

Estimation of some genetic parameters of Carp Fish (*Cyprinus Carpio*)

Ahed Alhelue*⁽¹⁾, Allaa Abed Alrazak AL-Haj⁽¹⁾ and Mohamed Alkhalf⁽¹⁾

(1). Department of Animal Production, Faculty of Agriculture, University of Aleppo.

(*Corresponding author: Ahed Alhelue. E-Mail: ahedalhelue27@gmail.com).

Received: 5/ 09/ 2023 Accepted: 15 / 09/ 2023

Abstract:

This study was conducted in a private fishery at the Sheikh Saeed area - Aleppo province - Syria on carp fish, to improve some productive traits and estimating their genetic indicators, through flock selected previously for the best productive characteristics. In this experiment (50 fish) were used. Productivity measurements were taken for some meat production traits (live body weight, total length, body depth, head length) from the age of marketing (6-7 months) until the age of sexual maturity (1.5-1 years). The results indicated that the estimates of the heritability for some productive traits were (0.50, 0.43, 0.37, 0.27) for (total length, total weight, body depth, and head length respectively), while the estimates of the genetic correlation between the live body weight trait with both total length and body depth were positive and relatively high, while the genetic correlation coefficients between the most of the productive traits were negative and relatively low, while the estimates of the phenotypic correlation between total length and (live weight, body depth, head length) were positive and relatively high.

Keywords: common carp, selection, genetic parameters, phenotypic correlation.

Introduction:

The fishery is one of important sectors that countries depend on it as it is an essential part in components of these countries' food security strategies especially for Arab food level, and it is considered as one of the sectors that opens unlimited vacancies for unemployed Arab people. The increase in fish consumption, which is increasing with the increase in population and economic growth worldwide is an indication of the huge potential required for the development of fish farming and an accelerated expanding in aquaculture is the solution to fill the growing gap between supply and demand for fish. (Beveridge et al., 2013).

The most important goals for fish selection are: increasing in growth level by well using of feed, increase in hypoxia resistance in high or low level of temperature or high salinity or any disturbances in normal environmental conditions, and it helps to improve the resistance to infectious diseases and parasites (by develop a new dynasties which is resistance to specific diseases), It also improves the nutritional value of fish (like increase calories, reduce the amount of inedible parts, reduce the amount of bones, and increase or reduce the amount of fat,...etc. (Kirpichnikov et al., 1966).

Cyprinus Carpio fish is one of the oldest and the most important domesticated type for aquaculture which has a big trade value as a resource for a human's food. It was entered a different regions of world and the secondary global production is more than 22% in 2022 and it was about 14% from all

aquaculture in pure rivers water, *Cyprinus Carpio* production have increased with world average 9.5% between 1985-2002 (FAO, 2012), and the study showed that the successful selection of mothers (male and female) used in hatching is the first step in a correct direction to get a high production in a fish culture (Mousli..., 2016).

In a study in which genetic indicators of productive traits were estimated in 3 year old common carp that were raised collectively in semi-intensive pond conditions, and the slaughter yield had high heritable, where $h^2=0.46$. for the yield of the headless carcass, and for a crop fillet had 0.50 also, they were closely related to each other $rg=0.96$, therefore the results showed that there is a strong possibility for genetic improvement of the yield through the selection of predictive traits recorded for common carp (Prchal et al., 2018).

The genetic correlations between most growth traits were ranged from (0.77- to 0.97) among all growth related traits and heritability estimate was recorded: 0.20 ± 0.11 , 0.28 ± 0.14 , 0.23 ± 0.16 , 0.14 ± 0.11 , 0.12 ± 0.09 for weight, height, head long, total height and long of body, respectively in carp aged seven months old (Chen et al., 2022).

An experiment was carried out by crossing 147 individuals aged two years old (2 males with 8 females) of *Carpio* fish which grew during 3 seasons. ; it had a high genetic susceptibility (<0.5), while the relative body height, relative body width and the percentage of treated body production and slides had an average heritability (0.2-0.5). The experiment also, showed a relatively high genetic relationship between body size (standard height and body weight) and fat percentage (0.71-0.59), as well as positive genetics correlation between body size and the proportion of the treated body (0.69 for standard height and 0.74 for body weight), and between body size and meat productivity (0.50-0.77). The genetic relationship between body size and body shape (relative head length, relative body height, and relative body width) were weak to moderate, so that the selection for best growth should have little effect on the more rounded shape as the relative head length had a strong negative correlation from -0.7 to -0.9. (Kocour et al., 2007).

In research on Carp fish the genetic indicators of body weight at about two years of age, $h^2 = 0.17$ the results also showed that body weight or other traits related to growth will continue to respond to selection, so that selection to increase body weight led to a significant improvement in growth of the current group of common carp (Dong et al., 2015).

In a study on the productive traits of Deniz fish, growth was heritable 0.37-0.25, the genetic correlations coefficients between growth traits were high and positive, and indirect selection for growth traits helped a well-predicted response (Bernabeu et al., 2021).

In other study on Turbot fish for morphometric growth traits, it found the heritability for the weight trait was ranged from 0.56 to 0.49, while the heritability estimates for all other traits were low to medium (0.29-0.04), and the genetic correlations between weight-related traits were positive and ranged from 0.70 to 0.99 (Schlicht et al., 2019).

Estimates of heritability in fish groups remain rare, and in a research which size was estimated for fish at maturity (body length immediately before mating), the heritability was moderate (0.27), while the genetic correlation was high (0.96) between age and size trait (Reed et al., 2018).

Mello et al (2016) studied the genetic parameters and estimated the components of variance for body weight of Carp fish at the age of 12-24 months. They results showed that the estimates of the heritability for body weight and morphological characteristics were high and ranged between 0.17 – 0.46, and for the daily weight gain had the highest estimate of the heritability ($h^2 = 0.49$), however the effect of the environment showed a percentage of 20% on total body depth variance.

The heritability of body measurements ranged from 0.4-0.6, for fish standard lengths, and the phenotypic correlations between body weight and length of body was high and ranged from 0.64 to 0.89; while phenotypic correlation between body weight and visceral weight was 0.48; and the genetic correlation was 0.20 (Karisa et al...,2007).

Aim of study:

- Estimating the heritability coefficient for all the studied productivity indicators.
- Estimating the correlation coefficient (genetic, and phenotypic) for some of the studied traits.

Materials and Methods:

The present study was conducted in a fishery located in Sheikh Saeed area - Aleppo countryside during the period from 2021-2023 for three groups of carp:

* Group 1: Basal population.

* Group 2: selected parents.

* Group 3: offspring group.

The ponds have a base of cement and hard soil with a depth of 3 meters, and the water in it has a volume of 500 m³, and it was renewed daily, basis to provide dissolved oxygen in the water with sufficient quantities, as the water temperature was between 21-27 °C, and its need for oxygen was ranged between 0.3-0.5 mg. liter of with PH ranged between 6.5-9.

Fish feeding in the early stages of life, included meat, well ground liver bread, bran and bulgur, in addition to alfalfa and azolla plants; poultry waste is introduced on the tenth day as a main feed to reach a high weight in a short period, and it continues to feed on the waste until the age of marketing 6-7 months.

The selection involved males and females, with ratio of 2:1, where each female needs two males, , the experiment continued from marketing age (7 months) up to sexual maturity age (1.5 years), as their body were free from bruises, wounds, and parasites, and their genitals were free from deformities; the male was distinguished from the female by observing its reproductive system, the female has a relatively wide genital opening with a red nipple, while the male's genital opening is was white, with small, prominent in the shape of a letter V (Warda., 2021).

The study was focused on estimating some genetic parameters such as heritability, phenotypic genetic, genetic correlation; and also phenotypic correlation.

1- Heritability :

Heritability was estimated from the relationship between parents and offspring, using dam components of variance:

$$h^2 = \sigma^2_A / \sigma^2_P = 2 b_{AP}$$

h^2 : heritability, b_{AP} : Regression coefficient of the breeding value of the trait by its phenotypic value, σ^2_A : additive genetic variance, σ^2_P : Phenotypic variance.

Heritability estimated for productive traits including (weight, total length, head length, body depth, standard length, mouth diameter, horizontal eye diameter, snout length, dorsal fin base and caudal peduncle length) in all selected individuals, basal population and offspring.

2- Genetic Correlation (r_g):

Genetic correlation coefficient was estimated between pairs of some productivity traits (weight, total length, body depth, head length from the relationship between Parent and Offspring according to the following equation:

$$r_g = (\text{cov } z1x2 + \text{cov } z2x1) / 2\sqrt{(\text{cov}z1x1)(\text{cov}z2x2)}$$

r_g : Genetic correlation coefficient cov: Covariance, z: Data taken on offspring, x: Data taken on the dam, 1: First studied trait, 2: Second studied trait.

3- Phenotypic Correlation(r_p):

Phenotypic correlation coefficient, which was calculated between pairs of some productivity traits (weight, total length, body depth, head length); as following equation:

$$r_{pxy} = \text{Cov}_{xy} / (\sigma_x \sigma_y)$$

r_{pxy} : Pearson correlation coefficient between two variables (x, y), Cov xy: Covariance between two traits (x, y), σ_x : Standard deviation of the first traits, σ_y : Standard deviation of the second traits.

Statistical analysis:

The experiment was designed using a Completely Randomized Design (CRD) method, and the statistical analysis of the data of this study was done using the SPSS program (SPSS, 2019); the Office-Excel (2016) program was used as assistant program.

Results and discussion:

Genetic Parameters:

1- Heritability estimates:

Table (1) shows the estimation of the heritability as average, for all studied traits (total weight, total length, body depth, head length, dorsal fin base, horizontal eye diameter, snout length, mouth diameter).

Table (1): the measurement of the heritability among the studied individuals.

Studied traits	Heritability estimate
live weight	0.43
Total height	0.50*
Body Depth	0.37
Head length	0.27
The base of the dorsal fin	0.69*
The horizontal diameter of the eye	0.72**
snout length	0.77**
mouth diameter	0.49
Standard length	0.89**
caudal peduncle length	0.21

****:** Significant at the 1% level. *****: Significant at the level of 5%.

$h^2 = (4 * \text{Var of generation}) / \text{Var of phenotype or total variance}$

Table 1, shows the estimation of the values of the heritability coefficient for all the studied traits (total weight, total length, body depth, head length). The heritability estimated as 0.21, 0.89, 0.49, 0.77, 0.72, 0.69, 0.27, 0.37, 0.50, 0.43, for live weight, total length, body depth, head length, dorsal fin base, horizontal eye diameter, snout length, mouth diameter, standard length and caudal peduncle length respectively, the heritability estimate for the total length trait was 0.50 which indicates that selection helped to inherit the total length trait well and thus obtained next generation with high lengths, as the length trait is considered one of the most important productive traits on the basis of which fish are selected, for body weight trait, the heritability was also high reaching 0.43, that indicates insure well inherited trait. As for the characteristic of body depth its heritability was intermediate (0.37), while for the head length the value was 0.27, which is considered an undesirable trait in females, so it is preferable to be applied by direct selection. However, inheritance of such characteristic (head length) was 0.37; this did not agree with the result of (Chen et al., 2022), as the heritability was 0.28. The inheritance of the weight trait was 0.43, and this was agreed with (Chen et al., 2022), and the heritability for the total height was 0.50; and it did not agree with the same

author Moreover, the estimation of the heritability is required to predict the response to selection for most accuracy (Jamieson et al...2020).

2- Genetic correlation:

Following table (2) shows the genetic correlation measurement for all measured traits (total height, weight, body depth, head length) for the basal population, the selected individuals, and the individuals resulting from the mating of the best individuals.

According to the genetic correlation through the relationship between parents and children (geometric method).

Table (2) : shows the genetic correlation among the studied individuals.

studied trait	weight	Total length	Body depth	Head length
Weight	1.00			
Total length	0.15*	1.00		
Body depth	0.75**	-0.18	1.00	
Head length	-0.62**	-0.12	-0.16	1.00

****:** Significant at the 1% level. *****: Significant at the level of 5%.

$rg = \text{SQRT}(\text{Covz2x1} * z1x2) / (\text{covz1x1} * \text{covz1z2})$.

The following measurements show the genetic correlation between all individuals used in the experiment (basal population, selected individuals, offspring resulting from selection) (Population & Parents & offspring) with the relationship between each of two productive traits (total weight, total length, body depth, head length), it is noted from the results that the highest correlation was between weight and body depth as it reached 0.75 and was significant at the level of 0.01, while the correlation between weight and body depth followed by 0.15 and was significant at the level of 0.05, these two characteristics are considered the most important in indicating the inheritance of productive traits, as their increase indicates the inheritance of high weight and high height, which also indicates that selection led to high and good results and obtaining a generation that have the best of these traits, and that was similar to the results of the researcher (Schlicht et al..., 2019). As for the correlation of weight with head length, it was negative and significant at a significant level of 0.01 which indicates that an increase in one of these two traits leads to a decrease in the other trait, and it is preferable that selection leads to an increase in weight with a decrease in head length because trait of head length is considered an undesirable trait in marketing, as the genetic correlation between two traits height and each of the body depth and head length was negative (-0.18, -0.12) respectively, while the correlation between the traits of body depth and head length was also negative as it reached -0.16.

3- Phenotypic Correlation:

The following table (3) shows the phenotypic correlation for all measured traits (total height, weight, body depth, head length) for the basal population, the selected individuals, and the individuals resulting from the mating of the best individuals.

Table (3) shows the phenotypic correlation among the studied individuals

studied trait	weight	Total length	Body depth
Weight	1.00		
Total length	-1.00	1.00	
Body depth	-0.33	0.20	1.00
Head length	-0.39*	0.96**	0.21

****:** Significant at the 1% level. *****: Significant at the level of 5%.

The following measurements show the phenotypic correlation between pairs of productive traits (total weight, total length, body depth, head length) for each of the basal population, the selected individuals, and the generation of offspring resulting from the mating of the selected individuals

(Population & Parents & Offspring). These results were not consistent with the researcher (Karisa et al., 2007) and the correlation was negative between weight characteristics and each of the characteristics of total length, body depth and head length, and its values were (-1.00, -0.33, -0.39) respectively, and the correlation between the characteristics of live weight and head length was significant at the level of 0.05, while the correlation between the characteristic of total length and body depth was positive and amounted to 0.20, as well as the correlation between the characteristic of total length and head length was positive and amounted to 0.96 and was significant at the level of 0.01. And the correlation between the two characteristics of body depth and head length was 0.21.

The total indicators (weight, total length, body depth, head length) that were measured indicate the possibility of significantly improving the performance of the important characteristics related to fish productivity and the upcoming new technology (selection), which depends on selecting the best individuals that possess the best productive morphological characteristics. It is possible to select for more than one trait at a time, which increases the response to selection and speeds up obtaining improved strains that contain the best desirable traits, which means obtaining the desired goals of selection in terms of growth, disease resistance, cold and heat tolerance, carcass formation and feeding efficiency. ...and other qualities in a shorter time.

Conclusions:

-Applying genetic improvement programs via selection on common carp fish led to the best results, where it improved relatively the studied productivity indicators.

-Most estimates of the heritability coefficient for the fish studied were relatively high and make the genetic improvement program by selection easy to apply.

References:

- Bernabeu, S.L.; Shin, H.S.; Feilpe, A.L.; Perez, C.G.; Berbel, C.; Elalfy, I.S.; Armero, E.; Sanchez, J.P.; Arizcun, M.; Zamora, M.J.; Manchado, M.; Afonso, J.M. (2021) Genetic parameter estimations of new traits of morphological quality on gilthead seabream (*Sparus aurata*) by using imAfish-ML software. *Aquaculture Reports*, Volume 21, 100883.
- Beveridge, M.C.M. ; Thilsted, S.H. ; Phillips, M.J. ; Metian, M. ; Troell, M. and Hall, S.J. (2013). Meeting the food and nutrition needs of the poor : the role of fish and the opportunities and challenges emerging from the rise of a quaculture . *Journal of fish Biology*/Volume 83, issue 4/p.1064.1084.
- Chen, G ; Liu, H; Muyu, X; Luo, W; Tong, J. (2022). Estimation of herita abilities and quantitative trait loci for growth traits of bighead carp (*Hypophthalmichthys nobilis*), <https://doi.org/10.1016/j.aquaculture.2022.739213>.
- Dong, Z. ; Hong , N.N. and Zhu , W. (2015). Genetic evaluation of a selective breeding program for Common Carp *Cyprinus carpio* conducted from 2004 to 2014. *BMC Genetics* 16, Article number: 94 (2015)
- FAO (2012), The State of World Fisheries and Aquaculture 2012. for the table. Dar Alaa for publishing, distribution and translation.
- Jamieson, A.; Anderson, S.J.; Fuller, J.; Cote, S.D; Northrup, J.M. and Shafer, A.B. (2020). Heritability estimates of antler and body traits in white-tailed deer (*Odocoileus virginianus*) from genomic relatedness matrices. *The American Genetic Association* 2020. e-mail: journals.permissions@oup.com.
- Karisa-Charo, H.; Bovenhuis, H.; Rezk, M.A.; Ponzoni, R.W.; Van Arendonk, J.A.M.; Komen, H. (2007). Phenotypic and genetic parameters for body measurements, reproductive traits and gut length of Nile tilapia (*Oreochromis niloticus*) selected for growth in low-input earthen ponds. *Aquaculture*, Volume 273, Issue 1, pages 15-23.
- Kirpichnikov, V.S.; 1966 a Goals and methods of progeny testing in Carp breeding. *IZV.gosud.nauchno.-issled.Inst. Ozer, reck.ryb.Khoz.*, 61:40.61
- Kocour, M ; Mauger, S ; Rodina, M ; Gela, D; Linhart, O ; and Vandeputte, M. (2007). Heritability estimates for processing and quality traits in common carp (*Cyprinus Carpio* L.) using a molecular pedigree. Volume 270, Issues 1-4, pages 43-50. <http://doi.org/10.1016/j.aquaculture.2007.03.001>.

- Mello,D,F; AlOliveira,C; Jr Streit, D; Resende,K,E; Oliveira,N,S; Fornari,C,D;Barreto,V,R;Povh,A,J;and Ribeiro,P,R.(2016).Estimation of Genetic parameters for body weight and morphometric traits to tambaqui colossoma macropomum.<https://doi.org/10.1016/j.smallrumres.2021.1066446>.
- Mousalli,A,H.(2016).Fish(its production,methods of preserving it, and ways of preparing it
- Prchal,M ; Bugeon,J ;Vandeputte,Marc ;Kause,A ;Vargnet,A ;Zhao,J ;Glea,D ; Genestout, Bestin,A; Haffray,P; and Kocour,M.(2018).Potential for Genetic improvement of the main slaughter yields in common carp with in vivo morphological predictors.Original research article front.Genet.,30July 2018 Sec.Livestock Genomic.Volume9-2018.<http://doi.org/10.3389/fgene2018.00283>.
- Reed,T,E;Prodoni,P;Bradley,C;Gilbey,J,M;Ginnity,P;Primer,G,R;and Bacon,P,J.(2018).Heriability estimation via molecular pedigree reconstruction in a wild fish population reveals substantial evolutionary potential for a sea age at maturity, but not size within age classes.Canadian Journal of Fisheries and Aquatic Sciences.<https://doi.org/10.1139/cifas-2018-0123>.
- Schlicht,K;Krattcnma,N;Lugert,V;Schulz,C;Thallar,G;Tetens,J.(2019) Estimation of genetic parameters for growth and carcass traits in turbot.Arch Anim Breed .2019,62(1):265-273.published online 2019 may 6.
- Warda,S.(2021).Information about breeding common carp..Dar Alaa for publishing, distribution and translation.

تقدير المؤشرات الوراثية لجيلين من أسماك الكارب الشائع المنتخبة لبعض الصفات الإنتاجية

عهد الحلو⁽¹⁾ و آلاء عبد الرزاق الحاج⁽¹⁾ و محمد الخلف⁽¹⁾

(1). كلية الهندسة الزراعية جامعة حلب، سورية.

(*المراسلة:م. عهد الحلو، البريد الإلكتروني: ahedalhelue27@gmail.com).

تاريخ القبول: 2023/09/15

تاريخ الاستلام: 2023/09/5

الملخص

أجريت هذه الدراسة بمسكة بمنطقة الشيخ سعيد في ريف حلب على سمك الكارب لتحسين بعض الصفات الإنتاجية وتقدير مؤشرات الوراثية وذلك من خلال الانتخاب لأفضل الأفراد التي تمتلك أفضل المواصفات الإنتاجية، استخدم في هذه التجربة (50 سمكة) تم أخذ القياسات الإنتاجية لبعض صفات إنتاج اللحم (الوزن الحي، الطول الكلي، عمق الجسم، طول الرأس، الطول القياسي، قاعدة الزعنفة الظهرية، القطر الأفقي للعين، طول الخطم، قطر الفم، طول السويقية الذيلية) من عمر التسويق 6-7 شهر حتى عمر النضج الجنسي 1.5-1 سنة، أجريت هذه الدراسة في 2021 حتى 2023. وأشارت النتائج إلى تقديرات كل من معامل التوريث للصفات الإنتاجية 0.27, 0.37, 0.43, 0.50 (الطول الكلي، الوزن الكلي، عمق الجسم، طول الرأس) على التوالي، في حين كانت تقديرات الارتباط الوراثي بين صفة الوزن الحي مع كل من الطول الكلي وعمق الجسم هو ايجابية وعالية المعنوية بينما الارتباط الوراثي بين بقية الصفات الإنتاجية كانت سلبية ومنخفضة، بينما تقديرات الارتباط المظهري بين صفات الطول الكلي و (عمق الجسم، طول الرأس) قد كانت ايجابية وعالية المعنوية.

الكلمات المفتاحية: الكارب الشائع، الانتخاب، مؤشرات وراثية، الارتباط المظهري.