance components for all traits were determined according to Fortran program by simultaneous solution of the mean squares. Phenotypic, genetic and environmental correlation coefficients for data on all traits were calculated from variances and covariances.

3. RESULTS AND DISCUSSION

3.1. Heritabilities

The estimates of heritability had a value of 0.34 for body weight and 0.53 for standard length (Table 1). These results indicated that selection for both traits will yield reasonable potential to selection improvement in growth rate and consequently body weight.

Both body depth and body width showed reasonable estimates of heritability being around one third. They seem to be reasonable values. One can depend on these results for a selection program.

Moreover, estimates of heritability for trunk length showed values more than one. These vague values could be explained as a likely results of the artificial environmental conditions under which the population was raised(tank effect) .

Kronert *et al.*, (1989) found that heritabilities for body weight ranged between 0.60-0.70 and 0.30 – 0.37 for Nile tilapia based on full-sib and half-sib analysis, respectively.In the red tilapia, realized heritability estimates were 0.17 for body length and 0.19 for body weight (Jarimopas, 1986).

Estimates of heritability for body weight (0.34) , standard length (0.53) and SGR (L) (0.99) showed reasonable values. Estimates of heritability for head length (0.11), total length (0.17) and gill rackers(-0.54) were small.

Table (1). Estimates of heritabilities (± SE) for biometeric and blood traits.

Character	Heritability	Character	Heritability	Character	Heritability
1-body weight	0.338 ± 0.288	7-trunk length	1.025±0.444	13-SGR(L)	0.991±0.438
2- body length	0.179±0.237	8-snout length	0.762±0.392	14-TP	1.413±0.511
3- standard length	0.532±0.119	9-No of gill rackers	-0.052±0.140	15-ALB	1.225±0.480
4-condition factor	1.711±0.588	10-body depth	0.334±0.286	16-LDH	3.190±0.747
5-head length	0.111±0.212	11-body width	0.17±0.281	17-ALP	2.189±0.625
6-tail length	1.387±0.507	12-SGR (W)	1.397±0.508		

Owing to the fact that the population under study was unselected and this was the first time for estimating these genetic parameters on the population, it is assumed that some traits will show large estimates of heritability. Condition factor trait showed an estimate for heritability over one (1.71). Moreover, estimates of heritability for trunk length (1.02), tail length (1.38) and SGR (W) (1.39) were over one.

No single estimate of (h^2) for the four characters of blood serum was reasonable, all values were more than one. Those blood serum traits may be affected by the nature of cold-blooded animal physiology, or the artificial environmental conditions in rearing tanks. This also may be due to the unharmony of population since no selection practice was done for these parameters on the population under study. Zycznski *et al.,* (1995) indicated that possible causes of overestimation (> 1.0) are maternal and tank effects during separate rearing.

The heritabilities for body weight in Nile tilapia were 0.3 to 0.4, in combination with the high genetic variability, even indicates promising responses for selection on an individual basis (mass selection) (Kronert *et al*., 1989). The estimated heritabilities in *Oreochromis niloticus* indicated that all traits of body development are clearly genetically controlled. Moreover trait variability suggests very promising chances for selective changes in growth (Kronert *et al*., 1989).

3.2. Genetic correlations

Estimates of genetic correlation between body weight and body length was very high and significant being 0.86 (Table 2). This estimate means that the transferrable genes from parents to offspring are almost the same for both characters, the accuracy here is about 0.74 (r^2). The same holds true with the correlation between standard length and body length which showed reasonable estimate of 0.74. The above results indicated that selection for these two characters, body weight and standard length may give a clear-cut selection pressure. Selection pressure for one of the characters will improve significantly the other.

To design a breeding program, heritabilities, phenotypic variances, economic values for all traits under selection and the genetic and phenotypic correlations between traits should be known (Bailey and Loundenslager, 1986).

Condition factor trait showed negative and insignificant correlations with body weight, standard length and body length . A positive genetic correlation between body weight and condition factor should be considered unfavourable from a marketing point of view since a normally shaped fish is preferred by the market (Pontus and Kjell, 1993). Since condition factor can be easily calculated for live fish by including body length, it should have value as trait for use in negative indirect selection for the amount of visceral fat deposits. Direct selection for a decrease in condition factor is not to be recommended (Pontus and Kjell, 1993).

In this connection (Ankorion *et al.*, 1992) reported that bidirectional mass selection for the ratio of height/length in *Cyprinus carpio* generated a response in both directions. They found that heritability was 0.47 and 0.33 for up and down selection, respectively. This means that body shape of common carp can be changed rapidly by mass selection. The result may be applied in aquaculture by selecting for an increasing ratio of height/length if high backed fish have some advantage such as a higher price or improved market acceptance.

Lactate dehydrogenase correlated positively and significantly with both SGR (W) and SGR (L), being 0.50 and 0.73 , respectively. Moreover, SGR (W) correlated positively with total protein lactate dehydrogenase which has a great role in regulating growth in weight and length in fish . This may be due to the fact that this blood character plays a role in metabolic activities.

Body depth correlated significantly and positively with body width. This means that selection for one of them will yield an increase in the other positively in the same direction. There were highly significant correlations among body weight, body depth and body width which mean almost that the same genes transmitted from parent to offspring are the same for the three characters.

Trunk length correlated positively with body weight, body length and standard length being 0.71, 0.69 and 0.98, respectively. This proved that selection for trunk length will cause a great improvement in the three mentioned characters. Meanwhile, body depth and width were found to be correlated positively with trunk length being 0.676 and 0.758, respectively. Head length correlated negatively and highly significant with SGR (L) being –0.829.

Only standard length showed a highly significant genetic correlation (0.83) with body width, which means that growth is isometric in Nile tilapia in young stages. Due to the fact that the three above-mentioned traits (body weight, body depth, and body width) had almost the same hertiability magnitudes, selecting for one of them will potentially lead to improvement in the others . The improvement in body weight will be much greater indirectly if the standard length is selected.

Selection of stocks to be used for aquaculture would be simplified if stock performance under culture conditions could be predicted from phenotypic characteristics of natural populations (Wither, 1987).

3.3. Phenotypic correlations

The phenotypic correlations between the three body traits: body weight, body length and standard length are shown in Table (2). The weight, length and condition factor were genetically and phenotypically correlated with production ability in rainbow trout (*Oncorhynchus mykiss*) (Sylven and Elvingson, 1992). Common environmental effect may result from the competition for space *within* families owing to the particular rearing procedures used for the experiment (Su-Guo-Sheng *et al.*, 1996).

Body depth showed a very high significant phenotypic correlation with body width being 0.91. Meanwhile the correlation obtained between specific growth rate for weight and length is positive and highly significant.For planning effective breeding programs, information on phenotypic variability and amounts of additive genetic variation for characters to be improved is necessary(Nilsson,1994).The development of selection programs requires knowledge of the genetic and environmental parameters and the potential for genotype by environment (GE) interaction (Winkelman and Peterson 1994 a & b).

The phenotypic correlations found among body weight, body length, standard length and trunk length were all very high and significant ranged between 0.44 and 0.85 Table (2). Weight and length measurements taken early in the production cycle are logical candidates as predictors of subsequent performance. Length may be a useful predictor of weight since it does not require a scale (Winkelman and Peterson, 1994 a & b).

Based on heritability estimates for body weight, standard length, body depth, body width and specific growth rate , great genetic improvement is expected in these characters in Nile tilapia. It is concluded that there are four traits of economic importance in Nile tilapia through selection: body weight, body depth, body width and standard length. The selection for these traits would improve meat yield (dressout percentage) than that for total length since the head region is considered inedible part. In selection programs these four traits should be included in a selection index.

Table (2). Estimates of phenotypic (above diagonal) and genetic (below diagonal) correlations for biometeric and blood traits.

Characters	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
A- Body weight		0.95	0.92	0.22	0.85	0.43	0.82	0.77	0.77	0.92	0.92	-0.09	-0.31	0.01	-0.01	-0.07	-0.05
B- Body length	0.86		0.93	0.11	0.87	0.53	0.83	0.75	0.76	0.90	0.88	-0.16	-0.21	0.00	0.00	-0.02	-0.03
C- Standard length	0.80	0.74		0.10	0.81	0.19	0.95	0.70	0.68	0.88	0.87	-0.13	-0.25	0.01	0.00	-0.03	0.02
D-Condition factor	-0.07	-0.08	-0.11		0.16	0.04	0.06	0.08	0.15	0.20	0.29	0.03	-0.16	-0.14	-0.06	-0.01	-0.03
E- Head length	0.29	0.07	-0.02	-0.18		0.47	0.59	0.68	0.71	0.86	0.83	-0.26	-0.37	0.03	-0.04	0.00	0.01
F- Tail length	-0.33	-0.10	-0.74	0.08	0.10		0.03	0.41	0.48	0.39	0.36	-0.14	0.02	-0.12	0.00	0.02	-0.02
G- Trunk length	0.71	0.69	0.98	0.09	-0.22	0.75		0.60	0.56	0.75	0.76	-0.05	-0.16	0.03	0.02	-0.05	-0.05
H- Snout length	0.67	0.69	0.46	-0.25	0.50	0.01	0.34		0.64	0.67	0.71	0.00	-0.13	0.15	0.12	0.09	0.08
I- No of gill rackers	0.16	-0.02	-0.40	-0.35	0.36	0.58	0.50	0.23		0.72	0.69	-0.17	-0.24	-0.05	-0.05	0.00	-0.09
J- Body depth	0.91	0.64	-0.68	0.07	-0.17	-0.37	0.67	0.47	0.01		0.90	-0.12	-0.32	0.01	-0.40	-0.07	-0.05
K- Body width	0.90	0.73	-0.81	0.18	0.06	-0.47	0.75	0.59	-0.10	0.93		-0.08	-0.31	0.00	-0.03	-0.04	0.00
L- SGR (W)	0.38	0.24	0.36	-0.19	-0.12	-0.28	0.34	0.41	0.19	0.64	0.49		0.62	0.15	0.10	0.19	0.15
M- SGR (L)	-0.50	-0.36	-0.19	-0.08	-0.82	-0.06	-0.05	-0.11	-0.64	-0.22	-0.28	-0.57		0.00	0.01	0.01	0.02
N- TP	0.35	0.40	0.18	-0.33	0.05	0.13	0.15	0.74	0.27	0.18	0.22	0.49	0.18		0.84	0.35	0.28
O- ALB	0.20	0.46	0.13	-0.26	0.21	0.25	0.08	0.66	0.32	-0.03	0.12	0.32	-0.26	0.91		0.35	0.41
P- LDH	-0.29	-0.11	-0.14	-0.09	-0.26	0.10	-0.11	0.06	-0.23	-0.34	-0.21	0.50	0.73	0.64	0.81		0.44
Q- ALP	0.32	0.65	0.24	-0.06	0.51	0.28	0.13	0.67	0.63	0.20	0.42	0.36	0.28	0.64	0.85	0.67	

4. REFERENCES

Ankorion Y., Moav, R. and Wohlforth, G. W. (1992). Bidirectional mass selection for body shape in common carp. Genet. Sel. Evol., 24: 43 – 52.

Bailey J. K. and Loundenslager, E. J. (1986). Genetic and environmental components of variation for growth of juvenile Atlantic salmon (*Salmo salar*). The Second International Symposium on Genetics in Aquaculture. Gall, G. A. and Busack, C. A. eds., 57: 125 – 132.

Gjerde B. and Schaeffer, L. R. (1989). Body traits in rainbow trout 2.Estimates of heritabilities and of phenotypic and genetic correlations. Aquaculture, 80: 25 – 44.

Guo-Sheng, S., Liljedahi, L. E. and Gall, G. A. (1996). Genetic and environmental variation of body weight in rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 144: 171 – 180.

Hershberger W. K., Myers, J. M., Wamoto, R. W., Macauley, W. C. and Saxton, A. M. (1990). Genetic changes in the growth of coho salmon (*Oncorhychus kisutch*) in marine net pens, produced by ten years of selection. Genetics in aquaculture III. Gjedrem, T. –ed., 85 (1-4): 187 – 197.

Jarimopas P. (1986). Realized response of Tai red tilapia to weight-specific selection for growth. P.109 in J.L. Maclean, L.B. Dizon and L.V. Hosillos (eds.). The first Asian fisheries forum. Asia Fisheries Society, Manilla, Philippines.

Kronert U.,Horstgem-Schwork G. and Langhoiz, H. J.(1989). Prospects of selecting for late maturity in tilapia *Oreochromis niloticus*. I. Family studies under laboratory conditions.Aquaculture,77: 121 – 133.

Lutz C. G. (1996). Quantifying genetic variance: Heritability. Aquacult. Mag., 22: 79 – 86.

Nilsson J. (1994). Genetics of growth of juvenile Arctic charr. Trans. Am. Fish. Soc., 123: 430 – 434.

Pontus E. and Kjell, J. (1993). Genetic and environmental components of variation in body traits of rainbow trout (*Oncorhynchus mykiss*) in relation to age. Aquacult., 118:191-204.

Sylven S. and Elvingson P.(1992). Comparison of rainbow trout (*Oncorhynchus mykiss*) strains for body weight, length and age at maturity in different Swedish production systems. Aquaculture, 104: 37 – 50.

Winkelman A. M. and Peterson, R.G. (1994a).Heritabilities, dominance variation, common environmental effects and genotype by environment interactions for weight and length in *Chinook salmon*. Aquaculture, 125: 17 – 30.

Winkelman A. M. and Peterson, R. G. (1994 b). Genetic parameters for body weight and length of *Chinook salmon* after 9 and 22 months of saltwater rearing. Aquaculture, 125 : 31 – 36.
Wither R. E. (1987). Genetic variation in flesh pigmentation of *Chinook salmon* (*Oncorhynchus tshawytscha*). Aquaculture, 18: 421 – 429.
Zyczynski A., Olech, W., Dobosez, K., Goryczko, K. and Kohlmann, K. (1995). An attempt to evaluate the genetic parameters of rainbow trout (*Oncorhynchus mykiss*) population. Fortschr – Fischereiwiss. ADV. Fish. Science, 12: 77 – 83.

تقدير المكافىء الوراثي لبعض الصفات المظهرية وخواص الدم في صغار البلطي النيلي بإستخدام العائلات أنصاف الأشقة

محمد النادى أحمد ، على عبيده ، هشام عبدالله حسنين

قسم الإنتاج الحيوانى – كلية الزراعة – جامعة القاهرة

ملخص

تم في هذا العمل دراسة التباين الوراثي لـ 17 صفة من صفات الجسم والدم في البلطي النيلي عن طريق تكوين 12 عائلة أنصاف أشقة وتربيتها منفصلة حتى عمر ثابت. وقد بلغ المتوسط العام فى جميع العائلات لوزن الجسم 23.2 جرام عند نهاية التجربة.وقد تم قياس جميع المؤشرات الوراثية باستخدام 25 سمكة في العائلة الواحدة . كانت الصفات التي تم تقديرها علي الجسم والدم هى : وزن الجسم – طول الجسم – الطول القياسي – طول الرأس – طول الذيل – طول الجذع – عمق الجسم – سمك الجسم – طول الأنف – عدد الأشواك الخيشومية – معدل النمو النوعي للوزن – معدل النمو النوعي للطول – معامل الحالة – البروتين الكلي في السيرم – الالبيومين – إنزيم اللاكتات ديهيدروجينيز و إنزيم اللكالاين فوسفاتيز.

وقد كانت قياسات المكافيء الوراثي لوزن الجسم (0.34) وطول الجسم القياسي (0.35) ومعدل النمو النوعي للطول (0.99) ذات قيم معقولة . و كانت قياسات المكافيء الوراثي لعمق الجسم وسمك الجسم الثلث تقريباً. أما قياسات المكافيء الوراثي لطول الرأس (0.11) وطول الجسم الكلي (0.17) وعدد الأشواك الخيشومية (–0.54) فقد كانت منخفضة . وثمة بعض الصفات ذات قيمة مكافيء وراثي أكبر من (1) وهي معامل الحالة (1.71) وطول الجذع (1.02) وطول الذيل (1.38) ومعامل النمو النوعي للوزن (1.39) .

وقد كان الارتباط الوراثي بين وزن الجسم وطول الجسم (0.86) والطول القياسي للجسم والطول الكلي للجسم (0.74) والطول القياسي للجسم وسمك الجسم (0.813) وسمك الجسم وطول الجذع (0.758) وعمق الجسم وطول الجذع (0.676) موجبا ومعنويا ومرتفعا. وهذا يعني أن الانتخاب لصفة واحدة من هذه الصفات سوف يؤدي إلي الزيادة الموجبة في الصفات الأخرى في نفس الاتجاه .

ونستطيع تحسين وزن الجسم بكمية أكبر إذا أجرينا الانتخاب غير المباشر علي صفة الطول القياسي للجسم أو أجرينا الانتخاب المباشر على صفة وزن الجسم مباشرة لأن الإرتباط الوراثى ما بين صفات الطول القياسى للجسم ووزن الجسم و طول الجذع وعمق الجسم وسمك الجسم موجب ومرتفع .ويتضح أن هذه الصفات مرتبطة وراثيا ومظهرياً مع صفات الإنتاج في البلطي النيلى.

ونستخلص من هذه الدراسة أن أهم الصفات التي يجب أن نستخدمها لتحسين الوزن النهائي للجسم في اسماك البلطي النيلي هي صفات الطول القياسي للجسم ووزن الجسم حيث أنها سهلة القياس علي الأسماك .

المجلة العلمية لكلية الزراعة -جامعة القاهرة- المجلد (51) العدد الثالث (يوليه 2000):283-292.